MINISTRY OF HEALTH, LABOR AND WELFARE

PROJECT TO PROVIDE PLANNING GUIDANCE FOR THE WATER SUPPLY PROJECT (PHASE-2)

PROJECT FOR IMPROVEMENT OF WATER SUPPLY SYSTEM IN VAVA'U, THE KINGDOM OF TONGA

FINAL REPORT

MARCH 2020

NJS CONSULTANTS CO., LTD.

PROJECT TO PROVIDE PLANNING GUIDANCE FOR
THE WATER SUPPLY PROJECT (PHASE-2)

PROJECT FOR IMPROVEMENT OF WATER SUPPLY SYSTEM IN VAVA'U, THE KINGDOM OF TONGA

FINAL REPORT

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SUMMARY

1. Background of the Project

The Kingdom of Tonga (the Kingdom) is an island nation in the South Pacific Ocean consisting of around 172 islands ranging 620 km extension from the southernmost to the northernmost. The total population is estimated at 100,651, of which 74,611 or 74.1 percent inhabits in Tongatapu island where Nuku'alofa as its capital city is located (Source: Tonga Census of Population and Housing 2016).

The Kingdom has the common issues as the PICs (Pacific island countries) such as small domestic markets and distance far from the major international markets and the various vulnerability to natural disasters and climate changes. To overcome these issues will be essential for the Kingdom's socio-economic development. The Kingdom is reported that it is ranked as second in the world risk index of the most vulnerable countries following Vanuatu to the natural disasters such as cyclones ("World Risk Report 2016").

GOJ (Government of Japan) has already formulated Japan's aid policy for the Kingdom as per the Kingdom's national development plan and the aid policy in the Pacific Islands Leaders Meeting (PALM). It is intended that Japan will assist the Kingdom on enhancement of sustainable economic growth including improvement of basic social service and infrastructure development with consideration of environmental conservation and climate changes.

Vava'u, the project area, is located at a distance of about 200 km from the Tongatapu Island. Vava'u has its population of 13,738 inhabitants or 13.6 percent of the total population of the Kingdom, of which 5,251 or 38.1 percent inhabits in Neiafu as its city center and the remaining inhabitants scatter in the rural areas (source: Tonga Census of Population and Housing 2016).

Neiafu where is the largest city following Nuku'alofa is an economically important area for the Kingdom with its attractive tourism place of 80,000 international tourists annually visiting its beautiful scenery, harbor and its famous yacht port worldwide. Vava'u Island is expected to be developed further in the field of tourism industry by the improvement and expansion of the existing Vava'u International Airport by the ODA assistance from GOJ toward expected increase of international flights.

The Kingdom's urban water supply service is provided by TWB (Tonga Water Board) under a jurisdiction of MPE (Ministry of Public Enterprise). TWB has developed water supply system, mainly in Tongatapu Island where the capital of the Kingdom locates in, with financial supports by various international donors. However, in the remote islands such as Vava'u Island, sufficient investment has not been made for the development and maintenance of the water supply system and the following issues on water supply service becomes clear;

- Deterioration of existing water supply facilities
- Salinization of existing water source due to seawater intrusion and shortage of water source
- Remaining Asbestos Cement (AC) pipes which cause water leakages and adverse effects to human body

- High NRW rate (40 to 50 % in Vava'u) due to water leakages caused by the deteriorated existing pipes
- Malfunction of water/flow meters and chlorine injection unit

On the other hand, the water supply in rural or village areas, which is currently under the jurisdiction of the MOH (Ministry of Health), has the following issues in terms of its water volume and quality;

- Water supply only for three (3) hours due to insufficient capacity of the water supply system
- Occurrences of waterborne diseases due to lack of chlorine disinfection and appropriate sewerage treatment
- Water source pollution due to lack of appropriate management

In above situation, the national plan named "National Infrastructure Investment Plan 2013 to 2023" was formulated and the priority projects were proposed in each sector to put development plans into execution. With regard to water sector in this investment plan, Vava'u island was emphasized as one of target areas of the development plan in the water supply sector as clearly described in the report of "Outer Islands Water Supply Improvement Project".

2. Current Situation of Water Supply in the Project Area

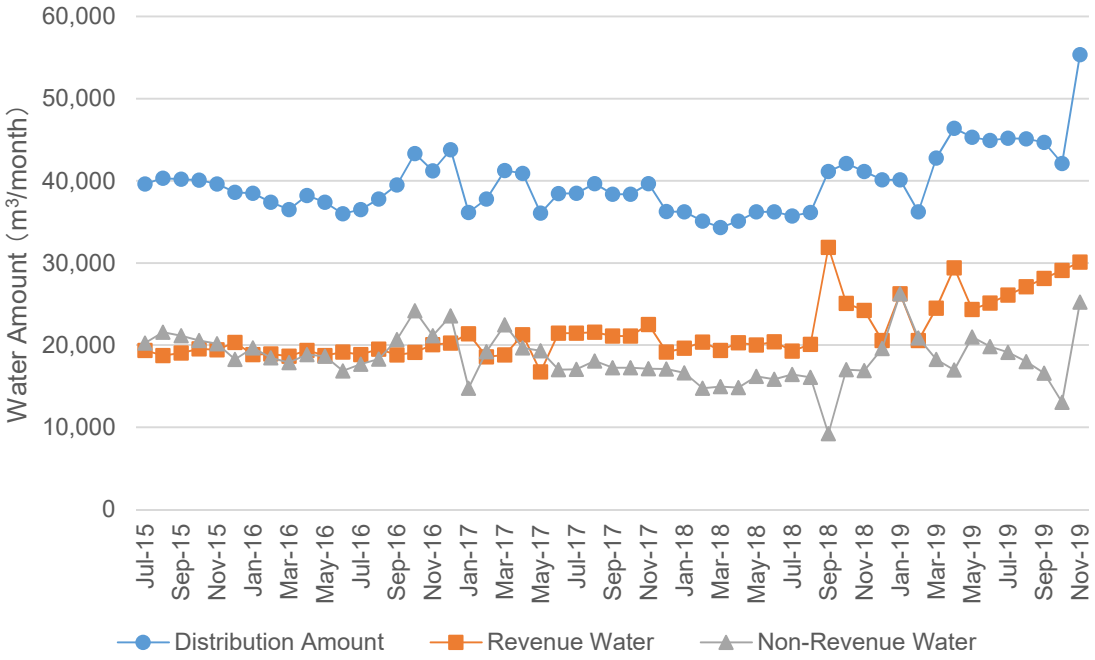
In Vava'u Island, TWB provides their water supply service in Neiafu and its nearby area, while the rural area far from the city center is supplied by the Village Water Committee (VWC) at each village unit under the management / supervision of the MOH. As of 2019, TWB provides their water supply service to about 1,240 households, approximately 45 % of 2,745 households totally in Vava'u Island.

Table S-1 and Figure S-1 show the TWB's performance (production / distribution amount and revenue water consumption) in the recent years. The each indicator of the performance has increased and as of 2018, the distribution amount is 1,348 m^3/day in average, 1,525 m^3/day in maximum and NRW is 41 %.

Table S-1 TWB's Performance on Water Supply Service in Vava'u in Recent Years

Item / Year	2015	2016	2017	2018
Average Water Production (m^3/day)	1,638	1,762	1,987	1,984
Maximum Water Production (m^3/day)	1,683	1,976	2,176	2,282
Average Distribution Amount (m^3/day)	1,267	1,295	1,216	1,348
Maximum Distribution Amount (m^3/day)	1,325	1,440	1,305	1,525
Authorized Water Consumption (m^3/day)	630	643	677	798
NRW (%)	50%	50%	44%	41%

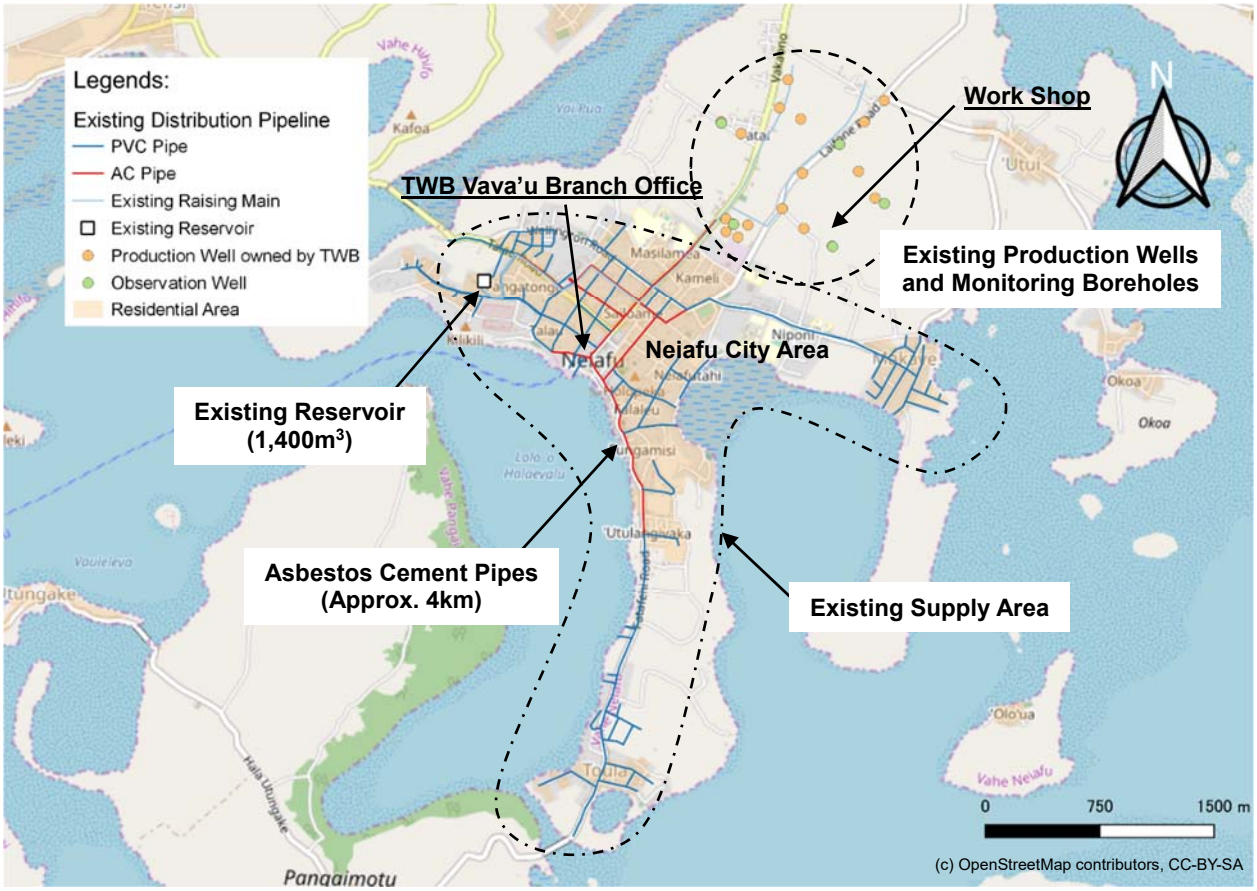
Source: Survey Team based on TWB's data



Source: Survey Team based on TWB's data

Figure S-1 TWB's Performance on Water Supply Service in Vava'u in Recent Years

Figure S-2 illustrates the TWB's current water supply system in Vava'u. The water supplied to Neiafu and its nearby area is distributed from the existing reservoir of 1,400 m^3 in total by gravity following to transmission of the pumped groundwater of the current five (5) production wells to the reservoir. On the other hand, on the water supply in the rural area operated by VWC, the water at the overhead tank that is transmitted from the production wells is distributed to the households in the village by gravity.



Source: Survey Team

Figure S-2 Location of Existing TWB's Water Supply System in Vava'u

3. Current Issues on Water Supply

(1) National Level

The following issues on water supply in national level have been identified;

- Degradation of water distribution function and water quality due to the deterioration of the water supply facilities in remote islands
- With regard to the degradation of water distribution function, high rate of NRW potentially caused by the leakage of the existing deteriorated pipes and another risk of sea water intrusion to the current water source due to its excess yield
- With regard to the degradation of water quality, potential risk of outbreaks of waterborne diseases such as typhoid due to lack of disinfection process by chlorination and another health risk potentially to be caused by existing AC pipes
- In some area in the remote islands, a water supply for 24 hours has not been realized because enough quantity of water source cannot be secured
- Appropriate maintenance has not been conducted because of the lack of the equipment and their staffs' experience and technical skills

Table S-2 summarizes the relation and the issues on water supply in national level.

Table S-2 Relationship of the Project with the Issues on Water Supply

Issue	Requirements by the Project
Degradation of water distribution function and water quality in remote islands	Reconstruction of water supply facilities
Water supply for 24 hours is not realized because enough quantity of water source cannot be secured	Securing of a new water source
Appropriate maintenance has not been conducted because of the lack of the equipment and their staffs' experience and technical skills	Provision of equipment and implementation of soft component

Source: Survey Team

(2) Project Area

The current situation and the issues on water supply service in Vava'u and relation of the project with them are shown in Table S-3.

Table S-3 Relation between Issues (Project Area) and the Project

Classification	Issue	Project
Overall	Review of the master plan toward the reconstruction of the water supply facilities	Formulation of water supply system improvement plan based on appropriate water demand calculation
Water source	Sea water intrusion to the current water source	Securing of a new water source
Transmission / Distribution Facilities	Malfunction of existing facilities	Reconstruction of water supply facilities
	Remaining AC pipes and high rate of NRW	
	Low level of water supply service in village areas	
Operation and Maintenance	Lack of equipment for O&M	Provision of equipment
Financial	Lack of appropriate management of water volume and financial management capacity	Implementation of soft component

Source: Survey Team

4. Outline of the Project

(1) Goal of the Project

The goal of the project is to contribute to realization of stable, safe and reliable water supply, improving the water supply system in Vava'u Island through grasping the future water demand by an appropriate calculation method, and studying the validity and necessity of the water source. Table S-4 shows the basis conditions for planning the project.

Table S-4 Basic Conditions for Project Planning

Target Year	2030
Planned served population	8,200
Daily maximum water distribution amount	2,730m^3/day

Source: Survey Team

(2) Outline of the Project

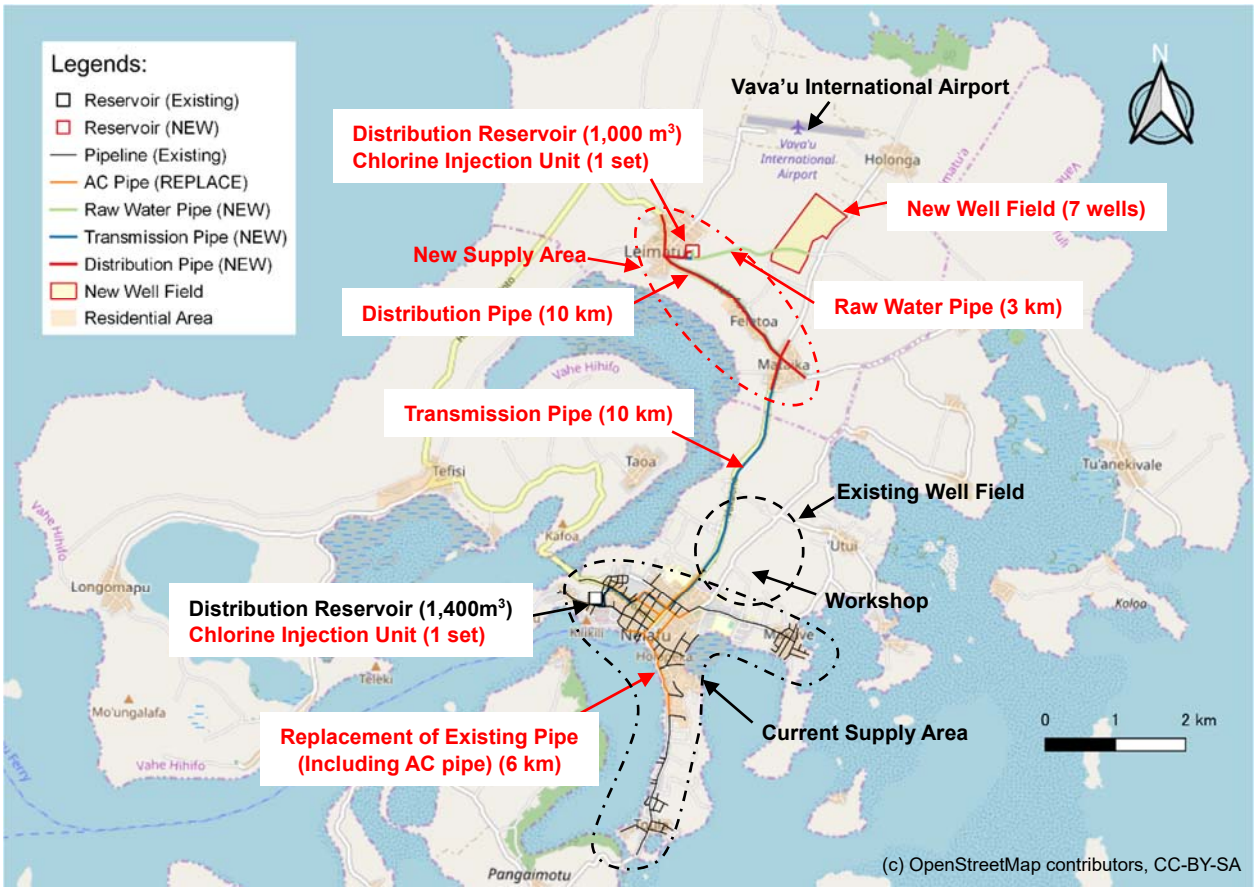
To achieve the above goal, construction of a new production wells, a new reservoir, raw water, transmission and distribution pipelines, and replacement of existing AC pipes are implemented in the project. In addition, procurement of materials and equipment for O&M and soft component toward enhancement of TWB's capacity are also included in the project.

Table S-5 shows the outline of the project, Figure S-3 shows the scheme of overall improvement plan and Figure S-4 shows its system flow, respectively.

Table S-5 Outline of the Project

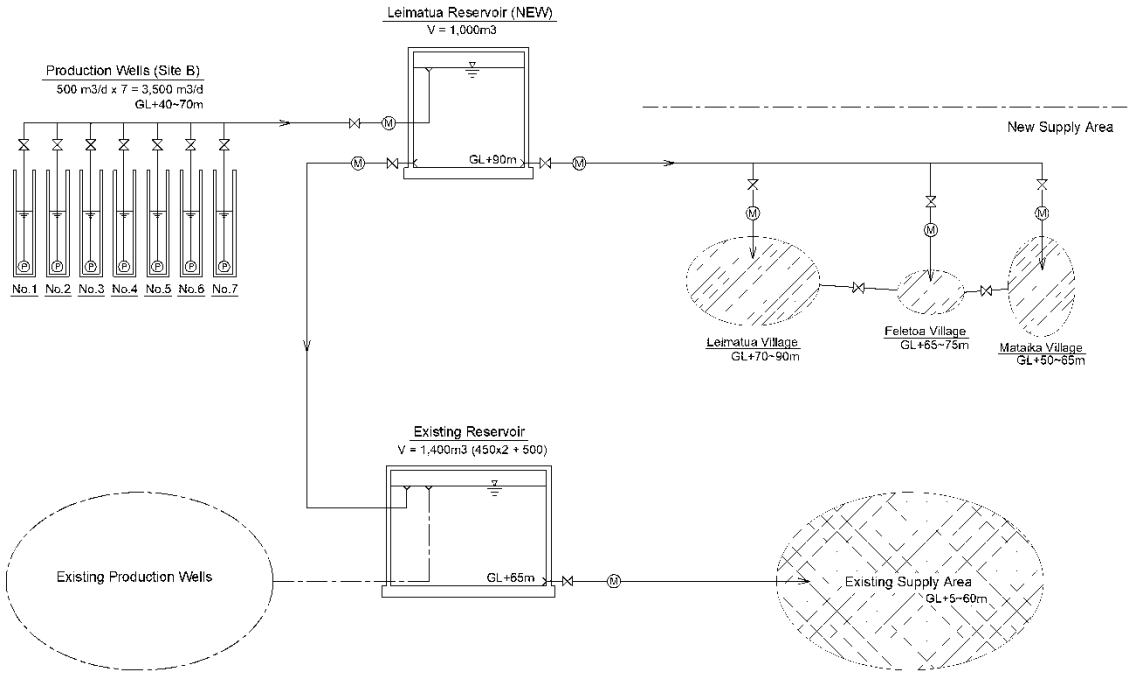
Scope	Outline of the Project
Construction Works	• Production Well : 7 places • Generator: 100KVA, 3 sets • Reservoir（Leimatua）: 1,000 m^3 • Pipeline (raw water, transmission, distribution): 25 km • Replacement of AC pipe: 4 km • Chlorine injection unit: 2 sets (at two (2) reservoir) • Flow meter: Electromagnetic type, φ100 to 200, 7 sets • Monitoring system for flow management: 1 set
Equipment Procurement	• Small-scaled desalination equipment: 250L/h, 3 sets • Generator 7.5KVA, 3 sets • Water quality measurement instrument: 1 set • Water leakage detection equipment: 1 set • Heavy machines: small backhoe (0.06m^3, 1 unit), pick-up truck (1 unit) • Customer meter and, ancillaries, service pipes: 600 sets, pipe (10m)
Soft Components	• Training on O&M of water supply facility • Training on strengthening managerial capacity of water supply business • Training on strengthening supervising capacity of pipe installation including water leakage management

Source: Survey Team



Source: Survey Team

Figure S-3 Overall Improvement Plan of the Water Supply Facilities



Source: Survey Team

Figure S-4 Water Supply System Flow after Improvement

5. Conclusion

The Kingdom has vulnerabilities to natural disasters and climate changes, and overcoming these vulnerabilities has become an inevitable challenge for the social and economic development of the country. Especially, Vava'u where Fiji Airways operates direct flights, has abundant tourist attractions such as beautiful scenery and various marine activities. And it has made Vava'u an important hub in the tourism industry and economically important city of the Kingdom.

On the other hand, water supply facilities has not been developed adequately in Vava'u because most of donors have not made their support there. As the result, the issues of seawater intrusion to the current water source, deterioration of the existing facilities and remaining AC pipes have become exposed.

For further economic development, it is necessary to eliminate the impact of the sea water intrusion to the current water source on water supply by securing new production wells. In addition, in order to supply water from the new production wells, it is necessary to construct a distribution reservoir, transmission and distribution pipes. And it is also important to replace existing AC pipes and aging pipes to supply safe and reliable water.

This project aims to improve the water supply system in Vava'u based on the future water demand estimated by an appropriate method through studying adequacy and necessity of the new water source in Vava'u according to GOJ's ODA policies on the Kingdom. Implementation of the project will contribute to improving the living environment of local residents by supporting for realization of stable, safe and reliable water supply service in Vava'u.

The Royal Family of Japan and Tonga have been interacting closely so far. In addition, 2020 marks the 50th anniversary of Japan-Tonga diplomatic relations. From this reason, it would have significant meaning that GOJ implements this project in a grant aid scheme in the Kingdom.

BASIC INDICATORS

Table-1 Key Economic Indicators in the Kingdom of Tonga

Year	2017	1990
Population	10.8 Thousand	10 Thousand
GNI per Capita	4,010 US$	1,160 US$
Economic Growth Rate	2.70%	-2.00%
External Debt Balance	1.69 Hundred Million US$	0.54 Hundred Million US$
DAC Category	Upper Middle Income Countries	Lower Middle Income Countries
World Bank Category	iii/Upper Middle Income Countries	IBRD Loan (Redemption Period 17 years) Eligible Country

Source: Japan's ODA Data by Country, 2005 and 2018, Ministry of Foreign Affairs, Japan

Table-2 Millennium Development Indicators in the Kingdom of Tonga

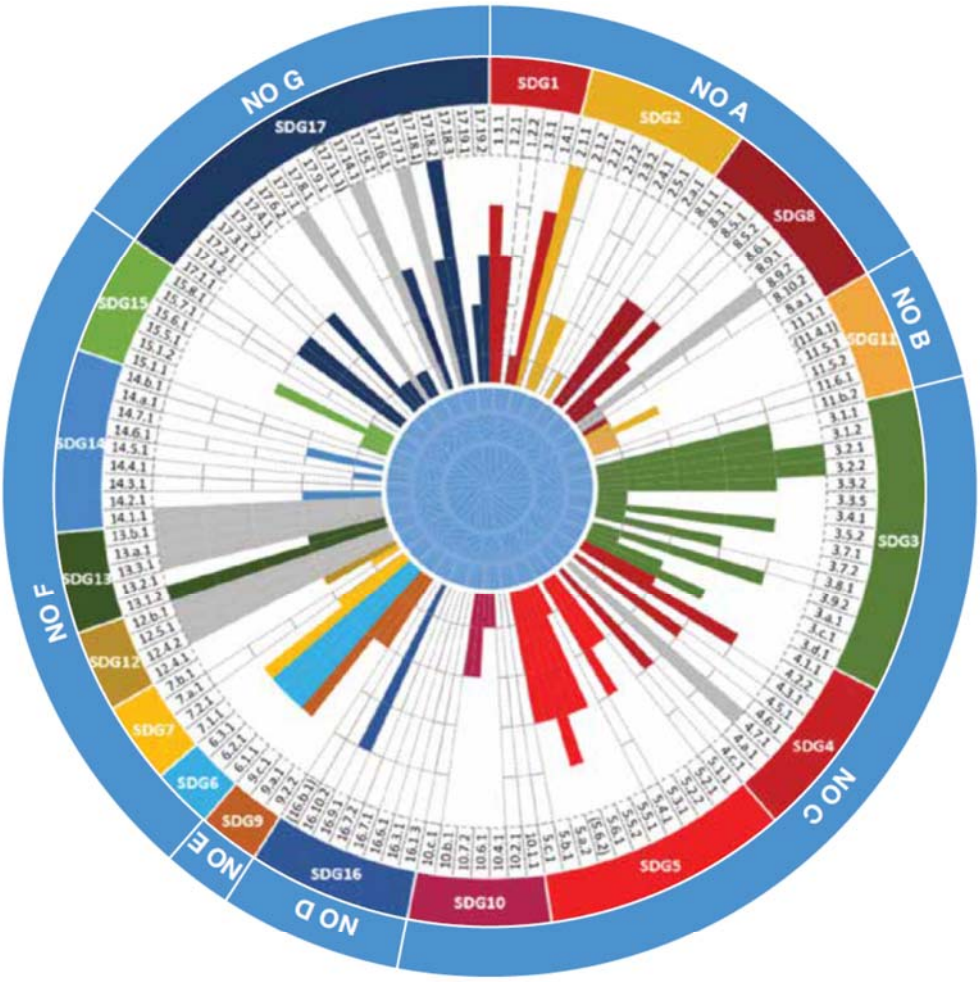
Millennium Development Indicators	Latest	Past
Goal 1: Proportion of population below $1.25 (PPP) per day: 5.9 % (2008)	—	—
Goal 2：Net enrolment ratio in primary education	84.6% (2013)	92.3% (1990)
Goal 3：Ratios of girls to boys in primary, secondary and tertiary education (Boy: 1.0)	1.00 (2013)	0.99 (1990)
Goal 4：Under-five mortality rate (per 1000 live births)	12.1 (2013)	22.8 (1990)
Goal 5：Maternal mortality rate (per 100 000 live births)	120 (2013)	71 (1990)
Goal 6：HIV prevalence among population aged 15-24 years	—	—
Goal 7：Proportion of population using an improved drinking water source (%)	99.6% (2015)	98.6% (1990)

Source: Japan's ODA Data by Country, 2016, Ministry of Foreign Affairs, Japan

Table-3 Infant, Under-five, Maternal Mortality and Life expectancy

	1990	2000	2010	2015
Infant mortality per 1,000 live births	21	17	13	14
Under-five mortality per 1,000 live birth	25	21	16	17
Maternal mortality per 100,000 live birth	-	-	36 (2010)	124 (2015)
Life expectancy at birth (years)	-	-	72	73

Source: The State of the World's Children, 2002, 2012 and 2016, UNICEF

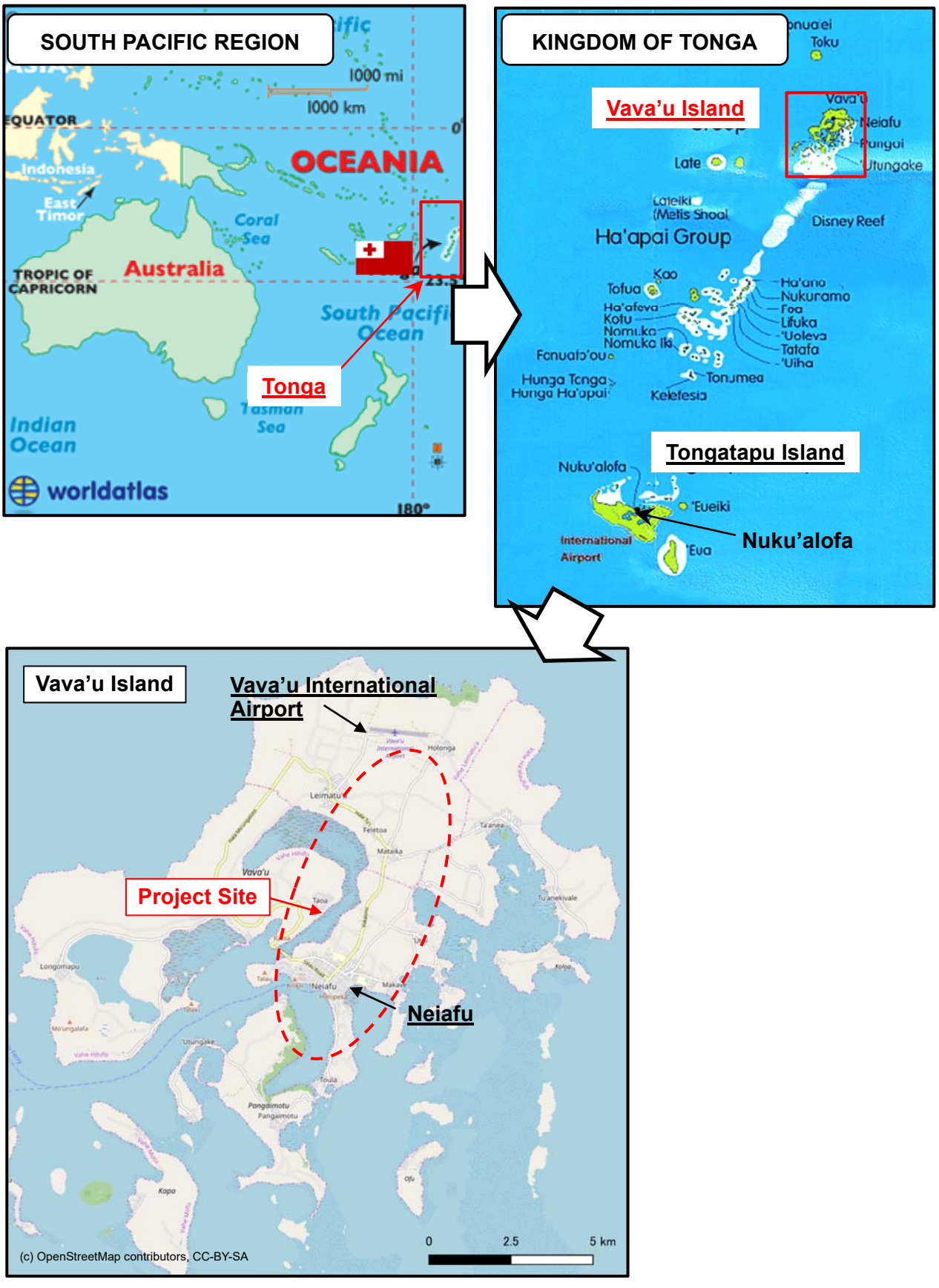


	BAR TYPE	VALUE
	Grey Bar	Tier 3 indicator. No established methodology
	Dashed Bar	None, or insufficient country data
	No colour bar	No achievement against the goal
	20% of colour bar shaded	Minimal achievement
	40% of colour bar shaded	Some achievement
	60% of colour bar shaded	Average Progress
	80% of colour bar shaded	Good Progress
	Full colour bar	Goal is fully achieved

Source: Voluntary National Review 2019, Kingdom of Tonga

Figure-1 Progress on Sustainable Development Goals (SDGs) in the Kingdom of Tonga

LOCATION MAP



PHOTOS

Photo-1: TWB's Main Office in Tongatapu:
TWB's main office in Tongatapu in a new building which was built in 2018 and shared by public enterprises of TPL, TWB and WAL.

Photo-2: Meeting with TWB
Meetings were carried out for the discussion on the formulation of the project between Japanese side and TWB of which 10 staffs attended including CEO.

Photo-3: Meeting with MLNR
A meeting was carried out with MLNR that has jurisdiction over water resources management including groundwater and land management. MLNR joined the site survey in Vava'u and provided relevant data.

Photo-4: Meeting with MOH
The survey team discussed with MOH with regard to the issues on the project formulation who has jurisdiction over the water supply in rural areas.

Photo-5: TWB's Branch Office in Vava'u
The TWB's branch office located in the city center of Neiafu which has a pay counter for the water bill.

Photo-6: Existing Reservoir (Vava'u)
RC structure of 1,400 m^3 (450 m^3×2, 500m^3×1). Efflorescence at some parts potentially caused by its deterioration was found on the wall surface.

Photo-7: Asbestos Cement Pipe exposed on ground surface

Asbestos Cement pipe od about 4 km extension is still remaining in Vava'u is to be replaced immediately to eliminate the water leakage and its potential impact on human health risk.

Photo-8: Chlorine Injection Unit (inside existing workshop)

Choline gas injection is not carried out because of the difficulty of the procurement of the chlorine gas. Instead, chlorine tablets are added to the extracted water once every morning. However, no residual chlorine is detected in the water at night time.

Photo-9: Flow Meter

The flow meter of the existing reservoir is working normally

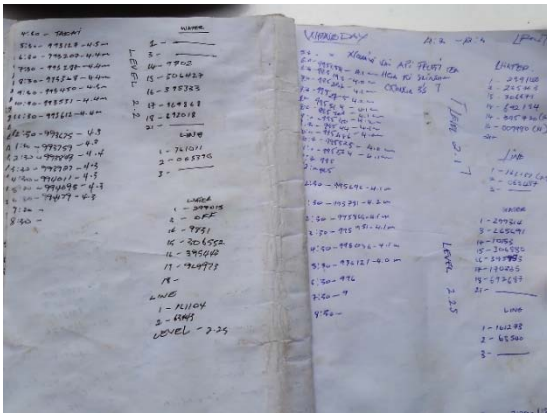


Photo-10: Manual Recording of O&M Data

Flow rate and water level of the existing reservoir is recorded manually in notebooks every hour. However, the data is not digitalized.

Photo-11: Current Well Field for Water Intake

The extraction pump and its control panel is installed inside the pump house.

Photo-12: Water Supply Facilities at Rural Areas (1)

The water supply is operated by VWC (Village Water Committee). The facility extracts groundwater and pumped up to the overhead tank and the water is distributed by gravity from the tank.

Photo-13: Water Supply Facilities at Rural Areas (2)（Leimatua）

The water is supplied only for three (3) hours without any disinfection by chlorine. Typhoid occurred in autumn in 2019 in the vicinity of Leimatua village.

Photo-14: Candidate Site of the Proposed Reservoir (Leimatua)

A wide vacant land is available for the proposed reservoir. The land is located on a hillside where the stored water at the reservoir can be distributed by gravity to the planned supply area.

Photo-15: Road Condition at the Project Site

Concrete pavement at the suburb areas. Less traffic compared to the city center.

Photo-16: Drilling Rig for Well

TWB owns a drilling rig for well extraction for the ground water that is only one water source in Vava'u.

Photo-17: Solar Panel and Pump Unit that was procured by Japan ODA Assistance

Solar Panel and Pump Unit that was procured by Japan ODA Assistance

Photo-18: Vava'u International Airport

An expansion of the current airport is under planning by Japanese ODA assistance. Vava'u has rich tourism resources and potential development of tourism industries.

ABBREVIATIONS

AC	Asbestos Cement Pipes
ADB	Asian Development Bank
AS	Australian Standard
ASTM	American Society for Testing and Materials
AusAID	Australian Agency for International Development
AWWA	American Water Works Association
CEO	Chief Executive Officer
DANIDA	Danish International Development Agency
DMA	District Metered Area
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EU	European Union
FS	Feasibility Study
ISO	International Organization for Standardization
IWRM	Integrated Water Resources Management
JICA	Japan International Cooperation Agency
KPI	Key Performance Indicator
MDGs	Millennium Development Goals
MLNR	Ministry of Lands and Natural Resources
MLSNRE	Ministry of Lands Survey Natural Resources and Environment
MOF	Ministry of Finance
MOH	Ministry of Health
MOR	Ministry of Road
MOT	Ministry of Tourism
MOW	Ministry of Works
MPE	Ministry of Public Enterprise
NGO	Non-Government Organization
NRW	Non-Revenue Water
NZAID	New Zealand International Aid and Development Agency
NZS	New Zealand Standard
ODA	Official Development Assistance
PACC	Pacific Adaptation to Climate Change
PALM	Pacific Islands Leaders Meeting
PEC	Pacific Environment Community
PIF	Pacific Islands Forum
RWH	Rainwater Harvesting
SDGs	Sustainable Development Goals
SIDS	Small Island Developing States
SOPAC	South Pacific Applied Geoscience Commission
SPCZ	South Pacific Convergence Zone
SPREP	South Pacific Regional Environment Programme
SWMP	Solid Waste Management Project
TCC	Tonga Communications Corporation
TEPB	Tonga Electric Power Board
TERM	Tonga Energy Road Map
TMS	Tonga Meteorological Service
TOP	Tongan Pa'anga
TVB	Tonga Visitor's Bureau
UFW	Unaccounted for water
VWC	Village Water Committee
WASABI	Water and Sanitation Broad Partnership Initiative

Chapter 1

Introduction

Chapter 1 Introduction

1.1 Background and Purpose of the Survey

1.1.1 Background

One of the goals of the MDGs (Millennium Development Goals), "Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation" has been achieved in 2010. However, about 660 million people is still cannot accessed to the safe water supply in the year of 2015. The SDGs (Sustainable Development Goals) adopted in 2015 set one of the goals of "By 2030, achieve universal and equitable access to safe and affordable drinking water for all". The Government of Japan (GOJ) has supported the developing countries in the water supply sector through construction of water supply facilities and dispatching experts in technical cooperation projects in the using ODA fund cooperation by applying the experiences and knowledges that have been developed in the spread of the water supply facilities in Japan.

In Japan, the water supply facilities has been constructed nationwide since 1952 and has achieved the water supply coverage rate at 98.0% (Basic Statistics on the Water Supply in Japan, 2017, Ministry of Health, Labor and Welfare), which shows a top service level in the world as shown in the low rate of water leakage and measures against earthquakes.

During the expansion of the water supply coverage, Japan has overcome the problems on water pollution, water shortage and high rate of Non-Revenue Water (NRW) caused by the high economic and population growth. Most of the developing countries faces those problems so that assistances based on Japanese experiences in water supply and potential utilization of Japanese technologies are expected in the developing countries. Utilization of Japanese high technologies and rich knowledge toward the assistance of the water supply sector in the developing countries will be a responsibility as a member of the international community and contributes to support overseas business development of Japanese companies and local governments.

Although the Japanese ODA scheme is adopted according to the request from the developing country in principle, the water supply project plan that the developing country has requested has poor contents or insufficient information in most cases and caused obstacles for formulation of excellent water supply projects.

Therefore, it is greatly required to study the specific measures toward solving the problems in the sector, enhance the capacity for planning water supply projects, formulation of the water supply strategic policy, water supply business operation in collaboration with the administrative officers in the sector and staffs of the water supply utilities.

1.1.2 Purpose

The purpose of the survey is to carry out the followings through providing advices and instructive directions

under public-private partnership based on the information in the developing countries with respect to the specific issues (e.g. development of water supply facilities, O&M (operation and maintenance) of water supply, human resources development) in the water supply sector and potential needs in the sector that have been acquired by Japanese companies or water supply utilities of Japanese local governments;

- To enhance planning capacity of the water supply projects in the developing countries
- To promote formulation of excellent and feasible projects that enable to fully demonstrate the knowledges and experiences in the water supply sector in Japan

1.2 Schedule and Contents of the Survey

The schedule and contents of the survey are shown in Table 1.1 and Table 1.2, respectively. The total period of the works is six (6) months and the submission of the reports is expected in February to March in 2020 as shown in Table 1.2.

Table 1.1 Survey Schedule

Item \ Year	2019									2020								
	October			November			December			January			February			March		
1.Preparation Works in Japan																		
(1) Preparation & Submission of Implementation Plan				▼														
(2) Preparation of Draft Report							▼											
2.Survey in Tonga																		
(1) Current & Future Issues in the Water Sector								▼										
(2) Technical Guidance on Preparation of Draft Application Form for Requesting the Project								▼										
3.Reporting in Japan																		
(1) Discussion on the Draft Report													▼					
(2) Preparation of the Report and its Executive Summary																▼		
(3) Submission of Final Report																		▼

Source: Survey Team

Table 1.2 Contents of the Survey

Date / Month	Task	Contents
Late Oct. 2019	Preparation of Implementation Plan	• Purpose of the Project • Basic Policy of the Project • Contents of the Survey Works • Work Schedule
Early Nov. to Early Dec. 2019	Preparation of the Draft Report	• Collection and Analysis of Data and Information • Preparation and Submission of Questionnaire • Review on the Basic Plan • Organizing the Current and Future Issues • Preparation of the Draft Report • Discussion on the Draft Report

Date / Month	Task	Contents
Early Dec. 2019	Discussion on the Draft Report	• Reflection of the Contents of the Discussion on the Report • Preparation of the Technical Guidance at the Site Survey
Mid-Dec. 2019	Technical Guidance on the Water Supply Project	• Findings on the Current Situation • Organizing the Current and Future Issues • Collection and Analysis of the Relevant Data on the Current Situation and Future Plans • Study on Alternative Plans • Technical Guidance on Preparation of the Draft Application Form for Requesting the Project
Late Dec. 2019 to Mid-Mar. 2020	Preparation of the Report and its Executive Summary	• Post-Guidance
Late Mar. 2020	Submission of the Final Report	• Submission of the Final Report • Submission of the Project Performance Report

Source: Survey Team

1.3 Survey Team

The survey team consists of the following members.

Table 1.3 Survey Team Members

Name	Job Title	Occupation
Mr. Kazuho TAGUCHI	Project Leader	Director, Office of Global Health Cooperation, Ministry of Health, Labor and Welfare (MHLW)
Mr. Ryuichi MORISHITA	Project Planning	Assistant Director, Office of Global Health Cooperation, Ministry of Health, Labor and Welfare (MHLW)
Mr. Daisuke YASHIRO	Chief Consultant	NJS Consultants Co., Ltd.
Mr. Sampei NAKANISHI	Water Supply Planning and Design (Water Source)	NJS Consultants Co., Ltd.
Mr. Kenta HAYASHI	Water Supply Planning and Design (Facility)	NJS Consultants Co., Ltd.
Mr. Kenta IMAI	Coordination and Local Logistics	Okinawa Pacific Partners
Mr. Yoshiharu YONEDA	Water Supply Management Operation and Maintenance	Okinawa Water Control Center Co., Ltd.

Source: Survey Team

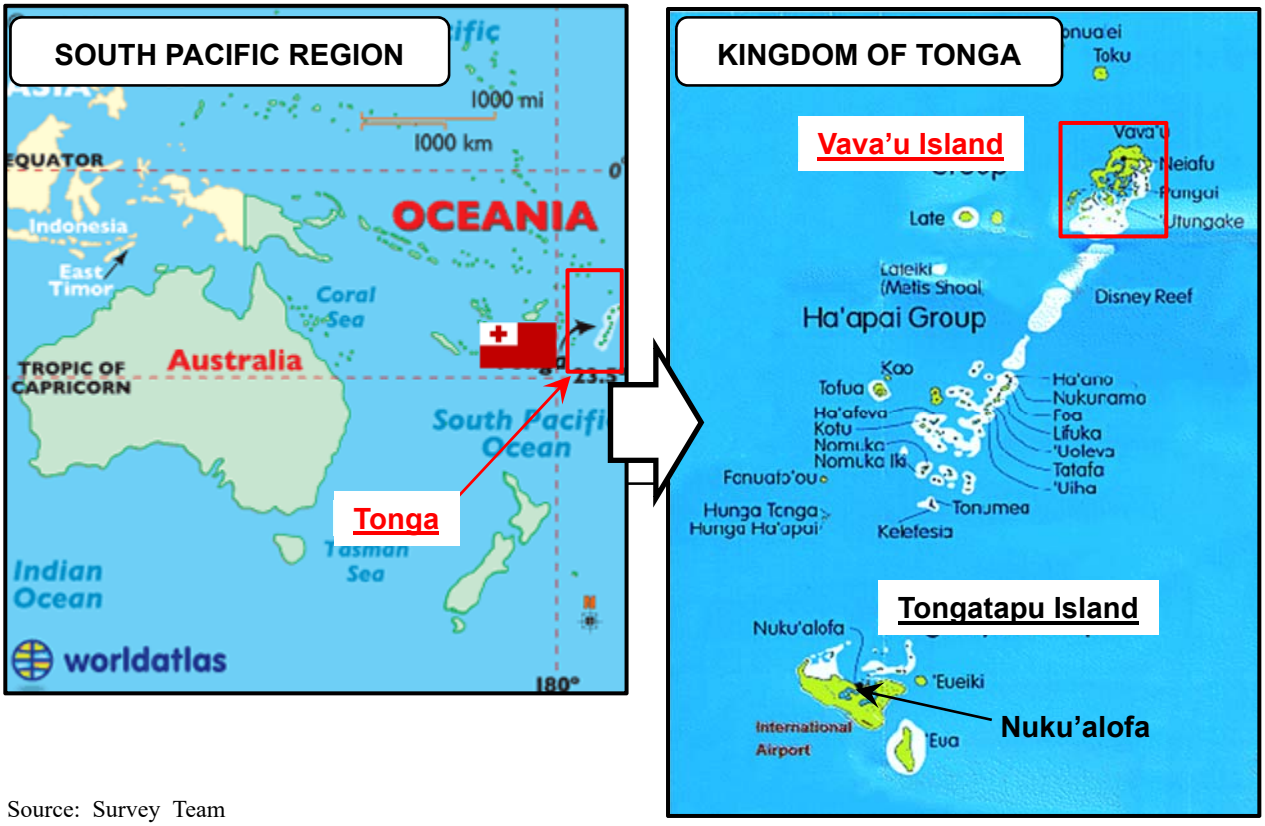
Chapter 2

Findings on the Current Situation on the Project

Chapter 2 Findings on the Current Situation on the Project

2.1 Outline of the Country and the Project Area

The country and the project target area are shown in Figure 2.1.



Source: Survey Team

Figure 2.1 Location Map of the Country and the Project Area

The Kingdom of Tonga (the Kingdom) is an island nation in the South Pacific Ocean consisting of around 172 islands ranging 620 km extension from the southernmost to the northernmost. The total population is estimated at 100,651, of which 74,611 or 74.1 percent inhabits in Tongatapu island where Nuku'alofa as its capital city is located (Source: Tonga Census of Population and Housing 2016).

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The national plan named "National Infrastructure Investment Plan 2013 to 2023" was formulated and the priority projects were proposed in each sector to put development plans into execution. With regard to water sector in this investment plan, Vava'u island was emphasized as one of target areas of the development plan

in the water supply sector as clearly described in the report of "Outer Islands Water Supply Improvement Project".

Under above background, the survey team conducted a field survey for gathering fact findings on the current situation on the water supply and the necessity of improvement of water supply system to formulate the project of "The Project for Improvement of Water Supply System in Vava'u, the Kingdom of Tonga".

2.2 Current Situation and Issues on the Water Supply of the Country

2.2.1 Current Situation on the Water Supply Sector (National Level)

(1) Water Supply Coverage

The coverage rate of the water supply in the Kingdom is shown in Table 2.1.

Table 2.1 Coverage Rate of the Current Water Supply in Tonga

Households Connected to Piped Water	9,751
Coverage Rate of Water Supply	53.5%（9,751/18,198）

Notes; No sewerage system is developed and each household has a septic tank for the treatment of the sewage.
Source：Tonga Water Board (TWB)

The status on the achievement of the SDGs (Target 6: Clean Water and Sanitation) in the Kingdom is shown in Table 2.2.

Table 2.2 The Current Status on the SDGs (Goal 6) in Tonga

Goal 6: By 2030, achieve universal and equitable access to safe and affordable drinking water for all

SDG Global Targets	SDG Global Indicators	2000（%）			2015（%）		
		Nationwide	Urban	Rural	Nationwide	Urban	Rural
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all	6.1.1 Proportion of population using safely managed drinking water services	98	97	99	100	100	100
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	6.2.1 Proportion of population using a) safely managed sanitation services and b) a hand-washing facility with soap and water	89	99	86	93	97	92
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and	6.3.1 Proportion of domestic and industrial wastewater flow safely treated	—	—	—	—	—	—

minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	6.3.2 Proportion of bodies of water with good ambient water quality		—	—	—	—	—
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	6.4.1 Change in water use efficiency over time	—	—	—	—	—	—
	6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	—	—	—	—	—	—
6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	6.5.1 Degree of integrated water resources management implementation (0-100)	—	—	—	—	—	—
	6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation	—	—	—	—	—	—
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes"	6.6.1 Change in the extent of water-related ecosystems over time	—	—	—	—	—	—
6.a By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programs, including water harvesting, seawater intrusion, water efficiency, wastewater treatment, recycling and reuse technologies	6.a.1 Amount of water- and sanitation-related official development assistance disbursements	—	—	—	—	—	—
6.b Support and strengthen the participation of local communities in improving water and sanitation management	6.b.1 Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management	—	—	—	—	—	—

Source: WHO unicef JMP, Progress on Drinking Water, Sanitation and Hygiene 2017

(2) Water Supply Facilities

The water supply system of the Kingdom is classified in two (2) types, namely, 1) an urban water supply system and 2) a water supply system in Rural or village area. The urban water supply is operated and managed by TWB (Tonga Water Board) for the islands of Tongatapu, Ha'apai, Vava'u and Niuas. The urban water is basically extracted from the underground aquifer called "Freshwater Lens" followed by a distribution by gravity after its chlorine disinfection.

TWB has developed water supply system, mainly in Tongatapu Island where the capital of the Kingdom

locates in, with financial supports by various international donors. However, in the remote islands such as Vava'u Island, sufficient investment has not been made for the development and maintenance of the water supply system and the following issues on water supply service becomes clear;

- Deterioration of existing water supply facilities
- Salinization of existing water source due to seawater intrusion and shortage of water source
- Remaining Asbestos Cement (AC) pipes which cause water leakages and adverse effects to human body
- High NRW rate (40 to 50 % in Vava'u) due to water leakages caused by the deteriorated existing pipes
- Malfunction of water/flow meters and chlorine injection unit

On the other hand, the water supply in rural or village areas, which is currently under the jurisdiction of the MOH (Ministry of Health), has the following issues in terms of its water volume and quality;

- Water supply only for three (3) hours due to insufficient capacity of the water supply system
- Occurrences of waterborne diseases due to lack of chlorine disinfection and appropriate sewerage treatment
- Water source pollution due to lack of appropriate management

2.2.2 Issues on Water Supply (National Level)

Table 2.3 summarizes the issues on water supply in the Kingdom.

Table 2.3 Issues on Water Supply in Tonga

Category	Issue	Expected Magnitude of Issue Level			Rationale for Evaluation of Issue Level
		Small	Middle	Large	
Institutional / Organizational	Legal / institutional position of the water supply business is not clear.	✓			TWB was established as a public enterprise as per the Public Enterprises Act 2002, and its legal institutional position is clearly regulated
	Their policy toward encouragement of self-efforts is not confirmed.		✓		TWB relies on the external financial support for a development of a new project, but the O&M is normally run by TWB's allocated budget.
	The organization of the TWB has not been established to fulfill the legal / institutional requirements as a water supply service provider.	✓			TWB's organization has already been established.
	Insufficient staff number or human sources for the requirement of the water supply service operation.		✓		Number of the staffs is sufficient, but the number of technical engineers with more skills is not sufficient.
Planning / Coordination	Upper-level plan such as a Master Plan on water supply has not formulated yet.			✓	The current master plan has been formulated in 1992 and not been updated from that time. A formulation of a new master plan toward future vision of water supply service is urgently needed.
	Coordination among the assistance of donors or international institution for water supply projects is not confirmed.		✓		With regard to water supply projects in Vava'u, small-scaled water supply project was implemented by the assistance of DANIDA. However, a development of a full-scaled project has not been implemented and needs another assistance of donors.

	Balance of the water supply service level (e.g. water supply amount, progress of improvement of facilities) has not been achieved.		✓		There is an unbalanced service level in Vava'u between the urban and rural areas. In rural areas, the time of the water supply is very short only for three (3) hours.
	There is unbalance issues on planning or development of the water supply sector with other relevant sectors (e.g. water resources management, sewerage and urban plan).	✓			Water source planning or its management is under jurisdiction of MLNR (Ministry of Lands and Natural Resources), there is no problems on the issues of the water supply facilities / system.
Business Operation / Financial Management	Insufficient budget for development of water supply projects			✓	The fund for the development of the new facilities cannot be provided only by TWB, and it needs a support of fund from donors.
	Water tariff system or policy has not been established.		✓		The water tariff system has already been established. The TWB's revenue comes from not only tariff collection but also other business activities such as plumbing works and training. However, the current tariff collection is not based on water metered system. In that sense, the current tariff collection system should be improved toward sound financial status.
	The service provider cannot maintain the independent accounting system.	✓			The TWB's financial management is carried out independently without any subsidy from the government.
	Repair cost is not secured in the annual budget of the service provider.	✓			The repair cost is secured in the annual budget plan.
	Cost of purchase of chemicals is secured.	✓			The cost of purchase of chemicals is secured.
Operation & Maintenance	A guideline or manual of the maintenance of the water supply facilities has not been established.	✓			The standard of the maintenance works that was formulated in New Zeeland is used in TWB.
	Regular maintenance works is not done.	✓			TWB conducts regular maintenance for the current deteriorated facilities.
	Data (e.g. water quality) or asset management is not conducted.			✓	Data management by utilization of PC is not conducted by TWB.
	Number of skilled maintenance staffs enough for the quantity or quality of the maintenance works is not sufficient.		✓		The current number of the staffs is enough, but TWB needs more skilled or matured staffs
Technical Aspect	Water source is vulnerable to the natural condition (e.g. topography, geology, disaster, climate change)			✓	The aquifer characteristics to the remote island with uplifted coral reef is subject to the natural condition such as topography, geology, disaster, climate change.
	Seawater intrusion is progressing to the current water source and drinking water cannot be supplied.			✓	Sea water has been intruded to the pumped water due to the characteristics of the hydrogeology and the concentration of the water extraction at the narrow recharge area due to the historical occurrence of pump failure and clogging of the wells.

	Enough water cannot be distributed due to the deteriorated water supply facilities.			✓	Water leakage has been progressing due to the remaining AC pipes and deteriorated pipes.
	The basic facilities are not functioning due to their malfunctions and causes hygienic problems The			✓	The malfunction of the chlorine injection cannot supply safe water.
	Design manual or criteria has not been established in the Kingdom.		✓		No design manual nor criteria has been established in Tonga. International standards are applied in international projects.
	The technical level for O&M works is not appropriate.	✓			The technical level for O&M works is appropriate.
	The technical level of the staffs appropriate does not reach the target level of facility planning, design and project management.		✓		TWB needs more skilled or matured staffs.
	The technical level of the staffs appropriate does not reach the target level of O&M.	✓			The technical level of O&M is appropriate.
Others		✓			Relevant equipment of O&M is not sufficient.

Source: Survey Team

2.2.3 Hygiene-related Issues and Waterborne Diseases (National Level)

No sewerage system has been developed nationwide in the Kingdom and the sewage is treated by septic tanks. Although the hygiene-related data is managed by the MOH, the systematic data management of the waterborne diseases has not been developed by the ministry. According to the MOH, the reported number of typhoid is 14 in 2017 and 40 in 2018, respectively.

2.2.4 Current Situation of Water Supply (Project Area)

(1) Current Situation of Water Supply

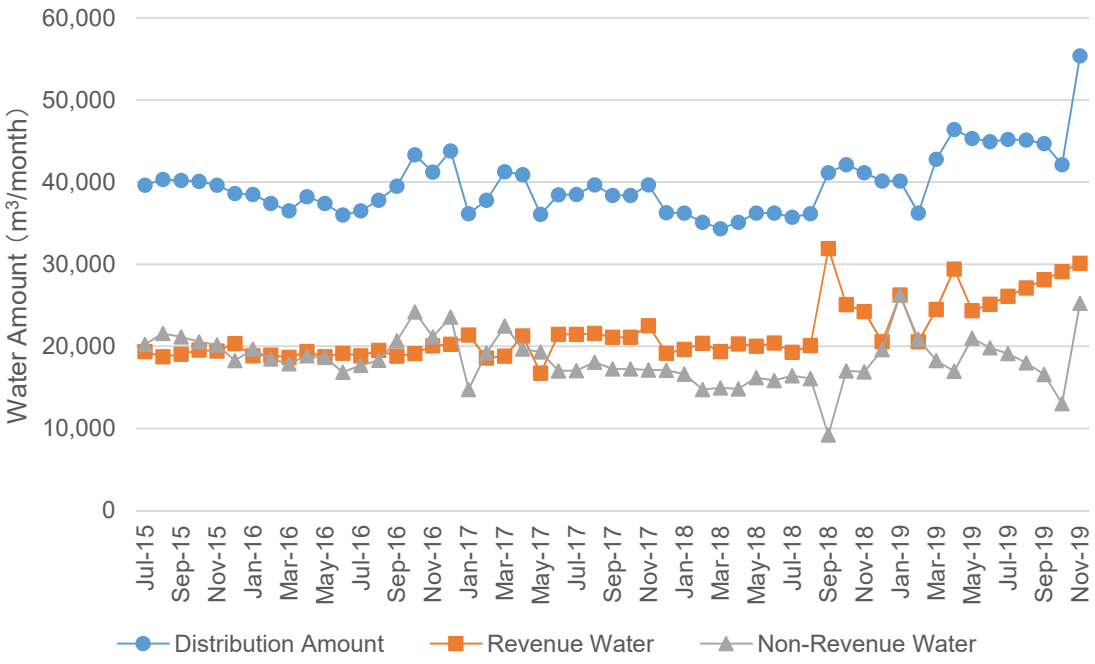
In Vava'u Island, TWB provides their water supply service in Neiafu and its nearby area, while the rural area far from the city center is supplied by the Village Water Committee (VWC) at each village unit under the management / supervision of the MOH. As of 2019, TWB provides their water supply service to about 1,240 households, approximately 45 % of 2,745 households totally in Vava'u Island.

Table 2.4 and Figure 2.2 show the TWB's performance (production / distribution amount and authorized water consumption) in the recent years. The each indicator of the performance has increased and as of 2018, the distribution amount is 1,348 m^3/day in average, 1,525 m^3/day in maximum and NRW is 41 %.

Table 2.4 TWB's Performance on Water Supply Service in Vava'u in Recent Years

Item / Year	2015	2016	2017	2018
Average Water Production (m^3/day)	1,638	1,762	1,987	1,984
Maximum Water Production (m^3/day)	1,683	1,976	2,176	2,282
Average Distribution Amount (m^3/day)	1,267	1,295	1,216	1,348
Maximum Distribution Amount (m^3/day)	1,325	1,440	1,305	1,525
Authorized Water Consumption (m^3/day)	630	643	677	798
NRW (%)	50%	50%	44%	41%

Source: Survey Team based on TWB's data



Source: Survey Team based on TWB's data

Figure 2.2 TWB's Performance on Water Supply Service in Vava'u in Recent Years

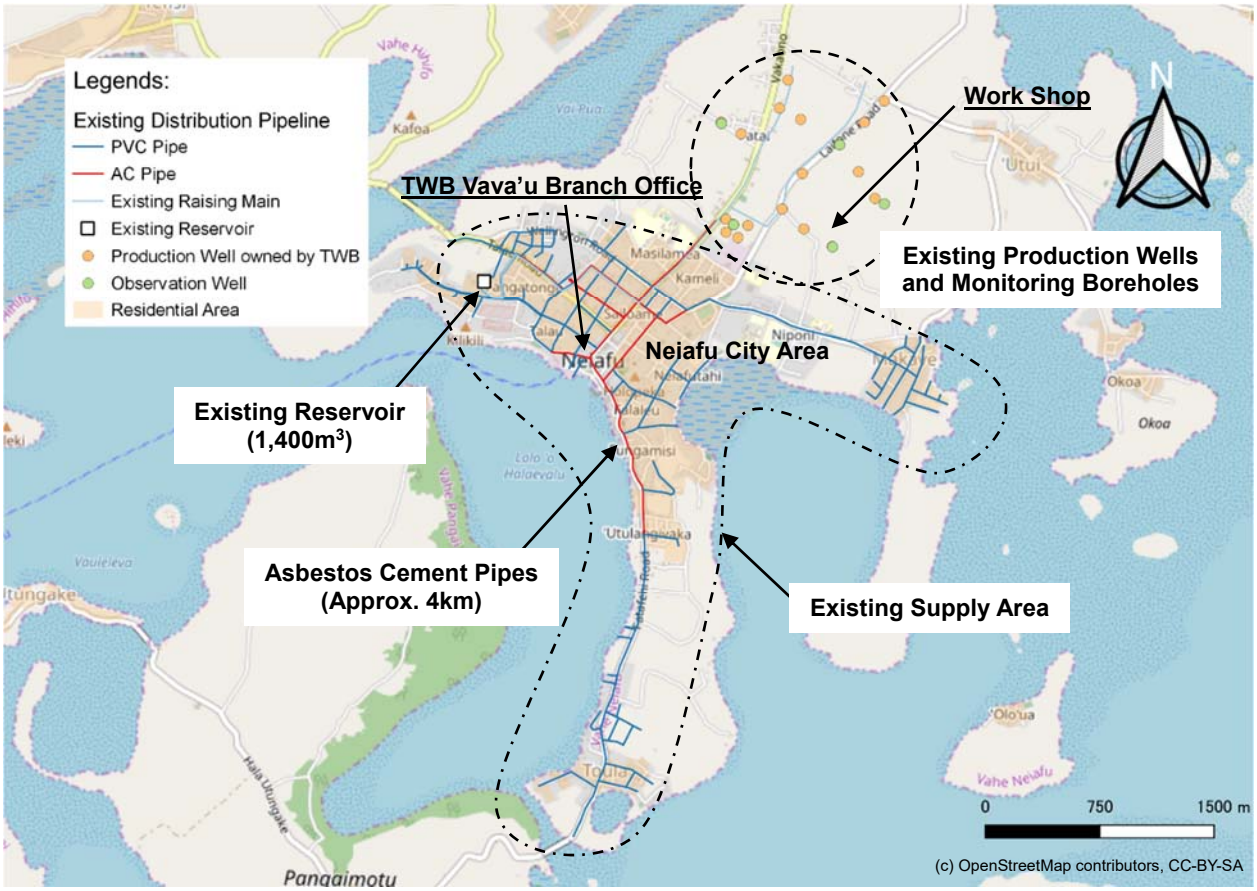
(2) Outline of the Existing Water Supply System

TWB commenced its water supply service in Vava'u in the 1970s with five (5) dug wells and in 1997 to 99, parts of the Neiafu town water supply were improved by AusAID and EU funded projects including development of fifteen (15) new wells and pump units, 8.9 km of distribution main and 1,000 m^3 new reservoir. However, no construction nor rehabilitation has been made since then.

Since that time, the number of operational wells has been gradually decreasing due to various reasons such as pump failures and clogging of the wells. At present, there are only five (5) production wells (consisting of three (3) boreholes and two (2) dug wells) in operation (the survey results by the team in 2019.)

Figure 2.3 illustrates the TWB's current water supply system in Vava'u. The water supplied to Neiafu and

its nearby area is distributed from the existing reservoir of 1,400 m^3 in total by gravity following to transmission of the pumped groundwater of the current five (5) production wells to the reservoir. On the other hand, on the water supply in the rural area operated by VWC, the water at the overhead tank that is transmitted from the production wells is distributed to the households in the village by gravity.



Source: Survey Team

Figure 2.3 Location of Existing TWB's Water Supply System in Vava'u

2.2.5 Issues on Water Supply (Project Area)

(1) Overall Issues in Water Supply

TWB formulated the "Tonga Water Supply Master Plan" in 1992 that oriented the future vision of the Kingdom's water supply for the improvement of water supply system in the outer islands. Furthermore, in 2012, TWB formulated the "Outer Islands Water Supply Improvement Project" that focused on improvement of the water supply system in the outer islands such as Vava'u, Ha'apai and 'Eua.

It is essential in operation of water supply business to formulate a master plan from the long-term and strategic perspectives. And it is also crucial to disclose the stability or sustainability of the water supply service to the consumers as a responsibility of a water supply service provider. However, the TWB's master plan has not been updated since 1992 and improvement of the water supply system has not been carried out

efficiently due to lack of a clear strategy.

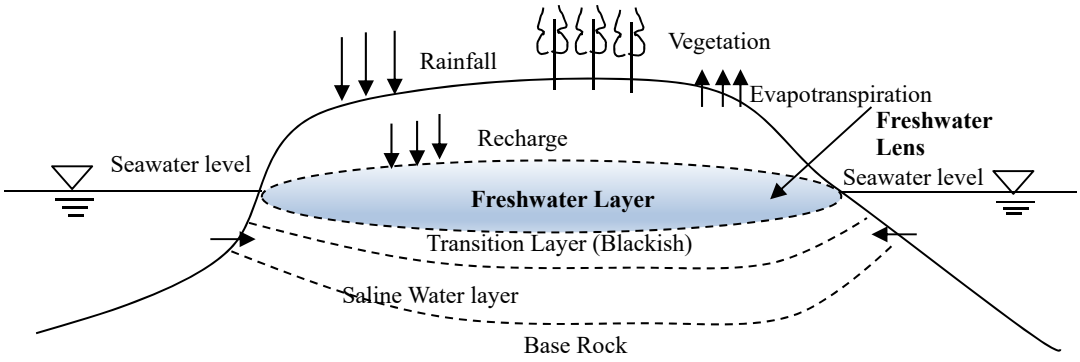
Neiafu, especially, has potential attractive places for the international tourists for its beautiful landscape and harbor and will need to update its master plan toward the improvement of the water supply service and system.

(2) Issues on Water Source

Groundwater as water source of the island country such as Tonga geologically formed in an uplifted coral reef is formed in "Freshwater Lens" that is recharged by rainfall from the ground surface, and two (2) layers of 1) the blackish water and 2) saline water intruded by the sea water are underlined below the freshwater layer. The depth of the each layers is controlled by the difference of the density and pressure of the fresh and saline water. The freshwater lens has a shape that has a thick depth at its middle part and thin at the peripheral parts (See Figure 2.4).

The water amount and quality of the freshwater lens is affected by several factors as shown below with regard to the conditions of the recharge and yield;

- Precipitation / rainfall
- Temperature, solar radiation, ecosystem, vegetation and soil pattern on the ground that may affect on the evapotranspiration
- Size of the island, hydrogeological characteristics such as permeability and porosity, etc.
- Seawater level
- Yield method and amount



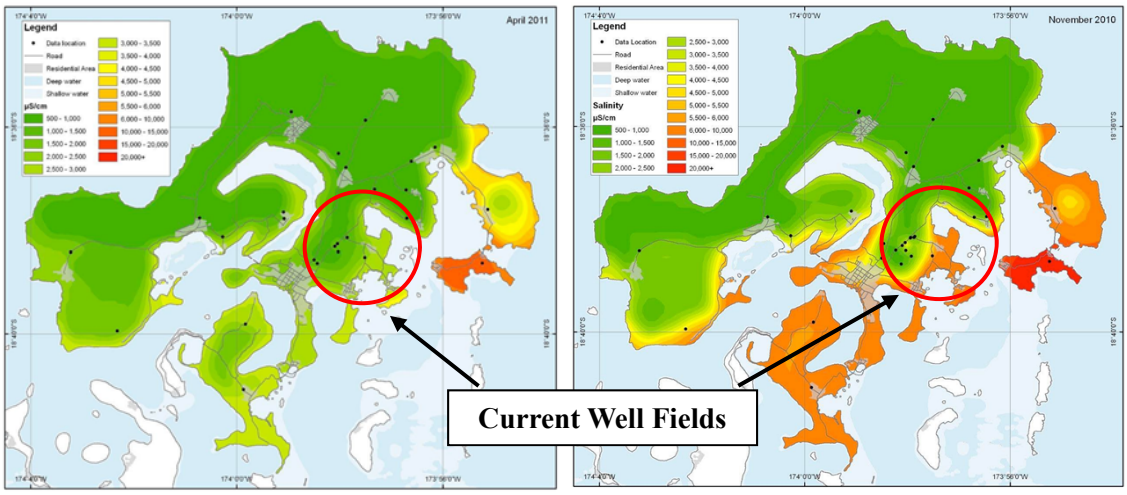
Source: Survey Team

Figure 2.4 Hydrogeological Schematic Diagram on Freshwater Lens in Vava'u

The supply of the freshwater is recovered in normal case when the yield by pumps stops and the rainwater is recharged to the aquifer. However, such freshwater will not be recovered even in the subsequent rainfall in case of an excessive amount extraction of the freshwater. It is a common challenge for the island countries to secure yield amount by simultaneously ceasing the seawater intrusion in an acceptable area.

The risk of the seawater intrusion to the freshwater lens in Vava'u has been increased as shown in Figure 2.5 by the recent raise of the sea level potentially caused by the global warming or the occurrence of tsunami induced by earthquakes.

Most of the TWB's production wells of the current well fields has about 30 m depth, however, the sea water intrusion has been progressing due to 1) the failure of the pumps and clogging of wells since the year of 2000 and 2) a concentration of the yield of the remaining wells.



End of Dry Season（November, 2010） **End of Rainy Season（April, 2011）**

Notes: The green color shows low EC (500 to 3,000 μS/m) while the orange to red colors show higher EC (above 5,000 μS/m)
Source: "Neiafu Groundwater Resources Assessment and Sustainable Management Report, Nicola Fry and Tony Falkland, December 2011" with revisions by the survey team

Figure 2.5 Seawater Intrusion after Dry and Rainy Season

Table 2.5 summarizes the relationships between the type of water and the salinity level that is indicated by EC (Electric Conductivity). With regard to the EC value that was measured in Vava'u for the two (2) seasons of rainy and dry in 2010 and 2011 as shown in Figure 2.4, the EC value in the rainy season (after the end of the rainy season) ranging 500 to 3,000 μS/m exceeds the allowable limit of WHO guideline value (1,500 μS/cm for portable water) in several occasions, while those of the dry season (after the end of the dry season) exceeds another WHO guideline (2,500 μS/cm for non-portable water).

Table 2.5 Type of Water and Salinity (EC: Electric Conductivity)

Type of Water	EC（μS/cm）	Remarks
Rainwater	50 -100	
Very fresh groundwater	250 - 500	
Fresh groundwater	500 – 1,500	
Maximum limit for potable water Suggested desirable limit of 'freshwater' for potable purposes	**1,500**	Based on WHO guideline for chloride of 250 mg/L
Suggested maximum limit of freshwater for non-potable purposes	**2,500**	Maximum limit for non-portable such as bathing and washing
Mildly brackish water	2,500 – 5,000	
Very brackish water	10,000 – 50,000	
Seawater	50,000 – 55,000	

Source: Survey team based on "Neiafu Groundwater Resources Assessment and Sustainable Management Report, Nicola Fry and Tony Falkland, December 2011"

(3) Issues on the Existing Water Supply Facilities

1) Malfunction of the Existing Facilities

Parts of the existing facilities have malfunctional equipment for appropriate O&M as described hereunder for the details.

a) Flow Meter

Some flow meters of the intake pumps are malfunctioned and left as they are because no budget is allocated for their repair and renewal (See Photo 2.1). The malfunction has brought an inaccuracy measurement of the intake volume for appropriate flow management. Therefore, improvement through repair or renewal of the equipment is urgently needed for the daily flow management. And to accumulate the daily performance data will provide basic information on the future improvement of the financial management or planning of the future facility plan.

Photo 2.1 Malfunctional Flow Meter

b) Chlorine Injection Unit

Since chlorine gas cannot be procured for the chlorine injection unit, located inside the workshop in the city center of Neiafu, which was installed by the support from the foreign donor, the unit is not used for the actual operation (See Photo 2.2). At present, instead of that, tablet of sodium hypochlorite is thrown into the reservoir once every morning by the operation staffs. The survey team obtained a data of residual chlorine exceeding 0.1 mg/L through their water quality measurement (Pack Test) at daytime (around 2 pm) in December 2019 in Toula village which locates at the southernmost boundary of TWB's supply area. However, the survey team also obtained another data at night time in the city center of Neiafu that no residual chlorine was detected, which showed water is distributed to the consumers without disinfection (See Photo 2.3).

Photo 2.2 Chlorine Injection Unit that is not in Use

Photo 2.3 Results of Pack Test for Residual Chlorine
Left: At Toula Village (PM 2:00), Right: City Center of Neiafu (PM 10:00)

2) Remaining Asbestos Cement Pipe and High NRW Rate

NRW of the water supply system in Vava'u ranges 40 to 50 percent that is expected to be caused mainly by water leakages from the deteriorated distribution pipes. Especially, AC pipe is still remaining in the distribution main in Neiafu, which needs to be renewed immediately (See Figure 2.6).

AC pipe used to be used for distribution pipes because it was easy for construction and low price. However, AC pipe has disadvantages of weaker strength and susceptible to physical damage compared to other materials. Thus, AC pipe needs to be replaced in terms of preventing water leakages and securing durability.

Other possible factors for the high rate of the NRW are

Source: Survey Team

Figure 2.6 Location of Existing AC Pipes

shown as below;

- Locations of the water leakages cannot be identified and left as they are, or, appropriate repairing for the leakages is not conducted.
- Replacement of pipelines is not implemented because of the deficit of the technical and financial capacity, and the distribution network has been deteriorated.
- Flow meter and water meter for the appropriate management of water production and consumption are not functional. Consequently, the operating loss due to the NRW cannot be evaluated precisely.

3) Low Service Level of Water Supply in Rural Areas

Water supply for schools or households in the rural areas is operated by VWC under the jurisdiction of MOH (See Photo 2.4), which cannot secure enough amount for the water supply service from the intake wells resulting in its operation hours of only for three (3) hours. The water source is concerned to be polluted by the coliform possibly caused by infiltration of some parts of the sewage from the septic tanks into the underground. In addition, the water is distributed to the consumers without any disinfection because the VWC's water supply system doesn't have any disinfection equipment. And it leads to high risk of occurrence of waterborne diseases. Furthermore, the water source in the village areas has another pollution risk to be caused by the use of pesticides or chemical fertilizers.

Photo 2.4 Water Supply Facility at Rural Areas

4) Harvesting of Rainwater for Drinking Use

Rainwater has been utilized as a water source for drinking purpose traditionally in the Kingdom due to the current situation of water supply system. Households or public facilities such as schools and hospitals have their own storage tanks of FRP (Fiber Reinforced Plastics) or concrete next to their facilities and store the rainwater in the tanks collected through the gutters on their roofs (See Photo 2.5). Almost 60 percent of the total population utilizes rainwater for drinking purpose and the rate has become higher in Vava'u as 70 percent compared to other areas (Source: Tonga Census of Population and Housing 2016). In contrast, only ten (10) percent of the population uses tap water for drinking purpose in the Kingdom and also in Vava'u.

Photo 2.5 Rainwater Harvesting Facility set at School

On the other hand, utilization of the rainwater for drinking has the following potential risks;

- Not enough water is available at events of droughts that may be caused by ENSO (El Nino-Southern Oscillation) as one of the irregularly periodic variation of the climate change,
- Seawater intrusion into storage tanks at the passing of cyclones, which cannot be used for drinking for several days, and
- Hygienic risk of the tank to be polluted by the dung of small animals or dead leaves

(4) Issues on Operation and Maintenance

The flow and water meters are not functional normally as mentioned before, and the operation of the intake pumps and the quantity of the water consumption is not managed appropriately. On the other hand, water level and distribution amount at the existing reservoir is recorded hourly in the daily reports by manual (See Photo 2.6).

Photo 2.6 Daily Report on Operation in Vava'u

On the aspect of water quality management, TWB Vava'u office has no water quality measurement instrument, and therefore transport the water samples by air to Tongatapu once a month and receive the results of water quality test by e-mail. Currently, the water quality test covers only three (3) parameters of fecal coliform sampled at the tap water, EC (water source, reservoir and tap water) and residual chlorine.

The issues on the aspect of O&M are as below;

- Necessary and sufficient data has not been acquired and managed through the daily work. However, TWB appears to try to acquire the data by themselves to some extent, and
- Lack of the knowledge how TWB utilizes the acquired data for their daily operation

(5) Issues on Financial Aspect

Table 2.6 shows the P/L (Profit and Loss) statement for the recent fiscal years of 2014 to 2018. The status of the financial balance of the TWB has been in surplus since 2012. In contrast, the Government of Tonga (GOT) has ordered the national public enterprises including TWB to pay the dividend against the GOT's past investment to them. The dividend paid by TWB was over 1.0 Million TOP during the fiscal year of 2014 to 2016, which puts pressure on TWB's finance. In the fiscal year of 2018, the dividend decreased to about 27 percent of the net profit or 341,921 TOP. In near future, GOT intends to introduce a new law that imposes the public enterprises to pay a dividend of one hundred (100) percent of the net profit, which may bring threat to the TWB's financial operation.

Furthermore, GOT has requested to TWB to lower the water tariff many times, and TWB has agreed to lower the price by 9.0 % in 2017 and 6.0 % in 2018, respectively. Table 2.7 and Figure 2.7 shows the transition of the water tariff of TWB for the recent years.

Table 2.6 Fiscal Balance of TWB (2014 to 2018)

Unit: TOP $

ITEMS	FY 2014/2015	FY 2015/2016	FY 2016/2017	FY 2017/2018	FY 2018/2019
Total Revenue	7,219,396	7,487,214	8,151,833	8,435,635	8,972,497
1) Operating Revenue	5,767,958	6,019,450	6,446,644	6,424,408	6,847,149
2) Other Revenue	1,451,438	1,467,764	1,705,189	2,011,227	2,125,348
Total Expense	5,378,337	5,655,502	6,487,230	6,738,304	7,546,670
1) Operating Expenses	-	-	5,104,581	5,372,274	5,924,474
2) Depreciation	-	-	1,382,649	1,366,030	1,622,196
Net Profit before Tax	1,841,059	1,831,712	1,664,603	1,697,331	1,425,827
Income Tax Expenses	460,265	457,928	416,151	424,333	332,002
Net Profit after TAX	1,380,794	1,373,784	1,248,452	1,272,998	1,093,825
Dividend	1,000,000	1,027,000	1,030,000	341,921	-
Dividend Percentage	72.42%	74.76%	82.50%	26.86%	-

※1 TOP $ = 45.13Japanese Yen（as of November, 2019）

Source: Survey Team based on Tonga Water Board Final Draft Business Plan

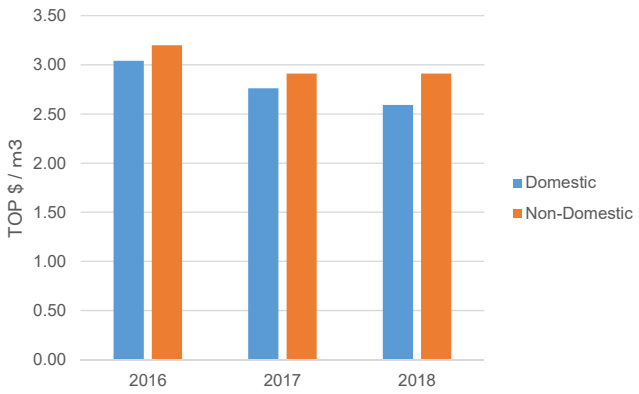
Table 2.7 Water Tariff Setting by TWB (2016 to 2018)

Unit: TOP $ / m^3

Branch / Year	Domestic				Non-Domestic			
	Nuku'alofa	Vava'u	Ha'apai	'Eua	Nuku'alofa	Vava'u	Ha'apai	'Eua
2016	2.98	3.04	3.01	1.33	3.14	3.20	3.16	1.40
2017	2.71	2.76	2.74	1.21	2.85	2.91	2.87	1.27
2018	2.55	2.59	2.58	1.14	2.85	2.91	2.87	1.27

※1 TOP $ = 45.13Japanese Yen（as of November, 2019）

Source: Survey Team based on TWB's Tariff Table



Source: Survey Team based on TWB's Tariff Table

Figure 2.7 Transition of Water Tariff in Vava'u (2016 to 2019)

Considering above situation, although TWB can allocate enough budget for O&M, funding for investment for construction of facilities or procurement of equipment appears to be difficult. In addition, most of international donors have put their financial support to the improvement of water supply facilities and equipment in Tongatapu as priority so far, not for the remote islands such as Vava'u. As the results, the issues on the water supply business become apparent, for example, the high rate of NRW due to the deterioration of the distribution networks, and inappropriate water flow management and water tariff collection due to the problem on flow and water meter.

2.2.6 Hygiene-related Issues and Waterborne Diseases (Project Area)

(1) Occurrence of Waterborne Diseases

According to the interviews with the TWB's staffs in Vava'u, the survey team obtained a fact that typhoid occurred in 2019 in Leimatua (total household: 235, population: 1,215) as a second large village in Vava'u. This fact implies that there is the need to supply safe water by disinfection because VWC's water supply has the potential risk of waterborne diseases to inhabitants due to lack of chlorine disinfection equipment.

(2) Drinking Water Quality Standards

TWB has no their original standards for drinking water quality and follows the WHO guideline.

2.2.7 Others

(1) Climate Changes

1) Situation on Climate Changes

The Kingdom is ranked as second in the world risk index of the most vulnerable countries to the increasing effects of natural disasters and climate changes. The Kingdom has been hit by a variety of natural disasters such as earthquakes, volcanic eruptions, cyclones and being additionally exposed to by the recent climate changes. The Kingdom has suffered from strong wind and storm surge associated with cyclones, sea level rise, extreme rainfall and droughts associated with the change of rainfall patterns and raised temperature of air and sea water. The maximum temperature in the Kingdom has gradually been raised by 0.1 degree Celsius during the recent ten (10) years and this shows almost the same results of the global tendency of the warming. The annual precipitation in rainy seasons in the Kingdom has been decreased continuously since 1950.

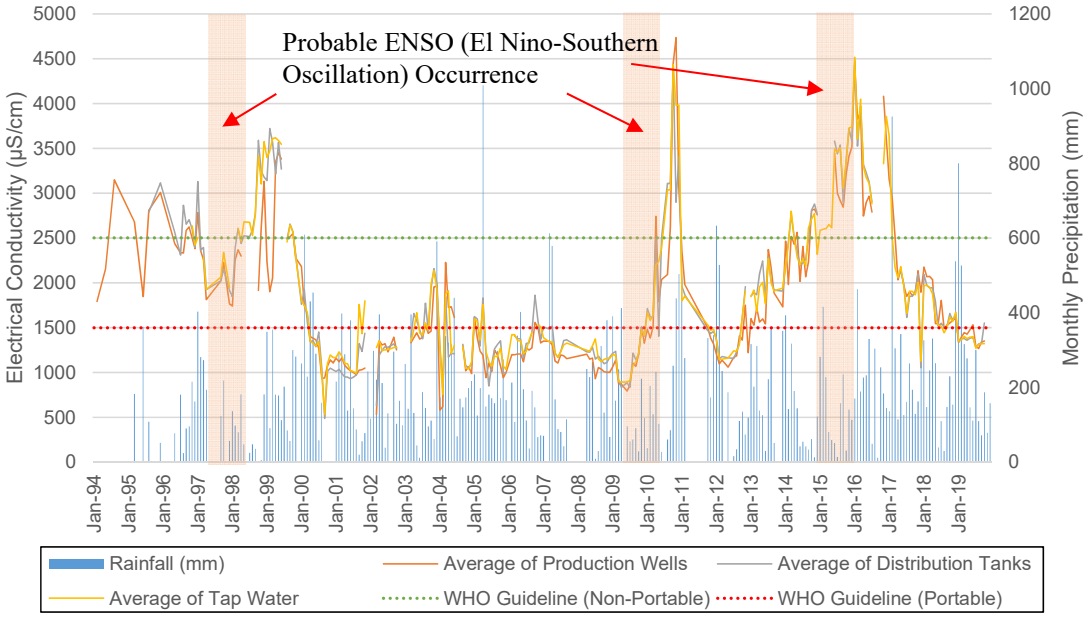
The sea water level, in contrast, has been raised by 6.0 mm since 1993 and its raising rate is higher compared to 2.8 to 3.6 mm of those of its world average. The sea water level is estimated to be raised up to 3 to 17 cm by 2030.

At the World Metrological Organization (WMO) regional association for Asia and the pacific hosted by the Kingdom dated 15 to 17 of October, 2018, Prime Minister Samiuela Akilisi Pōhiva briefed the opening session on the special report released last week by the International Panel on Climate Change (IPCC) on

the impacts of global warming of 1.5 °C and the Kingdom should reduce its warming to the same figure.

2) Trend of Climate Changes and Trend of Sea Water Intrusion

Figure 2.8 shows the transition of the monthly average rainfall for the past 26 years in Vava'u and the EC (Electric Conductivity) of the TWB's supplied water (production well, distribution tanks, tap water). In the south pacific area in the vicinity of the Kingdom, there were probable occurrence of El Niño-Southern Oscillation (ENSO) during the years of 1997 to 98, 2009 to 10 and 2015 to 16 with extremely low rainfall. The EC of the TWB's water, in contrast, were raised just after these periods and can be potentially affected by the ENSO.



Source: Survey Team based on TWB's data

Figure 2.8 Historical Transition of Rainfall and EC of TWB's Water in Vava'u and ENSO

(2) Damages by Past Cyclones

The Kingdom has natural environment which cyclone tends to be generated and developed due to its geographical condition and the damages by high surge or tsunami induced by the strong cyclone have become larger by the recent climate changes. The cyclone Ian hit the Ha'apai Island in January 2014, and the cyclone Winston hit the Vava'u islands in February 2016 and caused severe damages there. Another cyclone, Gita, which is a most gigantic in the history in the Kingdom, hit Tongatapu in February 2018 and caused catastrophic damages.

Table 2.8 lists the cyclones classified in Category 5 that hit the kingdom.

Table 2.8 Cyclones in Tonga (Above Category 5)

Name of Cyclone	Date / Year of Hit	Central Pressure (hPa)	Maximum Instantaneous Wind	Areas Damaged
Ron	January, 1998	900	270 km/h（75.0m/s）	Tongatapu
Heta	December, 2003	915	260 km/h（72.2m/s）	Tongatapu
Ian	January, 2014	930	285 km/h（79.2m/s）	Ha'apai
Winston	February, 2016	884	285 km/h（79.2m/s）	Vava'u
Gita	February, 2018	927	230 km/h（63.8m/s）	Tongatapu, 'Eua

Source: Survey Team

2.3 Relevant Plans

2.3.1 Outline of Development Plan

The Kingdom updated the "Tonga Strategic Development Framework (TSDF I) 2011 - 2014" and established "Tonga Strategic Development Framework (TSDF II) 2015‐2025 - a more progressive TONGA", which tackles a development plan toward promoting comprehensive and sustainable development with setting Key Performance Indicators (KPIs) for short, mid and long-term targets. To put the development plans into execution, "National Infrastructure Investment Plan 2013 to 2023" was also formulated, in which the priority projects were proposed by each sector. With regard to the water sector, in this investment plan, Vava'u Island was highlighted clearly as one of target areas of in "Outer Islands Water Supply Improvement Project Plan".

Furthermore, a development plan named "Pacific Plan" toward sustainable development, economic growth, enhancement of governance and security was established as pacific regionalism framework in PIF (Pacific Islands Forum).

The national development plan of the Kingdom is summarized in Table 2.9.

Table 2.9 Summary of National Development Plan in Tonga

Year	Name of Development Plan
2011	Tonga Strategic Development Framework (TSDF I) 2011 – 2014
2013	National Infrastructure Investment Plan 2013 to 2023
2015	Tonga Strategic Development Framework (TSDF II) 2015–2025, - a more progressive TONGA

Source: Survey Team

2.3.2 Upper Level Plans and Relevant Plans of the Project

TWB formulated the "Tonga Water Supply Master Plan 1992" in 1992 that oriented the future vision of the Kingdom's water supply. TWB also formulated the "Outer Islands Water Supply Improvement Project Plan"

in 2018 that oriented the improvement of the water supply facilities in remote islands. The "Tonga Water Supply Master Plan 1992" can be a substantial master plan for the project.

2.3.3 Urgency and Priority of the Project

(1) Urgency of the Project

The Kingdom has vulnerabilities to natural disasters and climate changes, and overcoming these vulnerabilities has become an inevitable challenge for the social and economic development of the country. Vava'u islands which consists of remote islands, are more vulnerable to natural disasters such as cyclones compared to the city area, and may need more time to recover and restore the water supply system once they are damaged. However, enough investment has not been made for the water supply facilities in the remote islands including Vava'u islands. And the issues such as the deterioration of facilities / equipment, seawater intrusion to the existing well field, and malfunction of the chlorine injection unit and water meters have been come out. Therefore, immediate improvement of the water supply facilities for maintaining appropriate water supply service and disaster-resilient facilities or system are needed. The remaining AC pipes with its potential health risk, in addition, also should be replaced immediately in terms of improvement of hygienic condition at the project area.

(2) Priority of the Project

Vava'u has become an important base for tourism industry in the Kingdom's economy as shown in the attractive marine activities such as whale watching, snorkeling, kayaking, kitesurfing, sailing, scuba diving, and fishing. Fiji Airways operates its direct flight to Vava'u from Nadi International airport.

From above reason, the improvement of the water supply facilities in Vava'u is mentioned in "National Infrastructure Investment Plan 2013 to 2023". However, its detailed plan toward its improvement has not been formulated yet.

Challenges such as the facility improvement and enhancement of TWB's capacity on O&M have been piled up, and thus, higher priority is put to the project toward the improvement. In addition, considering the situation that the past Japan's support to the Kingdom in hard and soft components, there is a strong expectation for its implementation through utilization of Japan's ODA scheme.

2.3.4 Possible Multiple Projects

There are no multiple projects.

2.3.5 Information of Relevant Sectors

There are is no information of relevant sectors.

2.4 Relevant and Implementation Agencies

TWB was established in 1966 and is responsible for providing urban water supply in major cities in the Kingdom as one of the public enterprises under a jurisdiction of MPE (Ministry of Public Enterprise) as per the national laws and regulations, namely, the "TWB Act CAP-92", then replaced with "TWB Act 32 – 2000" and subsequently complimented with the "Public Enterprise Act – 2002 with Amendments Acts No.40 of 2010".

TWB has its head office in Nukualofa and branch offices in Vava'u, Ha'apai and 'Eua Island. TWB is responsible for the operating and maintenance of water supply system and billing / collecting water tariff. Table 2.10 shows the lists of the relevant agencies or authorities to the project.

Table 2.10 List of Relevant Agencies and Authorities

Type	Name
Implementation Agency	TWB: Tonga Water Board
Relevant agency	MPE: Ministry of Public Enterprise
Relevant agency	MOH: Ministry of Health
Relevant agency	MLNR: Ministry of Lands and Natural Resources

Source: Survey Team

2.4.1 Relevant Agencies

(1) MPE

The water supply service in major urban areas in the Kingdom provided by TWB that is under jurisdiction of MPE. MPE is responsible for public works, transportation, telecommunication, and formulation of policies, planning, design, coordination and implementation for project related works.

(2) MOH

MOH provides its health service in preventive and therapeutic manners.

MOH is involved in the following tasks relating to implementation of the project;

- Administration of the Health Act, maintenance of public health database, and education on public health
- Inspection and support of the activities of VWC that was established under the Health Act.

(3) MLNR

MLNR's role is to manage the national lands, natural resources and energy for its contribution to their development and implementation. Their main activities are preparation of study, mapping, calculation, physical plans and geological survey.

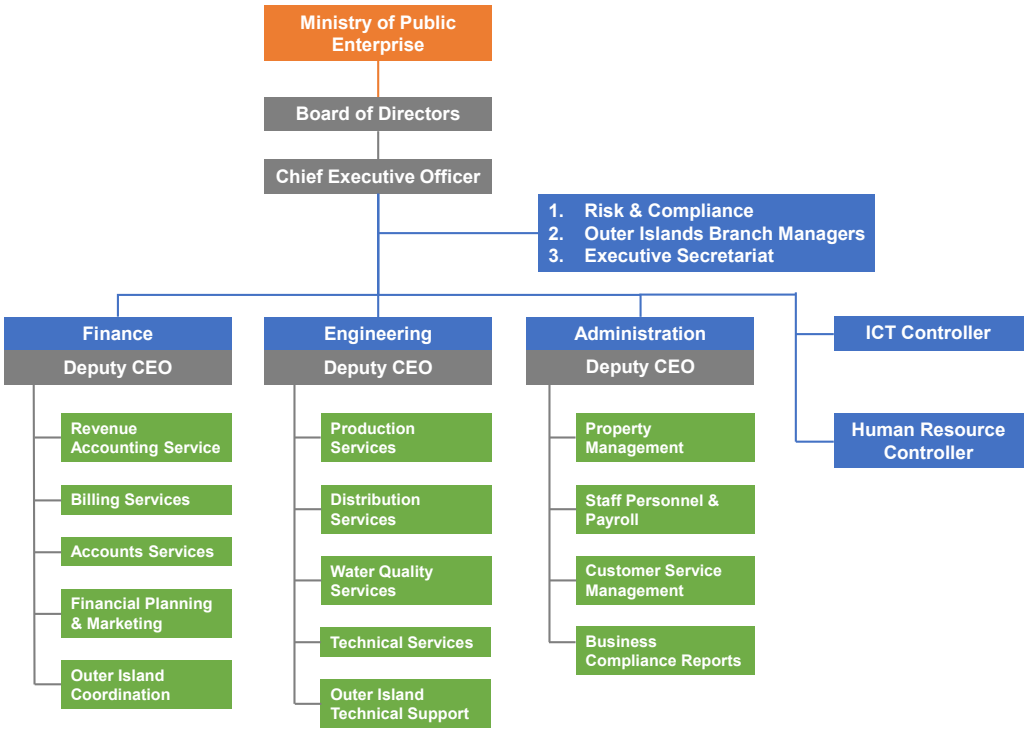
The MLNR's roles relating to the project are to;

- Management of natural water resource and decision of placement of well fields
- Implementation of a water resources monitoring program (including well census database with salinity,

temperature, pH, water level)

2.4.2 Organization of Implementation Agency

The organization structure and its number of staffs at each departments of the TWB is shown in Figure 2.9 and Table 2.11, respectively. TWB is composed of three (3) departments of finance, engineering and administration. As of 2020 and has total of 108 staffs of 85 permanent staffs and 23 day labors. Of which 69 staffs belong to the head office in Nukualofa and 17 staffs in Vava'u branch office.



Source: Survey Team based on TWB's data

Figure 2.9 Organization Chart of TWB

Table 2.11 Staff Number of TWB

Descriptions	Number of Staff		
	Whole Staff	Proper	Daily
1. Nuku'alofa			
1.1 Corporate/ Admin Services	19	14	5
1.2 Finance Services	28	23	5
1.3 Engineering Services	22	20	2
2. Outer Islands			
2.1 Vava'u	17	14	3
2.2 Ha'apai	10	8	2
2.3 'Eua	12	6	6
Total	108	85	23

Source: Survey Team based on TWB's data

2.4.3 Vision / Mission of Implementation Agency

TWB holds up the following vision and vision.

Vision

Our priority is to provide a reliable, safe and clean water supply twenty-four hours and seven days a week.

Mission

To achieve the maximum satisfaction of customers through the services we provide and in accordance with the Public Enterprise Act as amended in 2010.

Source: TWB's website

2.5 Japan's Assistance to the Kingdom

2.5.1 History of Assistance of Japan

(1) History of Japan's ODA Assistance

The past results of the Japan's ODA to the Kingdom in terms of monetary base is shown in Table 2.12

Table 2.12 Past Results of Japan's ODA to Tonga (Gross Disbursement)

Unit: 100 Million Yen

Fiscal Year	Loan Aid	Grant Aid	Technical Cooperation
2013	－	2.86	2.35
2014	－	5.53	3.16
2015	－	17.37	2.15
2016	－	15.94	3.52
2017	－	24.80	2.31
Total	－	257.93	114.36

Source: Japan's ODA Data by Country, 2018, Ministry of Foreign Affairs of Japan

The ODA in the water sector such as water resources / disaster management to the Kingdom has been executed through water supply projects by the scheme of grant assistance for grassroots human security projects and followed by several schemes of grant aid project, non-project grant aid and emergency grant aid. The following summarizes the results of the assistance in each scheme;

(2) Grant Assistance for Grassroots Human Security Projects

The Japanese embassy in the Kingdom has provided the support of construction of intake wells and overhead tanks to the remote villages from Neiafu in Vava'u Island.

Table 2.13 shows the list of the projects in the Kingdom that have been implemented by the scheme since 2013. The projects in 2014 and 2015 that were implemented in the five (5) villages in Vava'u islands of Vaimalo, Ovaka, Ha'alaufuli, Holonga and Feletoa. The equipment that was supplied in Feletoa is shown as below and same equipment was provided in other villages;

- Intake pumps (2 units) with solar panel and diesel generator (each; 1 unit)

- Pump house
- Water tank (5,000 gallon)
- Ancillary equipment such as fence and pipes

Table 2.13 List of Grant Assistance for Grassroots Human Security Projects

Year	Name of Projects
August , 2018 (GA)	The Project for Upgrading of Water Supply System for Lavengatonga Village, Tongatapu
August , 2018 (GA)	The Project for Upgrading of Water Supply System for Talafo'ou Village, Tongatapu
September, 2017 (Completion)	The Project for Upgrading of Water Supply System for Folaha Village
September, 2017 (Completion)	The Project for Upgrading of Water Supply System for Tatakamotonga Village
December, 2016 (Completion)	The Project for Upgrading of Water Supply System for Nukuleka Village
November, 2016 (Completion)	The Project for Upgrading of Water Supply System for Naptoka Village
June, 2016 (Completion)	The Project for Upgrading of Water Supply System for Hihifo Village
June, 2016 (Completion)	The Project for Upgrading of Water Supply System for Vaipoa Village
June, 2016 (Completion)	The Project for Upgrading of Water Supply System for Falevai Village
May, 2016 (Completion)	The Project for Upgrading of Water Supply System for Puke Village
August, 2015 (Taking-over)	The Project for Upgrading of Water Supply System for Vaimalo Village
August, 2015 (Taking-over)	The Project for Upgrading of Water Supply System for Ovaka Village
June, 2015 (Completion)	The Project for Upgrading of Water Supply System for Fua'amotu Village
September, 2014 (Handover)	The Project for Upgrading of Water Supply System for Ha'alaufuli Village
September, 2014 (Handover)	The Project for Upgrading of Water Supply System for Holonga Village
September, 2014 (Handover)	The Project for Upgrading of Water Supply System for Feletoa Village
October, 2013 (Handover)	The Project for Upgrading of Water Supply System for Mala'evakapuna Village

Notes: GA means "Grant Agreement".
Source: Survey Team

(3) Grant Aid Projects

Grant aid project on replacement of AC pipes, construction of water treatment plant and equipment provision of flow meters and leakage detection equipment for Nukualofa, Tongatapu was executed as shown in Table 2.14.

Table 2.14 Grant Aid Projects

Year	Name of Project
August, 2001 (Completion)	The Project for Upgrading of Water Supply System for Nukualofa

Source: Survey Team

(4) Non-project Grant Aid

The following equipment was procured for NEMO (Tonga National Emergency Management Office) through non-project grant aid scheme.

Handover in August, 2017:

Crane truck (4 units), water truck (2 units), septic tank truck (1 unit), tent (15 sets), portable toilets (20 sets), lifeboat (2 ships), chainsaw (15 sets), emergency light with generator (10 sets), manual forklift (5 sets), and small excavator (1 unit)

Handover in June, 2015:

Tent (200 sets), desalination equipment (2 units), diesel pump (4 units), plastic tank (2,000 box)

(5) Emergency Grant Aid

For the TOG's declaration of a state of emergency for the severe damage caused by the two (2) cyclones of Ian and Gita that landed the Kingdom in 2014 and 2018, respectively, GOJ procured tents, waterproof plastic sheets, generator, and plastic tanks.

Table 2.15 Emergency Grant Aid

Year	Name of Project
February, 2018	Emergency grant aid for the damages by cyclone in the Kingdom of Tonga
January, 2014	Emergency grant aid for the damages by cyclone in the Kingdom of Tonga

Source: Survey Team

(6) Other Assistance

A solar power electrification project was implemented in the rural and remote communities of Vava'u and Ha'apai islands, in the Kingdom through Japan's Pacific Environment Community (PEC) Fund. 22 solar powered water pumps were installed at 17 villages in Vava'u islands, and 36 solar powered deep freezers were installed in the remote islands of both islands by the project (the groundbreaking ceremony was held in July, 2017). In addition, technical cooperation has been implemented for the TWB's staffs through JICA's senior volunteer's training on water leakage detection and Knowledge Co-Creation Program.

2.5.2 History of Technical Cooperation

Technical cooperation training toward capacity building on water supply systems that are adaptable for remote islands has been implemented mainly by Okinawa prefecture for receiving the trainees in the pacific countries including the Kingdom.

The training on the following subjects were carried as shown in Table 2.16 for their details;

- Understanding on policies and legal framework on water supply facilities
- Understanding on biological purification method (Slow filtration system)
- Understanding on water sources development targeting the countries with vulnerable water resources
- Understanding on way of water supply business
- Understanding on protection or reservation of water sources

In addition, transfer of technical knowledge and know-how that has been accumulated in Okinawa on the

issues on the lack of water sources for stable secure of water supply, lack of water purification system and water leakage was also carried out in this training.

Table 2.16 History of Technical Cooperation to Tongan Technical Staffs

Implementation Agency	Name	Contents of Training	Year
Okinawa Prefectural Enterprise Bureau	Water reservation management in remote islands	Lectures, practices and site inspection in Japan	2010
Okinawa Prefectural Enterprise Bureau	Water reservation management in remote islands (Total: 13 trainees including 2 Tongans)	Lectures, practices and site inspection in Japan	2011
Okinawa Prefectural Enterprise Bureau	Water reservation management in remote islands (Total: 13 trainees including 2 Tongans)	Lectures, practices and site inspection in Okinawa Prefecture	2012
Okinawa Prefectural Enterprise Bureau	Water reservation management and water utility operation in remote islands (Total: 9 trainees)	Lectures, practices and site inspection in water utilities related authorities and with partnerships with JICA Okinawa	2013
Okinawa Prefectural Enterprise Bureau	Water reservation management and water utility operation in remote islands (Total: 11 trainees)	Lectures, practices and site inspection in water utilities related authorities and with partnerships with JICA Okinawa	2014
Okinawa Prefectural Enterprise Bureau	Water reservation management and water utility operation in remote islands (Total: 12 trainees)	Lectures, practices and site inspection in water utilities related authorities and with partnerships with JICA Okinawa	2015
Okinawa Prefectural Enterprise Bureau	Water reservation management and water utility operation in remote islands (Total: 12 trainees	Lectures, practices and site inspection in water utilities related authorities and with partnerships with JICA Okinawa	2016

Source: Survey Team

2.5.3 Opinions of Recipient Country or Agency on Technical Cooperation

Mr. Waterski Ma'afu of the branch manager of the TWB's branch office in Vava'u, one of the trainees in the training in Table 2.16 made the following comments on the training with his gratitude;

- The training with their excellent technical knowledges brought great benefits on the Kingdom's water supply sector,
- These knowledges cannot be fully utilized considering the current capacity of the TWB's O&M due to lack of necessary equipment

In addition, in the training in 2015, introduction on DMA (District Metered Area), watershed management, effective method for leakage repair and biological purification method were given as useful subjects.

2.6 Assistance by Third Party's Countries / International Donors

2.6.1 History of Assistance Related to the Project

The following improvement of the water supply system and provision of the equipment were carried out by the AusAID and EU funded projects in 1997 to 1999.

- 15 new wells and their intake pumps
- Raw water pipes of 200 mm x 8.9 km from the water source to the reservoir
- Extension of distribution pipes with uPVC pipes
- Construction of 1,000 m^3 reservoir
- Construction of new office and working places
- Chlorine injection unit and water level transmission system

After above projects, TWB was notified by DANIDA (Danish International Development Agency) that DANIDA is willing to provide their fund for specific tied projects using mixed credit loan. The loan included a condition of implementing a FS (Feasibility Study), and the FS was carried out through receiving a subsidy from Swedish trust fund and the project in Vava'u was selected as a target area by the FS.
The major component of the project is a connection of the distribution pipes between Okoa and Utui, taking the two (2) villages into TWB's supply area and the replacement of the AC pipes in the city area of Neiafu.

2.6.2 Existence of Request to the Project by International Donors

TWB requested to Denmark government to provide the credit loan for the project for improvement of water supply system based on the FS. However, it was canceled because the TWB's financial status was not good at that time.

2.6.3 Consistency with Japanese Aid Policy (e.g. Aid Policies for Each Country and Water and Sanitation Broad Partnership Initiative)

(1) Relationship with Government of Japan

In order to enhance the partnership between the PICs (Pacific island countries) and GOJ, Japan has been hosting Summit-level meeting named Pacific Islands Leaders Meeting (PALM) every three (3) years since 1997. Japan and PICs have been building close cooperative relationships, forging the bond of friendship through candid discussion at PALMs. Leaders openly discussed various issues such as the small size of their countries and islands scattering over a wide area, distance far from major international markets, and the vulnerability to natural disasters and climate change.

In PALM 8, the following declaration was adopted as the outcome of the discussions;

- Understanding of the importance of taking actions for the climate change disaster prevention and environmental conservation toward strengthening the basis for resilient and sustainable development,
- Understanding of development of high quality infrastructures through rules-based order: commitment to the respect for sovereignty, rule of law, and peaceful resolution of disputes in accordance with international standards,
- Confirmation on Japan's commitment in PALM 7 by the statement of Prime Minister Abe that Japan will provide the cooperation of providing fund in the extent of no less than 55 Billion Yen to the FICs over the next three (3) years and people-to-people exchanges of 4,000 people from the FICs over the

next three (3) years

Japan has contributed to the Kingdom's development as its major donors' country through grant aid projects and technical cooperation aid since the dispatches of the JOCV (Japan Overseas Cooperation Volunteers) in 1973. PICs such as Micronesia, Melanesia and Polynesia are very friendly to Japan and important countries because they have supported to Japan's stance for the international relationships.

(2) Consistency of the Project with Japanese Aid Policies for Each Country

The project has the consistency with the Japan's aid policy for the Kingdom on its objectives that Japan will conduct an assistance on the aspect of conservation of the environment and climate change and also another assistance on enhancement of sustainable economic development including improvement of basic social service and infrastructure development.

(3) Consistency of the Project with Water and Sanitation Broad Partnership Initiative

The Water and Sanitation Broad Partnership Initiative (WASABI) has its goal that GOJ will conduct its effective support to the developing countries' self-help efforts through utilization of its experience, expertise and technology. The project has a consistency with the basic policy of "Sustainability of water use" and "Human security"

2.6.4 Necessity of the Project's Linkage with Third Party Countries / International Donors

No other international donors will not implement the project through its aid or cooperation. However, the project will have to have a strong linkage with the Grant Assistance for Grassroots Human Security Projects that have been implemented by the Japanese Embassy.

2.6.5 Interest of Third Party's Countries / International Donors to implementation of the Project

TWB has proceeded its water supply business by concentrating on the improvement or expansion of the existing water supply facilities in Tongatapu by the funding support of ADB and AusAID.

Major water supply system in Tongatapu has almost completed after the drilling of new sixteen (16) boreholes, rehabilitation of thirteen (13) wells, construction of a reservoir of 3,000 m^3 and laying of transmission pipes of 9.5 km. In future, TWB intends to expand the distribution pipes in Tongatapu, shift to the reconstruction of water supply facilities in remote islands which are expected to be implemented by other donors.

Chapter 3

Outline of the Project

Chapter 3 Outline of the Project

3.1 Approach to Solve Issues

3.1.1 Relation with Issues on Water Supply (National Level)

The following issues on water supply in national level have been identified;

- Degradation of water distribution function and water quality due to the deterioration of the water supply facilities in remote islands
- With regard to the degradation of water distribution function, high rate of NRW potentially caused by the leakage of the existing deteriorated pipes and another risk of sea water intrusion to the current water source due to its excess yield
- With regard to the degradation of water quality, potential risk of outbreaks of waterborne diseases such as typhoid due to lack of disinfection process by chlorination and another health risk potentially to be caused by existing AC pipes
- In some area in the remote islands, a water supply for 24 hours has not been realized because enough quantity of water source cannot be secured
- Appropriate maintenance has not been conducted because of the lack of the equipment and their staffs' experience and technical skills

Table 3.1 summarizes the relation and the issues on water supply in national level.

Table 3.1 Relationship of the Project with the Issues on Water Supply

Issue	Requirements by the Project
Degradation of water distribution function and water quality in remote islands	Reconstruction of water supply facilities
Water supply for 24 hours is not realized because enough quantity of water source cannot be secured	Securing of a new water source
Appropriate maintenance has not been conducted because of the lack of the equipment and their staffs' experience and technical skills	Provision of equipment and implementation of soft component

Source: Survey Team

3.1.2 Current Situation and Issues on Water Supply (Project Area), and Relation of the Project with them

The current situation and the issues on water supply service in Vava'u, which are described in Section 2.1.4 and 2.1.5, and relation of the project with them are shown in Table 3.2.

Table 3.2 Relation between Issues (Project Area) and the Project

Classification	Issue	Project
Overall	Review of the master plan toward the reconstruction of the water supply facilities	Formulation of water supply system improvement plan based on appropriate water demand calculation

Classification	Issue	Project
Water source	Sea water intrusion to the current water source	Securing of a new water source
Transmission / Distribution Facilities	Malfunction of existing facilities	Reconstruction of water supply facilities
	Remaining AC pipes and high rate of NRW	
	Low level of water supply service in village areas	
Operation and Maintenance	Lack of equipment for O&M	Provision of equipment
Financial	Lack of appropriate management of water volume and financial management capacity	Implementation of soft component

Source: Survey Team

3.1.3 Scope of the Project

The scope of the project is 1) the improvement of water supply system utilizing Japanese technology toward stably, safe and reliable water supply and 2) the soft component through technical guidance for the training of knowhow on effective and efficient operation and management of the facilities and equipment.

3.1.4 Scheme of Implementation of the Project

The project utilizes a Japan's ODA scheme of Grant Aid Project including a Soft Component. This is a type of ODA Grants in which the government of a partner country enters into contracts with consultants or contractors to construct facilities or to procure equipment and materials.

3.1.5 Implementation Schedule of the Project

The implementation schedule of the project is shown in Table 3.3.

Table 3.3 Implementation Schedule of the Project (Tentative)

Contents of the Project	Expected Year
Submission of Application form by the Kingdom for request of the project	2020
Evaluation of the request by GOJ (Government of Japan)	2020 to 2021
Preparatory survey (Basic design)	2021 to 2022
Detailed design	2023
Implementation (Construction, procurement, soft component)	2024 to 2025

Source: Survey Team

3.2 Objective of the Project

3.2.1 Short-term Objective of the Project

The short-term goal of the project is to improve the living and hygienic environment of the residents of Vava'u by following components:

- Secure of a new water source responding to the increasing water demand
- Reconstruction of the deteriorated facilities and construction of new facility for effective and efficient water supply
- Replacement of remaining AC pipes and renewal of the chlorine injection unit for safe and reliable water supply.

3.2.2 Medium- and Long-term Objective of the Project

The medium and long-term goal of the project is to improve the living and hygienic environment in the future and to develop the tourism industry by optimizing the water supply operation through utilizing of the daily O&M data, and realizing a sound water supply business through securing financial source for the investment for the maintenance of the facilities.

3.3 Contents of the Project

3.3.1 Outline of the Project

(1) Goal of the Project

The goal of the project is to contribute to realization of stable, safe and reliable water supply, improving the water supply system in Vava'u Island through grasping the future water demand by an appropriate calculation method, and studying the validity and necessity of the water source. Table 3.4 shows the basis conditions for planning the project.

Table 3.4 Basic Conditions for Project Planning

Target Year	2030
Planned served population	8,200
Daily maximum water distribution amount	2,730m^3/day

Source: Survey Team

(2) Outline of the Project

To achieve the above goal, construction of a new production wells, a new reservoir, raw water, transmission and distribution pipelines, and replacement of existing AC pipes are implemented in the project. In addition, procurement of materials and equipment for O&M and soft component toward enhancement of TWB's capacity are also included in the project.

Table 3.5 summarizes the outline of the project.

Table 3.5 Outline of the Project

Scope	Outline of the Project
Construction Works	• Production Well : 7 places • Generator: 100KVA, 3 sets • Reservoir（Leimatua）: 1,000 m^3 • Pipeline (raw water, transmission, distribution): 25 km • Replacement of AC pipe: 4 km • Chlorine injection unit: 2 sets (at two (2) reservoir) • Flow meter: Electromagnetic type, φ100 to 200, 7 sets • Monitoring system for flow management: 1 set
Equipment Procurement	• Small-scaled desalination equipment: 250L/h, 3 sets • Generator 7.5KVA, 3 sets • Water quality measurement instrument: 1 set • Water leakage detection equipment: 1 set • Heavy machines: small backhoe (0.06m^3, 1 unit), pick-up truck (1 unit) • Customer meter and, ancillaries, service pipes: 600 sets, pipe (10m)
Soft Components	• Training on O&M of water supply facility • Training on strengthening managerial capacity of water supply business • Training on strengthening supervising capacity of pipe installation including water leakage management

Source: Survey Team

3.3.2 Contents, Scale and Quantity of the Project

The content of the project is described as follows.

(1) Water Demand Calculation

The result of rough estimation of water demand based on the conditions and assumptions as described below is shown in Table 3.6 and Figure 3.1. Water demand of 2,700 m^3/day was estimated for the future water demand as of 2030 and used in the planning of the water supply facilities of the project as follows.

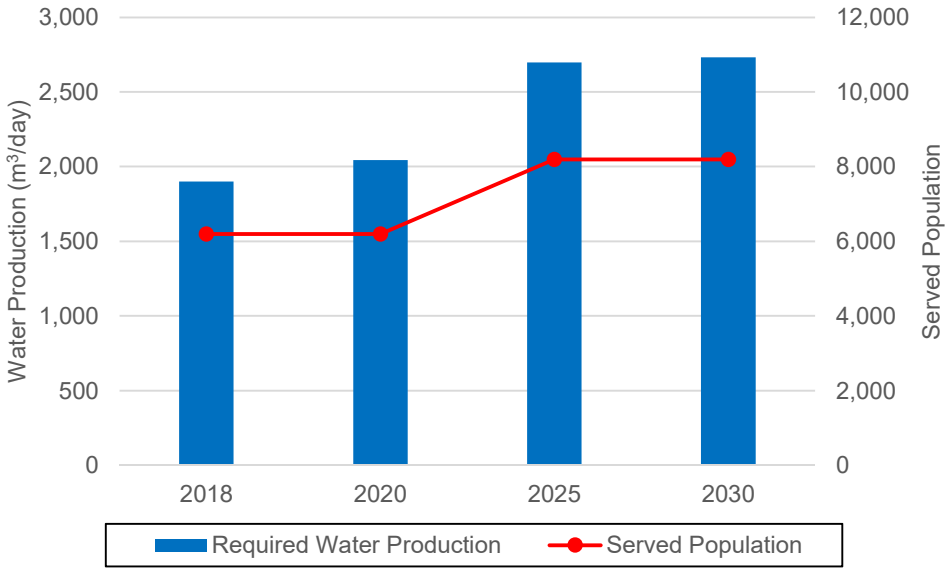
Conditions and Assumptions for Calculation:

- Target year: 2030 after 10 years from the current base year of 2020
- Target supply area: Current supply area by TWB + new area at the three (3) villages (Leimatua, Feletoa, Mataika) as new supply area after the project
- Current served population: 6,200 person = 1,240 households × 5.00 person/household (source: Tonga Census of Population and Housing 2016)
- Future population at the target year: Set flat as the population of the baseline considering the past trend for the twenty (20) years from 1996 to 2016 (See 3.4.6 for details)
- Water consumption per capita: 120 lpcd by 2030 in stepwise increase annually commencing 93 lpcd at 2019
- Connection rate to the TWB's water supply at the supply area: 95 %
- Percentage of non-domestic demand (e.g. commercial, industry purpose): 28 % by referring similar projects
- NRW rate: Improved to 30 % by the project from that of the baseline (41 %)
- Design load factor: Maximum production amount / average production amount = 1.0 / 0.71 (Source: Study reports on the water supply in Tonga including DANIDA reports, Design Criteria for Water Works Facilities 2012, Japan Water Works Association)

Table 3.6 Calculation Result of Future Water Demand of Vava'u

	Items	Unit	Equation	2018	2020	2025	2030	Assumption
(1)	No. of Connection	Unit		1,240	1,240	1,639	1,639	Supply area assumes to be expanded in 2025
(2)	Served Population	Person		6,200	6,200	8,197	8,197	Supply area assumes to be expanded in 2025
(3)	Water Consumption per Capita	L / capita/day		93	100	110	120	Water consumption per capita assumes to increase stepwisely to 120lpd by 2030
(4)	Total Demand (m³/d)	m³ / day	(5) / (1-0.28)	801	861	1,252	1,366	
(5)	Domestic demand (m³/d)	m³ / day	(2) x (3)	577	620	902	984	
(6)	Non-domestic demand (m³/d)	m³ / day	(4) x 0.28	224	241	351	383	Ratio of non-domestic demand to total demand assumes as 28 %
(7)	NRW (%)	%		41%	41%	35%	30%	NRW rate assumes to improve to 30 % stepwisely
(8)	NRW (m³/d)	m³ / day	(4) x (7)	557	598	674	585	
(9)	Water Production (m³/d)	m³ / day	(4) + (8)	1,357	1,460	1,927	1,952	
(10)	Design Load Factor	-		1.40	1.40	1.40	1.40	Design Load Factor assumes as 1.4
(11)	Required Water Production	m³ / day	(9) / (10)	1,900	2,043	2,697	**2,732**	

Source: Survey Team



Source: Survey Team

Figure 3.1 Calculation Result of Future Water Demand in Vava'u

(2) Securing of New Water Source

The quantity and quality of the freshwater lens as a water source is affected by the meteorological, topographical, sea water level rise and the land use at the ground surface of the catchment. Therefore, the location of the new water source should be decided through studying its potential water amount.

According to the literature of Japan's National Institute for Agro-Environmental Sciences (No. 217 - 2015) titled "The causes and issues for sea water intrusion to the freshwater lens in Vava'u and Lifuka islands, the Kingdom of Tonga", Ishida, the water quality of the current well field in Neiafu show high EC values exceeding the allowable limit of WHO guideline for portable water (EC: 150 mS/m) at the depth of 8 and 11 m of the well No. 10 and 15 (See Figure 3.2).

The high salinity of the TWB's supplied water is expected to have been caused by the past historical background that 1) number of TWB's production wells had been decreased because of failure of the pumps and clogging of wells since 2000, 2) yield amount per one well had been increased and that 3) finally the "Up-coning", namely, intrusion of sea water to the extracted water occurred at the freshwater lens to accelerate the intrusion. In contrast, the well filed in the north part from the current well field still shows lower EC values even at the deeper level of the wells exceeding 13 m compared to that of the WHO guideline (See No. 18 in Figure 3.3: Mataika and Prison). And also, Table 3.7 shows that lower EC values were observed at the northern parts (in the vicinity of the prison) far from the current well field, which reveals that this area has not been intruded by the sea water with its thick depth of the fresh aquifer and can be a potential candidate site for the new water source.

Figure 3.2 Current Well Filed

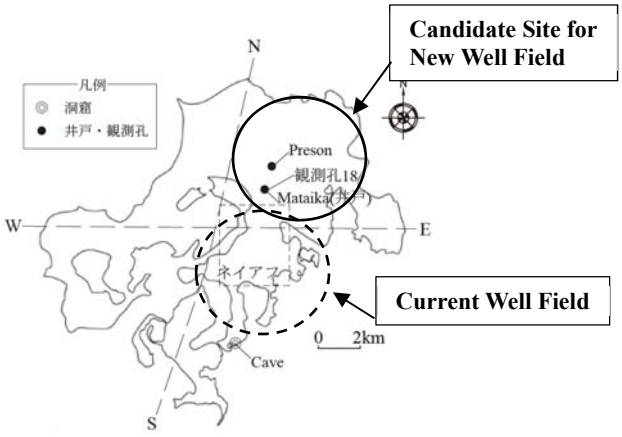


Figure 3.3 Candidate Site for New Well Filed

Source: The causes and issues for sea water intrusion to the freshwater lens in Vava'u and Lifuka islands, the Kingdom of Tonga", Ishida, 2015

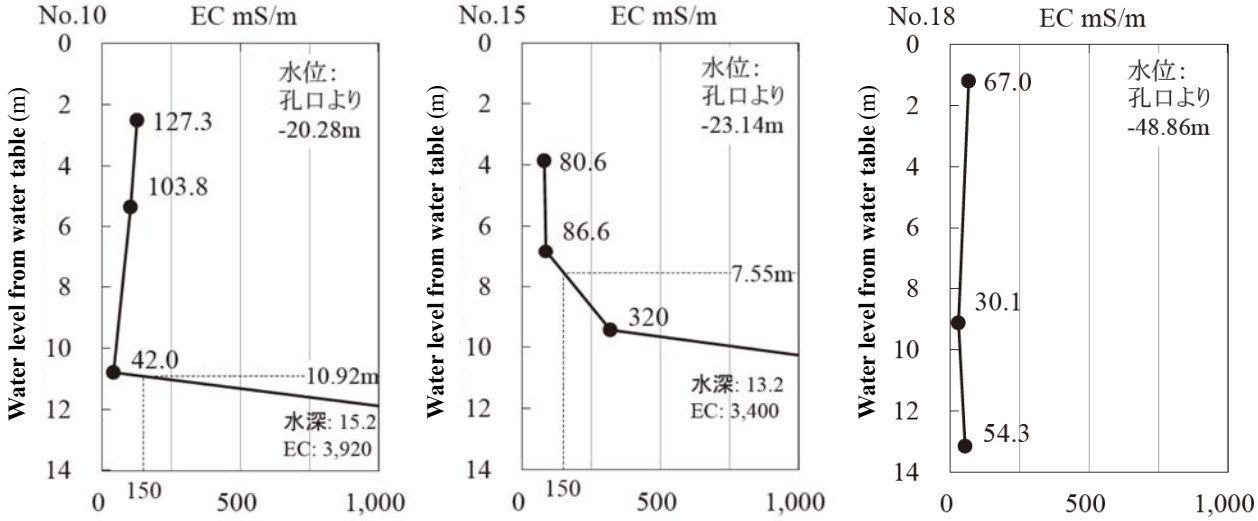


Figure 3.4 Transition of EC Value by Depth at Each Well

Source: The causes and issues for sea water intrusion to the freshwater lens in Vava'u and Lifuka islands, the Kingdom of Tonga", Ishida, 2015

Table 3.7 Location of Measurement and Trend of Sea Water Intrusion

Location	EC Value（mS/m）	
	Measured in 2015 *1)	Measured by the Survey Team in December, 2019
Existing reservoir	-	190
Existing dug well inside the workshop	-	158.0
No. 10 (Current well field)	160	-
No. 15 (Current well field)	121	-
No. 19 (Current well field)	219	-
Prison（Candidate site of new well field）	59.8	60.3
Mataika (Monitoring well No.18)	88.2	-
Candidate site of the new reservoir（Leimatua）	-	69.9

Notes;
1) Measured by Prof. Ishida: The causes and issues for sea water intrusion to the freshwater lens in Vava'u and Lifuka islands, the Kingdom of Tonga", Ishida, 2015
2) WHO guideline of EC for portable water: 150 mS/m

Source: Survey Team

With regard to the candidate site, the data on hydro-geology, water quantity and quality of the freshwater lens in two (2) and three (3) dimensions and drawdown by the possible interference by multiple pumps yield was not available by the survey. The survey on the water source at the candidate site should be carried out as shown in Table 3.8.

Table 3.8 Survey on Water Source at Preparatory Survey (Draft)

Item	Requirements by the Project	Survey Item
Location of wells (Test boring)	• Consistency with the project plan (e.g. Distance to the new reservoir, capacity of the pumps and pipe length) • No obstacles for occupying the project site for construction of wells for permanently operating the facilities • Securing of the work space and access to the construction sites of the wells • Obtaining of the residents of Vava'u • Obtaining of the agreement among the stakeholders such as TWB and MLNR with regard to the management responsibility of the wells • No pollution source such as discharge points of sewage in the vicinity of the wells	• Site inspection • Interview with relevant authorities • Identification of the surrounding environment including the facilities (e.g. pig farm)
Hydro-geological data / information	• Area of the aquifer • Depth of the aquifer	• Obtaining of general geology and geomorphology of the project site • Electric sounding in vertical direction (resistivity exploration) in the vicinity of the prison • Data of the existing wells with regard to the water level, quality of the wells

Item	Requirements by the Project	Survey Item
Influence of yield by multiple wells, permeability	• Capacity of aquifer on storage of freshwater • Efficiency of well extraction • Permeability • Drawdown of the water table by multiple pumps • Sustainable yield amount / volume of freshwater	• Pumping test by test boring at multiple wells
Groundwater quality	• Appropriateness as water source • Degree of seawater intrusion • Existence of pollution as water source • Appropriateness for possible water source for the desalination in terms of the impact on the fouling at the desalination process (survey at existing wells)	• Water quality measurement at each wells • Verification of the survey results with the WHO guideline • Measurement of the parameters that may affect on the fouling (e.g. hardness, organic matter, heavy metals))
Seasonal variation of water table	• Depth of freshwater that is not affected by the seasonal change • Critical yield amount	• Measurement of water table and quality at dry and rainy seasons (at end of dry and rainy seasons)

Source: Survey Team

The number of the well at the water source can be assumed as seven (7) wells (its maximum yield limit is calculated as 432.0 m^3/day x 7 = 3,024 m^3/day ≧ the planned production amount = 2,700 m^3/day if the yield limit per day is 5 l/sec or 432 m^3/day per one (1) well)

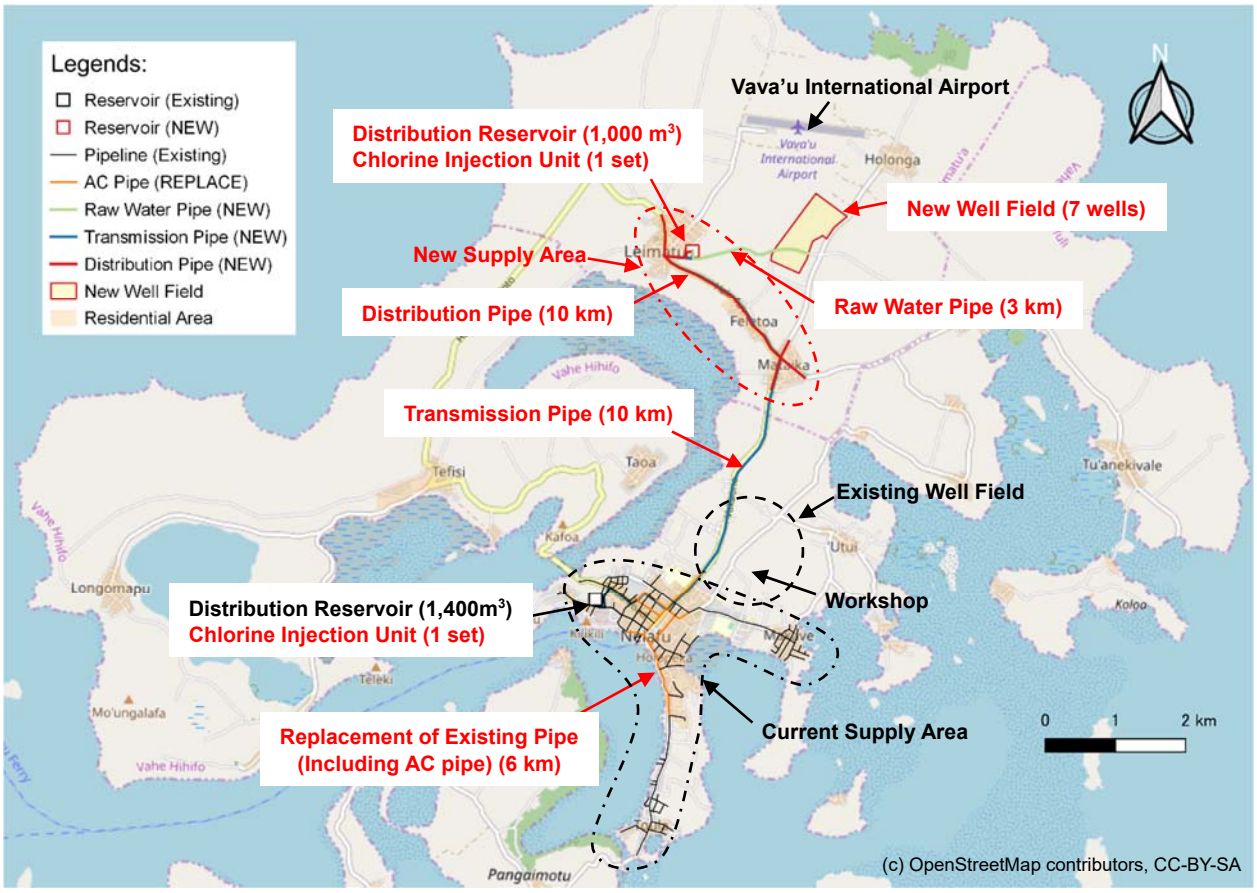
In addition, a flow meter of electric-magnetic type is installed at each well at the seven (7) wells.

(3) Reconstruction of Water Supply Facilities

It is essential to maintain the water supply facilities effectively and efficiently from a long-term perspective of life cycle for sustainable water supply service through reconstruction or rehabilitation of the facilities as planned based on the mid-to-long term financial balance.

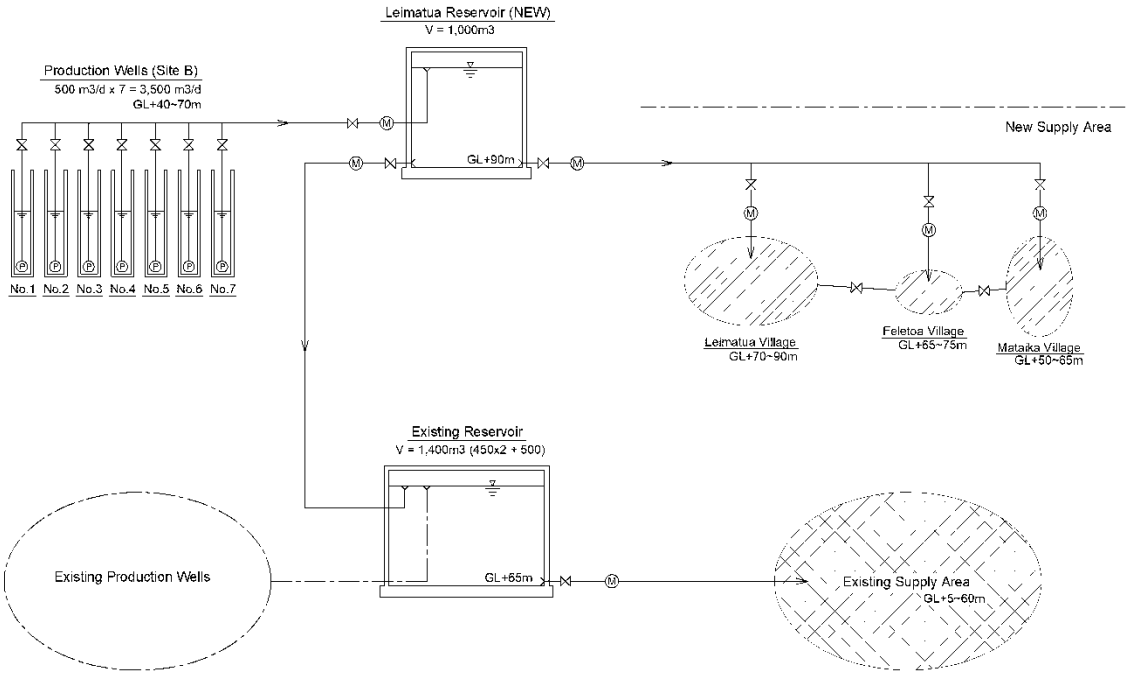
The water supply facilities in Vava'u that were constructed in the late 1900 has already been over the end of their lifetime expectancy and facing the increased of renewal demands. The reconstruction of the facilities should be taken into consideration based on the appropriate demand calculation as mentioned above.

Figure 3.5 shows the scheme of overall improvement plan and Figure 3.6 shows its system flow, respectively. It is planed that the new well field will be acquired in the northern part of Vava'u Island, and the new distribution reservoir will be constructed on a hill at high elevation, from which water will be distributed to the new supply area by gravity. In addition, it is planned to temporarily transmit water from the new reservoir to the existing reservoir by gravity, followed by distributing water from the existing reservoir to the current supply area by gravity.



Source: Survey Team

Figure 3.5 Overall Improvement Plan of the Water Supply Facilities

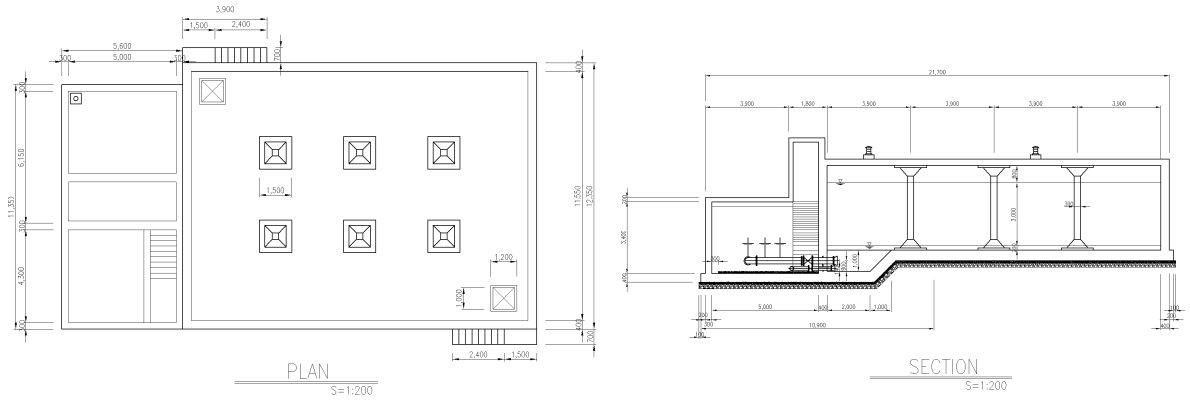


Source: Survey Team

Figure 3.6 Water Supply System Flow after Improvement

1) New Reservoir

The capacity of the new reservoir is set as 1,000 m^3 that is almost equivalent to nine (9) hours volume of the daily maximum water demand of 2,700 m^3/day after the project. The detail of the candidate site of the reservoir is described in the section of 3.4.1.



Source: Survey Team

Figure 3.7 Plan and Section of New Reservoir (1,000 m^3)

2) New Transmission and Distribution Pipes

Total of 23 km pipeline will be laid for the raw water pipe (3 km) from the new well field to the new reservoir, transmission main (10 km) between the existing and new reservoir and the distribution main and its branch pipes (10 km) for the newly expanded supply areas at the three (3) villages. Establishment of DMA at the three (3) villages to enhance the management capacity of the distribution flow will be studied by the project.

3) Replacement of Asbestos Cement Pipes and Diameter Increase of Existing Distribution Pipes

The remaining AC pipes in Neiafu (4 km) connecting the existing distribution main will be replaced. And also, the diameter increase of the distribution pipe at the end of the current supply area (2 km) will be conducted to settle the issue of the insufficient pressure.

4) Chlorine Injection Unit

Chlorine injection unit will be installed at the two (2) locations at the outlets of the two (2) reservoirs. The chlorine injection unit in Vava'u that was procured at the past project is no more used due to difficulty of procurement of the chlorine gas. The potential introduction of sodium hypochlorite that is used in Tongatapu should be studied in the preparatory survey to examine the easiness of its procurement.

5) Management System of Distribution Flow

A management system for the distribution flow, which consists of flow meters, personal computers and peripheral devices, will be introduced. And the database for the daily O&M works will be established.

The flow meter will be installed at locations below;

- Inlet of new reservoir: One (1) set
- Outlet of new reservoir: Two (2) sets (Transmission main and distribution main)
- Outlet of existing reservoir: One (1) set

- Inlet of three (3) DMA at the new villages: Three (3) sets

The data of the flow meters will be transmitted to the personal computer and its peripheral devices to be installed inside the workshop to enable an off-site management of the distribution flow at daily operation and develop its database for their effective use.

6) Emergency Generator

Basically the new intake pumps will be electric type using the grid. However, introduction of emergency generator as disaster countermeasure will contribute to establish a flexible water supply system which enable to supply water even at the possible events of power failures caused by natural disasters such as cyclones in the Kingdom.

(4) Procurement of Equipment for Operation and Maintenance

1) Small-scaled Desalination Equipment

The Kingdom is exposed to the natural disasters and new threat of climate change. Especially, the remote islands are vulnerable to these disasters and climate change and it will not be easy to secure drinking water at such hazard events. In worst case, the condition may continue for several days or weeks. Thus, small-scaled mobile desalination equipment (Production capacity: 250 L/h, Weight: 100 kg, Quantity: 3 units) will be procured by the project in terms of disaster prevention measures.

Figure 3.8 Sample Photo of Small-scaled Desalination Equipment

Source: Manufacturer's Website

2) Water Quality Measurement Instrument

Currently, the water samples of the water supply system in Vava'u is transported by air to a laboratory in Tongatapu for the water quality analysis, and the result is sent back to the Vava'u branch office by e-mail. The branch office has no water quality measurement equipment for its mandatory parameter. Therefore, the equipment for water quality measurement are to be procured by the project.

3) Water Leakage Detection Equipment

Large parts of the water supplied by TWB has become NRW with its current rate of 40 to 50 percent even though the water source in the Kingdom is limited. Effective utilization of limited water including its reservation will be essential for the stable water supply, and control of NRW has become a common

challenge to promote independent accounting system of the water supply business in developing countries. Therefore, water leakage detection equipment will be procured to practice on control of NRW in effective and efficient manners and the training on acquisition of detection methods using the equipment will be carried out as the soft component.

4) Heavy Machines

TWB desires to take in all villages into their supply area in the future and to realize continuous water supply for twenty-four (24) hours. TWB has to construct distribution pipes by their own budget when TWB will expand their supply areas in the future. Therefore, heavy machines such as small backhoe and pickup truck will be procured by the project to support their construction.

5) Service Pipe and Customer Meter

For the three (3) villages that is newly taken into the water supply area of TWB by the project, this project will procure 200 sets of customer meters and ancillaries per one village and 10 m service pipes (GI pipe) per meter, namely, 600 sets (200 sets per village x 3 villages) of customer meters and 6 km pipes (10 m per set x 600 sets) in total.

(5) Implementation of Soft Component

1) Background of Soft Component Planed

The project aims to improve the current situation of water supply in Vava'u by securing the new water sources, and renewing the deteriorated existing facilities / equipment.

Considering the following TWB's current / future challenges, the soft component needs to be carried out in the project to support the TWB's smooth launching after implementation of the project and secure sustainability of the outcome of the project;

- Lack of knowledges and experiences on O&M,
- Necessity of more effective operation of water supply business because TWB's supply area will be expanded after completion of the project,
- And, necessity of improvement of quality control for the pipe laying works

Based on the above, the soft component focus on the following three (3) contents as shown in Table 3.9.

Table 3.9 Contents of the Soft Component

No.	Contents	Purpose of Soft Component
1	O&M of water supply facility	Capacity development on O&M of entire water supply system covering water intake facility to house connection
2	Management of water supply business	Capacity development on business management of water charge billing / collection and accounting works, customer information management, and customer services
3	Supervision of pipe laying works	Enhancement on the quality control for pipe laying works and leakage detection skills

Source: Survey Team

2) Goal of Soft Component

The goal of the soft component is to contribute "to realize stable, safe and reliable water supply to consumers by proper O&M of water supply facilities based on a sound business foundation" after a certain period from the completion of the project.

3) Outcome of Soft Component

a) O&M of water supply facility

TWB's staffs will comprehend the composition / purposes of the entire water supply system which includes the facilities constructed by the project and acquire the proper O&M skills of the system.

b) Management of water supply business

TWB staff will acquire the knowledge for the water supply business such as financial management (budget management and cost analysis), customer information management, and customer services. In addition, they will acquire proper methods of water billing, tariff collection and accounting works. They will also understand the way of public relations and public awareness to enhance customer's consciousness on hygienic improvement by providing information related to their water supply service to the customers.

c) Supervision of pipe laying works

By understanding the importance of the construction supervision for pipe laying works, TWB staffs will acquire the capacity for proper supervision to improve the construction quality. In addition, a technical skill on water leakage control also will be acquired through the training using the leakage detection equipment procured in the project.

3.3.3 Dispatch of Experts, Contents, Scale and Quantity of Materials and Equipment

(1) Dispatch Schedule of Experts

The dispatch schedule of experts is shown in Table 3.10.

Table 3.10 Dispatch Schedule of Experts (Tentative)

Works \ Year	1st Year												2nd Year												3rd Year												4th Year						Required M/M
	Basic Design												Detailed Design												Construction Supervision												Coonstruction Supervision & Soft Componenet						
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	
【Basic Design】																																										
Study on basic conditions (Planned Served Population)																																										2
Study on water supply system																																										3
Study on intake and conveyance facilities																																										4
Study on transmission and distribution facilities																																										5
Study on cost estimate, procurement and construction supervision																																										3
Study on sustainable water supply service																																										2
Study on environmental & social consideration																																										2
【Detailed Design / Construction Supervision】																																										
Intake Wells																																										15
Reservoir																																										11
Pipelines (Conveyance, Transmission & Distribution) and Distribution Networks																																										20
Replacement of Asbestos Pipes																																										12
Water flow management system																																										8
Chlorine injection unit																																										5
Procurement of materials & equipment																																										5
Cost Esitmate / Bidding																																										4
【Soft Component】																																										
Training on O & M of water supply facility																																										2
Training on strengthening managerial capacity of water Supply undertaking																																										2
Training on strengthening supervising capacity of pipe laying																																										2
【Dispatch of Experts】																																										
1.Water supply plan expert																																										9
2.Water source expert																																										16
3.Water distribution and its O & M expert																																										12
4.Pipe design and its O & M expert																																										18
5.Environmental & social consideration expert																																										2
6.Mechanical expert																																										9
7.Electrical expert																																										9
8.Cost Estimate / Contract Expert																																										8
9.Business management expert																																										4
10.Water leekage detection expert																																										2
11.Water quality management expert																																										2

Source: Survey Team

(2) Required Experts

Expert	Task
Team leader / Water supply planning	1. Overall project management 2. Formulation of improvement plan 3. Support to updating water tariff 4. Formulation of soft component plan
Water source planning	1. Formulation of improvement plan 2. Evaluation of existing and new water source 3. Groundwater survey (e.g. Physical exploration, pumping test, permeability and drawdown) 4. Reevaluation of the recharge amount of the new water source 5. Introduction of small-scaled desalination equipment as a disaster countermeasure
Civil design and O&M	1. Formulation of improvement plan 2. Design of new reservoir 3. Study on effective use of the existing reservoir 4. Guidance on the O&M of the reservoir 5. Guidance on the general concept of asset management 6. Guidance on the process of reconstruction planning of facilities
Pipeline design and O&M	1. Formulation of improvement plan 2. Study on replacement of AC pipes 3. Pipeline design (raw water, transmission, distribution pipes) 4. Guidance on maintenance of distribution networks 5. Guidance on installation of customer meters 6. Guidance for safety control in construction works
Environmental & social consideration	1. Formulation of improvement plan 2. Study on land use and land acquisition for the new water source and reservoir 3. Study on water right of the new water source 4. Assistance to TWB for its EIA for the project 5. Assistance to TWB for holding a stakeholder meeting on introduction of new tariff system at the villages newly supplied water by the TWB
Mechanical Design and O&M	1. Formulation of improvement plan 2. Study on mechanical equipment for the new production wells 3. Study on mechanical equipment for the new facilities
Electrical Design and O&M	1. Formulation of improvement plan 2. Study on electrical equipment for the new production wells 3. Study on electrical equipment for the new facilities 4. Study on water flow monitoring system
Cost estimation / Bidding	1. Formulation of improvement plan 2. Cost estimation at basic and detailed design stages 3. Formulation of construction / procurement plan 4. Preparation of bidding documents
Business management	1. Study on management situation of water supply business 2. Assistance to TWB on review of water tariff system 3. Guidance on management of water supply business
Water leakage control	1. Guidance on water leakage control 2. Guidance on use of the leakage detection equipment procured 3. Basic education for reduction of NRW
Water quality	1. Guidance on water quality management 2. Guidance on use of the water quality measurement instrument procured 3. Guidance on utilization of acquired water quality data

Source: Survey Team

(3) Procurement of Equipment

The equipment to be procured in the project is shown as below.

- Small-scaled desalination equipment and its emergency diesel generator
- Water quality measurement instrument
- Water leakage detection equipment
- Heavy machines (Small backhoe, pickup truck)
- Customer meter and ancillaries, service pipes

3.3.4 Rough Estimate of the Project Cost

The estimated project cost including the construction, equipment procurement, soft component and design / supervisions is about 700 Million Japanese Yen as shown in Table 3.11.

Table 3.11 Estimated Project Cost

Unit in 1,000 JPY

Scope	Item	Price
Construction Works	• Production Well : 7 places • Generator: 100KVA, 3 sets • Reservoir（Leimatua）: 1,000 m^3 • Pipeline (raw water, transmission, distribution): 25 km • Replacement of AC pipe: 4 km • Chlorine injection unit: 2 sets (at two (2) reservoir) • Flow meter: Electromagnetic type, φ100 to 200, 7 sets • Monitoring system for flow management: 1 set	570,000
Equipment Procurement	• Small-scaled desalination equipment: 250L/h, 3 sets • Generator 7.5KVA, 3 sets • Water quality measurement instrument: 1 set • Water leakage detection equipment: 1 set • Heavy machines: small backhoe (0.06m^3, 1 unit), pick-up truck (1 unit) • Customer meter and ancillaries, service pipes: 600 sets, pipe (10m)	41,000
Soft Components	• Training on O&M of water supply facility • Training on strengthening managerial capacity of water supply business • Training on strengthening supervising capacity of pipe installation including water leakage management	21,000
Engineering	• Design / Supervision	61,000
Grand Total		693,000

Source: Survey Team

3.4 Condition of the Project Site

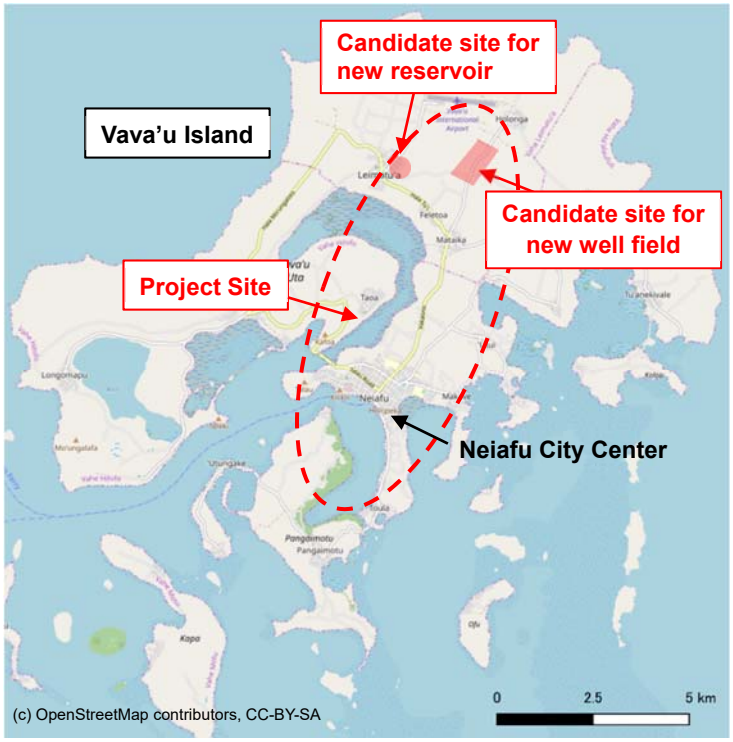
3.4.1 Location (Land Acquisition, Land Use, Pollution Sources, etc.)

(1) Status of Land Acquisition

The land of the following facilities should be secured for the project and their candidate sites are shown in Figure 3.9.

- Construction site of the new reservoir
- New well fields of the raw water intake

Basically, the land of the Kingdom is classified as i) "Royal Land" that is owned by the King, ii) "Noble Land" that is owned by nobles and iii) "Government Land" that is managed by the government. The candidate site of the new reservoir belongs to "Noble Land". On the other hand, as the site of the new well field ranges wide area, the actual status of the acquisition of the lands should be clarified in more details at the preparatory survey. For the government land, an official letter from the Governor of the Vava'u Island has already been obtained as shown in Photo 3.1. However, more detailed survey on the actual process and schedule for the land acquisition especially for the royal and noble lands should be carried out with a collaboration with TWB and MLNR because the process appears to be more difficult compared to the government lands.



Source: Survey Team

Figure 3.9 Location Map of Candidate Sites

OFFICE OF THE GOVERNOR OF VAVA'U,
KINGDOM OF TONGA

P.O.Box 39
Neiafu, Vava'u
Kingdom of Ton

Phone: (676) 70-070
Fax: (676) 70-501
Email: govvavau@kalianet.gov.to

Mr. Sione Finau
CEO
Tonga Water Board
Nukuálofa

28 January 2020

Dear Sir,

This is to officially certify that Government Land is available for your proposed project with the Japanese Government. The aforementioned Government land will be available at Haalefo – Holonga area.

I am very thankful for the Japanese Government for their assistance towards water distribution. They will be assisting us with our water distribution which will be for the whole of Vavaú.

So I am looking forward for further update of the project.

Your's sincerely,

Lord Fakatulo
(Governor of Va

GOVERNOR OF VAVA'U
GOVERNOR'S OFFICE TONGA

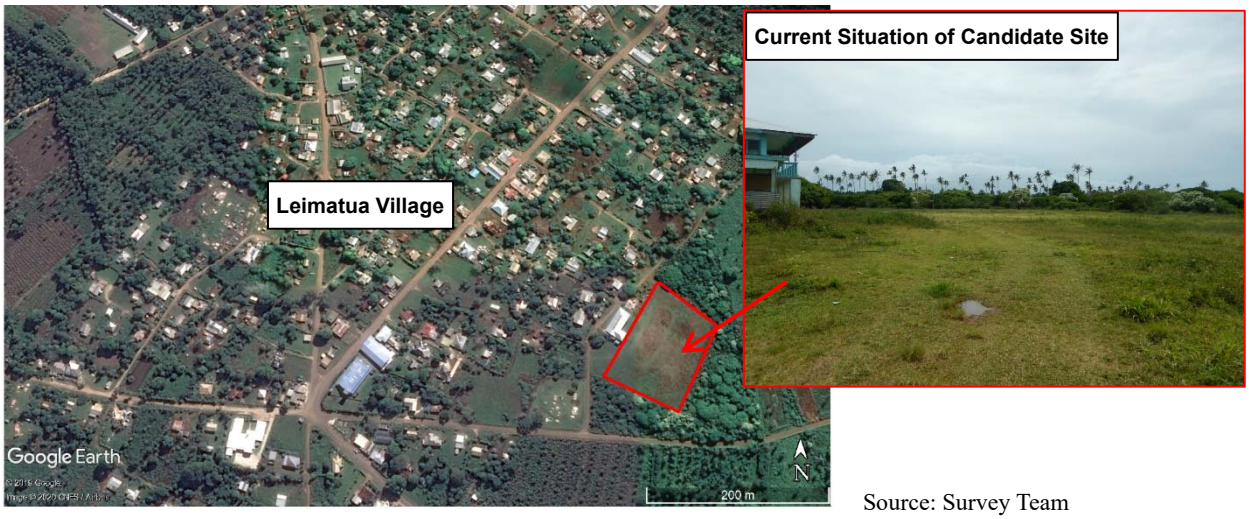
Photo 3.1 Official Letter from Governor of Vava'u on the Availability of the Government Land

(2) Land Use of the Project Site

The land use in the Kingdom is jurisdiction under MLNR. MLNR is also responsible for the groundwater management of the wells operated by TWB and VWCs.

1) Candidate Site of New Reservoir

The location and site condition of the candidate site of the new reservoir is shown in Figure 3.10. The site is located in front of the community center of Leimatua village and currently used for a playground and belongs to a noble estate. The land area is around 80 m x 100 m that is enough large to allocate the reservoir of volume of 1,000 m^3. Its elevation can also distribute its stored water by gravity to the city center of Neiafu as its current TWB's supply area finally around the city area of Neiafu via the existing reservoir (See Figure 3.6 and Figure 3.11).



Source: Survey Team

Figure 3.10 Location of New Reservoir (Left) and its Site Condition (Right)

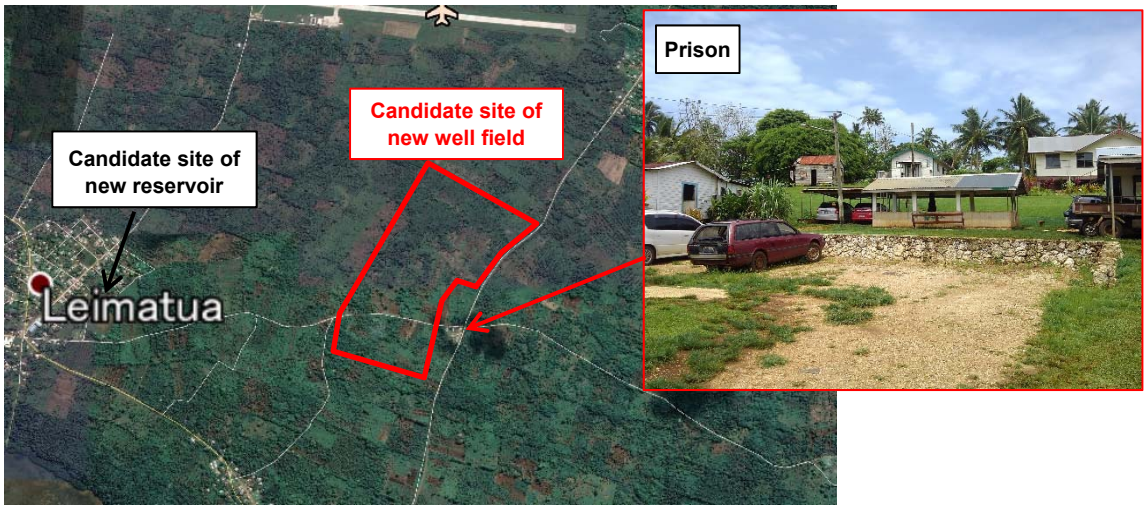
Source: Survey Team

Figure 3.11 Geomorphological Profile of Distribution Main from Leimatua to Neiafu

2) Candidate Site of New Well Field

The project site is located in the vicinity of the existing prison at the middle part between Mataika and Holonga as shown in Figure 3.12. The site appears to be suitable for the candidate site of the well field in terms of its reservation because there is a low risk of the pollution to be caused by the infiltration of sewage and domestic wastewater. There is the existing well in the prison for the water supply to the surrounding

villages, and it is confirmed that its water quality is more suitable for the water source with its lower EC level compared to the existing water source and that its aquifer appears to be thicker.



Source: Survey Team

Figure 3.12 Candidate Site of New Well Field (Left) and Condition near the site (Prison)

3) Road Condition for Pipe Laying

The pipes will be laid underground of the road that are currently under jurisdiction of MOI (Ministry of Infrastructure). According to the survey team's interview with TWB, the approval for the pipe laying works is easily obtained from MOI. Photo 3.2 shows the current conditions of the road in Vava'u. The main road from the Vava'u International Airport to the city area of Neiafu is currently concrete pavement, whereas the suburb road is paved with concrete mixed including the aggregate originating coral limestone. The roads in Vava'u has low traffic generally, which can cause low impact on these road during the pipe laying works.

Photo 3.2 Road Conditions in Vava'u

(Left: Concrete pavement, Right: Concrete pavement using aggregates of coral limestone)

(3) Potential Pollution Source

Currently, the water at the existing well field is conveyed to the existing reservoir of GL. 60 to 70 m and distributed to the city center of Neiafu. Human activities in the vicinity of the well filed can be major

pollution source. Therefore, the new well field should be located with consideration on any impact of pollution by the wastewater of the domestic lives and agricultural works. Especially, the free-range wild pigs in the wide area of Vava'u is observed and can be a potential pollution source for discharge of fecal coliform. Another pollution source can be 1) the potential infiltration of the diesel oil to the underground by the use of diesel-driven pumps that is currently operated in some places of the island and 2) the intrusion of wastewater from the leakage points of the deteriorated pipes.

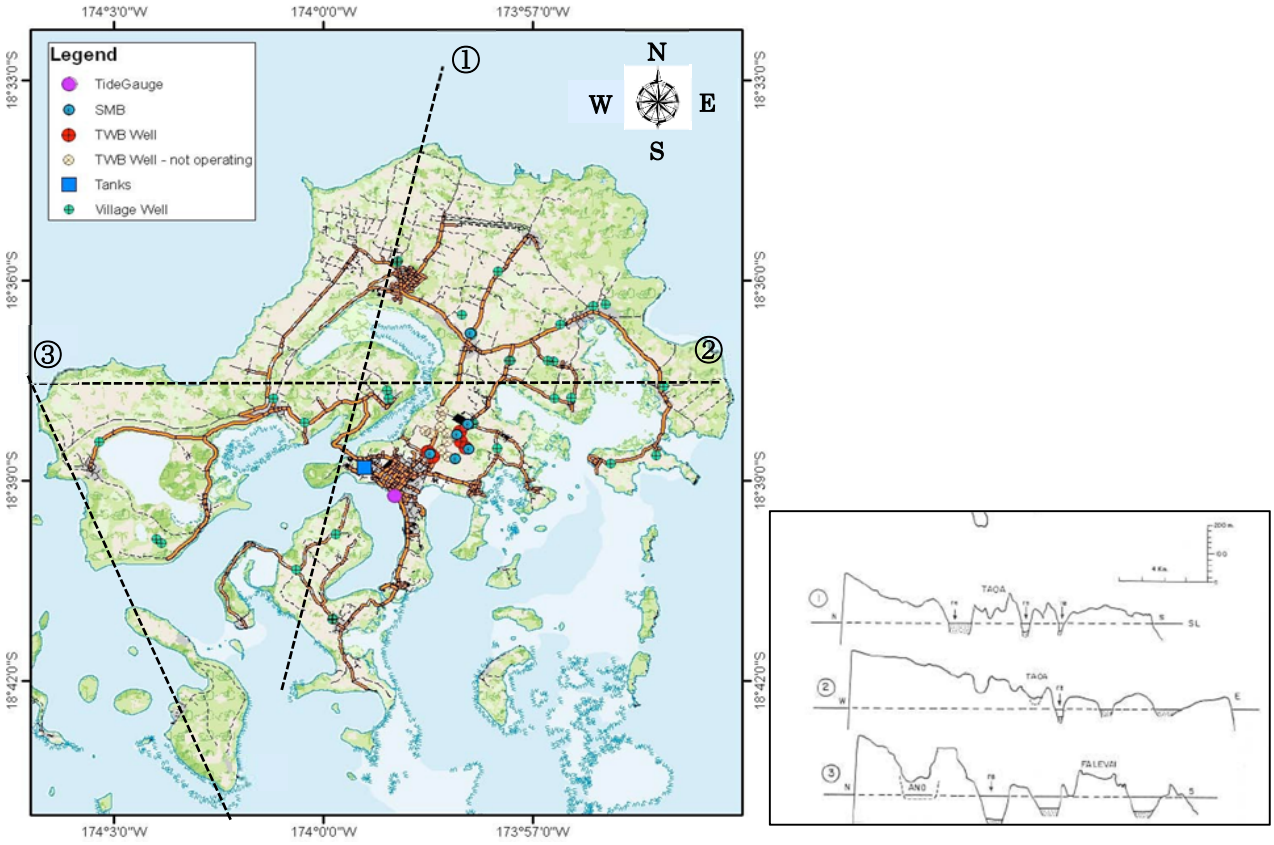
3.4.2 Natural Condition

(1) Geomorphology / Geology

The Tongan Islands sit on the easternmost of the Australia-India plate and become a crescent-shaped archipelago that was formed by the uplift at the peripheral parts of the Australia-India plate by sinking of the Pacific plate. The volcanic activity of the main island group of Vava'u, Ha'apai, and Tongatapu is not active, while Tofuac Arc with comparatively active volcanos lies on the west part of this island group.
The northern coast of Vava'u island face the open sea continuously where steep sea cliffs have a scalloped plan-form that suggests prolonged marine erosion. In contrast, the southern margin is highly irregular with a fragmented, ria-like appearance (See Figure 3.13).

The geology of the Vava'u comprises three types (3) of limestone, namely, 1) limestone lying at the lowest layer of the marine erosion that was formed after the age of Pliocene, 2) limestone originating corals overlying the layer of 1) and 3) those originating calcareous algae. At the top of the ground surface, the red-brown soil originating fine volcanic ash overlies these limestone with the thickness less than 10 m. There is no outcrop of the base rock on the ground of the island although it was potentially formed as volcanic rock.

Rainfall infiltrates immediately into the underground because the limestone at the surface layer has higher permeability. Therefore, the island has no surface water like lakes and rivers. Thus, the freshwater lens as the water source for the island is formed in the limestone layer due to its higher permeability that is recharged by the rainfall and finally balances with the sea water at the lowest layer.



Source: Preparation by the survey team based on the TWB's GIS map

Figure 3.13 Geomorphological Map and its Profile of Vava'u Island

(2) Meteorology

1) Temperature

The Kingdom has a semi-tropical climate with moderate rainfall and high relative humidity. The annual average temperature ranges 23 to 28 °C and its moisture is about 75 %. There is a latitude variation of the annual average temperature that is highest in the north (27 °C) and lowest in the south (24 °C). The temperature of Vava'u ranges from 30 °C in its highest to 20 °C in its lowest for the past thirty (30) years of 1981 to 2010 as shown in Table 3.12 and Figure 3.14, which presents its highest in February and lowest in July to August. As its seasonal change, respectively. Thirty five (35) °C has been recorded as a highest temperature in February, 11th, 1979.

2) Rainfall

The Kingdom has a rainy season from November to April and dry season from May to October, and 60 to 70 percent of the annual rainfall is observed for those of the rainy season. The precipitation of the Kingdom arises mainly from cyclones and the movement of the SPCZ (South Pacific Convergence Zone).

The northern islands including Vava'u is easily influenced by the convection of the SPCZ and have its annual average of 2,500 mm at the northernmost islands. The islands in the southern areas, in contrast, have their annual average rainfall of 1,700 mm. Table 3.12 and Figure 3.14 shows the monthly average

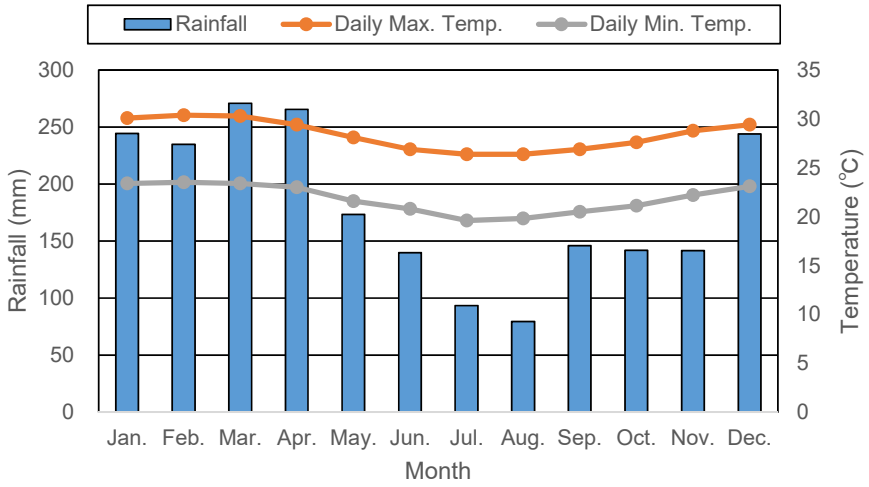
temperature and rainfall of Vava'u that has been recorded in the past thirty (30) years of 1981 to 2010, respectively. Its highest and lowest rainfall has been recorded at 270 mm in March and 80 to 90 mm in July and August, respectively.

Cyclone and ENSO can be the two (2) factors affecting the precipitation pattern in the Kingdom. The cyclone causes more rainfall in rainy seasons in case of its passing compared to those of the seasons of no cyclones, and the occurrence of ENSO causes drought in a long period especially in the middle and south parts of the Kingdom.

Table 3.12 Climate Characteristics in Vava'u

Month	Mean Temperature(°C)		Mean Total Rainfall (mm)	Mean Number of Rain Days (>0.1mm)
	Daily Max.	Daily Min.		
January	30.1	23.4	244.4	19
February	30.4	23.5	234.7	19
March	30.3	23.4	270.8	20
April	29.4	23.0	265.6	17
May	28.1	21.6	173.4	15
June	26.9	20.8	139.9	14
July	26.4	19.6	93.5	14
August	26.4	19.8	79.5	13
September	26.9	20.5	145.9	13
October	27.6	21.1	141.8	13
November	28.8	22.2	141.6	13
December	29.4	23.1	244.0	16

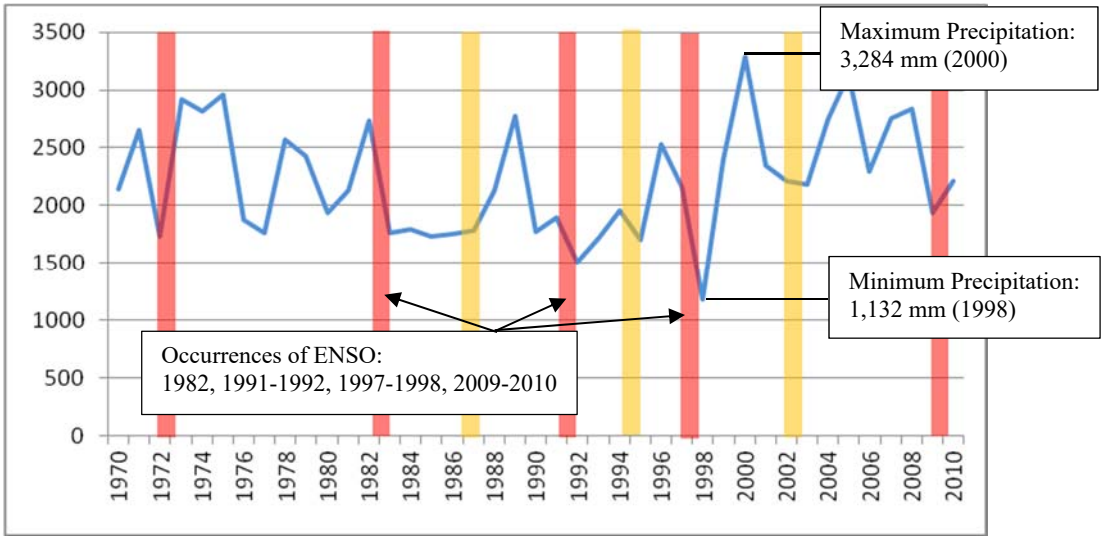
Source: Climatological Information-Lupepau'u Airport (Vava'u) based on monthly averages for the 30-year period 1981-2010, Tonga Meteorological Service



Source: Survey Team

Figure 3.14 Climate Characteristics in Vava'u

Figure 3.15 shows the transition of the annual rainfall of Vava'u for the past forty (40) years, in which the possible occurrence of ENSO caused extremely low rainfall in the years of 1982, 1991 to 1992, 1998 and 2009 to 2010 with its minimum rainfall of 1,131.9 mm recorded in 1998.



Source: Modified by the survey team for "Neiafu Groundwater Resources Assessment and Sustainable Management Report, Nicola Fry, and Tony Falkland, December 2011"

Figure 3.15 Relation between Occurrences of ENSO and Annual Precipitation in Vava'u

(3) Groundwater Recharge

1) Hydrogeological Characteristics of Vava'u

The freshwater lens as the water source of the Vava'u is the aquifer of low salinity concentration that was formed in the limestone with high permeability overlying the volcanic base rock. In the existing literature studies, no data on its hydrogeological characteristics such as permeability, specific spring capacity was not available in the literatures.

2) Characteristics of Groundwater Recharge in Vava'u

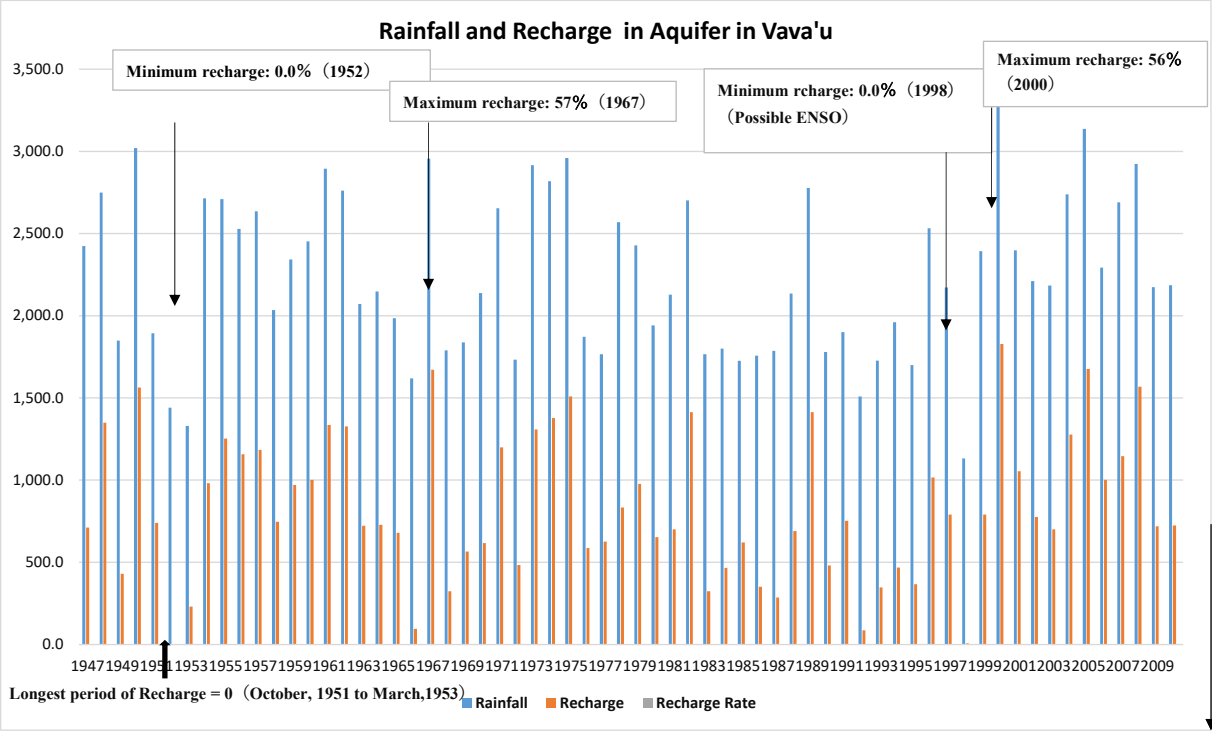
The depth of each layer of the aquifer of the remote isolated island such as Vava'u is affected by various factors as shown below;

- Rainfall amount and distribution
- Amount and nature of surface vegetation and the nature and distribution of soils (influencing evapotranspiration)
- Size of the island, particularly the width
- Permeability and porosity of the geological formation, and the presence of cave systems and solution cavities
- Tidal rise or range
- Methods of extraction and quantity of water extracted by pumping

The recharge amount of Vava'u was studied through a water balance study using the parameters of the past rainfall for 65 years of 1047 to 2011, evapotranspiration calculated using by Penman method and soil

characteristics ("Neiafu Groundwater Resources Assessment and Sustainable Management Report", Nicola Fry, and Tony Falkland, December 2011). According to the study, the following results were obtained;

- The rate of the recharge to the average monthly rainfall: 0.37 in average (0.0 to 0.57)
- Zero (0) recharge in 1998 when the ENSO possibly occurred with its low annual precipitation of 1,132 mm
- Another zero (0) recharge for the period of 17 months of October, 1951 to March, 1953



Source: Modified by the survey team for "Neiafu Groundwater Resources Assessment and Sustainable Management Report, Nicola Fry, and Tony Falkland, December 2011"

Figure 3.16 Historical Trend of Precipitation and Groundwater Recharge in Vava'u

(4) Yield Amount

1) Sustainable Yield Amount

Sustainable yield amount can be defined as the possible yield amount that can be extracted continuously without causing any depletion of its aquifer or adverse impact on the surrounding environment in a long period including droughts. The aquifer of the Vava'u, the water quality of the freshwater lens should be maintained within the permissible limit of the target quality.

The groundwater yield amount of such aquifer in the remote and isolated island such as Vava'u should be maintained to smaller amount than those of the recharge amount that is mainly supplied by the precipitation because more freshwater recharge is needed to flush the saline water at the bottom of the area of the recharge. According to Falkland (1992), the rate of the sustainable yield estimate to its recharge or rainfall amount in the areas such as Vava'u with comparatively more rainfall, the sustainable yield rate to the recharge or

rainfall amount was calculated as 30 to 40 % or 11 to 15 %, respectively. The result shows that the sustainable yield estimate of 248 mm/year can be obtained for the average annual rainfall of 2,250 mm in Vava'u considering its margin for the actual calculated results of 248 to 338 mm/year. Table 3.13 shows the sustainable yield estimate for each cases of the catchment area of the recharge. The detailed data on the area and depth of the catchment, drawdown by multiple pumping and water quality should be acquired through site survey of physical exploration (e.g. resistivity sounding) in the preparatory survey as described in Section 2.

Table 3.13 Sustainable Yield Estimate at the New Well Filed

Catchment (km^2)	Rainfall (mm/year)	Rate of Yield to Rainfall (%)	Sustainable Yield Estimate (m^3/day)
5	2,250	11	3,390
6	2,250	11	4,068
7	2,250	11	4,747

Source: Survey Team

2) Long-term Issue on Water Source

The planned maximum water distribution amount of 2,700 m^3/day by the project is less than the sustainable yield estimate, which bring a stable water supply to the long-term operation of TWB's water supply service. However, the freshwater lens may have a potential risk of shrinkage of its area and depth because it depends on the natural condition, yield pattern or methods. Therefore, multiple options such as effective use of rainfall harvesting or desalination of sea water should be studied in the future.

3.4.3 Transportation

The transportation of the Kingdom comprises three types of land, sea and air route. The total extension of the trunk road is 680 km including its paved section of 184 km. The major harbors is located in Neiafu in Vava'u, Nukualofa in Tongatapu, in Pangai in Ha'apai. The main transportation between islands is made by the sea transportation.

The Kingdom has six (6) airports, in which Fua'amotu the Tongatapu and Vava'u International airport Vava'u has paved runway and are operated by the international airways such as Fiji Air, Air New Zealand, Tongan Air, Virgin Pacific and Air Pacific.

Fiji Air has operated two (2) direct flights per week for the route between Fiji (Nadi) and the Kingdom (Vava'u) since 2018. The reason of the commencement of the operation is that Vava'u is attractive place for the marine sports such as whale watching, snorkeling, kayaking, kite surfing, sailing, diving and fishing.

JICA has commenced a survey for data collection on the study toward its potential direction of cooperation that can contribute to the sustainable development of tourism and relevant industries to improve the current state that the tourism industries has not been developed because its infrastructure development is not making a good progress.

In addition, JICA has also has commenced another survey on the data collection of the project for the expansion of the runway and terminal of existing main airports of Fua'amotu and Vava'u International Airport that has contributed to the crucial roles of social and medical service in addition to the tourism and their means of movement and transportation between islands and for international trades. It is expected that the expansion of the airports will accelerate the development of the tourism of the Kingdom.

3.4.4 Electric Power Supply / Telecommunication

(1) Electric Power Supply

The electric power supply in the Kingdom provided by the TPL (Tonga Power Limited). The Kingdom is a country poor in energy sources. The Kingdom has depended on the diesel power generated by imported oil. However, the Kingdom has a vulnerability on energy security on its background that its economy has been affected by the variation factor of international oil price due to the recent increase of the oil consumption reflecting its transition to an energy-intensive economy. From above situation, the Kingdom intends to introduce the power supply by renewable energy to fifty (50) percent by 2020 for the total energy supply based on the national policy of TERM ("Tonga Energy Road Map") to secure multiple energy supply and realize stable power supply. GOJ has already made a statement at the PALM 7 (The 7th Pacific Islands Leaders Meeting) that GOJ will promote a diversification of energy source and secure the stable energy supply in the PICs (Pacific Island Countries). In response to above statement, a grant aid project of "The Project for Installation of Wind Power Generation System in the Kingdom of Tonga" toward introduction of renewable energy, diversification of energy supply and stable supply in its ultimate goal is currently on going.

(2) Telecommunication

The Kingdom has its telephone market that 11 thousand fixed lines (14 percent) and 80 thousand mobile lines (70 %). The coverage of the internet is estimated as forty (40) percent as July, 2016. TCC (Tonga Communications Corporation) that was established in 1984 as a state-owned corporation, and a private company of Digicel are the major service providers of the internet communication.

3.4.5 Security

The Kingdom is one of the countries of comparatively better security. According to the GOJ's "Overseas Travel Safety Information" as of December 2019, no information for warning for caution nor evacuation has been released.

3.4.6 Others

(1) Population

The Kingdom has carried out the national census survey every ten (10) years since 1956 and every five (5)

years since 2011 with the latest survey in 2016. Table 3.14 shows the results of the survey in 2016 that the country has its population for 100,651, 18,005 households and 193 public institutions. Its annual average growth rate of population has been gradually decreased from 1.1 percent in 1986 to the minus 0.5 percent in 2016. The population ratio in urban and rural areas has not changed since 2016 with the rate of 77 percent in urban and 23 percent in the rural areas.

Table 3.14 Transition of the Population in the Kingdom

Census	1986	1996	2006	2011	2016
Population	94,649	97,784	101,991	103,252	100,651
Average Annual Growth (%)	1.1	0.5	0.4	0.2	-0.5
Median Age (years)	19	20	-	21	22
Urban	-	-	23,658	24,229	23,221
Urban (%)	-	-	23.2	23.5	23.1
Rural	-	-	78,333	79,023	77,430
Rural (%)	-	-	76.8	76.5	76.9

Source: Tonga Census of Population and Housing 1996, 2006, 2011 and 2016

The Kingdom comprises five (5) administrative divisions of Ongo Niua in the northernmost, Vava'u, Ha'apai, Eua and Tongatapu in the southernmost. Furthermore, these divisions comprises twenty-three (23) districts and multiple villages under the districts. With regard to the transition of the population by division, Tongatapu has a largest population of 74,611 (74.1 % for the total population in the Kingdom) followed by 13,378 (13.6 %), that of Vava'u.

The population in each district has been decreased from the year 2011 to 2016 as shown in Table 3.15. Especially, the population in Vava'u and in Ha'apai has decreased at 1.65 percent and 1.54 percent in annual average, respectively.

Table 3.15 Transition of Population in the Kingdom of Tonga by Division and District

Division	2016 Census (Person)	2011 Census (Person)	Population Change 2011-2016 (Person)	Population Change 2011-2016 (%)	Average Annual Growth 2011-2016(%)
Tongatapu	74,611	75,416	-805	-1.1	-0.21
Vava'u	13,738	14,922	-1184	-7.9	-1.65
Ha'apai	6,125	6,616	-491	-7.4	-1.54
Eua	4,945	5,016	-71	-1.4	-0.29
Ongo Niua	1,232	1,282	-50	-3.9	-0.8
TONGA (Total)	100,651	103,252	-2601	-2.5	-0.51

Source: Tonga Census of Population and Housing 2016

Table 3.16 shows the transition of the population in Vava'u, the project target area. Neiafu, the city center of Vava'u has its largest population of 5,251 or almost 38 percent of its total and followed by that of

Leimatua in which the candidate site of the new reservoir located with its figure of 2,489 or 18 percent as of 2016.

Table 3.16 Transition of Population of Vava'u Division

District	1996	2006	2011	2016
Neiafu	5,650	5,787	5,774	5,251
Pangaimotu	1,298	1,412	1,325	1,242
Hahake	2,291	2,422	2,297	2,021
Leimatua	2,753	2,742	2,436	2,489
Hihifo	2,375	2,267	2,105	1,990
Motu	1348	875	985	745
Total	15,715	15,505	14,922	13,738

Source: Tonga Census of Population and Housing 1996, 2006, 2011 and 2016

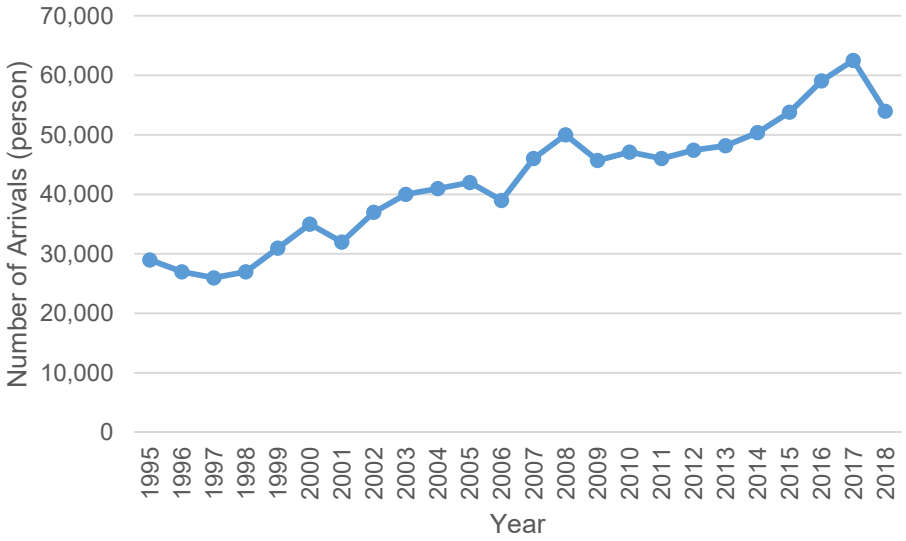
(2) Tourism Industry

The Kingdom has the abundant tourism source and its expansion is essential to develop its economy over the future. Third party's countries and international donors have provided their support to the tourism sector of the Kingdom, and GOJ also has commenced the following surveys in the sector in the PICs (Pacific Island Countries) including the Kingdom.

- Data collection survey on the projects for expansion of airports in the PICs (targeting at the Kingdom of Tonga and the Republic of the Marshall Island as the survey areas)
- Data collection survey on the projects for development in the tourism sector in the pacific island countries

Figure 3.17 shows the transition of the tourist population visiting the Kingdom in annual base. The tourist from overseas countries has been gradually increased year by year, marking its largest tourist population of 62,500 in 2017, except the year of 2018 affected by the largest cyclone Gita. Figure 3.17 targets only for tourist by the air transportation, and another tourist of 20,000 to 25,000 by ship and 2,000 by yacht visits the country, and total of approximately 80 thousand tourists is expected to visit the country every year.

Statistic information on the tourist number visiting Vava'u was not available. However, Vava'u is the high potential island for the tourism industry in the Kingdom with its famous yacht harbor of the beautiful coast lines in the world. Actually, the number of the hotel has increased to 52 in 2019 from that of 41 in 2017, which shows the increasing tourist visiting Vava'u. Further increase of the tourists is expected by the future increase of international flights after the airport expansion as described above. For the future development of the tourism industry in Vava'u, the stable supply of safe and reliable water will be absolutely essential and the importance of the project has come to be recognized again.



Source: Ministry of Tourism Tonga, Yearbook of Tourism Statistics (World Tourism Organization)

Figure 3.17 Transition of International Tourists visiting the Kingdom (1995 to 2018)

Chapter 4

Effects and Impacts of the Project

Chapter 4 Effects and Impacts of the Project

4.1 Effects of the Project

4.1.1 Expected Improvement Level on the Current Situation in Water Supply

The sector in the Kingdom has the issue of the degradation both of the distribution function and water quality. With regard to the degradation of the distribution function, the leakage of the existing deteriorated distribution pipes has caused the high rate of NRW, and the excess yield amount and has led the progressing of the sea water intrusion to the existing water source finally. The degradation of the water quality, in contrast, has the potential risk of occurrence of waterborne diseases such as typhoid to be caused by the current state of no implementation of disinfection by chlorination and another risk of health by the remaining AC pipes.

Above issues on the water supply sector in Tonga are expected to be solved by the implementation of the project through the development of the new well field, replacement of the deteriorated pipes and renewal of the chlorine injection unit.

4.1.2 Expected Solution Level for the Issues on Water Supply

The following issues are pointed out for the drinking water supply sector in Vava'u;

- Sea water intrusion to the existing water source
- Dysfunction of the existing facilities and equipment
- Remaining AC pipes and high rate of NRW
- Poor quality of the water supply service level in rural areas
- Insufficient materials and equipment for O&M
- Lack of management capacity for water volume and financial aspect

The Grant Aid project will develop the construction of a new well field, new reservoir, renewal of the chlorine injection unit, procurement of small scaled desalination equipment, water quality measurement instrument and leakage water detection equipment and implementation of the soft component toward enhancement of the capacity of O&M, water supply utility business and the technical knowledge on the leakage water detection.

The following effects are expected by the project through providing safe and stable water supply;

<u>Effective indicators relating to the water supply in urban area:</u>

- Increased NRW (Current: 40 to 50 percent to Future: 30 percent)
- To secure the residual chlorine concentration inside the pipelines (Current: 0 ppm to Future: 0.1 ppm)

<u>Effective indicators relating to the water supply in rural area:</u>

- Increased hours of water supply (Current: Three (3) hours to Future: 24 hours)
- No detection of E. coli. and fecal col as indicators for the waterborne diseases

4.1.3 Expected Solution Level for Hygiene-related Issues and Waterborne Diseases

The renewal of the existing deteriorated water supply facilities and the chlorine injection unit by the project will improve the level of safety and stability of the water supply services. Utilization of the hygienic tap water also will improve the hygienic environment and reduce the health risk to be caused by the water borne diseases.

4.2 Impact of the Project

4.2.1 Political Impact

According to the survey team's interview with the Japanese embassy in the Kingdom, three (3) members of the national parliament have been elected from Vava'u. In addition, next general election is expected to be carried out in 2021 and the project will bring a great political significance if it is committed by both governments and implemented successfully.

4.2.2 Social Impact

Unless enough water is supplied for the water demand and the existing deteriorated facilities are renewed, the safe and secure water cannot be utilized and it will not be easy to maintain the better-quality life. The project will enable to supply hygienically safe water for twenty-four (24) hours stably to the communities through securing a new water source, replacing the AC pipes and renewal of the new chlorine injection unit. The expected impact to the local society in the target communities will be great through its direct contribution to the improvement of the living environment.

4.2.3 Economic Impact

The promotion of the tourism industry in Vava'u is the national strategic initiative, and the expected economic benefit by the industry will bring a significant revenue to the national budget. Based on the national plan named "National Infrastructure Investment Plan 2013 to 2023", Vava'u Island was clearly emphasized as one of target areas of the development plan, namely, "Improvement of water supply systems in outer islands" Thus, the improvement of the water supply system by the project will develop its tourism industry further more with its expected large benefit to the national economy.

4.2.4 Technical Impact

The Grant Aid project will bring the following technical impact through its implementation of 1) development of the new well field, new reservoir, renewal of the chlorine injection unit, 2) procurement of small scaled desalination equipment, water quality measurement instrument and leakage water detection equipment and 3) implementation of the soft component toward enhancement of the capacity of O&M,

water supply utility business and the technical knowledge on the leakage water detection.

- Effective utilization of the facilities and equipment
- Enhancement of the technical skill of the TWB's staffs
- Dissemination of the technical knowledge acquired by the project to other areas nationwide in the Kingdom via the TWB's staffs

Another technical impact by the acquisition of the most advanced technology on water supply in the world through the technical guidance of good experiences in Japan in above soft component will be expected. In addition, the small-scaled desalination equipment will solve the challenge of the Kingdom's vulnerability to the national disasters with its expected demonstration of the high level of Japanese technology.

4.2.5 Diplomatic / Public-related Impact

The project by the GOJ comprising the Japan grant aid project including the soft component to the water / sanitation sector in the Kingdom will enhance the relationship between Japan and the Kingdom, and serve as a bridge between Japan and the Kingdom for solving the issues for the islands vulnerable to the climate change and natural disasters with the expected spreading effect to the nationwide. The project also meets the prime minister's statement on "development of high-quality infrastructure in both side of facility development and providing soft component to bring self-reliant and sustainable prosperity, which will bring a great impact in diplomatic and public-related aspects.

The project on the improvement of the water supply system in Vava'u as the center of the tourism industry in the Kingdom, especially, will cause the following impact in the aspect;

- Public-related impact to be caused by its contribution to the improvement of the living environment
- Diplomatic impact of the technical knowledge on O&M management and water quality management through the soft component

Chapter 5

Validity of the Project

Chapter 5 Validity of the Project

5.1 Results of Comparative Study with Major Alternative

A new water source has to be developed to meet future increase of water demand and to achieve continuous water supply for twenty-four (24) hours under the situation of progressing sea water intrusion to the existing water source.

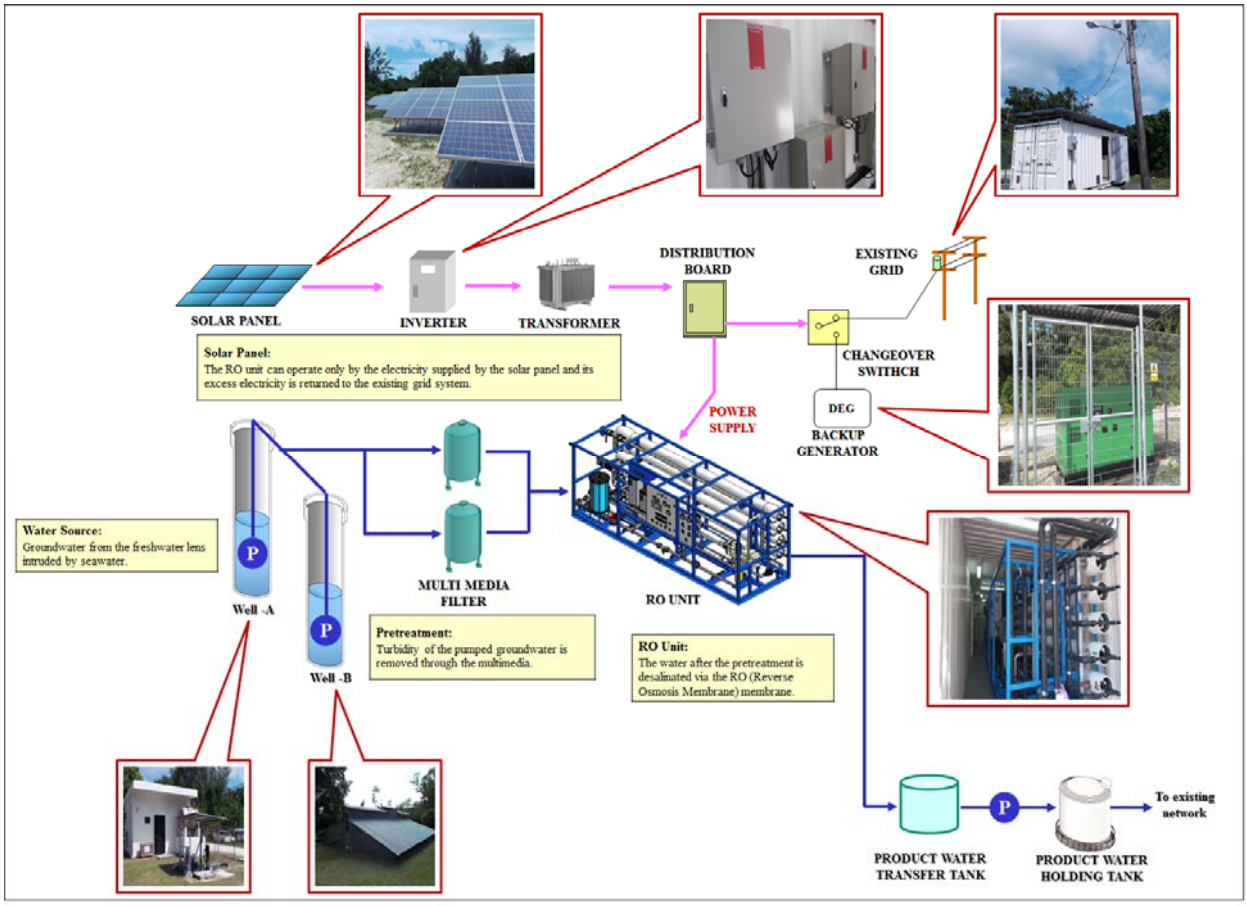
However, a desalination system, one of the Japanese key technologies, for the existing water source intruded by sea water can be an alternative option for a new water source to the project plan. Therefore, the following describes the study results on the potential utilization of the desalination system.

(1) Outline of Desalination System

The utilization of the desalination system for the groundwater intruded with sea water will be an effective approach. However, there is a biggest technical challenge that energy cost accounts for high percentage of the production cost of drinking water.

Recently, the introduction of the desalination system utilizing sea water has been studied in island countries from various aspects. However, the utilization has not made good progress because of the issue of the secure of energy source (e.g. power, fuel) for driving the system. Under this situation, a utilization of solar power to the system has been considered promising and several types of process has been studied. A biggest challenge of this technology is how to effectively collect and utilize solar energy which is low energy density and large fluctuation. In that sense, a small-scaled desalination system is suitable for utilization of the solar power of its low density.

The Kingdom has depended significantly on the imported diesel by its percentage above 93 % for the total energy because of its poor energy source. Therefore, the Kingdom has a vulnerability on the energy security influenced by the external factors such as international oil price and higher transportation cost and is a major emission source of GHGs (Greenhouse Gases). In above situation, in the national policy of TERM (Tonga Energy Road Map) formulated in June 2010, the Kingdom has set its ultimate goal that 50 percent of total energy supply will be covered with renewable energy by 2020. The possible utilization of solar power was studied as an energy option for the introduction of the desalination system using the existing water source intruded by sea water (See Figure 5.1).



Source: Catalogue of manufacturer

Figure 5.1 Illustrated Image of Desalination System Using Existing Wells

(2) Study Results

TWB has a great concern about the desalination system using the existing wells. In addition, the alternative can be one of inevitable systems in future considering the future risk of progressing of sea water intrusion due to the excess of water extraction and sea water rise to be caused by future climate change.

However, the Kingdom has another risk of disasters by cyclones that may cause damage the solar panels of the desalination system and it will take considerably more time and cost to recover the system once it is damaged. Thus, the system needs to be connected to the existing power grids to supply electric power to the system. However, the system requires large amount of electric power and it will be difficult to operate the system and supply the desalinated water to the whole areas of Vava'u unless enough amount of the electricity supply is secured in the entire area of Vava'u. It will be considered unrealistic to secure enough amount of the electric power to operate the desalination system stably, even though the situation of the electric supply has been gradually improved as shown in the recent development of the introduction of the wind power generation system in Tongatapu by the support from GOJ.

In addition to above, the fouling of the membrane can be a common issue for the membrane system. Thus, at the introduction of the membrane system, appropriate water quality analysis of the water source,

appropriate pretreatment and technical knowledges for selecting the suitable membrane will be needed. Moreover, on the O&M, a training through using the real equipment also will be important because it is difficult to operate the system in a long period unless it is operated by the technical staffs with full experiences and knowledge.

From above situation, various issues are still remaining for the introduction of the desalination system in Vava'u, development of a new water source and its improvement of the water supply system should be a priority for solving the issues. Future improvement of the electricity supply may increase the momentum for the introduction of the system as an alternative water source to the freshwater lens that is facing the sea water intrusion and water pollution.

5.2 Organizational Validity and Sustainability of the Project

Table 5.1 to Table 5.3 show the validity of TWB's capacity by capacity level (good, medium and bad) on organization for water supply business, project (construction) management and the capacity for O&M.

5.2.1 Management Capacity as Water Supply Utility

Table 5.1 Evaluation Result on Management Capacity as Water Supply Utility

Issue	Capacity Level (Good to Bad)			Explanation
	Good	Medium	Bad	
Organizational Vitality				
Does TWB rely on upper / superior agency or superior staffs too much?	✓			TWB is an independent public enterprise for water supply and its staffs understand their roles and perform their tasks with pride.
Does TWB show negative stance on current issues?		✓		An implementation of a new project needs huge investment cost, and therefore, TWB needs a financial and technical support from international donors. However, TWB has a capacity of carrying out their O&M works by their own budget.
Top Management's Policy				
Does the management have clear recognition on outstanding issues on water supply service?	✓			The top management recognizes the issues on technical, financial and business operation.
Does the management have future vision?			✓	TWB has the master plan. However the master plan is too old on the viewpoints that it was formulated in 1992. A revised edition of the master plan toward future vision of water supply service and water service management is urgently needed.
Does the management have their policy toward encouragement of self-efforts?		✓		An investment of a new project for water supply facilities is beyond TWB's control. However, TWB's efforts toward its sound business operation through diversified

				business operation other than income of collection of water charge can be seen.
A power of running business independently is dedicated to TWB?				
Power to organize staffs	✓			TWB has a power to organize its staffs.
Power to recruit, arrangement or assignment of staffs	✓			TWB has a HR unit and has a power to recruit, arrangement or assignment of staffs
Does the organization unit have a power to conclude contracts in each projects	✓			TWB Board of Directors has the authority to conclude contracted projects
Power to decide operational income and expenditure through independent accounting system	✓			TWB has an independent accounting system.
Has a unit to handle customer management already been established?				
Building of customer management information system	✓			Customer Management information system has been implemented
Building of information system of invoice and tariff collection system	✓			TWB has an existing billing system
Has a unit for accounting information management system toward planning annual budget, settlement of account and long-term budget allocation plan been already established?				
Unit for preparation of annual budget, settlement of account and long-term budget allocation plan?	✓			TWB has a financial department. The financial Department manage the estimated budget and annual settlement.
Unit for materials management?	✓			TWB has an engineering department. The engineering department manage the existing material.
Unit for asset management (Land, Facility, Building, etc.)?	✓			TWB has an administration department. The administration department manage the existing assets.
Unit for HR (Human Resources) management?	✓			A unit for HR management has already been established.
Others (Public Relations, communication with other agencies, etc.)	✓			Newly established Public Relations unit

Source: Survey Team

5.2.2 Capacity for Construction Management

Table 5.2 Evaluation Result on Capacity for Construction Management

Issue	Capacity Level (Good ⇔Bad)			Explanation
	Good	Medium	Bad	
Does TWB has a unit for overall management for construction works?	✓			TWB has a project management section in the engineering department. The project management department manage the construction work.

Does above unit have a power to control influence management?	✓			The project management section has an appropriate power and articulate.
Does TWB rely on donor's country too much at construction works in each projects?	✓			TWB usually seeks to work side-by-side with donor partners.
Does TWB have positive or aggressive stances toward participation in planning, design and construction?	✓			TWB always willing to participate and assist in the planning, design and construction.
Have past good experiences been accumulated?	✓			TWB has accumulated positive experiences from execution of past water projects

Source: Survey Team

5.2.3 Capacity for Operation and Maintenance

Table 5.3 Evaluation Result on Capacity for O&M

Issue	Capacity Level (Good ⇔Bad)			Explanation
	Good	Medium	Bad	
Does TWB has a unit for overall management for O&M?	✓			The engineering department has an operation and maintenance section.
Does above unit have a power to influence TWB's management	✓			The operation and maintenance section has an appropriate power and articulate.
Does TWB have a management center for storage and supply of materials?	✓			TWB has an existing stock and inventory center
Are the materials are stored and supplied appropriately?	✓			TWB has an appropriate storage system.
Does TWB have a management center and workshops for repairing works?	✓			TWB has an existing workshop for repairing works.
Have past good experiences been accumulated?	✓			TWB has accumulated good experiences from execution of past water projects

Source: Survey Team

5.3 Financial Validity and Sustainability of the Project

5.3.1 Financial Source for the Cost to be Borne by the Kingdom

The cost for installation of the customer meters and service pipes, the personal cost for the pipe laying should be borne by the Kingdom (from TWB's own budget).

5.3.2 Current Status of Key Performance Indicators for Water Supply Service

TWB set their six (6) KPI (Key Performance Indicator) as the indicators or overall water supply service operation in "Strategic Plan 2018 to 2023".

Table 5.4 TWB's KPI for Water Supply Service

Key Indicator	TWB's Goal
KPI 1: Delivery Service	• Customer survey records a satisfaction level of >95% • All customer complaints resolved within 1 working day. • Increased number of customer new installations.
KPI 2:Infrastructure Upgrading Products & Technology	• Quality of water meets WHO Guideline 2003 • Water pressure to be ≥ 3m at all customer installations at peak times • Overall reduction of NRW losses by 20% • Complete removal of all AC pipes from reticulation system
KPI 3: Leadership & Governance	• All projects have a staff and contractor risk management plan • Toolbox meetings are routine • Integrate Customer focus in all Staff Job Description and Work-Plan Activities • Management review health and safety at each monthly meeting with view to continuously improving the safety culture
KPI 4: Information Policy & Planning	• Lost time accidents are routinely reported and are within annual targets • Non-compliances with safety procedure are reducing annually • Improve health standard and perception of customers.
KPI 5: Tonga Water Board Finance	• $30,000 of domestic plumbing repairs income in the first year and $40,000 in the following years; • $50,000 of new installation income in the first years and $65,000 in the following years; • Drilling rig operational within first year and 3 drills completed each year to earn $100,000 consecutively. • Consultancy income of $30,000 • Revenue increases by more than 10%
KPI 6: Initiative New Business Activities	• 200 domestic plumbing repairs in the first year and 500 repairs in each of the following years; • 100 new installations in the first year and 200 in each of the following years • NPAT of the water bottling venture to be >TOP1.5m pa after FY 18-19 and TOP2m pa after each following FY 20-21

Source: Preparation of Survey Team based on TWB's "Strategic Plan 2018 to 2023"

Figure 5.2 Relation Diagram of KPI for Water Supply Service

Source: Strategic Plan 2018 to 2023, TWB

5.3.3 Transition of Financial Balance

The financial balance of TWB's water supply business management for the past five (5) years is shown in Table 5.5. The TWB's financial balance has maintained its surplus since 2012. On one hand, the GOT has ordered the public corporations to pay the dividend for their investment and its annual amount above 1,000,000 TOP (equivalent to 45 Million Japanese Yen) for the FY of 2014 to 2016 has put a pressure on TWB's finance.

Table 5.5 TWB's Financial Balance (FY 2014 to 2019)

Unit: TOP $

ITEMS	FY 2014/2015	FY 2015/2016	FY 2016/2017	FY 2017/2018	FY 2018/2019
Total Revenue	7,219,396	7,487,214	8,151,833	8,435,635	8,972,497
1) Operating Revenue	5,767,958	6,019,450	6,446,644	6,424,408	6,847,149
2) Other Revenue	1,451,438	1,467,764	1,705,189	2,011,227	2,125,348
Total Expense	5,378,337	5,655,502	6,487,230	6,738,304	7,546,670
1) Operating Expenses	-	-	5,104,581	5,372,274	5,924,474
2) Depreciation	-	-	1,382,649	1,366,030	1,622,196
Net Profit before Tax	1,841,059	1,831,712	1,664,603	1,697,331	1,425,827
Income Tax Expenses	460,265	457,928	416,151	424,333	332,002
Net Profit after TAX	1,380,794	1,373,784	1,248,452	1,272,998	1,093,825
Dividend	1,000,000	1,027,000	1,030,000	341,921	-
Dividend Percentage	72.42%	74.76%	82.50%	26.86%	-

※1 TOP $ = 45.13Japanese Yen（as of November, 2019）

Source: Preparation of Survey Team based on TWB's "Tonga Water Board Final Draft Business Plan"

5.3.4 Prospect of Financial Balance

The prospect of TWB's financial balance for the future five (5) years is described in TWB's "Final Draft Business Plan for the Period 2019-2024" and its outline is shown in Table 5.6. Financial surplus is expected for the future five (5) years, while 100 percent of the net profit has to be paid back as a dividend to the central government. The prospect brings a hard situation to develop the water supply facilities by their own capital and formulate a loan project because TWB has no financial ability for the repayment for the loan.

Table 5.6 Prospect of TWB's Financial Balance (2019～2023)

Unit: TOP $

ITEMS	FY 2019/2020	FY 2020/2021	FY 2021/2022	FY 2022/2023	FY 2023/24
Total Revenue	8,670,589	8,742,048	8,910,066	9,083,539	9,261,705
1) Operating Revenue	6,234,900	6,297,249	6,425,909	6,558,211	6,695,474
2) Other Revenue	2,435,689	2,444,799	2,484,157	2,525,328	2,566,231
Total Expense	7,752,858	7,713,816	7,820,611	7,965,727	8,091,413
1) Operating Expenses	5,311,067	5,187,024	5,278,820	5,408,935	5,534,622
2) Depreciation	2,441,791	2,526,792	2,541,791	2,556,792	2,556,791
Net Profit before Tax	917,731	1,028,232	1,089,455	1,117,812	1,170,292
Income Tax Expenses	229,433	257,058	272,364	279,453	292,573
Net Profit after TAX	688,298	771,174	817,091	838,359	877,719
Dividend	688,298	771,174	817,091	838,359	877,719
Dividend Percentage	100.00%	100.00%	100.00%	100.00%	100.00%

※1 TOP $ = 45.13Japanese Yen（as of November, 2019）

Source: Preparation of Survey Team based on TWB's "Tonga Water Board Final Draft Business Plan"

5.4 Technical Validity and Sustainability of the Project

5.4.1 Consistency with Technical Level of the Recipient Country

TWB has no technical guidelines nor criteria on water supply system and they follow international standards (e.g. ISO, AWWA/ASTM, AS, NZS) by each project. The Kingdom also follows WHO guideline for the water quality standard for drinking water. It is judged appropriate to develop the water supply facility by the project because a same system with the existing water supply facility in Vava'u is developed. Likewise the facility, the technical guidance on O&M through the soft component does not differ widely with the existing manner of O&M in the Kingdom, which will secure the technical sustainability.

5.4.2 Personnel Recruitment and Assignment

The project will utilize the project type grant aid scheme that the recipient country will make an agreement with consultants or contractors for the construction of facilities, provision of equipment and carrying out a soft component for development of a water supply system for safe drinking water. In contrast, the soft

component is to provide services to support to the recipient country on the soft aspect at its initial stage same as the hard component of construction of the facilities. Therefore, in order that the project is to be implemented effectively, an allotment of a counterpart team comprising the staffs of TWB main office and the Vava'u branch office should be established. Taking the current status on the TWB's permanent staffs, that is, 85 (78.7 %) in its head office and 14 personnel (82.4 %) in the branch office into consideration, the TWB's technical sustainability will be secured by these staffs after the technical guidance for O&M in the soft component.

5.4.3 Maintenance of Facilities and Equipment

The maintenance management of the facility and equipment in Vava'u is not carried out appropriately including the data management for water flow, volume and quality. Therefore the improvement on the maintenance management situation is expected by the implementation of the technical guidance.

5.5 Environmental Considerations

5.5.1 Estimated Environmental Impact

Generally, ground subsidence by the extraction of groundwater is one of possible impacts. Clay layer at its surface may cause such impact. However, the geology of the limestone formed by the uplifted coral reef with high porosity at the project site will cause less impact compared to above case. Possible environmental impact is noise / vibration at construction of the road areas and impact on health risk to surrounding communities and construction workers by the replacement works of AC pipes.

5.5.2 Environmental Impact Assessment

The Environmental Impact Assessment Act was enacted on December 3rd, 2003. Based on the Environmental Impact Assessment Act, an Environmental Impact Assessment (EIA) must be conducted for the projects of the 29 categories which may permanently change the environment and generate pollutants for the surrounding area such as water system and ecosystem including abattoirs, breweries, airports, livestock farms, chemical factories, power plants, logging of trees and vegetation over 0.5 ha and tourist facilities.

The project that possibly change the groundwater system will need above EIA as per the requirements of Tongan regulation.

Chapter 6

Conclusion

Chapter 6 Conclusion

6.1 Special Mentions

Neiafu, the center city of Vava'u Island, is the second largest city in Kingdom following the capital Nuku'alofa, and is an economically important area for the Kingdom with its attractive tourism place of 80,000 international tourists annually visiting its beautiful scenery, harbor and its famous yacht port worldwide. The tourism industry in Vava'u is expected to be developed further by improving the Vava'u International Airport by the support from GOJ toward the increase of international flights. At that time, the stable supply of safe and reliable tap water by the project will be essential as a basis of the development of the tourism industry and will become more meaningful.

On the other hand, the impact of natural disasters and climate changes on the urban function is also another important issue in the Kingdom. For the future event of a suspension of the government function or public transportation system for long time, TWB intends to construct the stable, safe and reliable water supply system in Vava'u where geomorphological undulation suitable for effective water distribution is spread and more availability of potential water source is expected compared to Tongatapu.

In that sense, it will be meaningful to develop a flexible water supply system in Vava'u by the project so that water can be supplied even in the events of disasters or climate changes.

6.2 Points of Concern

In this survey, secure of the new well field was proposed, and possible intake amount was estimated based on literature and field survey. However, it is most important to select the water intake points through detailed surveys for acquisition of multi-dimensional data of the aquifer. Number and location of wells for the sustainable yield should be determined with consideration on the pumping method and pattern by carrying out field survey in the preparatory survey.

Land acquisition in the Kingdom requires different process according to its land tenure, namely, royal, noble and government land. Therefore, more detailed processes for land acquisition for project sites of intake facilities and a distribution reservoir should be confirmed during the preparatory survey.

6.3 Conclusion

The Kingdom has vulnerabilities to natural disasters and climate changes, and overcoming these vulnerabilities has become an inevitable challenge for the social and economic development of the country. Especially, Vava'u where Fiji Airways operates direct flights, has abundant tourist attractions such as beautiful scenery and various marine activities. And it has made Vava'u an important hub in the tourism industry and economically important city of the Kingdom.

On the other hand, water supply facilities has not been developed adequately in Vava'u because most of donors have not made their support there. As the result, the issues of seawater intrusion to the current water source, deterioration of the existing facilities and remaining AC pipes have become exposed.

For further economic development, it is necessary to eliminate the impact of the sea water intrusion to the current water source on water supply by securing new production wells. In addition, in order to supply water from the new production wells, it is necessary to construct a distribution reservoir, transmission and distribution pipes. And it is also important to replace existing AC pipes and aging pipes to supply safe and reliable water.

This project aims to improve the water supply system in Vava'u based on the future water demand estimated by an appropriate method through studying adequacy and necessity of the new water source in Vava'u according to GOJ's ODA policies on the Kingdom. Implementation of the project will contribute to improving the living environment of local residents by supporting for realization of stable, safe and reliable water supply service in Vava'u.

6.4 Closing Remarks

During and after the field survey in the Kingdom conducted by the survey team in December 2019, the team perceived TWB's strong expectations for the implementation of the project and also received generous supports by TWB in providing necessary data and information for the survey.

In addition, the deputy CEO of MLNR, one of the stakeholders of the project, accompanied the field survey in Vava'u and provided the team relevant data. And the governor of Vava'u issued the official letter on the acquisition of the government land for this project. From these fact, the team has come to realize that how much interest in the water sector of the Kingdom is high and the implementation of this project is expected significantly.

The project needs to be implemented immediately, taking the issues regarding the operation of the water supply in Vava'u, the future development of tourism industry in the Kingdom and the issues related to natural disasters and climate changes into consideration.

It is expected that solving the issues through the implementation of this project will bring a greater impact to the Kingdom more than the direct benefits of improvement of living environment and public health. It also strengthen the relationship between the two countries.

The Royal Family of Japan and Tonga have been interacting closely so far. In addition, 2020 marks the 50th anniversary of Japan-Tonga diplomatic relations. From this reason, it would have significant meaning that GOJ implements this project in a grant aid scheme in the Kingdom.

Appendix

Appendix-1 Survey Schedule

Itinerary		Destination	Investigation Contents
13th Dec	AM		
Friday	PM	Leave Narita to Auckland, New Zealand	
14th Dec	AM	Arrival at Auckland, New Zealand	
Saturday	PM	Leave Auckland to Tongatapu, Tonga	
15th Dec	AM	Internal Meeting	Current and Future Issue/Arrangement of Current and Future Issue
Sunday	PM		
16th Dec	AM	Tonga Water Board	Courtesy Call, Explanation of the Project, Exchange of the Information, Confirmation of Basic Plan for VaVa'u
Monday	PM	Japanese Embassy in Tonga, JICA Tonga, Ministry of Lands and Natural resources, Ministry of Hearth—Rural water supply and sanitation section	Courtesy Call, Explanation of the Project, Exchange of the Information
17th Dec	AM	Tonga Water Board	Organization of Issue on Current and Future, Confirmation of Basic Plan
Tuesday	PM	Moving（Tongatapu to VaVa'u）	Courtesy Call, Explanation of the Project, Exchange of the Information, Grasping of current situation
18th Dec	AM	Tonga Water Board in VaVa'u Existing Water Facilities Proposed Construction Site	Organization of Issue and Probrem、Investigation of Construction Site and surrounding area、 Consideration of Alternative Plan、Instruction of Planning
Wednesday	PM		
19th Dec	AM	Moving (VaVa'u to Tongaapu)	
Thursday	PM	Tonga Water Board, HQ Leave Tongatapu to Auckland	Share of Issue and Problem、Organization of Requesting Contents、 Consideration of Alternative plan、Instruction of Planning
20th Dec	AM	Arrival at Auckland, New Zealand	
Friday	PM	Leave Auckland to Narita	

Appendix-2 Visited Institution

Institution	Name	Position
Embassy of Japan in Tonga	Mr. Tetsuya Ishii	Ambassador Extraordinary and Plenipotentiary
	Mr. Kazunari Fujiwara	Chief of Political and Economic Section, Second Secretary
Japan International Cooperation Agency (JICA) Tonga Office	Mr. Yasushi Hayashi	Project Formulation Advisor, Project Formulation and Management
Tonga Water Board (TWB) Head Office	Mr. Sione Finau	Chief Executive Officer
	Mr. Quddus Fielea	Deputy Chief Executive Officer - Engineer
	Mr. Kolo Peau Tonga	Deputy Chief Executive Officer - Finance
	Ms. Elisiva Tapueluelu	Deputy Chief Executive Officer - Administration
Tonga Water Board (TWB) Vava'u Branch	Mr. Water Ski Maafu	Vava'u Branch Manager
Ministry of Land and Natural Resources (MLNR)	Ms. Rosamond C. Bing	Chief Executive Officer
	Mr. Tukua Tonga	Chief Operations Officer
	Mr. Tamiele Kula	Deputy Secretary
	Mr. Seei Tounfa	Deputy Chief Executive Officer - land administration division
Ministry of Health (MOH)	Ms. Sela Akolo Fau	Supervising Public Health Inspector

Appendix-3 List of References

No.	Name of Document
1	Water resources report (1992), Australia
2	Neiafu masterplan (1992), Australia
3	Summary report wellfield development proposals (1997), EU
4	Neiafu water supply scheme development feasibility study (1997), EU
5	Feasibility study for water supply improvement, Kingdom of Tonga (2004), Sweden
6	Appraisal of water supply improvement project (2006), Danish
7	Methodology for undertaking economic analysis of water infrastructure projects (2006), Danish
8	Neiafu groundwater resources assessment and sustainable management report (2011), GEF-IWRM
9	Outer islands water supply improvement project (2012), TWB
10	The causes and issues for sea water intrusion to the freshwater lens in Vava'u and Lifuka islands, the Kingdom of Tonga (2015), S. Ishida
11	Annual audit accounts (2016-2017, 2017-2018, 2018-2019), TWB
12	Tonga water board final draft business plan 2019-2024, TWB
14	Tonga national infrastructure investment plan 2013-2023, GOT
15	Tonga strategic development framework 2015-2025, GOT
13	Voluntary national review 2019, GOT

Appendix-4 Notification Letter on Dispatch of the Survey Team

Ministry of Health, Labour and Welfare
Japanese Government
1-2-2, Kasumigaseki,
Chiyoda-ku, Tokyo 100-8916
Tel ＋ 81-3-5253-1111

日本国厚生労働省
〒100-8916
東京都千代田区
霞が関1－2－2
電話 03-5253-1111

December 9, 2019

Attention: Mr. Sione Tutulu Finau
Chief Executive Officer Tonga Water Board

Subject: Request for acceptance of a survey team of "The Project for Improving Water Supply System in VaVa'u Island" by the Ministry of Health, Labour and Welfare of Japan

Dear Sir;

I am writing to you to seek a possibility of your arrangements for an on-site survey.

The Ministry of Health, Labour and Welfare of Japan (MHLW) has a program "Water Supply Project Formation Program" to encourage international cooperation in the field of water supply. This program technically reviews a potential program or plan together with water supply authority in a country which has challenges to be addressed on their water supply, provides appropriate guidance and advice, and transfers the technical expertise of Japan, in order for those countries to become able to form a carefully designed good project.

This year, the MHLW commissioned the program to NJS Consultants Co., Ltd.
The Company proposed an idea for water supply improvement in VaVa'u Island in Tonga, and would like to dispatch the survey team in December, 2019. Resume is given in the enclosed document and Detail schedule will be informed by the survey team later.

It is highly appreciated if you could kindly accept the survey team and coordinate visits and consultations with institutions concerned.
I thank you for your consideration and I look forward to hearing from you.

Sincerely yours,

田口一徳

Mr. Kazuho TAGUCHI
Director, Office of Global Health Cooperation, International Affairs Division
Minister's secretariat, Ministry of Health, Labour and Welfare

RESUME

1. SUMMARY OF PROGRAM

Japanese ODA is implemented by Ministry of Foreign Affair (MOFA) and Japanese International Cooperation Agency (JICA), Ministry of Health, Labour and Welfare (MHLW) is ordinary indirectly associated with ODA on water supply sector through consultation with MOFA and JICA as the ministry holding jurisdiction over water supply in Japan. The Water Supply Project Formulation Program is provided by MHLW to stimulate improvement projects in countries having big challenges on water supply sector.

This time, NJS Consultants Co., Ltd. proposed the study plan for VaVa'u Island, to the MHLW and the MHLW decided to entrust the study.

2. PURPOSE OF THE STUDY

The study team conducts a fact-finding investigation from professional and technical points of view, aiming to support formulating a water supply improvement project in VaVa'u Island in Tonga.

3. SURVEY ITEM

Major Survey items are following;

A) Survey on the current situation of water supply system in VaVa'u Island (Water resources, water supply facilities, operation and maintenance and etc.)
B) Interview of the current situation (facilities, organization, O&M, water quality and finance, etc.)
C) Confirmation of water supply master plan
D) Investigation of project site
E) Study on the business planning

4. EXPECTED INTERVIEWEE

A) Mr' Taniela Kula, Deputy Director, Ministry of Land Survey and Natural Resources
B) Dr. Renold 'Ofanoa, Chief Medical Officer, Ministry of Health
C) Mr. Sione Tutulu Finau, Chief Executive Officer Tonga Water Board
D) Mr. Quddus Fielea, Deputy CEO, Manager - Engineer, Tonga Water Board

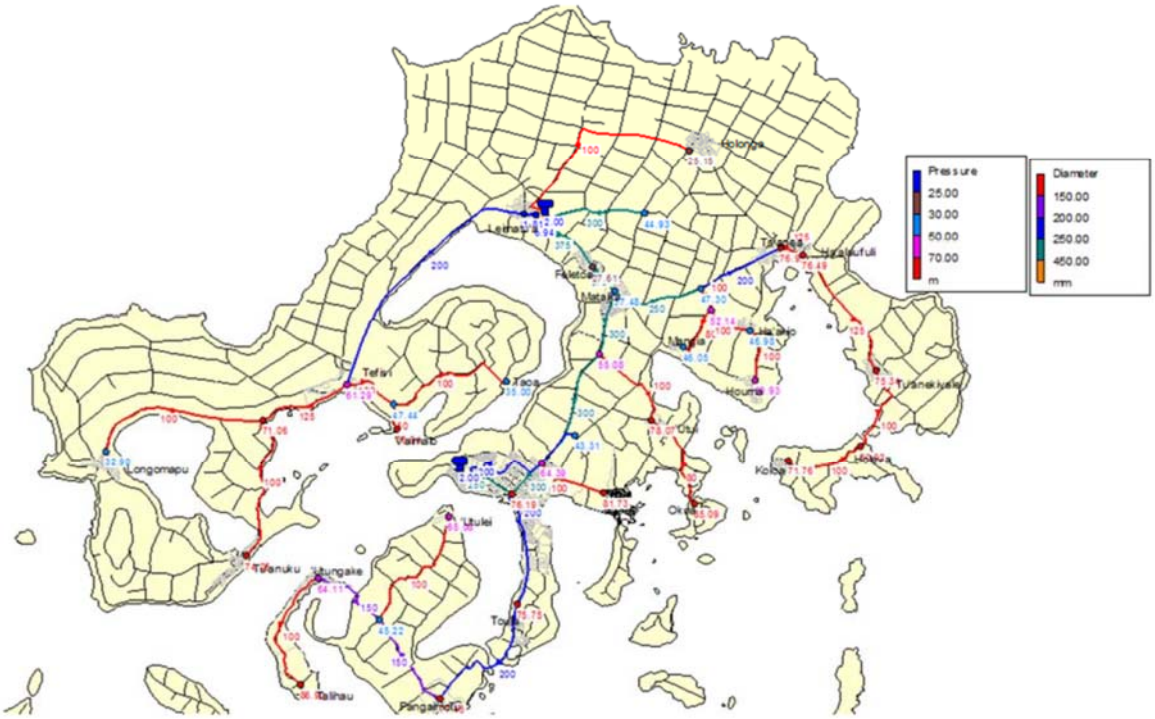
5. MEMBERS OF THE SURVEY TEAM

The Survey Team consists of the following members;

Name	Job Title	Occupation
Mr. Kazuho TAGUCHI	Project Management	The Ministry of Health, Labour and Welfare of Japan (MHLW)
Mr. Ryuichi MORISHITA	Project Planning	The Ministry of Health, Labour and Welfare of Japan (MHLW)
Mr. Daisuke YASHIRO	Chief Consultant	NJS Consultants Co., Ltd.
Mr. Sampei NAKANISHI	Water Supply Engineer	NJS Consultants Co., Ltd.
Mr. Kenta HAYASHI	Water Supply Engineer	NJS Consultants Co., Ltd.
Mr. Yoshiharu YONEDA	Water Supply operation and maintenance	OKINAWA Water Management Center Co., Ltd.
Mr. Kenta IMAI	Coordination and local logistics	OKINAWA pacific partners Co., Ltd.

6. SURVEY AREA

The survey area is the water supply area in VaVa'u Island



7. SURVEY SCHEDULE

Item \ Year	2019									2020								
	Ocober			November			December			January			February			March		
1.Preparation in Japan	◀	―	―	―	―	―	―	―	▶									
(1) Submission of Planning Documents				▼														
(2) Submission of Draft Report							▼											
2.Survey in Tonga							◀	―	▶									
(1) Arrangement of current/future issue								▼										
(2) Explanation of Draft request letter								▼										
3.Reporting in Japan							◀	―	―	―	―	―	―	―	―	―	―	▶
(1) Discussion of the report													▼					
(2) Submission of Draft Report																▼		
(3) Submission of Final Report with request letter																		▼