REPUBLIC OF FIJI
WATER AUTHORITY OF FIJI (WAF)

REPUBLIC OF FIJI
PROJECT FOR FORMULATION OF WASTEWATER TREATMENT MASTER PLAN IN WESTERN DIVISION

FINAL REPORT
PART 2：REGIONAL WASTEWATER MASTER PLAN

OCTOBER 2024

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NIHON SUIDO CONSULTANTS CO., LTD.
YACHIYO ENGINEERING CO., LTD.

GE
JR
24-076

Preface

The Final Report (F/R) of "the Project for formulation of Wastewater Treatment Master Plan in Western Division" is composed of the following four parts:

Part 1: Executive Summary

Part 2: Regional Wastewater Treatment Master Plan

Part 3: Municipal Sewerage Master Plan

Part 4: Pre-F/S of Priority Projects

This report is Part 2: Regional Wastewater Treatment Master Plan of the F/R.

TABLE OF CONTENTS

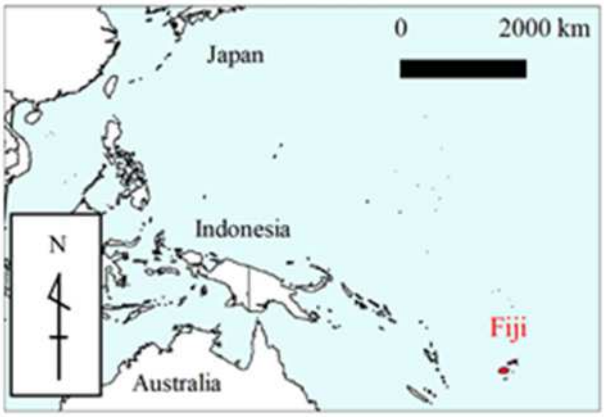
APPENDIX

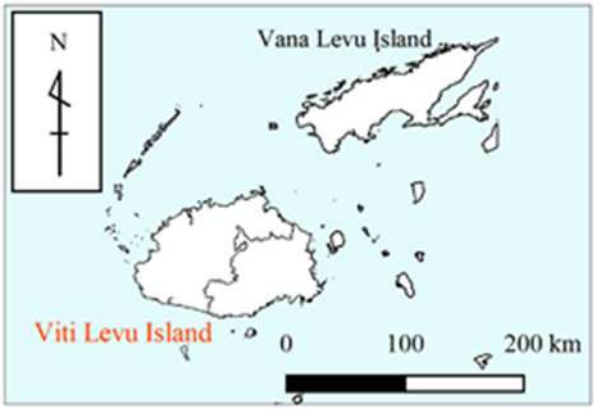
List of Tables

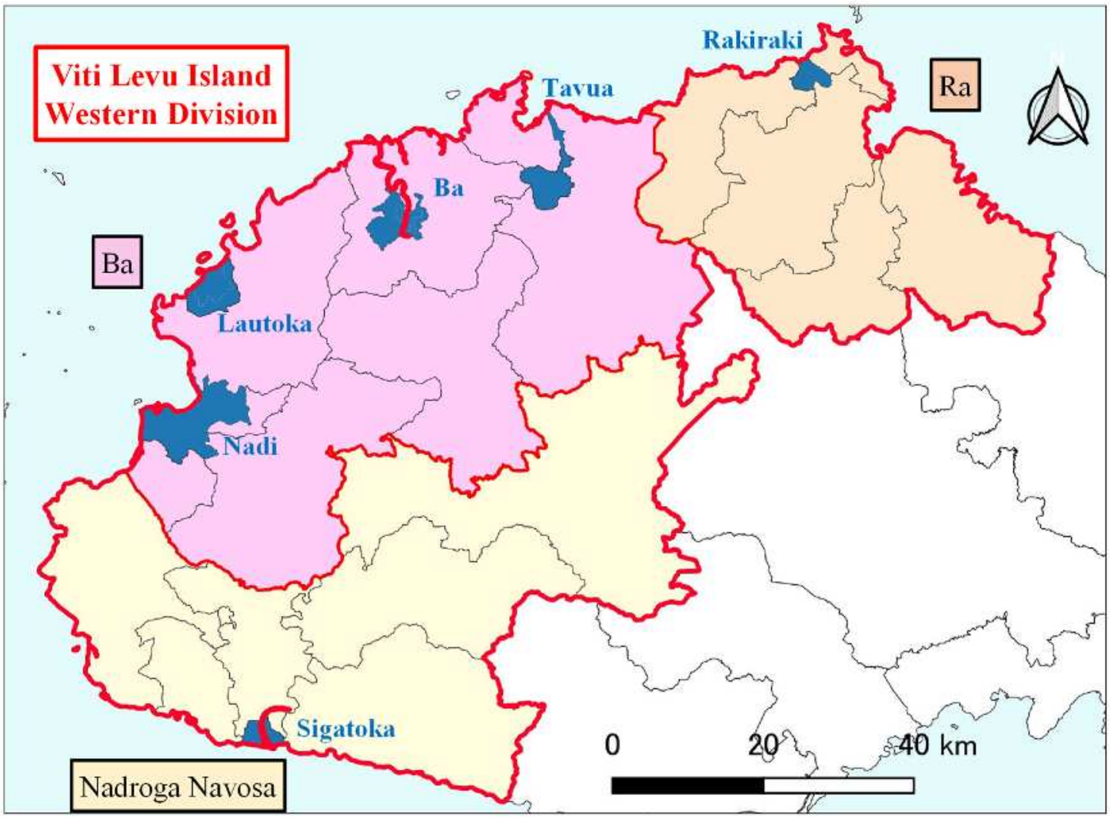
List of Figures

List of Photos

Location Map







Province	Population		
	Urban	Rural	Total
Ba	165,411	82,297	247,708
Ra	5,987	24,445	30,432
Nadroga Navosa	10,293	48,638	58,931
Sub-total: Western Division	181,691	155,380	337,071
Entire Fiji	494,252	390,635	884,887

Source: Fiji Population & Housing Census 2017

Municipalty	Name of WWTP
Nadi	Navakai
Lautoka	Natabua
Ba	Votua
Sigatoka	Olosara

ABBREVIATIONS

ADB	Asian Development Bank
AHP	Analytic Hierarch Process
AL	Aerated Lagoon
ATP	Affordable To Pay
BOD	Biochemical Oxygen Demand
CAPEX	Capital Expenditure
CD	Capacity Development
CHB	Central Health Bureau
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COD	Chemical Oxygen Demand
C/P	Counter Part
CWIS	Citywide Inclusive Sanitation
DF/R	Draft Final Report
DOE	Department of Environment
DOL	Department of Land
DWS	Department of Water and Sewerage
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EIRR	Economic Internal Rate of Return
ESC	Environmental and Social Considerations
FIRR	Financial Internal Rate of Return
FOG	Fats, Oil, Grease
F/S	Feasibility Study
F/R	Final Report
GCF	Green Climate Fund
GIS	Geographic Information System
HQ	Headquarters
IBA	Important Bird Area
IC/R	Inception Report
IDEA	Intermittent Decant Extended Aeration
IEE	Initial Environmental Examination
JCC	Joint Coordination Committee
JET	JICA Expert Team
JICA	Japan International Cooperation Agency
JPP	JICA Partnership Programs
KBA	Key Biodiversity Area
KCCP	Knowledge Co-Creation Program (JICA)
LMMA	Locally Managed Marine Area
L&D	Lecture & Discussions
MBBR	Moving Bed Bioreactor
MDGs	Millennium Development Goals
MHCD	Ministry of Housing and Community Development
MHMS	Ministry of Health and Medical Services
MIMS	Ministry of Infrastructure and Meteorological Service (before organizational restructuring: current MPW)
MIS	Management Information System

MLIT	Ministry of Land, Infrastructure, Transport and Tourism (Japanese)
MLMR	Ministry of Lands and Mineral Resources
MOE	Ministry of Economy (before organizational restructuring: current MOF)
MOF	Ministry of Finance (after organizational restructuring: former MOE)
MoF	Ministry of Forestry
MOWE	Ministry of Waterways and Environment
MPW	Ministry of Public Works, Meteorological Services and Transport (after organizational restructuring: former MIMS)
M/P	Master Plan
MWCPA	Ministry of Women, Children and Poverty Alleviation
NLWMP33	Nadi/Lautoka Regional Water Supply Scheme Master Plan 2013-2033
NPO	Non-Profit Organization
OD	Oxidation Ditch
ODA	Official Development Assistance
OJT	On the Job Training
O&M	Operation and Maintenance
PG/R	Progress Report
PI/R	Project Implementation Report
Pre-F/S	Pre-Feasibility Studies
R/D	Record of Discussion
SCF	Standard Conversion Factor
SDGs	Sustainable Development Goals
SEA	Strategic Environmental Assessment
SOP	Standard Operation Procedure
SS	Suspended Solids
SP	Stabilization Pond
SPREP	Secretariat of the Pacific Regional Environment Programme
TC	Technical Committee
TLTB	iTaukei Land Trust Board
T-N	Total Nitrogen
TOR	Terms of Reference
T-P	Total phosphorus
TSS	Total Suspended Solids
WAF	Water Authority of Fiji
WASH	Water, Sanitation and Hygiene
WDPA	World Database on Protected Areas
WHO	World Health Organization
WWTP	Wastewater Treatment Plant

CHAPTER 1 Introduction

1-1 Background

The Western Division of the Republic of Fiji (hereinafter referred to as "Fiji"), which includes Lautoka and Nadi (the second and third largest cities of Fiji, respectively) as well as Nadi International Airport, is an important location for tourism and other major Fijian industries. Despite robust growth in recent years, wastewater treatment capacity has not kept up with increases in resident and tourist populations. Development of this essential infrastructure corresponding to the increasing demand is urgently needed.

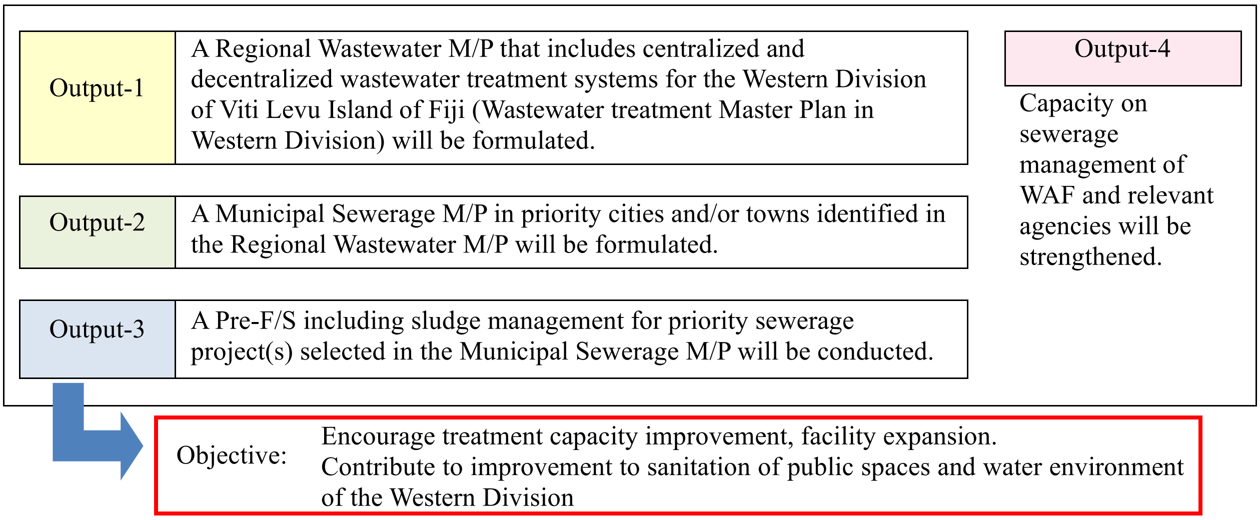
"National Development Plan 2017-2036" formulated by Fijian Government in 2017 targets to provide access to centralized treatment systems for 70% of the Fijian population by 2036, thorough the construction and expansion of public wastewater treatment systems in all urban centers. The "Data Collection Survey of Water Supply and Wastewater Sector in the Republic of Fiji" conducted by JICA in 2019 confirmed that the treatment performance of the four existing wastewater treatment plants located in the Western Division is insufficient. The main reasons were found to be over-capacity operation and lack of proper operation and maintenance (hereinafter referred to as "O&M"). The cause of the over-capacity operation was determined to be due to the existing sewerage master plan (hereinafter referred to as "M/P") being outdated and not reflecting current conditions. The causes of inadequate O&M were found to be a) O&M not being performed according to operational/water quality data, and b) lack of standardized O&M manuals.

To strategically improve the sewerage infrastructure of the Western Division of Fiji, JICA implemented the "Detailed Planning Survey for the Project for Formulation of Sewerage Master Plan in the Western Region" to confirm roles of each agencies/departments involved with sewerage works. The project contents were discussed and agreed to as the following:

- ✓ "Wastewater Treatment Master Plan in Western Division" (hereinafter referred to as the "Regional Wastewater M/P") which considered centralized and decentralized treatment systems for the Western Division
- ✓ "Sewerage M/P for Priority Cities in the Western Division" (hereinafter referred to as "Municipal Sewerage M/P")
- ✓ Pre-Feasibility Studies for the Priority Projects (hereinafter referred to as "Pre-F/S").
- ✓ Strengthen O&M of sewerage facilities

1-2 Objectives and Expected Outcomes

This project, entitled "Project for Formulation of Wastewater Treatment Master Plan in Western Division," will carry out various activities necessary to achieve the four outputs summarized below. By achieving these outputs, the Project aims to improve the performance of sewerage facilities in the Western Division, promote projects for the expansion of facilities, and contribute to the protection and improvement of urban and public health and the water environment of the Western Division.

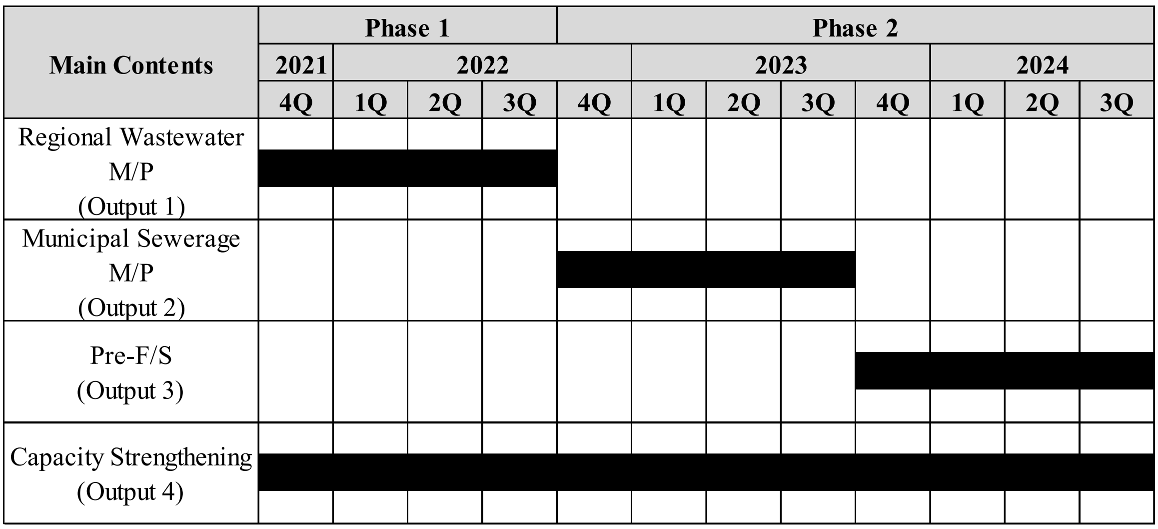


Source：JET and R/D

Figure 1-2.1 Objectives and Expected Outcomes

1-3 Project Phasing

This project will be implemented in a total of three years. The formulation of the Regional Wastewater M/P from Output-1, and a part of Output-4, will be carried out in the first year as Phase 1. Activities for Output-2 and 3 will be conducted in Phase 2 of this Project, to be carried out in the second and third years.

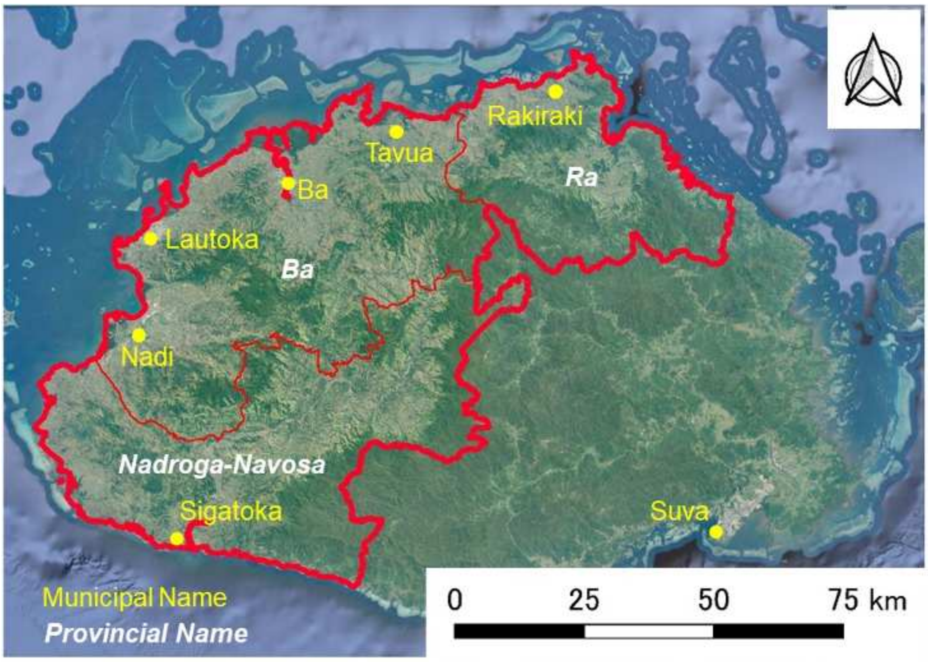


Source：JET and R/D

Figure 1-3.1 Project Phasing and Contents

1-4 Project Area

The Western Division of the Republic of Fiji is the target area for this Project. According to the 2017 national census, the population of the Western Division is 337,000 people, with an urban population of 182,000 and a rural population of 155,000 (refer to the location map provided in the Introduction). In order to achieve 70% access to centralized treatment systems in the Western Division, large-scale expansion of wastewater treatment services, including rural areas, is required.



Source : JET

Figure 1-4.1 Project Area for Regional Wastewater M/P

1-5 C/P Agency

The counterpart (hereinafter referred to as "C/P") agencies for the project are as follows. Through the first field survey which started from mid-November, two C/Ps were added to the original list due to their important roles in Phase 1.

Implementing agency:	Water Authority of Fiji (WAF): Authority for centralized treatment systems
Related agencies:	Ministry of Infrastructure and Meteorological Service (MIMS[1]), Department of Water and Sewerage (DWS): Authority for decentralized treatment systems
	Ministry of Waterways and Environment, Ministry of Economy (MOE[2]), Ministry of Lands and Mineral Resources, Ministry of Housing and Community Development, Ministry of Health and Medical Services (Central Board of Health: CBH), Fiji Bureau of Statistics, iTaukei Land Trust Board, Ministry of Local Government, Municipal Councils, Provincial Councils, others

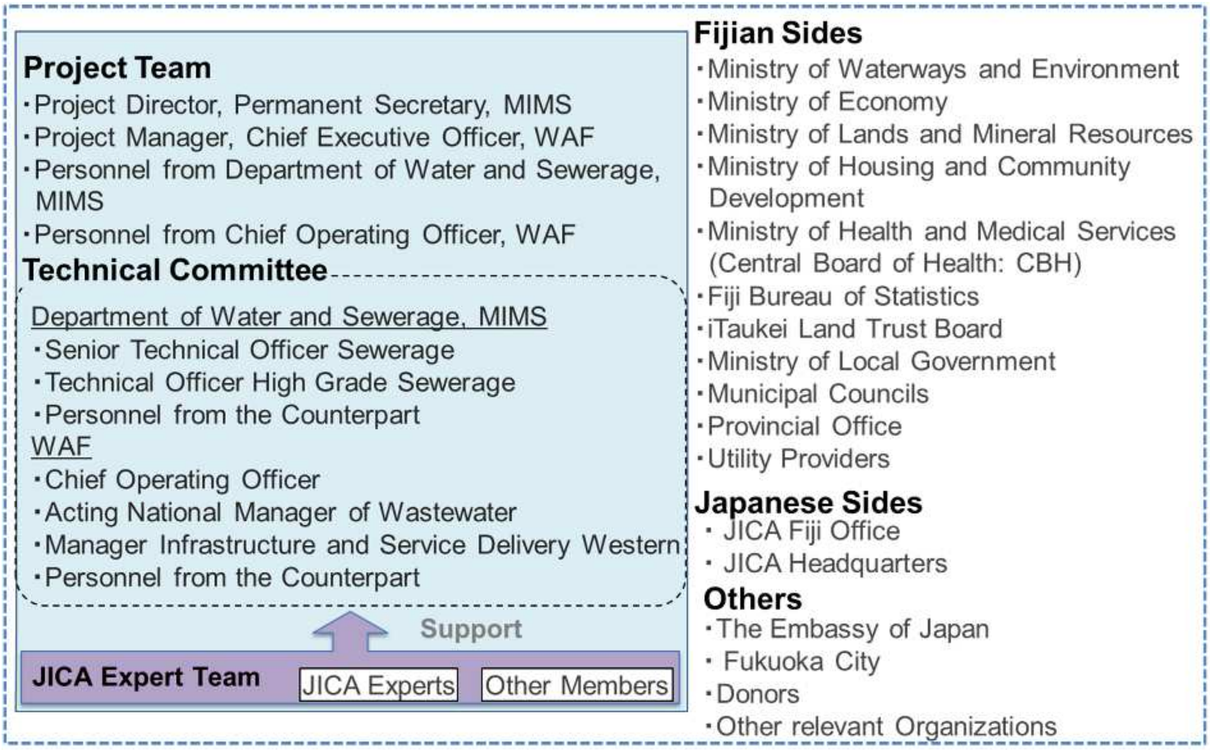
[1] MIMS: before organizational restructuring; current Ministry of Public Works, Meteorological Services and Transport (MPW)
[2] MOE: before organizational restructuring; current Ministry of Finance (MOF)

1-6 Project Implementation Structure

(1) Joint Coordination Committee

The project implementation structure is shown in **Figure 1-6.1**, with the Joint Coordination Committee (hereinafter referred to as "JCC") at its nucleus. This project will use the JCC to ensure mutual communication between parties throughout the planning process, and to ensure prompt approval of the formulated plans. The main role of the JCC is summarized as follows.

- ✓ Confirm and approve progress of Phase1 Regional Wastewater M/P, Phase 2 Municipal Sewerage M/P and Pre-F/S
- ✓ Discuss overall direction of the project and build consensus between relevant authorities



*1: MIMS: before organizational restructuring; current MPW
*2: MOE: before organizational restructuring; current MOF
Source：Created by JET based on R/D

Figure 1-6.1 Project Implementation Structure

(2) Advisor

Upon the formulation of the Master Plans and implementation of the Pre-F/S study in this project, the Road and Sewerage Bureau of Fukuoka City will be participating as an advisor to provide advice from a professional and technical standing point. In addition, Fukuoka City will also cooperate as the lecturer/instructor of the training program for WAF. Fukuoka City has a record over the years participating/cooperating with Fiji in its water and sewerage projects, holding connections with WAF and familiar with its institutional system; it is hoped that their knowledge will greatly support this project.

1-7 Members of the JICA Expert Team

JICA officials and JICA Expert Team (hereinafter referred to as "JET") consists of the following members (see **Table 1-7.1**). In addition, JICA has asked Fukuoka City to participate as an advisor, and the bureau provides advice on project activities and plans as appropriate.

Table 1-7.1 Member of the JICA Expert Team

JICA	
NAME	**TITLE**
Hideaki MATSUOKA	Director, Environmental Management Group, Global Environment Department, JICA HQ
Yukiya HOSAKA	Officer, Environmental Management Group, Global Environment Department, JICA HQ
Takashi OBA	Assistant Resident Representative, JICA FIJI Office
Shigeki NAMBA	Project Formulation Advisor, JICA FIJI Office
Advisor: Fukuoka City	
Hironori YASHIMA	Director, Policy Coordination Section, Road and Sewerage Bureau
Shingo MORIKAWA	Assistant Section Chief, Policy Coordination Section, Road and Sewerage Bureau
Shojiro HASHIZUME	Chief, Policy Coordination Section, Road and Sewerage Bureau

CONSULTANT TEAM		
NAME	**TITLE**	**OCCUPATION**
Yoshinobu NAKAJIMA	Team Leader/ Sewerage Works Management	Nihon Suido Consultants Co., Ltd.
Kiyohiko HAYASHI	Deputy Team Leader/ Organization & Institutions	Nihon Suido Consultants Co., Ltd.
Tetsuo WADA	Sewerage Planning	Nihon Suido Consultants Co., Ltd.
Hiroyuki KAWASHIMA	On-site Wastewater Treatment Planning	Nihon Suido Consultants Co., Ltd.
Shinichi SASAKI / Yoko KOTEGAWA	WWTP Planning and Design	Nihon Suido Consultants Co., Ltd.
Hideyuki IGARASHI	Sewer Network System and Existing Drainage Survey	Yachiyo Engineering Co., Ltd.
Yasuaki MATSUMOTO	Mechanical Engineering	Nihon Suido Consultants Co., Ltd.
Jyoji WAKAMOTO	Electrical Engineering	Nihon Suido Consultants Co., Ltd.
Yuichiro KONNO	Implementation Plan and Cost Estimation	Nihon Suido Consultants Co., Ltd.
Yoshiyuki CHOSO	Economic & Financial Analysis	Nihon Suido Consultants Co., Ltd.
Yuriko KUDO	Environmental & Social Considerations/ Public Awareness	Yachiyo Engineering Co., Ltd.
Yasuo IIJIMA	Natural Condition Survey	Yachiyo Engineering Co., Ltd.
Koichi OKAZAKI	Water Supply Planning Advisor	Nihon Suido Consultants Co., Ltd.
Divesh SAMI	Sewerage Planner	NRW Macallan (Fiji) Ltd
Andrew BANNER	Civil Engineer	NRW Macallan (Fiji) Ltd
Aneshwar AMIT	Economic/Financial Analyst	NRW Macallan (Fiji) Ltd
Ashika SINGH	Secretary	NRW Macallan (Fiji) Ltd

Source：JET

1-8 Results of Main Committee Meetings in the Project

The results of the main committee meetings that took place in the first phase of the project (started from October 2021) are summarized below in **Table 1-8.1**.

Table 1-8.1 Results of Main Committee Meetings

Committee Meeting	Subjects of the committee
Kick-off Meeting 17, November 2021 (WAF) 18, November 2021 (MIMS*1、MOE*2)	・ Explanation of the project outline and implementation schedule (by JET) ・ Explanation of the activities scheduled for the first dispatch (November to December 2021) ・ Collection of comments on the activities and implementation schedule from the Fijian side ・ Consultation with WAF on the project logistics
The First JCC Meeting 20, December 2021	・ Explanation of project activities and schedule ・ Discussions on adding the Ministry of Housing and Community Development and the Central Board of Health (CBH) to the JCC members ・ Confirmation of the six target municipalities for the Regional Wastewater M/P in the Western Division
Technical Committee Meeting 19, April 2022	・ Explanation of the activities scheduled for the second dispatch (scheduled April 2022) ・ Discussions on the projections of the population/wastewater flowrate, sewer service area for the six municipalities, and selection of priority municipalities, etc.
The Second JCC Meeting 22, July 2022	・ Explanation of the outline of the Regional Wastewater M/P in the Western Division (target year, target population, generated wastewater flowrate, wastewater treatment processes, construction/ O&M cost, priority municipalities, implementation schedule, alternative plan for 70% sewerage connection, decentralized treatment). ・ Collection of comments from the Fijian side.
The Third JCC Meeting 19, September 2022	・ Explanation of the Regional Wastewater M/P in the Western Division, reflecting the comments from the Fijian side (i.e. addition of MBBR method to wastewater treatment process options, addition of land acquisition costs to the construction cost) and approval from the Fijian side ・ Due to the absence of the WAF CEO, a separate meeting was scheduled to explain the Regional Wastewater M/P to the CEO on September 28th, and approved

*1: MIMS: before organizational restructuring; current Ministry of Public Works, Meteorological Services and Transport (MPW)
*2: MOE: before organizational restructuring; current Ministry of Finance (MOF)
Source：JET

CHAPTER 2 Plans and Regulations Related to the Wastewater Sector

2-1 Current State of the Wastewater Sector

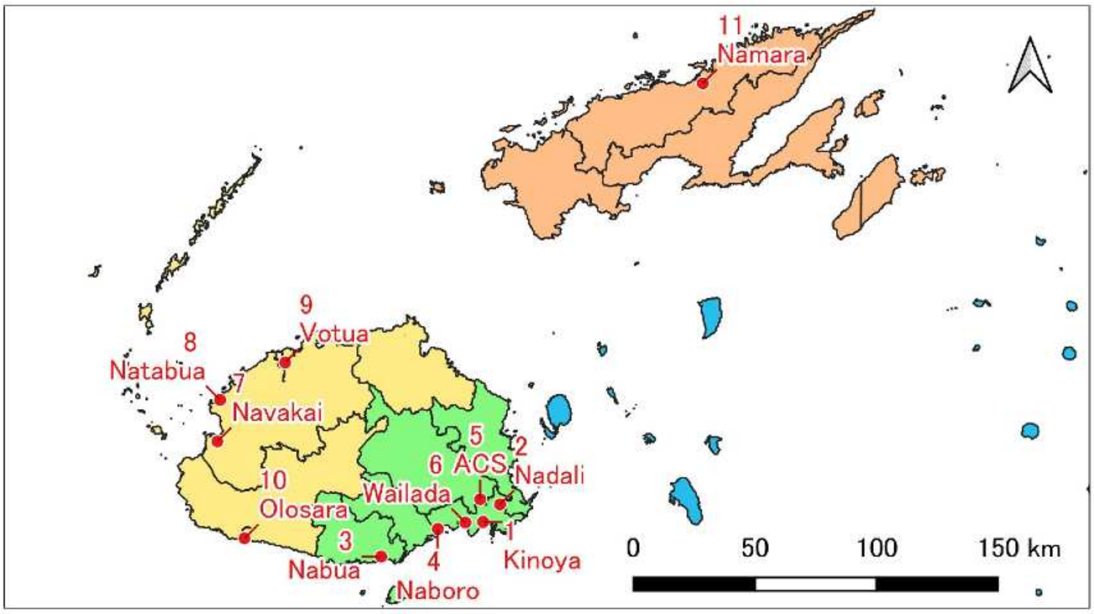
2-1-1 Current Conditions of Sewerage Facilities

Fiji currently has 11 wastewater treatment plants (hereinafter referred to as "WWTP") throughout the country. They are outlined in **Table 2-1.1**. There are four WWTPs in the Western Division, six in the Central Division, and one in the Northern Division. The largest is Kinoya WWTP in the Central Division, with a treatment capacity of 180,000 people. Most WWTPs do not operate at design capacity due to aging and failure of equipment. The locations of WWTPs are shown in **Figure 2-1.1**. Separated sewer systems are adopted for wastewater collection in Fiji.

Table 2-1.1 Summary of WWTPs in Fiji

No.	Division	WWTP (Municipality)	Treatment Process	Treatment Capacity (EP*)	Collection Method
1	Central	Kinoya (Suva)	High-Rate Trickling Filter + IDEA	180, 000	Separated Sewer System
2		Nadali (Nausori)	Extended Aeration and Polishing Ponds	2,500	
3		Nabua (Pacific Harbor)	High-Rate Trickling Filter	2,500	
4		Naboro (Suva)	Extended Aeration Activated Sludge	5,000	
5		ACS (Nausori)	Trickling Filter	800	
6		Wailada (Lami Industrial)	Extend Aeration Package Plant	5,000	
7	Western	Navakai (Nadi)	IDEA	35,000	
8		Natabua (Lautoka)	Oxidation ponds	43,000	
9		Votua (Ba)	Oxidation ponds	8,000	
10		Olosara (Sigatoka)	Oxidation ponds	4,000	
11	Northern	Namara (Labasa)	Oxidation ponds	11,000	

* EP: Population Equivalent
Source: Created by JET based on documents provided by WAF



Source: JET

Figure 2-1.1 Location of Existing WWTPs

2-1-2 Laws and Regulations Related to Wastewater Treatment

(1) Environmental Laws and Regulations

- Environmental Management Law-2005: Provides a legal framework for environmental impact assessment, waste management, pollution controls, and related penalties.
- Environmental Management (Solid Waste Disposal and Recycling) Regulations 2007: Regulates the discharge, control, and storage of solid waste, liquid waste, polluting gasses, smoke, vapor, soot, and dust from a wide range of facilities.
- Regulation of Environmental Management (EIA Process) 2007: Describes the environmental screening and EIA implementation process.
- Environmental Impact Assessment (EIA) Guideline 2008: Describes the EIA process

(2) Sewerage Laws and Regulations

- Water Authority of Fiji Act 2007: Defines the functions and authorities of WAF. Chapter 4 Paragraph 27 specifies that households are required to connect to sewer lines within 30 days if a sewer line is laid within 30 m of their property.
- Fiji National Liquid Waste Management Strategy and Action Plan 2007: Describes the importance of reducing the volume of domestic and commercial wastewater, improving treatment capacity to improve water quality, and increasing public awareness of sewerage works.
- National Liquid Trade Waste Policy for Discharge to Wastewater Systems Owned and Operated by Water Authority of Fiji: Indicates that households are required to connect to the sewer network if a sewer line is available within 30 m of their property. It also requires WAF to establish water quality standards as well as special tariffs for commercial establishments to discharge into the sewer

network. Currently, water quality standards, special tariffs, and penal regulations are awaiting Parliament approval.

(3) Public Health and Hygiene Laws and Regulations

- Public Health Act 1936 (Amended 2020): Article 30 of this act requires houses that are not connected to sewerage to install a "sufficient privy."
- Public Health (National Building Code) Regulation 2004: Household septic tanks and pit latrines are included in the collection of standard drawings of toilet facilities. It shows that pit latrines are for areas where water supply is not widespread. Therefore, pit latrines are commonly installed outside of the water supply area while septic tanks are installed for buildings that are within the water supply area but are not connected to sewer lines.
- The supervising authority of the Public Health Law is the Central Board of Health (hereinafter referred to as "CBH") of the Ministry of Health and Medical Services. However, Article 34 of the law specifies that it is the responsibility of the local authorities to ensure that all toilets and sewerage facilities are constructed and maintained so they do not impair health. The management and supervision of "sufficiently functioning toilets" are given to the local authorities.
- This law outlines the regulations and ordinances regarding the CBH and local authority's responsibilities and powers, building requirements (privies, dustbins, drains, etc.), consent in writing from the CBH required for offensive trade, etc.
- According to this law, all of Fiji is categorized as either an "urban sanitary district" or a "rural sanitary district" and cities/towns are categorized as "urban sanitary districts. "Rural sanitary districts" are defined in CBH meetings and approved by the Minister. Both urban and rural sanitary districts are administered by the local authorities given jurisdiction under this law. Nowhere in the law does it state whether districts other than urban or rural exist in Fiji (Article 9).
- This law defines the local authority as an individual or organization nominated by the city/town council located within the city/town boundary, or in the case of rural districts, the minister of the rural district (delegated to the Division Commissioner by decree in 1965). In areas not included in the rural or sanitary districts, CBH acts as the local authority (Article 10).
- With CBH approval, the local authority may appoint a sanitary inspector as needed. They can also prepare draft and submit rules to CBH for approval by the Minister (Article 11). Regarding on-site systems, roles such as health inspector, building inspector appear in the text. However, roles and authorities of each have not been clearly defined.
- Under this law, all new, rebuilt, or remodeled buildings must be equipped with appropriate toilets (privies), solid waste collection (dustbins), and drainage channels (drains) as defined in the Rules of the Local Authority (Article 31).
- Under this law, it is the responsibility of the local authority to ensure that toilets and drainage channels in the area constructed and maintained as required to prevent harm to health (Article 34).
- Under this law, no person may establish or carry out offensive trade activities within the local authority area without the written consent of CBH (Article 90)

(4) Land Use Laws and Regulation

- The Crown Land Act describes the use and management of national land.
- The Crown Acquisition of Lands Act is the law that governs the acquisition of land for public works. Land acquisition for the construction of WWTPs and pumping stations requires compliance with this Act.
- The iTaukei Land Act describes the rights to land owned by indigenous peoples.
- The iTaukei Land Trust Act defines the authority of the iTaukei Land Trust Board and leasing of land from indigenous peoples. Leasing land for sewerage projects requires compliance with this Act.
- Land Transfer Act describes the use, management, and sale of free hold land.

(5) Local Government Laws and Regulations

- Local Government Act 1972 (Amended 2009): The Act states that "Municipalities, with the approval of the Minister, alone or in collaboration with governments, corporations or other legal entities, or other legal public bodies, shall build and maintain public works that are necessary or beneficial to the municipality." It also states that "All schemes for urine drainage, waste collection, and other hygienic requirements must be approved by the Local Authority." Therefore, implementation of sewerage projects requires the approval of the local authority.

(6) Waste and Waste Disposal Laws and Regulations

- Environmental Management (Solid Waste Disposal and Recycling) Regulations 2007: These regulations require proper disposal of solid waste, including sludge from WWTPs. Currently, sludge generated at WWTPs are stored on site. If it is removed and disposed of at another location, the approval of DOE, which has jurisdiction over this regulation, is required.

2-1-3 Wastewater Regulatory Structure

The Government of Fiji consists of 23 ministries, including the Ministry of Indigenous Relations, the Ministry of Foreign Affairs, the Ministry of Infrastructure and Meteorological Services, the Ministry of Local Authorities, the Ministry of Education, the Ministry of Health, and the Ministry of Environment. All are under the Office of the President, the Office of the Prime Minister, and the Attorney General's Office. The offices relevant to the sewerage sector are described below.

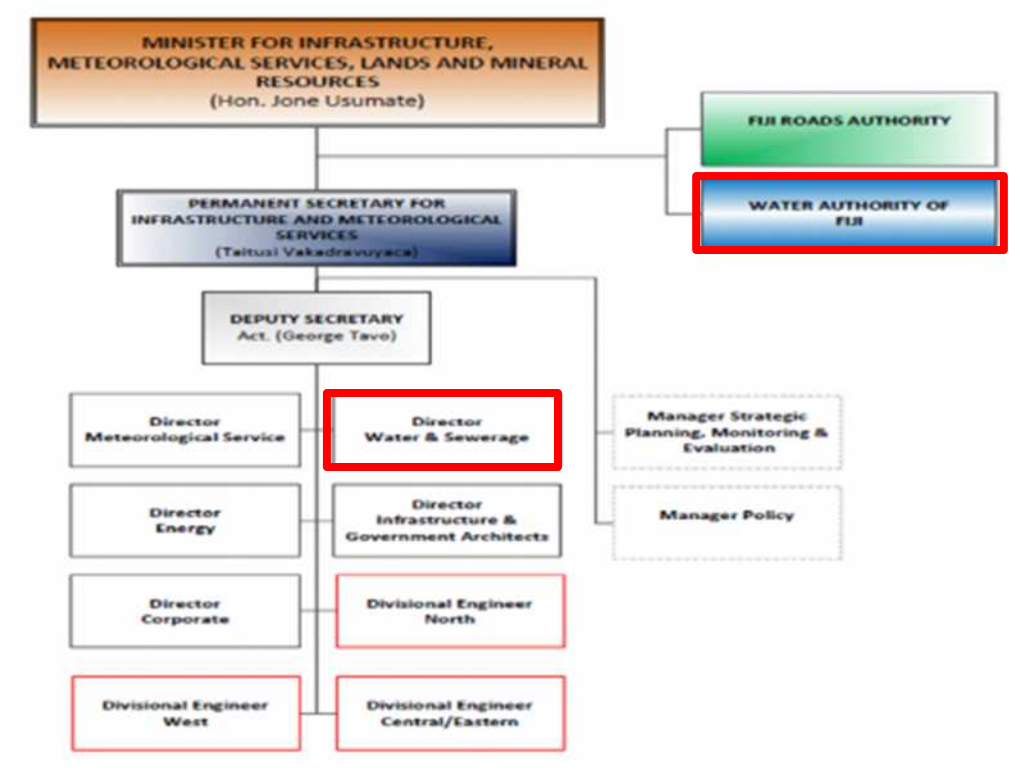
(1) Main Organizations Related to Wastewater Treatment

i) Ministry of Infrastructure and Meteorological Services (MIMS[3])

The sewerage sector in Fiji is under the jurisdiction of the Ministry of Infrastructure and Meteorological Services (hereinafter referred to as "MIMS"). The organization chart of MIMS is shown in **Figure 2-1.2**. There are eight departments under the Deputy Secretary Act, one of which is the Department of Water and Sewerage (hereinafter referred to as "DWS"). In addition, Fiji Roads Authority (hereinafter referred to as

[3] MIMS: before organizational restructuring; current Ministry of Public Works, Meteorological Services and Transport (MPW)

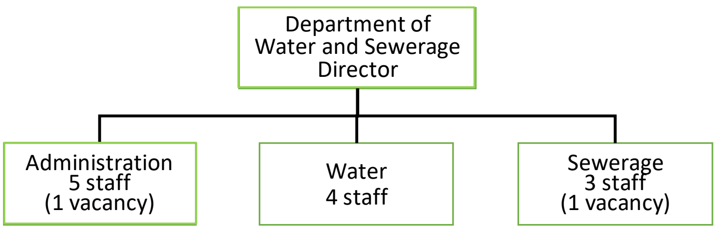
"FRA") and Water Authority of Fiji (hereinafter referred to as "WAF") exist as external bodies of the Ministry.



* MIMS: before organizational restructuring; current MPW
Source: MIMS*

Figure 2-1.2 Organizational Structure of MIMS*

DWS is responsible for the sustainable development of water and wastewater services in Fiji through the formulation of policies and legislation, and delivery of water supply and wastewater services to new areas. In addition, DWS supervises the projects carried out by WAF and provides technical support in the approval process when businesses install on-site wastewater treatment facilities. **Figure 2-1.3** shows the organizational structure of DWS. The department is divided into Administration, Water supply, and Sewerage departments. The water supply department has four technical staff, including the department manager. The sewerage department is currently staffed by three members including the department manager, with one vacancy in the technical officer position.



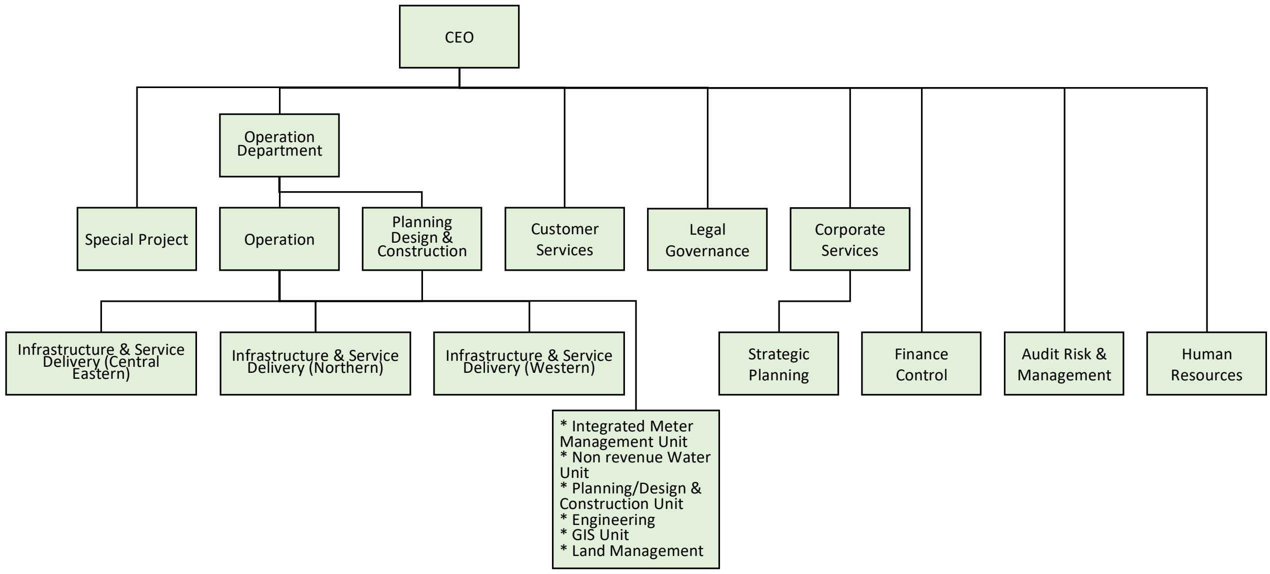
Source: Created by JET based on documents provided by MIMS*
* MIMS: before organizational restructuring; current MPW

Figure 2-1.3 Organizational Structure of DWS

ii) Water Authority of Fiji (WAF)

The water and wastewater operations in Fiji were carried out by the Fiji Water and Sewerage Department until 2007. "The Water Authority of Fiji Promulgation 2007" established WAF in 2007 "to provide efficient and effective water and sewerage services in a healthy and sustainable manner" (citing WAF). After a three-year transition period, WAF officially took over the implementation of water and sewerage operations on January 1, 2010.

The organizational structure of WAF is shown in **Figure 2-1.4.**



Source: Created by JET based on documents provided by WAF

Figure 2-1.4 Organizational Structure of WAF

Sewerage planning, design, and construction is done by the Planning, Design, and Construction Unit of the Planning, Design and Construction Division of the Operation Department, together with WAF.

Sewerage O&M is managed by Infrastructure and Service Delivery arm of the Operation Department established for each division.

(2) Other Organizations Relevant to Wastewater Treatment

Organizations involved in wastewater operations from planning through the O&M stages are described below.

i) Ministry of Waterways and Environment – Department of Environment (MOWE-DOE) (MOWE-DOE)

The Department of Environment (hereinafter referred to as "DOE") under the Ministry of Waterways and Environment (hereinafter referred to as "MOWE") implements environmental protection initiatives and the EIA processes as established under the Environmental Management Act 2005. When an EIA is required for the construction or expansion of wastewater treatment facilities, DOE approval is required. DOE also monitors the quality of effluent from WWTPs. Existing WWTPs often do not meet discharge standards and DOE is requiring improvements.

ii) Ministry of Economy[4]

The national budget of Fiji is managed by the Ministry of Economy (hereinafter referred to as "MOE"). MOE assesses and allocates the annual construction and operation budget for wastewater services and allocates funds to WAF. New wastewater projects need to be approved by MOE to obtain budgetary support.

iii) Ministry of Land and Mineral Resources

The Ministry of Land and Mineral Resources (hereinafter referred to as "MOLMR") oversees managing the country's land as well as mineral and groundwater resources.

The expropriation of public land is carried out under the authority of MOLMR, except the case of water supply and sewerage facilities. In these cases, land expropriation is under the authority of WAF. However, if the land to be used belongs to indigenous people, acquisition will take place under MOLMR authority.

iv) Ministry of Health and Medical Service

According to the Public Health Act, operators dealing with wastewater, solid waste, and other hygiene related operations must obtain approval from the Central Board of Health of the Ministry of Health and Medical Services (hereinafter referred to as "MHMS") for the installation of related facilities. This means that CBH approval is required when WAF implements a new wastewater project or when a business such as a hotel installs an on-site wastewater treatment facility.

v) Local Authorities

Fijian National Law Chapter 125 Paragraph 90 states that "the Council, with the approval of the Ministry, alone or in collaboration with government or other statutory public bodies shall (a) promote, establish, and maintain public works, including public transport and (b) build and maintain public works that, in the opinion of the Council, may be necessary or beneficial to the municipality. This means that public works will be carried out by the local authorities in concert with statutory public bodies and, therefore, water and wastewater operations carried out by WAF require approval of the local authorities.

In addition, the Public Health Act requires local authorities to ensure all toilets and sewerage facilities are constructed to protect public health and maintained appropriately. This means that on-site treatment facilities such as septic tanks require approval from the local authorities.

(3) Organizations Relevant to On-site Wastewater Treatment

"Local Authorities" stipulated in the Public Health Act are summarized in **Table 2-1.2**.

[4] MOE: before organizational restructuring; current Ministry of Finance (MOF)

Table 2-1.2 "Local Authority" According to the Public Health Act

Region	Category	Local Authority
City/town Boundary	Urban Sanitary District	City/Town Council
Out of City/town Boundary	Rural Sanitary District	Person or organization specified by the minster
	Neither of the above	CBH

Source: JET

Populations and informal settlements in the periphery areas (or Peri-urban areas) surrounding city/town boundaries are increasing rapidly. The government authority with jurisdiction in these areas is not clearly defined and government services provided by the city/town council is limited. However, in a survey conducted by JET, waste collection and building control (including inspection) based on the National Building Code in these areas are the duties of the city/town council.

The roles of these organizations related to on-site wastewater treatment are summarized below.

1) MIMS

In a survey with MIMS (conducted November 18th, 2021), it was found that MIMS is also the ministry responsible in the field of on-site wastewater treatment facilities. Organizations involved with sanitation and sanitation facilities other than MIMS are shown below. As the ministry overseeing WAF and its construction/O&M of centralized treatment systems, MIMS' role is significant. On the other hand, its role concerning on-site wastewater treatment systems is unclear.

Regarding informal settlements, in principle, they are not connected to centralized treatment systems, even if they are located within city/town boundaries. Formalization of informal settlements is managed by MHCD. Communal septic tanks are installed when appropriate.

Table 2-1.3 Ministries and Agencies with Jurisdiction of Sanitation Facilities by Region

Region	Ministry/Agency
Urban Formal Community	WAF (Water Authority Fiji)
Urban Informal Community	MHCD (Ministry of Housing and Community Development)
Rural Formal Community	CBH (Central Board of Health) Sharing information and requests for approval with MIMS*
Rural Informal Community	Self-managed by communities

* MIMS: before organizational restructuring; current MPW
Source: JET based on MIMS Survey Results

2) WAF

WAF is a "Commercial Statutory Authority" (hereinafter referred to as "CSA") established through the WAF Act in 2007 by the Government of Fiji. For wastewater works, WAF is responsible for the construction and maintenance of centralized treatment systems in urban areas, including pipes, pumping stations, and WWTPs.

For on-site wastewater treatment, WAF accepts septic tank and pit latrine sludge collected by private companies to be treated at WWTPs managed by WAF. In the Western Division, three WWTPs accept septic tank sludge (septage) for treatment. The fourth, the Navakai WWTP at Nadi, does not.

3) MHMS, CBH

MHMS oversees the implementation of the Public Health Act. The National Building Code, which sets construction standards for septic tanks and other hygiene facilities, is based on the Public Health Act. In addition, the formulation of the National Standard Design for septic tanks by MHMS is scheduled to start as early as 2022.

4) MHCD (Ministry of Housing and Community Developments)

The MHCD is installing communal septic tanks in informal settlement areas.

5) City/Town Council

As the local authority under the provisions of the Public Health Act, the city/town council is responsible for the construction and maintenance of toilets and drainage systems to prevent harm to health within the city/town boundaries. In addition, waste collection and building control (including inspection) based on the National Building Code in the peri-urban areas surrounding the boundaries areas are the duties of the city/town council. Therefore, each city/town council has a sanitary inspector and a building inspector. Although the duties of the roles have not been clearly defined, they verify whether sanitation facilities of new, reconstructed, or retrofitted buildings meet the necessary standards.

6) Private Sector (Survey with Waste Clear West Co.)

Septage extraction and transportation to WWTPs (commonly referred to as "Bailing" in Fiji) is carried out by private companies. In the Western Division, there are roughly four private operators, including Waste Clear West, that provide bailing services, with a total of eight bailing trucks (vacuum trucks) among them. Waste Clear West is the largest, with four units. The other companies are smaller, with one or two trucks each. The services are provided on an on-call basis. Waste Clear West’s transport hub is located in Lautoka, where demand is high, and covers the entire Western Division (including remote islands). When servicing remote islands, trucks from multiple companies are loaded onto a barge and the companies cooperate to do the work.

- Environmental permit (from MOE)
- Sanitary certificate for offensive trades (from MHMS)
- Registration for dumping (from WAF) (car number, capacity)

2-2 High Level National Plans

The National Development Plan (hereinafter referred to as “NDP”) was formulated under an initiative of the Ministry of Economy with the vision of “transformation of Fiji” and is a plan that lays out the path to the future of Fiji and all Fijians. The plan includes a 20-Year Development Plan (2017-2036) and a comprehensive 5-Year Development Plan (2017-2021). Detailed action plans as well as specific goals and policies that are in line with the 20-Year Development Plan are provided in the 5-Year Development Plan.

One goal of the 20-Year Development Plan related to wastewater is to increase the connection rate to centralized treatment to 70% of the population by 2036. In addition, although no specific figures have been set, the plan states that measures to improve and expand access to centralized treatment systems for all urban centers, as well as on-site processing and public health protection measures in rural areas will be considered.

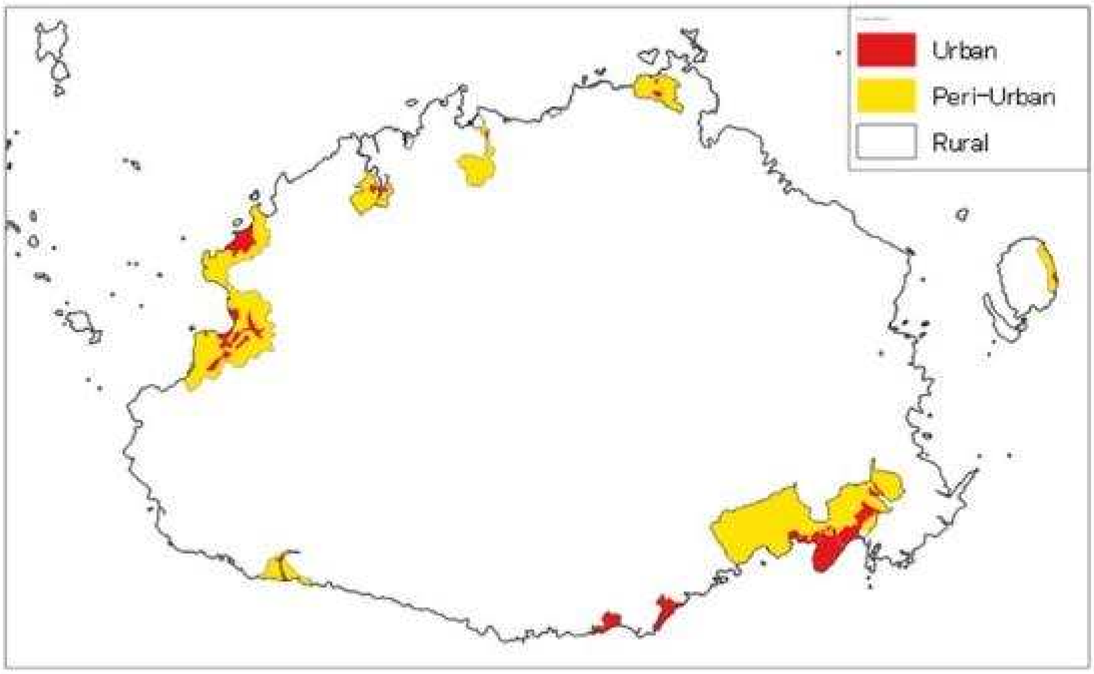
Specifics of some of the goals are shown in **Table 2-2.1**. The goal for access to centralized treatment system is 70% for both urban and rural areas. The NDP follows the definitions of "urban" and "rural" defined by the Fiji Bureau of Statistics and refers to the urban and peri-urban areas shown in **Figure 2-2.1** as urban areas, and all other areas as rural.

Table 2-2.1 National Development Targets (20-Year Development Plan)

Table 1: National Development Targets

	2015	2021	2026	2031	2036
Inclusive Socio-economic Development					
Access to clean and safe water in adequate quantities (% of population) (SDG 6.1)	78	90	95	100	100
Access to clean and safe water in adequate quantities, rural (%of population) (SDG 6.1)	58	85	90	100	100
Access to clean and safe water in adequate quantities, urban (% of population) (SDG 6.1)	98	100	100	100	100
Access to central sewerage system (% of population) (SDG 6.2)	25	40	50	60	70
Access to central sewerage system, urban (% of population) (SDG 6.2)	25	40	50	60	70
Access to central sewerage system, rural (% of population) (SDG 6.2)	0	40	50	60	70

Source: NDP



Source: Fiji Bureau of Statistics

Figure 2-2.1 Urban Areas Defined by the Fiji Bureau of Statistics

The "5-Year National Development Plan 2017-2021" sets out the following methods to increase the connection rate to centralized treatment systems from the current level to 40% by 2021.

- Allocate funds to strategically transition from septic tanks to centralized treatment systems
- Expand treatment capacity of urban WWTPs and procure energy efficient equipment
- Construct new small-scale WWTPs facilities in rural and coastal areas

The specific programs are shown in **Table 2-2.2**. Many have not been completed.

Table 2-2.2 Programs in the 5-Year National Development Plan

Program	Schedule					Output	Agency
	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022		
Greater Suva Area Regional Scheme	Implementation of M/P					M/P Implemented	WAF
Nadi/Lautoka Regional Scheme	Formulate M/P					M/P Formulated	WAF
Sigatoka	Formulate M/P					M/P Formulated	WAF
Ba	Formulate M/P					M/P Formulated	WAF
Navua	Formulate M/P					M/P Formulated	WAF
Pacific Harbour	Formulate M/P					M/P Formulated	WAF
Tavua/ Vatukoula	Formulate M/P and F/S	Detailed Design		Start Construction		Start Construction	WAF
Korovou	Formulate M/P and F/S					Complete Formulation of M/P and F/S	WAF
Labasa	Formulate M/P					M/P Formulated	WAF
Savusavu	Detailed Design		Construct WWTP			Complete 1 WWTP	WAF
Nabouwalu			Formulate F/S				WAF
Seaqaqa			Formulate F/S				WAF
Levuka		Formulate F/S	Detailed Design		Start Construction		WAF
Trade Waste	Implement Trade Waste Policy						WAF/ DWS
Programee							WAF
Sewer Network Extension Programee	60.8km	32.3km	29.0km	19.2km		Increase network by 141.3 km	WAF
WWTP Upgrade	Upgrade 11 WWTPs					Upgrade 11 WWTPs	WAF

Source: NDP

2-3 Budget of Fiji

(1) National Budget

The national finances and budgets of Fiji are shown in **Table 2-3.1**.

Table 2-3.1 The National Finances and Budgets of Fiji

(Units: million FJD)

Fiscal Year	2018-2019 Actual	2019-2020 Actual	2020-2021 Budget	2021-2022 Target	2022-2023 Target
Revenue	3,181.1	2,699.1	1,673.6	1,805.7	1,886.2
As a % of GDP	27.0%	26.4%	16.9%	16.4%	16.3%
Tax Revenue	2,819.8	2,189.3	1,465.7	1,626.9	1,708.3
Non-Tax Revenue	361.3	509.8	207.9	178.8	177.9
Expenditure	3,600.3	3,536.4	3,674.6	2,357.1	2,233.6
As a % of GDP	30.9%	34.6%	37.1%	21.4%	19.3%
Net Deficit	(419.2)	(837.2)	(2,001.0)	(551.4)	(347.4)
Budget deficit	-3.6%	-8.2%	-20.2%	-5.0%	-3.0%
Debt	5,735.2	6,705.4	8,256.4	8,807.8	9,155.1
Debt balance to GDP	49.3%	65.6%	83.4%	79.9%	79.1%
GDP at market price	11,635.9	10,214.9	9,905.3	11,027.5	11,578.9

Source：Ministry of Finance FIJI Economic and Fiscal Update Budget Supplement July 2020

Due to the impact of COVID-19, Fiji's economy faced a negative GDP growth from 2020, resulting in a significant decrease in tax revenue and an increase in the national budget deficit. The government expects that both GDP and budget deficits will improve after 2022, however, even at the year 2023, it will not return to the 2019 level before COVID-19.

(2) External Current Account Balance

The current account balance of Fiji is shown in **Table 2-3.2** below. It shows an increase in the debt ratio due to the recession.

Table 2-3.2 External Current Account Balance

(Units: million FJD)

Year	2018	2019	2020 Forecast	2021 Forecast	2022 Forecast
Current Account Deficit	-841.0	-572.5	-992.4	-941.7	-418.8
As a % of GDP	7.2%	5.6%	10.0%	8.5%	3.6%

Source：Ministry of Finance FIJI Economic and Fiscal Update Budget Supplement July 2020

(3) Government External Debt

The government's external debt status and the balance of external debt by currency are shown in **Table 2-3.3**, **Table 2-3.4**.

The ratio of external debt to GDP has risen sharply from 12.5% in 2019 to 17.1% in 2020.

Regarding the external debt composition by currency as of 2020, US dollar-denominated loans account for 73.2% of total external debt, following with the yuan at 23.8%, yen at 2.9%, and the euro at 0.1%.

Table 2-3.3 External Debt

(Units: million FJD)

Year	2016	2017	2018	2019	2020
Loans	846.9	968.6	1,037.2	1,023.8	1,314.6
Global Bonds	415.7	402.3	420.3	433.0	435.7
Total External debt	1,262.6	1,370.9	1,457.5	1,456.8	1,750.3
Externa Debt to GDP	12.50%	12.80%	12.80%	12.50%	17.10%

Source：Ministry of Finance FIJI Economic and Fiscal Update Budget Supplement July 2020

Table 2-3.4 External Debt Balance by Currency

(Units: million FJD)

	Jul-16	Jul-17	Jul-18	Jul-19	Jul-20
USD	684.0	854.2	954.5	982.6	1,281.4
CNY	557.9	501.3	489.3	462.0	415.7
JPY	20.7	13.2	11.5	9.7	50.9
EUR	0.0	2.1	2.2	2.5	2.3
Total External Debt	1,262.6	1,370.9	1,457.5	1,456.8	1,750.3

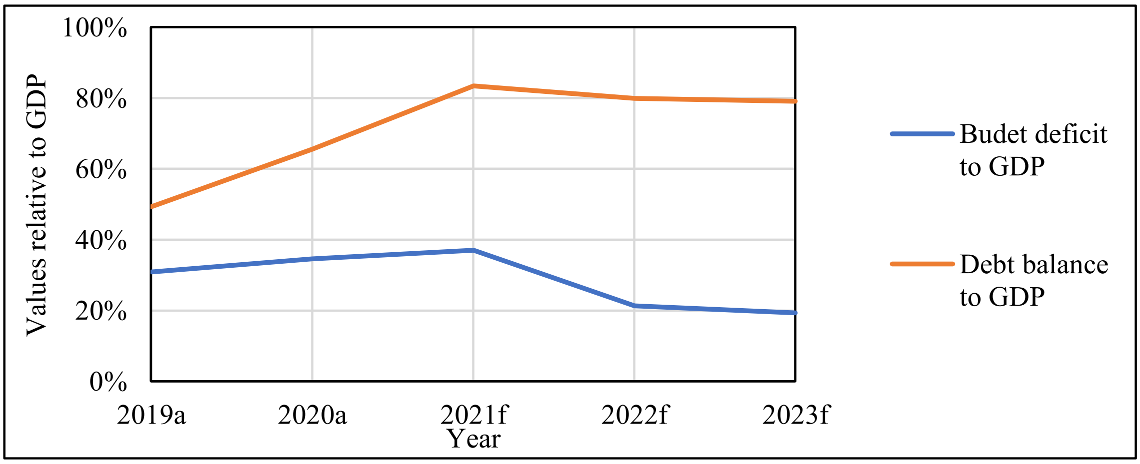
Source：Ministry of Finance FIJI Economic and Fiscal Update Budget Supplement July 2020

As shown in the **Table 2-3.4** above, US dollar-denominated loans have been on the rise for many years due to policy programs and ongoing infrastructure lending. In addition, RMB-denominated loans from China have risen to a high ratio of 30% to 50% of the balance until 2019.

(4) National Budget Finance and Debt Situation

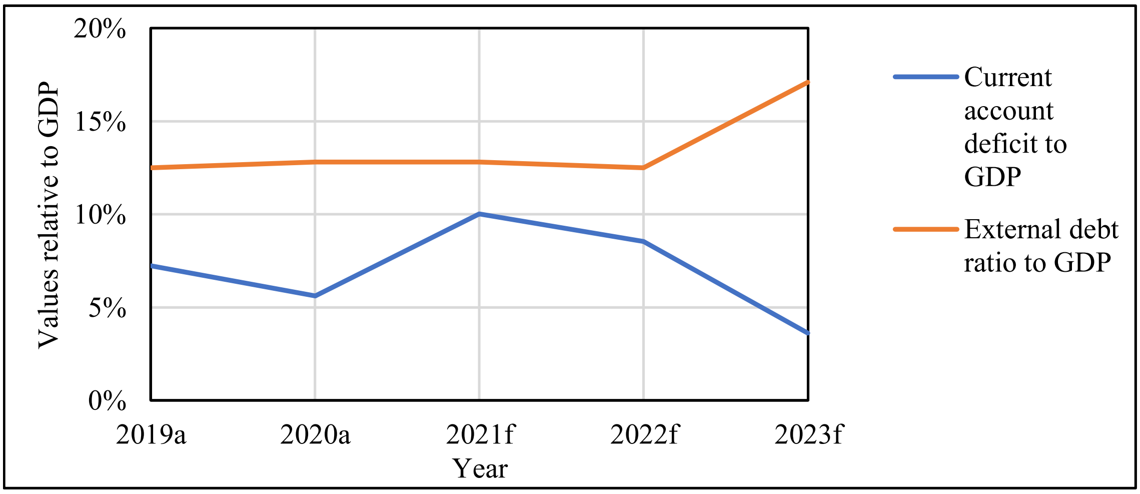
Fiji's medium-term fiscal policy for 2015 was to "control the budget deficit to 3.0% or less" and "reduce the government debt balance to 45%." However, despite stating such a fiscal policy, this has not been achieved due to the impact of the economic downturn caused by COVID-19.

According to the 2020 budget, the policy aims to reduce debt ratio, but no specific target figures have been given. According to the budget, the deficit will improve to 3%, but the debt balance ratio to GDP is high at 80% (**Figure 2-3.1**,**Figure 2-3.2**）.



Source：JET

Figure 2-3.1 Budget Deficit and Debt to GDP Ratio



Source : JET

Figure 2-3.2 Current Account Deficit and External Debt to GDP Ratio

The external debt ratio is more than 20% as of 2020, which requires an attention for repayment. The government predicts that further increases in the debt ratio can be avoided as the economy recovers. However, if the pandemic of COVID-19 will continue to have an adverse effect on the economy for a long period of time; it is necessary to pay close attention to the progress of improving the external debt ratio.

2-4 Support from Other Donors in the Wastewater Treatment Sector

Currently, aside from JICA, the Asian Development Bank (hereinafter referred to as "ADB") is supporting the development of the wastewater sector in Fiji[5]. It is implementing the "Urban Water Supply and Wastewater Management Investment Program" under ADB's Multitranche Financing Facility scheme. The planned project period is from 2016 to 2026. The first phase targeting mainly water supply is from 2016 to 2022, and the second phase targeting mainly wastewater is from 2022 to 2026.

The first phase was co-financed with the Green Climate Fund (31.04 million USD), ADB (42.11 million FJD) and European Investment Bank (26.06 million USD) to construct water supply facilities such as a new water intake, reservoir, and purification plant (loan assistance) and to implement technical cooperation for water supply and wastewater sector (grant). A decision for implementing the second phase will be made in 2022. In the second phase, expansion and renovation of sewerage facilities including a construction of a new IDEA facility in addition to the existing trickling filter and IDEA facilities in the Kinoya WWTP is planned.

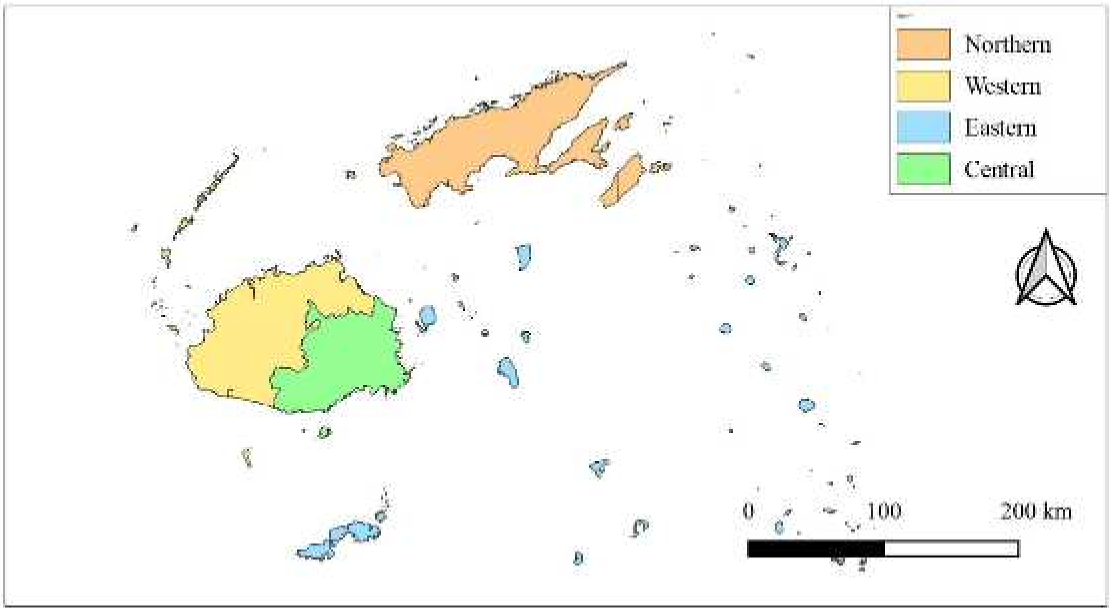
[5] By 2024, the United Nations Development Programme (UNDP) also started support programs for the development of the wastewater sector in Fiji

CHAPTER 3 Current Conditions and Plans in the Intended Target Area

3-1 Target Area

Fiji has a total land area of 18,270 km^2 located on 332 islands. Of those, 110 are inhabited islands. The country is divided into the four divisions shown below. The capital is located in the Central Division, Rewa Province, Suva City. The majority of the population lives on the largest island, Viti Levu, where Suva City is also located. The Western Division includes the western half of Viti Levu and the smaller Yasawa Islands and Mamanuca Islands to the northwest. The target area of this Project includes Ba, Ra, and Nadroga-Navosa Provinces, all in the Western Division.

- Central Division (Viti Levu Island)
- Western Division (Viti Levu Island)
- Northern Division (Vanua Levu Island and Taveuni Island)
- Eastern Division (Kadavu Island)



Source: JET

Figure 3-1.1 National Territory of Fiji and its Divisions

3-2 Natural Conditions

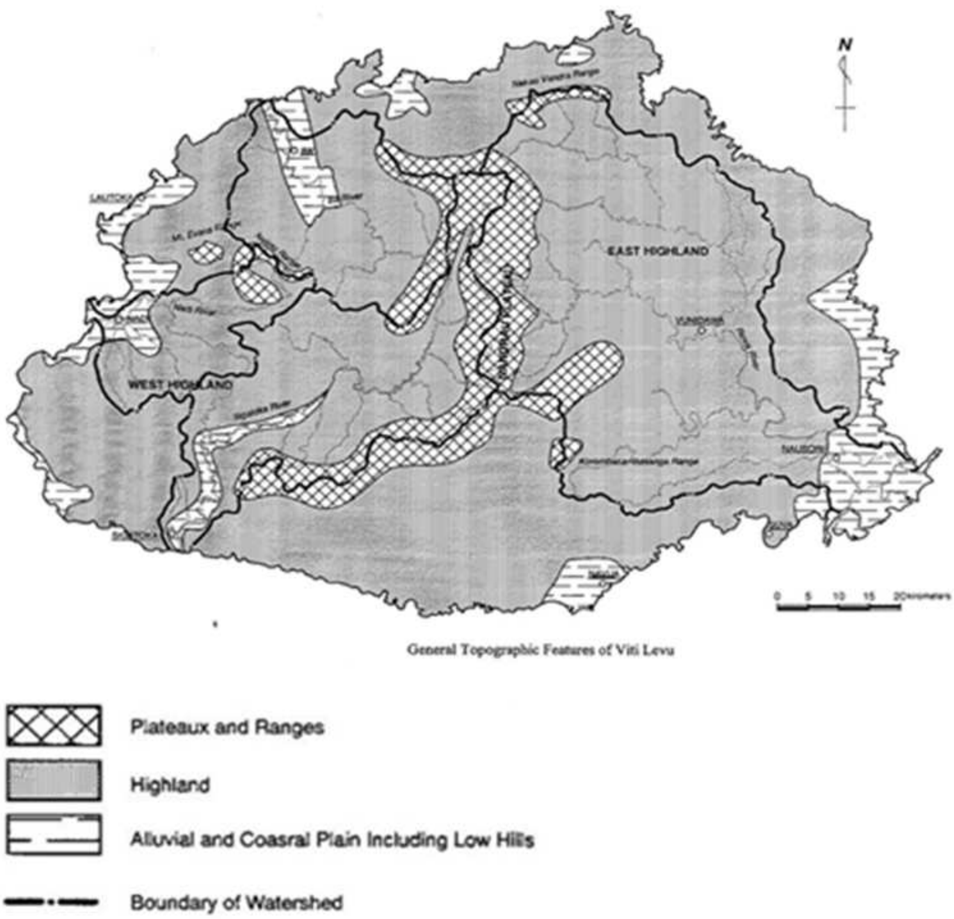
3-2-1 Location

Fiji is located in the central part of the southwestern Pacific Ocean. Its 332 islands are found between 174°and 177° east longitude and 15° and 22° south latitude. The land area of Viti Levu is 10,389 km^2, accounting for 57% of the total land area. It is an oval-shaped island 146 km east to west and 106 km north to south in size.

3-2-2 Topography and Geology

(1) Topography of Viti Levu Island

The Fiji Islands consist mainly of islands formed by volcanic activity during the Paleogene Eocene to Neogene Miocene. The central part of each island consists of steep terrain that gradually becomes gentler toward the coastline. Coral reefs and alluvial lowlands are found near the coast. Viti Levu Island is also a volcanic island, with the Nandlau Plateau, the highest peak of which is Mt Victoria (1,323m above sea level). This plateau runs north-south in the shape of a mountain range, dividing the island into east-west sections. The plateau extends from 300 to 600 m above sea level on the east and west sides, and hills and fans spread out toward the coast, followed by low terraces near the beach to reach the overseas areas. Especially along large rivers, fan-shaped flat surfaces that look like flood plains are found. Major towns such as Nadi, Ba, Rakiraki, Tavua, and Sigatoka are located along major rivers, and have developed on flat lands such as hills and low terraces.

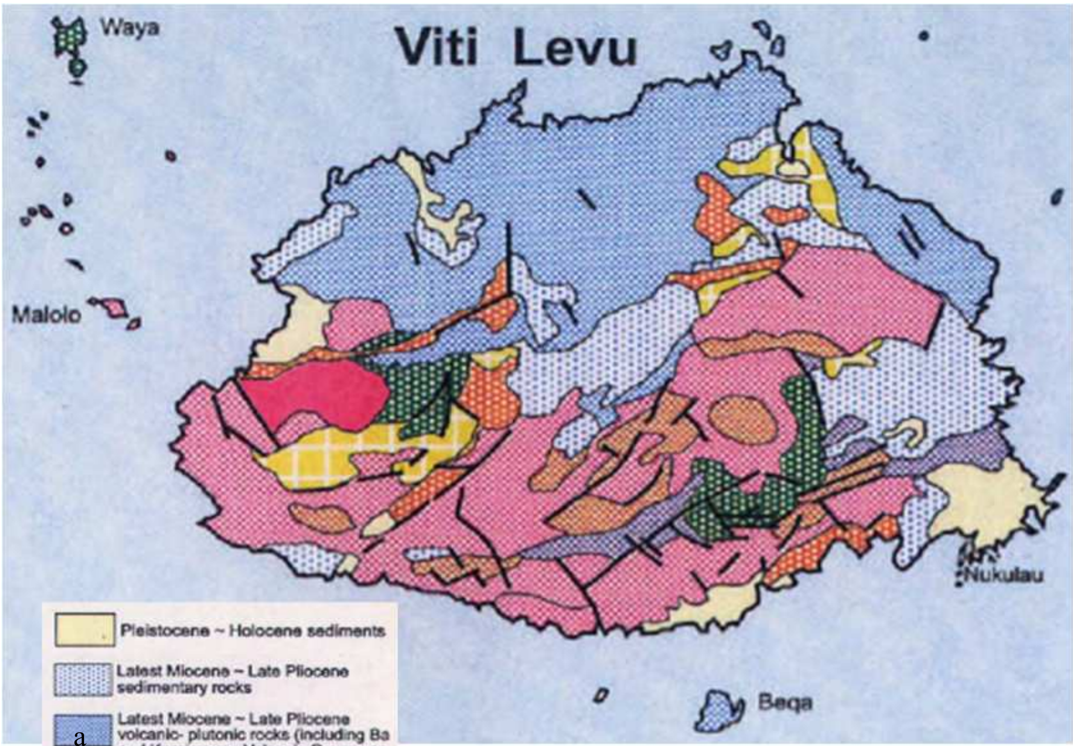


Source: JICA Fiji River Basin Management and Flood Control Planning Study (1998)

Figure 3-2.1 Topography of Viti Levu Island

(2) Geology of Viti Levu Island

Viti Levu Island is composed of igneous rocks of late Paleogene Eocene age (approx.40 Ma) to a late Miocene period (approx. 5.3 Ma). It is composed of igneous rocks from the late Paleogene Eocene (approx. 40 Ma) to the late Neogene Miocene (approx. 5.3 Ma), as shown in **Figure 3-2.2**. The oldest rocks (red in the figure) are Paleogene Eocene plutonic rocks that form a mountain range about 10 km south of Nadi. The other stones are basaltic and volcaniclastic rocks (volcanic ash, tuffaceous conglomerate, siltstone). The Neogene-Miocene volcanic rocks widely distributed in the island's northern part (blue area on the geologic map; legend a) are called the Ba Basalt Group. Tuffaceous sedimentary rocks (tuffaceous conglomerate to siltstone) are widely distributed in the southern part of the island (light red area on the geological map; legend b). Overlying these substrates are fan deposits (mudslide deposits), terrace deposits, and alluvial lowland deposits. Uplifted coral reefs and extant coral reefs are also found on the coast.



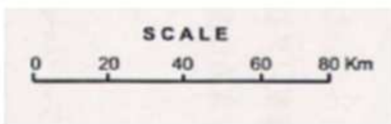


Figure 3-2.2 Geology of Viti Levu Island

(Source: Metal Mining Agency of Japan, Resource Information Center, Resource Development Environment of the Republic of Fiji)

3-3 Socioeconomic Conditions

3-3-1 Population

Table 3-3.1 shows the changes in the census population over time. The population has been increasing, reaching nearly 900,000 in 2020. Although the population is increasing, the rate of population growth is declining, which was about 2% until 1986, but most recently it is about 0.6%.

Table 3-3.1 National Census Population Trends

	1976	1986	1996	2007	2017	2020*
Population (1000 persons)	588.068	715.375	775.077	837.271	884.887	901.0
Annual growth ratio (%)		1.98%	0.80%	0.70%	0.55%	0.60%

* 2020: Bureau of Statics
Source: Census, Bureau of Statistics

Table 3-3.2 shows the changes in the population of the Western Division and the provinces of Fiji as a whole. The population ratio of the Western Division compared to all of Fiji has not changed significantly over the years, with about 40% of the population residing in the Western Division.

The population distribution of the three Provinces in the Western Division is also generally stable, but the population ratio of Ba is increasing, and the population ratios of Ra and Nadroga-Navosa are decreasing. The development of hotels and resorts in Nadi and Lautoka (both located in Ba Province), has attracted the population of the other two provinces in the Western Division.

Table 3-3.2 Population Trends in the Provinces of the Western Division

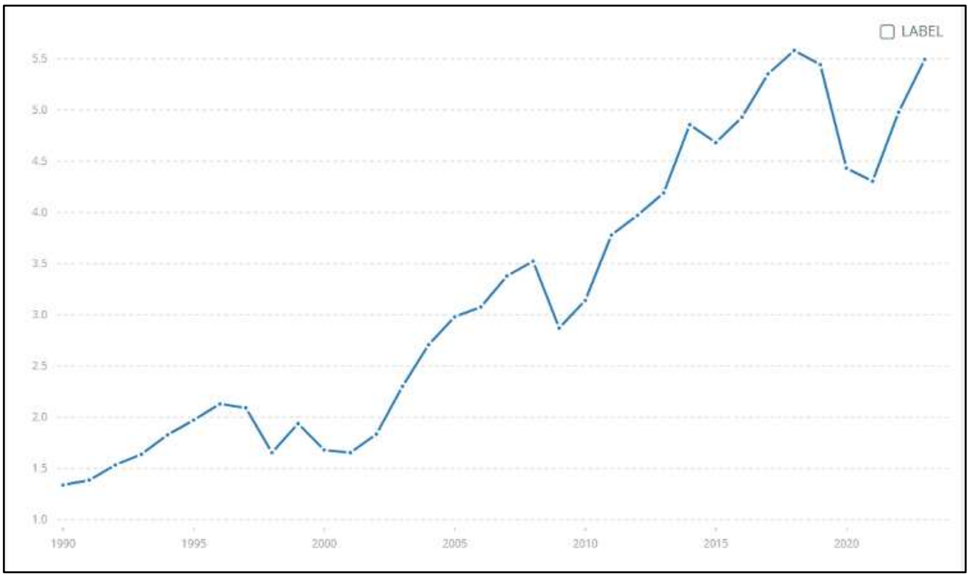
Year	National	Western Division		Ba Province		Nadroga-Navosa Province		Ra Province	
	Population	Population	Percentage	Population	Percentage	Population	Percentage	Population	Percentage
1986	715,375	283,349	39.6%	197,633	69.7%	54,431	19.2%	31,285	11.0%
1996	775,077	297,184	38.3%	212,197	71.4%	54,083	18.2%	30,904	10.4%
2007	837,271	319,611	38.2%	231,760	72.5%	58,387	18.3%	29,464	9.2%
2017	884,887	337,041	38.1%	247,685	73.5%	58,940	17.5%	30,416	9.0%
2020*	901,000	342,700	38.0%	252,900	73.8%	59,100	17.2%	30,700	9.0%

* 2020 data provided by the Bureau of Statistics
Source: Census, Bureau of Statistics

3-3-2 Economic Conditions

(1) General Economic Conditions

Fiji is one of the central economic countries of the Pacific Island nations. Its GDP in 2020 was the 4^{th} largest in Oceania, following Australia, New Zealand, and Papua New Guinea.

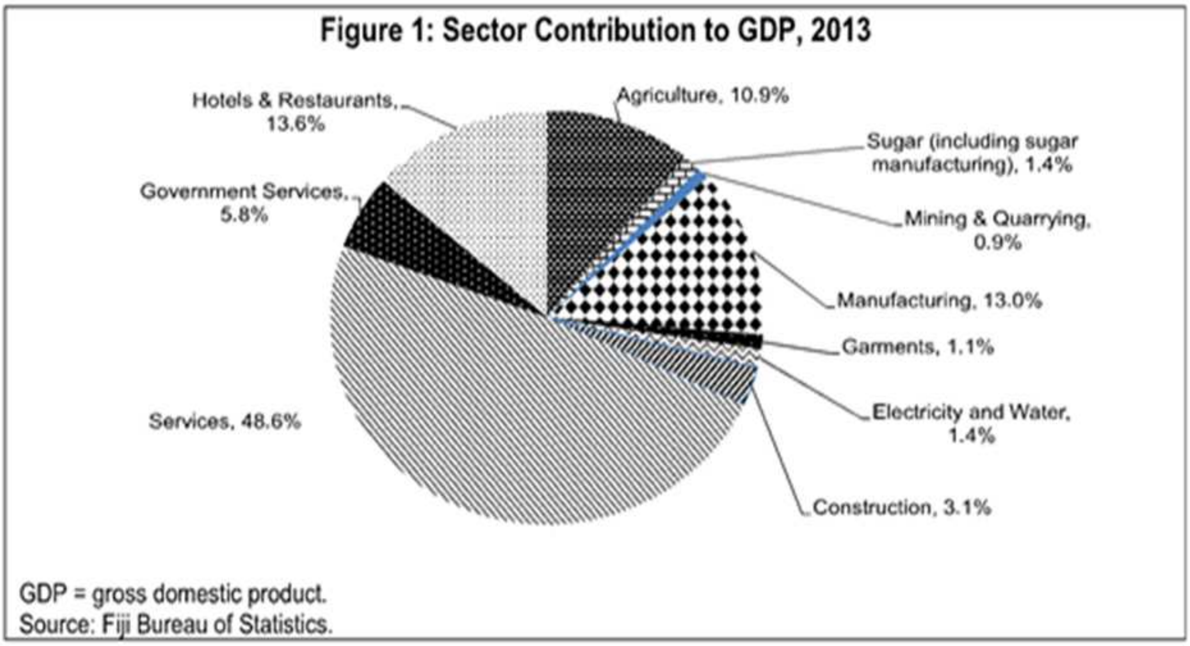


(Units: USD)

Source: "GDP (current US$-Fiji)," The World Bank (https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?contextual=default&end=2023&locations=FJ&start=1990&view=cha)

Figure 3-3.1 GDP Trends of Fiji

According to a 2013 ADB survey, the largest industry in Fiji is tourism, followed by manufacturing (sugar, fabrics, food processing, and timber processing), and agriculture which also contribute significantly to the total GDP. Of these, sugar and related industries are the main industries in rural areas. Fishing, forestry, mining, and other activities also support the economy of Fiji.



Source: "Economic Analysis: Summary (Country Partnership Strategy: Fiji2014-2018)," Asian Development Bank (2018) (https://www.adb.org/sites/default/files/linked-documents/cps-fij-2014-2018-ea.pdf)

Figure 3-3.2 Sector-wise Contribution to the GDP of Fiji (2013)

(2) Tourism in the Fijian Economy

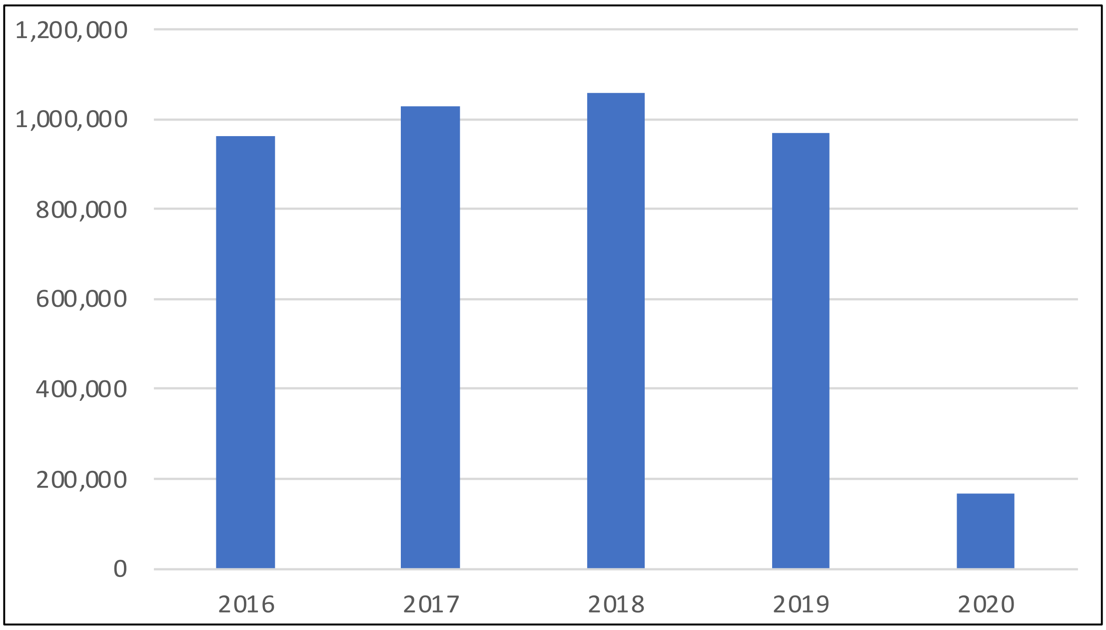
Tourism is an important driver of Fiji's economic activity, with approximately 118,500 Fijians engaged in tourism.

Table 3-3.3 below shows some major tourism data. About 1 million foreign tourists visit from overseas every year, and each tourist brings about 1,400 USD revenues to the Fijian economy. However, this pattern sharply changed in 2020, when number of tourists and tourism revenues declined due to the impact of the COVID-19 pandemic. Tourism revenue by 2019 contributes significantly to about 25% of gross domestic product (GDP), and a recovery in the number of tourists is essential for Fiji's economic recovery.

Table 3-3.3 Major Data of Tourism Industry

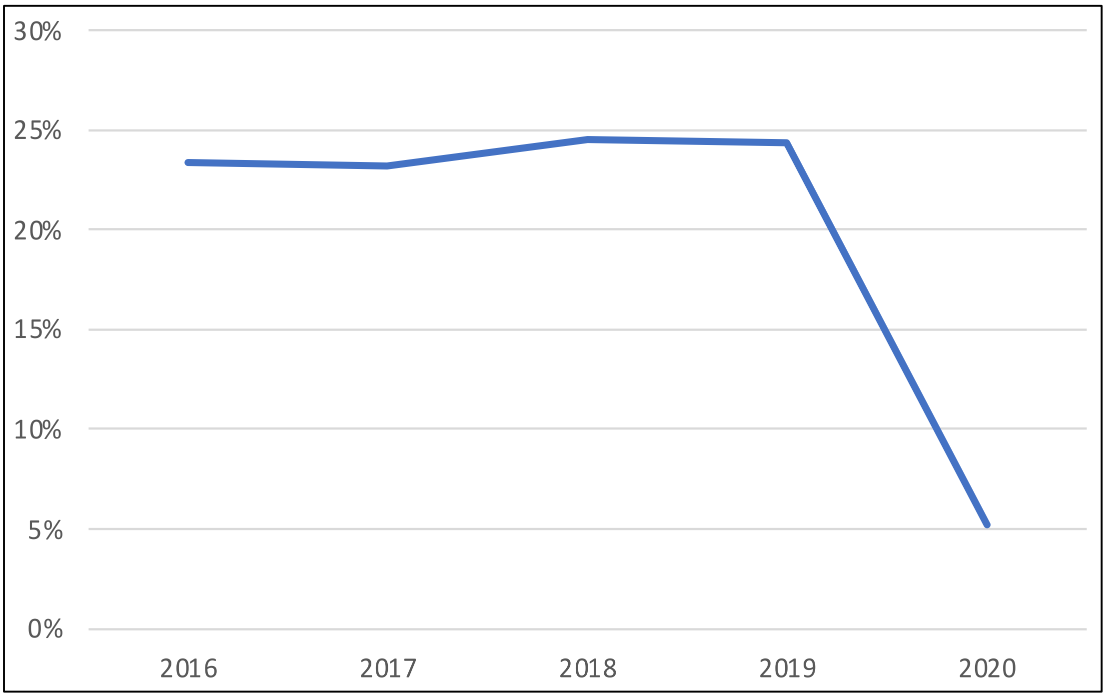
Year	2016	2017	2018	2019	2020
International Tourism Receipt (Current USD, million)	1,150	1,240	1,370	1,340	236
GDP (Current USD, million)	4,930	5,350	5,580	5,500	4,530
Tourism Receipt/GDP	23%	23%	25%	24%	5%
International Tourist, arrivals	963,000	1,027,000	1,058,000	969,000	168,000
Tourism Receipt per International Tourist (USD)	1,194	1,207	1,295	1,383	1,405

Source：JET on World bank data



Source：JET

Figure 3-3.3 Number of Tourists from Overseas



Source：JET

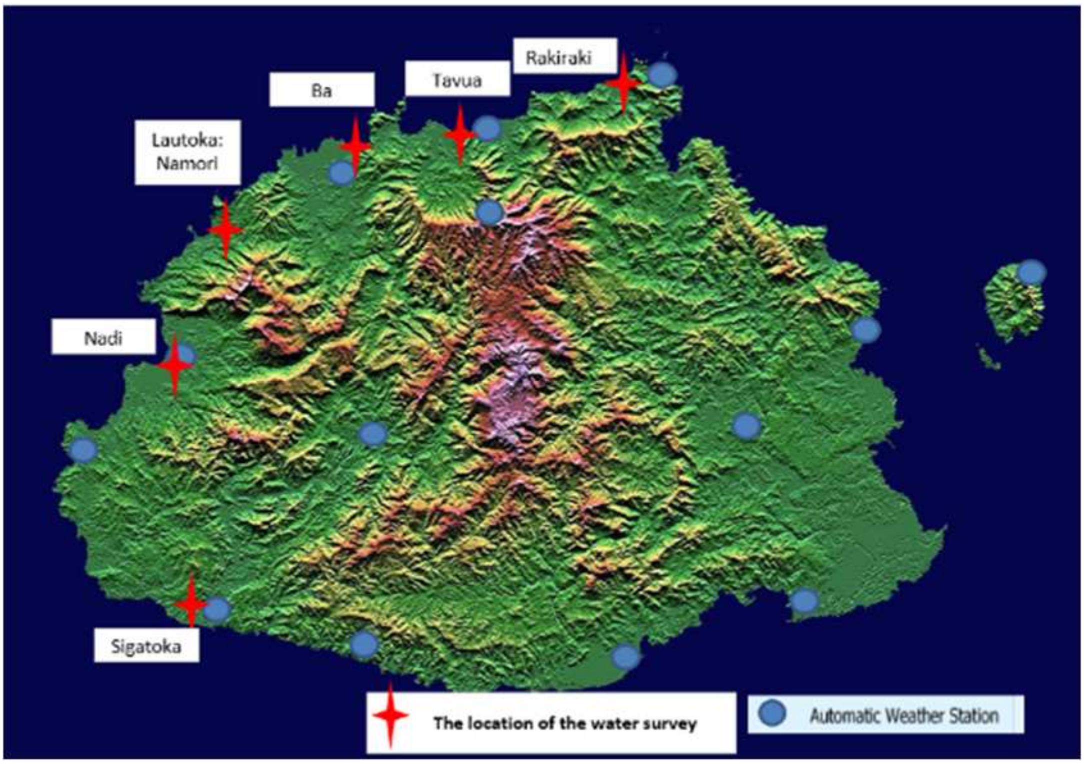
Figure 3-3.4 GDP Ratio of Tourism Revenue

3-4 Water Environment

The Ministry of Waterways and Environment is responsible for monitoring public water supplies, but regular observations are not conducted. Therefore, this project conducted river flow and water quality surveys in six municipalities in the Western Division.

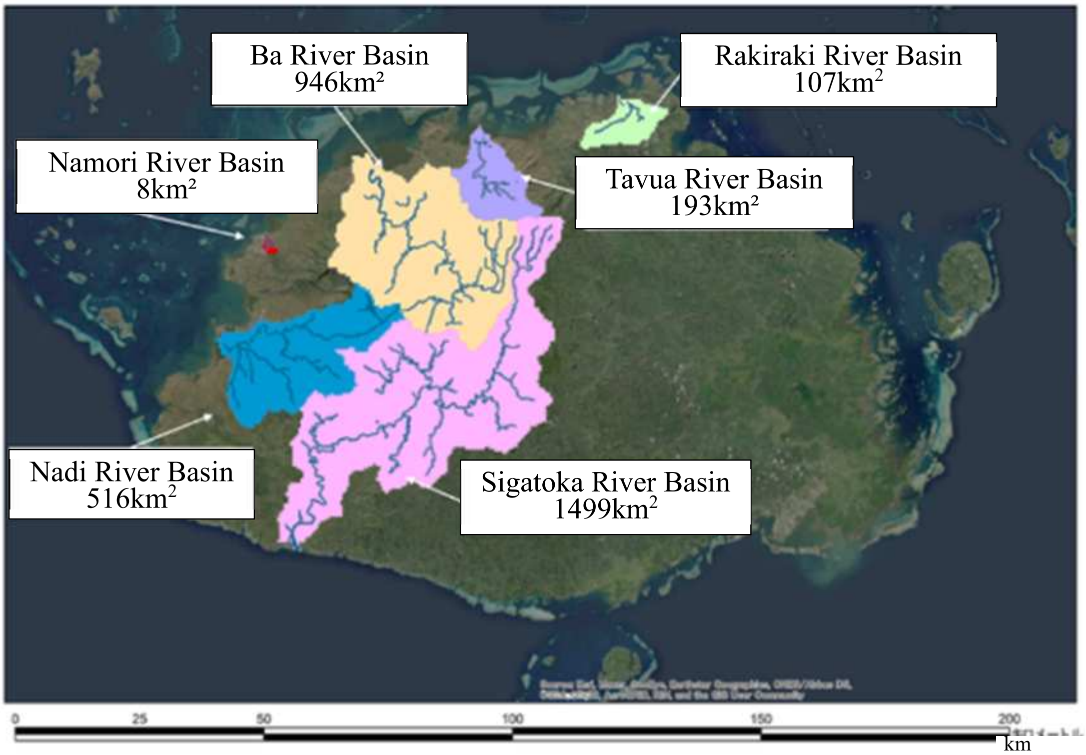
(1) Survey Site

River water volume measurements and water quality analysis were conducted on six rivers that pass through urban areas at bridge points near each urban area. The red asterisks in **Figure 3-4.1** shows the river observation points, and **Figure 3-4.2** shows the basin.



Source: JET compilation of MIMS*
* MIMS: before organizational restructuring; current MPW

Figure 3-4.1 Observation Sites and Automatic Weather Observation Points

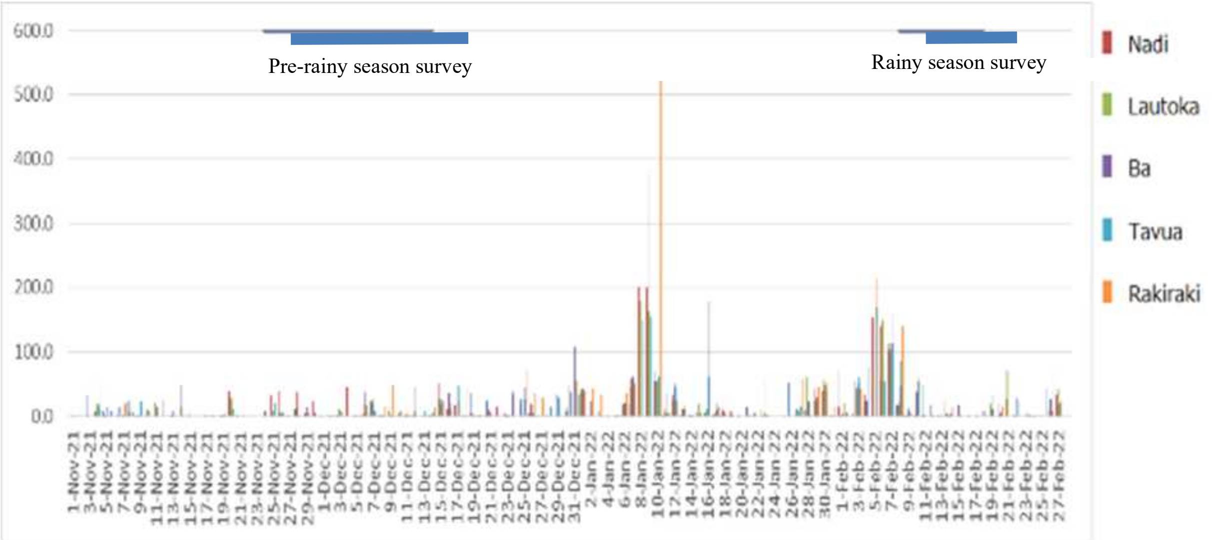


Source: JET

Figure 3-4.2 Watershed Map of Each River

(2) Survey Sites and Rainfall

River surveys were conducted twice. The first survey took place from November 29 to December 13, 2021, and the second survey took place from February 8 to February 18, 2022. **Figure 3-4.3** shows the relationship between each observation period and rainfall. In Nadi, rainfall of 50 mm/day or more starts on December 15. Rain of 100 mm/day or more is confirmed after December 30. Therefore, it is considered that the rainy season is after December 15. Especially from January 6 to 13th, January 16, and January 27 to February 10, rainfall of more than 50mm/day continued in various places, and some areas recorded 300-500 mm per day. The February survey corresponds to the heavy rainfall in the rainy season.



Source: JET compilation of MIMS*
* MIMS: before organizational restructuring; current MPW

Figure 3-4.3 Study Period and Daily Rainfall

(3) River Flow Survey Results

River flow study results are shown in **Table 3-4.1** and **Table 3-4.2**.

<Pre-rainy Season Survey Results>

- Comparing the results of the two water quality tests, it was found that the test results of (N-d2), (L-d1), and (S-d2) were relatively stable. Therefore, the typical water volumes of Nadi, Lautoka, and Sigatoka is determined to be the water volumes taken on these sampling dates.
- The water quality test results of Ba, Tavua, and Rakiraki are relatively stable throughout the survey, and the two flow rates are almost identical. Therefore, the representative value of the amount of water is determined as the average of the two measurements.

Table 3-4.1 River Flow Observation Results (Pre-rainy Season)

(Red font indicates representative values.)

River name	Date	Flow rate (m^3/s)	Conductivity (mS/cm)	Sample No.
Nadi River	7/Dec/2021	30.6	0.23	N-d2
	13/Dec/2021	24.4	0.24	N-d3
Lautoka Namoli Creek	30/Nov/2021	0.06	0.23	L-d1
	13/Dec/2021	0.21	0.21	L-d2
Ba River	25/Nov/2021	76.5	0.23	-
	2/Dec/2021	70.4	0.11	Ba-d1
	7/Dec/2021	88.0	0.51	Ba-d2
	Average	79.2		
Tavua River	6/Dec/2021	0.4	1.05	T-d1
	9/Dec/2021	0.7	0.85	T-d2
	Average	0.55		
Rakiraki River	6/Dec/2021	0.28	0.32	R-d1
	9/Dec/2021	0.39	0.33	R-d2
	Average	0.34		
Sigatoka River	8/Des/2021	180.9	2.20	S-d1
	14/Des/2021	158.7	0.21	S-d2
	29/Nov/2021	24.7	4.20	S+7km-d3

Source: JET

< Rainy Season Survey Results >

- Comparing the results of the two water quality tests, it was found that the test results of (N-d2), (L-d2), (Ba-r2), and (S-d2) are relatively stable. Therefore, the typical water volumes of Nadi, Lautoka, and Sigatoka is determined to be the water volumes taken on these sampling dates. These are the flow rates on the day about one week after the heavy rainfall exceeding 100 mm.
- The water quality test results of Tavua and Rakiraki are relatively stable throughout the survey, and the two flow rates are almost the same. Therefore, the representative value of the amount of water is determined as the average of the two measurements

Table 3-4.2 List of River Flow Survey Results (Rainy Season)

(Red font indicates representative values.)

River name	Date	Flow rate (m^3/s)	Conductivity (mS/cm)	Sample No.
Nadi River	8/Feb/2022	673.6	0.23	N-r1
	17/Feb/2022	79.8	0.23	N-r2
Lautoka Namoli Creek	8/Feb/2022	1.0	0.26	L-r1
	17/Feb/2022	0.4	0.26	L-r2
Ba River	9/Feb/2022	809.8	0.76	Ba-r1
	15/Feb/2022	224.0	0.79	Ba-r2
Tavua River	14/Feb/2022	5.4	0.20	T-r1
	18/Feb/2022	5.8	0.30	
Rakiraki River	14/Feb/2022	9.7	0.31	R-r1
	18/Feb/2022	7.7	1.93	
Sigatoka River	10/Feb/2022	382.0	0.162	S-r1
	16/Feb/2022	222.7	0.30	S-r2

Source: JET

<Specific Flow Rate>

Specific flow rate is flow rates divided by watershed area. Each flow rate is shown in **Table 3-4.3**. Lautoka (Namoli), Tavua, and Rakiraki have relatively small specific flow rates and smaller specific flows. Ba, Nadi, and Sigatoka have large watersheds, and the difference between the pre-rainy and rainy seasons is significant.

Table 3-4.3 Specific Flowrate

Place	Date	Flowrate (m^3/s)	River Basin Area (km^2)	Specific Flowrate ($m^3/s/km^2$)
Nadi	7/Dec/2021	30.6	516	0.059
Nadi	13/Dec/2021	24.4	516	0.047
Nadi	8/Feb/2022	673.6	516	1.305
Nadi	17/Feb/2022	79.8	516	0.155
Lautoka: Namoli	30/Nov/2021	0.06	8	0.008
Lautoka: Namoli	13/Dec/2021	0.21	8	0.026
Lautoka: Namoli	8/Feb/2022	1.0	8	0.125
Lautoka: Namoli	17/Feb/2022	0.4	8	0.050
Ba	2/Dec/2021	76.5	946	0.801
Ba	25/Nov/2021	70.4	946	0.074
Ba	9/Feb/2022	809.8	946	0.856
Ba	15/Feb/2022	224.0	946	0.237
Tavua	6/Dec/2021	0.4	193	0.002
Tavua	9/Dec/2021	0.7	193	0.004
Tavua	14/Feb/2022	5.4	193	0.028
Tavua	18/Feb/2022	5.8	193	0.030
Rakiraki	6/Dec/2021	0.37	107	0.003
Rakiraki	/9/Dec/2021	0.39	107	0.004
Rakiraki	14/Feb/2022	9.7	107	0.091
Rakiraki	18/Feb/2022	7.7	107	0.072
Sigatoka	8/Dec/2021	180.9	1499	0.121
Sigatoka	14/Dec/2021	158.7	1499	0.106
Sigatoka	10/Feb/2022	382.0	1499	0.255
Sigatoka	16/Feb/2022	222.7	1499	0.149

Source: JET

(4) Water Quality Survey Results

Water quality survey results are shown in **Table 3-4.4** and **Table 3-4.5**. All analysis results are attached in **APPENDIX-3-1**.

< Pre-rainy Season Survey Results>

- Nadi and Lautoka's Representative values are (N-d2) and (L-d1). Because the Coliform values of Nadi (N-d3) and Lautoka (L-d2) are unusually large; on the other hand, (N-d2) and (L-d1) are relatively stable.
- Sigatoka's representative value (S-d2) is considered as low salinity data.
- The water quality of Ba, Tavua, and Rakiraki is stable, and the average value of the analysis results is considered to be a typical value.

Table 3-4.4 List of Water Quality Survey Results (Pre-rainy Season)

Test results(Befpre Rainy Season)			pH	Conductivity (Chem)	Total Suspended Solids	Tatal Kjeldahl Nitrogen (TKN)	Total Phosphate	Chemical Oxygen Demand	Dissolved Oxygen	Biochemical Oxygen Demand	Total Coliform
Location	Number	Date		EC μS/cm	TSS mg/L	T-KN mg/L	T-P mg/L	COD mg/L	DO mg/L	BOD mg/L	T-Col cfu/100ml
Nadi	N-d1	30-Nov	8.09	123.7	61.8	0.36	0.72	36	8.5	1.72	7,200
	N-d2	7-Dec	7.47	223.5	62.7	0.2	0.42	N/D	8.36	2.52	5,200
	N-d3	13-Dec	7.88	202.5	103.9	0.18	0.39	N/D	9.08	3.16	86,000
Lautoka Namori	L-d1	30-Nov	7.69	237.4	13.7	0.64	0.8	28	8.44	4.92	360
	L-d2	13-Dec	7.89	211.5	9.8	0.3	0.32	N/D	9.09	3.55	72,000
Ba	Ba-d1	2-Dec	7.34	137.2	23	0.12	0.74	N/D	7.93	3.15	9,800
	Ba-d2	7-Dec	7.48	493	63.2	0.38	0.49	N/D	7.93	3.15	3,400
Tavua	T-d1	6-Dec	7.65	989	14.5	0.31	0.63	N/D	8.91	4.18	2,400
	T-d2	9-Dec	7.48	847.2	15	0.27	0.58	N/D	8.24	3.83	2,400
Rakiraki	R-d1	6-Dec	7.74	333.8	3.5	0.08	0.49	N/D	8.97	1.77	8,200
	R-d2	9-Dec	7.81	322.6	9.4	0.09	0.49	N/D	8.7	3	5,600
Sigatoca	S-d1	8-Dec	7.63	2515	28.5	0.09	0.41	44	8.39	2.46	4,200
	S-d2	14-Dec	7.72	213.6	57.3	0.17	0.66	4	7.78	2.35	10,400
Sigatoca+7km	S+7km-d3	29-Nov	7.57	4200	25.7	0.12	0.74	4	7.11	1.7	68,000

Source: JET

< Rainy Season Survey Results >

- Nadi (N-r1), Lautoka (L-r1), and Ba (Ba-r1) were water quality data immediately after heavy rain (flood), and Nadi (N-r2), Lautoka (L-r2), and Ba (Ba-r2) are water quality about one week after the heavy rain.
- Nadi (N-r2), Lautoka (L-r2), and Ba (Ba-r2) were water quality data taken during intermittent periods of a few~50 mm/day. Therefore Nadi (N-r2), Lautoka (L-r2), and Ba (Ba-r2) are considered representative values.
- The representative value of Sigatoka (S-r2) is considered to be a typical period during the rainy season.
- Tavua and Rakiraki were sampled approximately one week after heavy rainfall exceeding 100 mm, which was taken during a typical rainfall period during the rainy season, with continuous rain ranging from a few~50 mm. Therefore, they can be considered representative values.

Table 3-4.5 List of Water Quality Survey Results (Rainy Season)

Test results(Rainy Season)			pH	Conductivity (Chem)	Total Suspended Solids	Tatal Kjeldahl Nitrogen (TKN)	Total Phosphate	Chemical Oxygen Demand	Dissolved Oxygen	Biochemical Oxygen Demand	Total Coliform
Location	Number	Date		EC μS/cm	TSS mg/L	T-KN mg/L	T-P mg/L	COD mg/L	DO mg/L	BOD mg/L	T-Col cfu/100ml
Nadi	N-r1	8-Feb	7.47	95	450.7	0.38	0.85	36	9.47	2.85	62,000
	N-r2	17-Feb	7.19	248.8	22.5	0.1	0.1	8	8.08	0.95	4,400
Lautoka Namori	L-r1	8-Feb	7.47	118.2	58.6	0.31	0.27	32	8.89	2.79	56,000
	L-r2	17-Feb	7.12	220.1	7.9	0.95	0.1	12	7.84	2.31	56,000
BA	Ba-r1	9-Feb	7.31	84.8	97.3	0.15	0.13	8	9.32	2.43	144,000
	Ba-r2	15-Feb	7.38	113.9	1.4	0.08	0.11	4	8.38	0.64	4,200
Tavua	T-r1	14-Feb	7.44	328.9	7.9	0.26	0.13	40	8.68	1.29	4,600
Rakiraki	R-r1	14-Feb	7.62	299.6	59.4	0.12	0.15	20	8.46	1.19	12,600
Sigatoka	S-r1	10-Feb	7.14	154.6	153.7	0.19	0.09	60	8.66	1.53	4,000
	S-r2	16-Feb	7.48	215.3	0.09	0.11	14.7	16	8.39	0.89	620

Source: JET

3-5 Water Supply, Roads and Other Utility Development Plans

Table 3-5.1 shows other sewerage related development plans, such as water supply and the Fiji Road Authority (hereinafter referred to as "FRA").

Table 3-5.1 Development Plans in Other Sectors

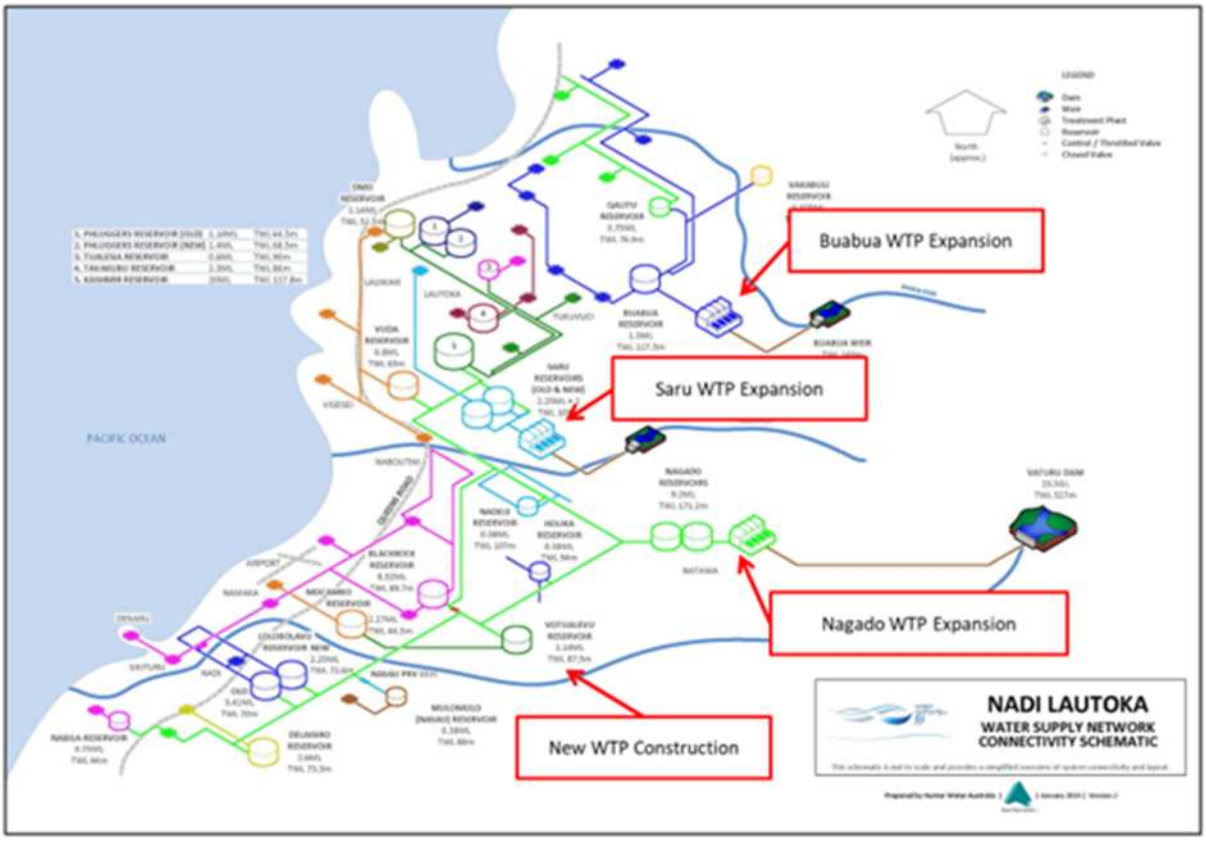
Sector	Organization	Development Plan
Water Supply	Water Authority of Fiji (WAF)	Nadi/Lautoka Regional Water Supply Scheme Master Plan 2013-2033
Roads	Fiji Road Authority (FRA)	Greater Suva Transportation Strategy 2015-2030
Electricity	Energy Fiji Limited (EFL)	Annual Report EFL 2020
iTaukei Land Development	iTaukei Land Trust Board (TLTB)	Regional Land Release Plan for the Greater West and Coastal Region (2019-2039)

Source: JET

(1) Water Authority of Fiji (WAF)

For the water supply sector, the Nadi/Lautoka Regional Water Supply Scheme Master Plan 2013-2033 (hereinafter referred to as "NLWMP33") was prepared by WAF in 2013 and finalized in 2015. However, since some measures were deemed not feasible, NLWMP33 has undergone review in recent years. Currently the draft is awaiting approval of the WAF board of directors, and revised plan has not been published.

In the NLWMP33, a daily average demand of 142.05 ML/day was predicted in 2033, and the result was that it was necessary to expand the capacity of facilities such as water sources and water treatment plants in order to meet increased future demands.

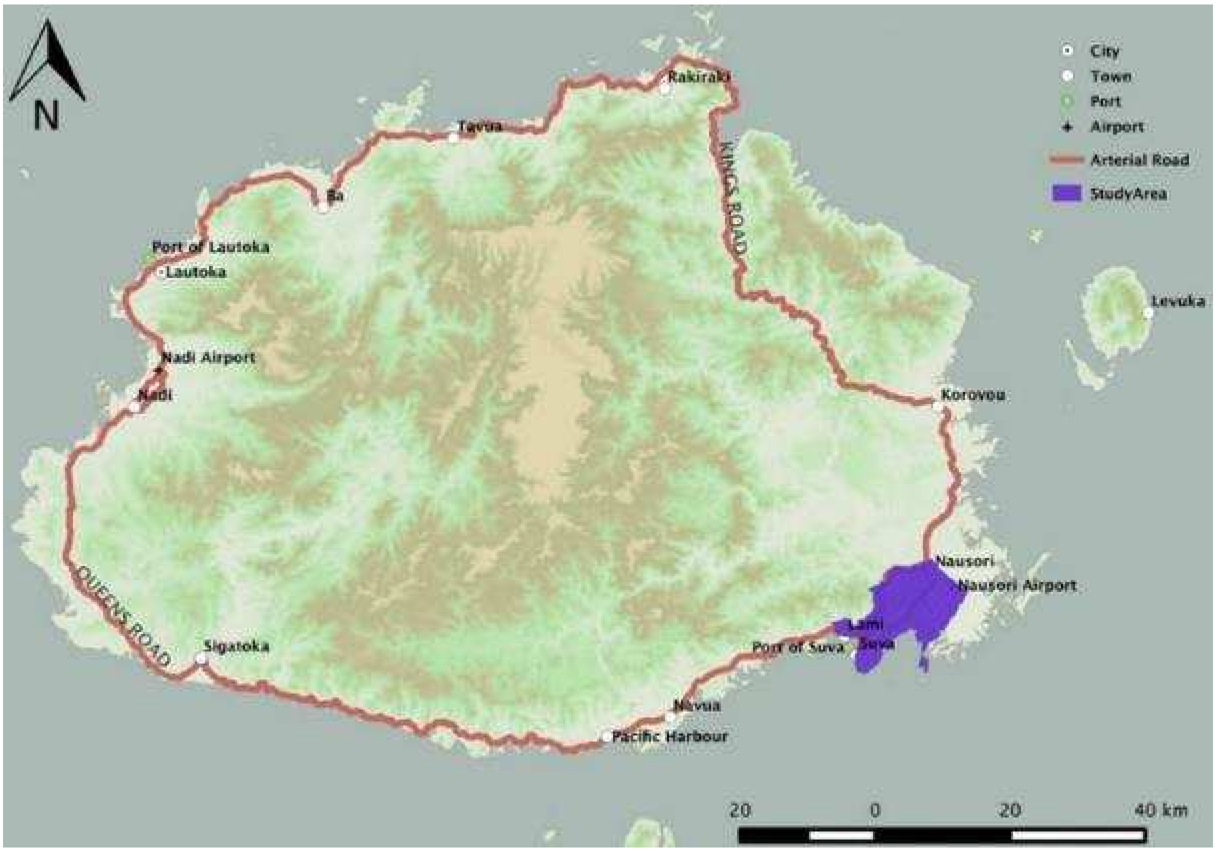


Source: Nadi/Lautoka Regional Water Supply Scheme Master Plan 2013-2033

Figure 3-5.1 Nadi/Lautoka Regional Water Supply Scheme Master Plan

(2) Roads Planning (FRA)

FRA has completed four-lane road on the Nadi-Denarau Island and Suva-Nausori Airport segments and has been working on pavement of the unpaved roads. Currently, a transportation strategy for the Greater Suva region is being formulated, and improvement of dedicated bus lanes and bus terminals is being planned as a measure to cope with the increase in vehicles due to economic growth. A transportation strategy for the Western Division has not yet been formulated.



Source: Greater Suva Transportation Strategy 2015-2030

Figure 3-5.2 Greater Suva Transportation Strategy by FRA

(3) Electric Power Planning (EFL)

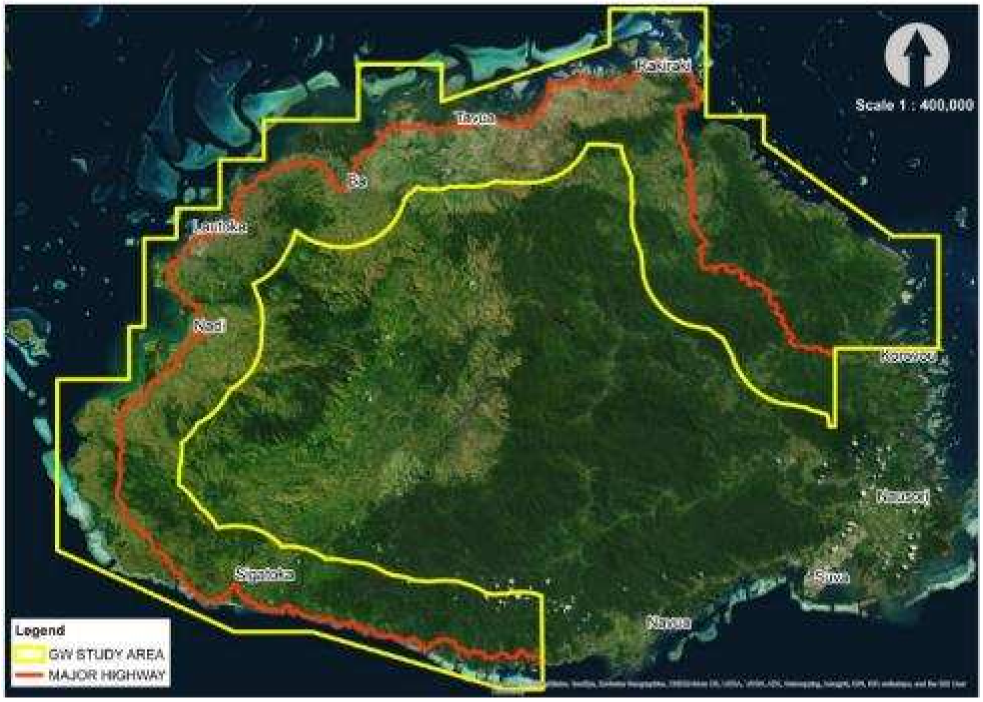
Figure 3-5.3 shows the current transmission network by EFL. The main cities, including six municipalities in the Western Division, are covered by the grid, and 33kV transmission is already developed. The main target is to build 11kV power transmission network for villages in mountainous areas.

Source: Annual Report EFL 2020

Figure 3-5.3 EFL's Transmission and Distribution Network

(4) iTaukei Land Development Plans (TLTB)

iTaukei refers to the indigenous people of Fiji. iTaukei land is the land in Fiji that is owned by them and is managed by the iTaukei Land Trust Board (hereinafter referred to as "TLTB"). The TLTB has formulated the "Regional Land Release Plan for the Greater West and Coastal Region (2019-2039)" (hereinafter referred to as "TLTB GWCR Master Plan"). The plan applies to the area known as the Greater West Coast Region, located along the coastline of the Western Division. The area is 399,334 ha, 76% of which is iTaukei Land.



Source: Regional Land Release Plan for the Greater West and Coastal Region (2019-2039), TLTB

Figure 3-5.4 Target Area of TLTB GWCR Master Plan

The TLTB GWCR Master Plan seeks to promote optimal use and development of iTaukei Land over the next 10~20 years. By coordinating concerned organizations and unifying policies, it seeks to find solutions to issues and needs related to population growth of the area which also keeps a balance between protection of historically/culturally significant lands and natural resources by contributing strategic land development and resource management plan. Policies related to infrastructure that relate directly to this project are summarized below.

Table 3-5.2 Sectors Covered in TLTB GWCR Master Plan

No.	Sectors	No.	Sectors
1	Residential	15	iTaukei Reserve Land
2	Commercial	16	Special Economic Zone
3	Industrial	17	Green Belt
4	Agriculture	18	Forestry
5	Sugar Industry	19	Environment
6	Civic& Community Development	20	Climate
7	Growth centre	21	Infrastructure Development
8	Neighborhood Centre	22	Telecommunication facilities
9	Local Area Planning	23	Land Use
10	Tourism	24	Growth Strategy
11	Housing	25	Rezoning
12	Heritage	26	Compatibility of Different Land Use
13	Open Space and Recreation	27	iTaukei Land Trust Board

Source: Regional Land Release Plan for the Greater West and Coastal Region (2019-2039)

Table 3-5.3 Policies for the Formulation of TLTB GWCR Master Plan Related to Infrastructure

ID1: Ensure the provision of adequate infrastructure to serve new development.
ID2: Seek cost-sharing solutions for the provision of infrastructure improvements to accommodate future growth within the GWCR.
ID3: Ensure that adequate water resources and wastewater treatment capacity are provided to serve the needs of the residents within the GWCR both now and in the future through:
a) Supporting the Water Authority of Fiji Master Plan to expand water facilities and to upgrade and expand wastewater treatment facilities.
b) Prioritize expansion of water and wastewater service in urbanized and peri-urban areas before expanding into rural areas.
c) Protect water resources from encroachment and contamination. This can be accomplished by working closely with WAF and other agencies involved in water quality issues to develop policies and guidelines for development near water resources.
ID4: Ensure a transportation system that efficiently and safely serves the current and future needs of residents within the GWCR through:
ID5: Assure drainage and storm water management through:
a) Ensuring that the drainage reserve is incorporated in all scheme plan proposals that is submitted to the LDVC.
b) The promotion of sustainable drainage system in suitable locations within the GWCR in order to reduce storm water and pollutant discharge.
ID6: The land where any new road project is proposed is to be preserved and protected from other types of development.
ID7: Water and sewerage infrastructure area to be extended to mixed use node sites and other growth areas within the GWCR.

Source: Regional Land Release Plan for the Greater West and Coastal Region (2019-2039)

3-6 Informal Settlements

3-6-1 Land Ownership in Fiji

There are three main type of land ownership in Fiji. The types and relative amounts are shown in **Table 3-6.1**.

- Native/iTaukei land
- Freehold land
- State/Crown land

Table 3-6.1 Land Ownership in Fiji

Type of Land	Percentage
Native Land/ iTaukei Land	83
Freehold Land	10
State Land/Crown Land	7

Source: Department of Town Country Planning

Indigenous people belong to hierarchical village groups or “land ownership units” such as “Tokatoka” (family level), “Matangari” (clan level), “Yabusa” (tribe level), and “Vanua” (federation level). Indigenous land leases are made available through the iTaukei Land Trust Board, the statutory authority that manages all of these lands on behalf of indigenous Fijian landowners. Freehold land can be purchased, transferred, or leased in accordance with the terms of the Land Sale Act. State Land is owned by the state and is managed by the Department of Land (hereinafter referred to as “DOL”) of MOLMR.

3-6-2 Informal Residents

In Fiji, residents who live on indigenous land (iTaukei Land) without having gone through the proper TLTB procedures are classified as informal settlers. This is a common issue in many cities in Fiji. In this M/P, it will be necessary to give consideration to these informal settlers and their residences in consultation with the city/town. The use of indigenous land requires registration with TLTB. People who use the land without having gone through this process are labeled “informal settlers.” In the event of land acquisition, they lose their rights to be compensated for those lands. The acquisition of indigenous land typically requires an agreement between the land user and TLTB to determine appropriate compensation. According to the 2017 census, of the 191,910 households across Fiji, 8,067 (4.2%) are living on indigenous land under the “informal Bakabanua agreement to occupy iTaukei Land.”

Table 3-6.2 List of Informal Settlements in the Western Division

No.	Name	Location	Land Type	Land Area (ha)	No. of Households
1	Valewaquyaya	Ba	iTaukei Land	3.56	38
2	Field 4	Lautoka	iTaukei Land	7.94	88
3	Nabare	Nadi	iTaukei Land	4.53	38
4	Tavela (Korovuto)	Nadi	iTaukei Land	3.99	68
5	Tore	Lautoka	iTaukei Land	3.23	60
6	Lovu	Lautoka	iTaukei Land	8.93	79
7	Delaisaweni	Lautoka	iTaukei Land	9.53	197
8	Tukutora	Lautoka	iTaukei Land	14.5	178
9	Tauvegavega	Ba	iTaukei Land	32.96	366
10	Tomuka	Lautoka	iTaukei Land	24.27	496
11	Ledrusasa	Nadi	iTaukei Land	4.06	76
12	Cuvu	Sigatoka	State Land	24	105
13	Sauyaro (Varavu)	Ba	iTaukei Land	12.63	158
14	Lawaki	Lautoka	iTaukei Land	11.26	137
15	Ulusila (Nadroumai)	Sigatoka	iTaukei Land	7.73	81
16	Vunarewa	Nadi	iTaukei Land	5.08	41
17	Delainamasimasi	Vuda	iTaukei Land	2.02	Survey in progress
18	Lovu & Tore 2	Lautoka	iTaukei Land	19.18	Survey in progress
19	Tukutora 2	Lautoka	iTaukei Land	9.28	Survey in progress
20	Tobabalavu (Tovilavila)	Vuda	iTaukei Land	6.67	Survey in progress

Source: Ministry of Housing

CHAPTER 4 Current Status of Wastewater Sector in the Western Division

4-1 Status of Centralized Treatment Systems

4-1-1 Summary of Centralized Treatment in Fiji

Currently, sewerage works in the Western Division are implemented in Lautoka, Nadi, Ba, and Sigatoka, as shown in **Figure 4-1.1**. The works in these municipalities are outlined in **Table 4-1.1**.

Source: JET

Figure 4-1.1 City and Towns in the Western Division Implementing Wastewater Works

Table 4-1.1 Outlines of Wastewater Works in Municipalities in the Western Division

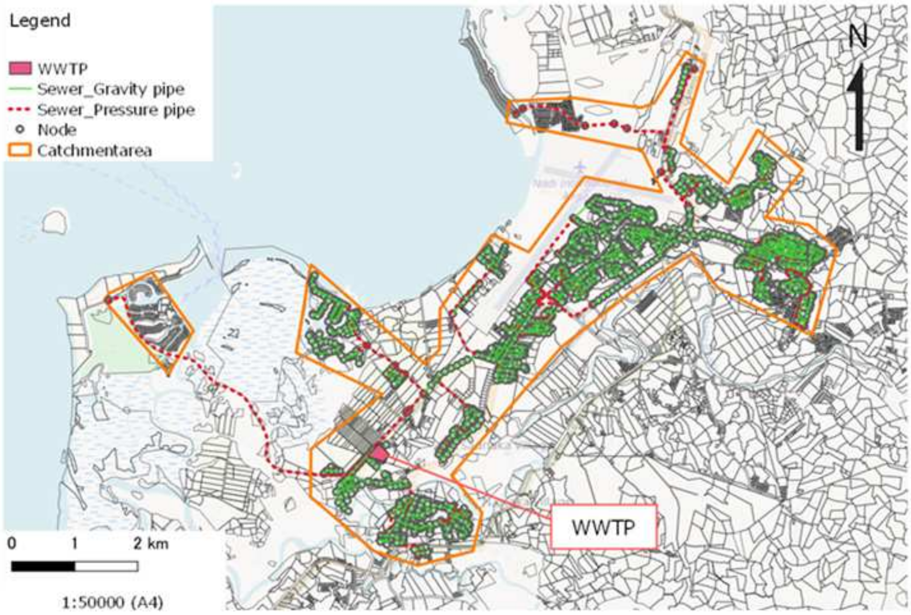
Facility		Nadi	Lautoka	Ba	Sigatoka
Sewer Pipes	Total length (km)	129	80.5	26	16
	Pipe material	Concrete PVC, AC, Clay	DIP, AC, Concrete, PVC	AC, PVC	DIP, AC, PVC
	Pipe diameter (mm)	100~550	150~750	150~375	100~300
Pumping Stations	Number of stations	42	12	8	6
	No. of pumps per station	2~3	2~3	2	2~3
WWTPs	Name	Navakai	Natabua	Votua	Olosara
	Started operation	1974	1983	1996	1986
	Capacity (estimation)	35,000EP ($7,000m^3$/day)	43,000EP ($8,600m^3$/day)	10,000EP ($2,000m^3$/day)	4,000EP ($800m^3$/day)
	Treatment process	IDEA	Stabilization pond	Stabilization pond	Stabilization pond
	Discharge to	Nadi River	Ocean outfall	Water channel	Sigatoka River

Source：JET

4-1-2 Navakai WWTP (Nadi)

(1) Sewer Service Area

The sewer service areas of the Navakai WWTP are shown in **Figure 4-1.2**. According to the 2017 census, the urban and peri-urban population of Nadi is 71,048 and the population per household is assumed to be 4.5 people (**APPENDIX 4-1**). WAF records show that there are 3,525 households connected to the centralized treatment system. The population connected to the sewer network is estimated to be 15,800.



Source: JET

Figure 4-1.2 Sewer Service Area of Nadi

(2) Treatment Facilities

1) Outline of WWTP

Table 4-1.2 Outline of Navakai WWTP

Name	Navakai WWTP
Commencement of operation	1974
Treatment capacity	8,200 m^3/day
Inflow volume	Not measured
Wastewater treatment process	IDEA (Intermittent Decanted Extended Aeration)
Component of facilities	IDEA tank: 2 (1 is currently not operational) Maturation tank: 1 Aerobic digestion tank: 2 Sludge drying bed: 1
Wastewater treatment process	Inflow → Mechanical screen* → IDEA tank → Maturation tank → Discharge
Sludge treatment process	Excess sludge form IDEA tank → Aerobic digestion tank → Drying beds → Dumping site in WWTP
Acceptance of septage	No
Discharging point	Nadi River

*: Currently not operated due to mechanical failure as of May 2022
Source: JET as per hearing survey at WAF

Source: JET

Figure 4-1.3 Layout of Facilities in Navakai WWTP

When it first started operation, the WWTP used the oxidation ditch (hereinafter referred to as “OD”) process for wastewater treatment; however, treatment capacity became insufficient due to increase in influent volume and IDEA process (capacity 10,000 EP) was added in 1997. The operation of the OD treatment facility was discontinued at this time. In 2008, a larger IDEA facility (capacity 25,000 EP) was added due to further increase in influent volume. Operation of the smaller IDEA has now stopped due to age related deterioration and poor maintenance conditions of all four aerators of the IDEA tank.

Although eight aerators are required in the new larger IDEA tank, only six were installed (the reason is not known). Furthermore, five of them became non-operational due to mechanical issues as of December 2021. Later, three units were newly installed, and the tank is currently operated with four aerators. It was found that several aerators became non-operational due to damage from natural disasters such as tropical storms.

Design-wise the excess sludge drawn from the IDEA tank is supposed to be aerobically digested, dewatered by belt-press dewatering machine, sun-dried, and disposed of in the disposal site in the treatment plant. However, as of December 2021, the dewatering machine has been out of order since 2011, and the sludge is directly sun-dried after digestion.

2) Influent and Effluent Quality

The central laboratory of WAF analyzes the water quality of each WWTP once a month. **Table 4-1.3** shows the annual average influent and effluent quality from 2014 to 2021. The influent quality in recent years is believed to be affected by the drastic decrease in the tourist numbers due to the closure of the border in Fiji as a response to COVID-19.

Table 4-1.3 Water Quality of Navakai WWTP

Year	Influent(mg/L)						Effluent(mg/L)					
	T-SS	BOD	COD	T-N	T-P	FOG	T-SS	BOD	COD	T-N	T-P	FOG
Standard							60	40	ー	25	5	5
2014	965	503	934	9.2	3.5	257	80.3	54.9	138	5.4	2.8	51.6
2015	926	355	884	9.2	2.8	187	43.5	41.4	90.8	5.6	2.3	55.3
2016	589	451	1310	12.8	2.3	23.8	54.4	49.2	124	10.9	1.6	10.7
2017	513	317	648	57.9	3.3	16.5	155	84.7	233	32.0	1.5	10.3
2018	447	241	586	47.2	3.2	57.2	122	68.2	176	29.4	2.4	22.8
2020	198.8	143.4	432.6	20.4	7.6	132.8	24.3	20	103.3	15	2.8	35.6
2021	201.5	131.6	287.5	20.6	9	153.9	29.2	31.3	54	20.3	4.3	53.7
Avg.* (~2018)	688	374	873	28	4	109	92	60	153	17	3	31
Avg. (~2021)	549	306	727	26	5	119	73	50	132	17	3	35

*Period unaffected by COVID -19 Pandemic
Source: JET based on WAF data

3) Equipment Failures

There have been no major changes in the state of equipment failure and operation of facilities since 2019 when the Data Collection Survey was conducted. As shown in **Photo 4.1-1**, the aerator, dewatering machine, and mechanical screen are out of order, and the smaller IDEA tank is not in operation.

Aerator

IDEA tank suspended operation

Mechanical screen

Belt-press sludge dewatering machine

Source: JET

Photo 4-1.1 Non-operational Equipment at Navakai WWTP

According to WAF Central and the M/E maintenance team, the following points are considered to be the causes of the failures and are the issues used in formulating the training programs in this project.

- Lack of preventive maintenance of equipment.
- Insufficient technical capacity of staff in maintenance of M/E equipment.
- Lack of maintenance manuals describing maintenance processes from the beginning of installation.
- Poor condition of procurement process of spare parts in Fiji.

4-1-3 Natabua WWTP (Lautoka)

(1) Sewer Service Area

The sewer service areas of the Natabua WWTP are shown in **Figure 4-1.4**. According to the 2017 census, the urban and peri-urban population of Lautoka is 71,573. WAF records show that there are 6,440 households connected to the centralized treatment system. Assuming 4.5 people per household, the population connected to the sewer network is estimated to be 29,000.

Source :JET

Figure 4-1.4 Sewer Service Area of Natabua WWTP

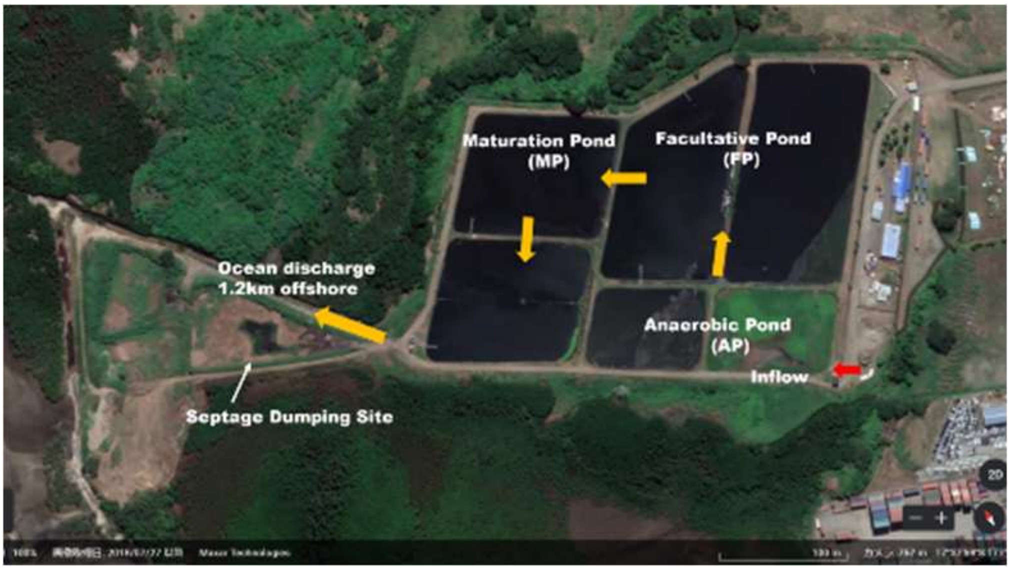
(2) Treatment Facilities

1) Outline of WWTP

Table 4-1.4 Outline of Natabua WWTP

Name	Natabua WWTP
Commencement of operation	1983
Treatment capacity	8,200 m^3/day
Inflow volume at present	Not measured
Wastewater treatment Process	Stabilization pond
Component of facility	Anaerobic pond: 2 Facultative pond: 2 Maturation pond: 2 Septage dump pit: 1
Wastewater treatment process	Inflow → Anaerobic pond → Facultative pond → Maturation pond → Pump facility → Ocean outfall
Sludge treatment process	Dredged sludge* → Mechanical dewatering → Disposal in WWTP site
Acceptance of septage	Accepted in an excavated pond
Discharging point	Ocean outfall (Pumped 1.2 km offshore)

*: Sludge in the ponds was dredged in 2021 for the first time since the commencement of operation.
Source: JST as per hearing survey at WAF



Source: JET

Figure 4-1.5 Layout of Facilities in Natabua WWTP

2) Influent and Effluent Quality

Table 4-1.5 shows the annual average influent and effluent quality from 2014 to 2021.

Table 4-1.5 Water Quality of Natabua WWTP

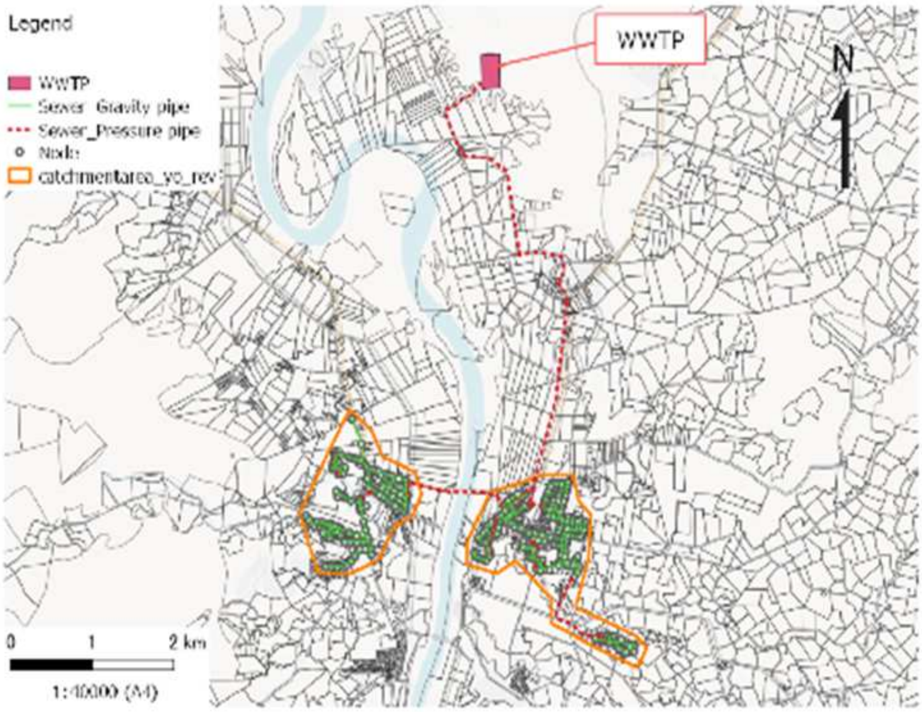
Year	Influent(mg/L)						Effluent(mg/L)					
	T-SS	BOD	COD	T-N	T-P	FOG	T-SS	BOD	COD	T-N	T-P	FOG
Standard							60	40	—	25	5	5
2014	533	318	594	8.4	4.6	236	81.6	64.3	170	4.4	3.4	38.2
2015	482	303	575	10.6	3.7	149	44.2	65.3	125	4.9	2.2	32.7
2016	439	394	828	—	0.6	22.4	52.3	43.6	117	—	0.8	4.2
2017	846	329	603	50.7	3.6	24.4	114	68.6	191	26.0	2.3	7.3
2018	295	207	517	41.3	2.3	71.4	54.8	51.1	140	21.6	1.2	32.3
2020	874.5	217.6	526	19.8	8.1	168.8	58.1	35.7	124.1	14.7	5.7	40.1
2021	425.8	169.5	483.0	21.8	7.0	128.4	57.4	83.4	213.5	1.9	3.9	49
Avg. (~2018)	519	311	624	28	3	101	70	59	149	15	2	23
Avg.* (~2021)	557	277	590	26	5	115	67	59	155	13	3	30

*Period unaffected by COVID -19 Pandemic
Source: JET based on WAF data

4-1-4 Votua WWTP (Ba)

(1) Sewer Service Area

According to the 2017 census, the urban and peri-urban population of Ba is 15,846. WAF records show that there are 709 households connected to the centralized treatment system. Assuming 4.5 people per household, the population connected to the sewer network is estimated to be 3,200.



Source: JET

Figure 4-1.6 Sewer Service Area of Votua WWTP

(2) Treatment Facilities

1) Outline of WWTP

The major features of the Votua WWTP are outlined in **Table 4-1.6**.

Table 4-1.6 Outline of Votua WWTP

Name	Votua WWTP
Commencement of operation	1996
Treatment capacity	1,100 m^3/day
Inflow volume at present	Not measured
Wastewater treatment Process	Stabilization pond
Components of facility	Anaerobic Pond: 2 Facultative Pond: 2 Maturation Pond: 1
Wastewater treatment process	Inflow → Anaerobic pond → Facultative pond → Maturation pond → Discharge
Sludge treatment process	Dredged sludge* → Mechanical dewatering → Disposal in WWTP site
Acceptance of septage	Accepted to anaerobic pond
Discharging point	A channel in mangrove forests flowing near the WWTP

*: Dredging of pond has not been carried out for more than 20 years since the start of operation of WWTP
Source: JST as per hearing survey at WAF

Source: JET

Figure 4-1.7 Layout of Facilities in Votua WWTP

2) Influent and Effluent Quality

Table 4-1.7 shows the annual average influent and effluent quality from 2014 to 2021.

Table 4-1.7 Water Quality of Votua WWTP

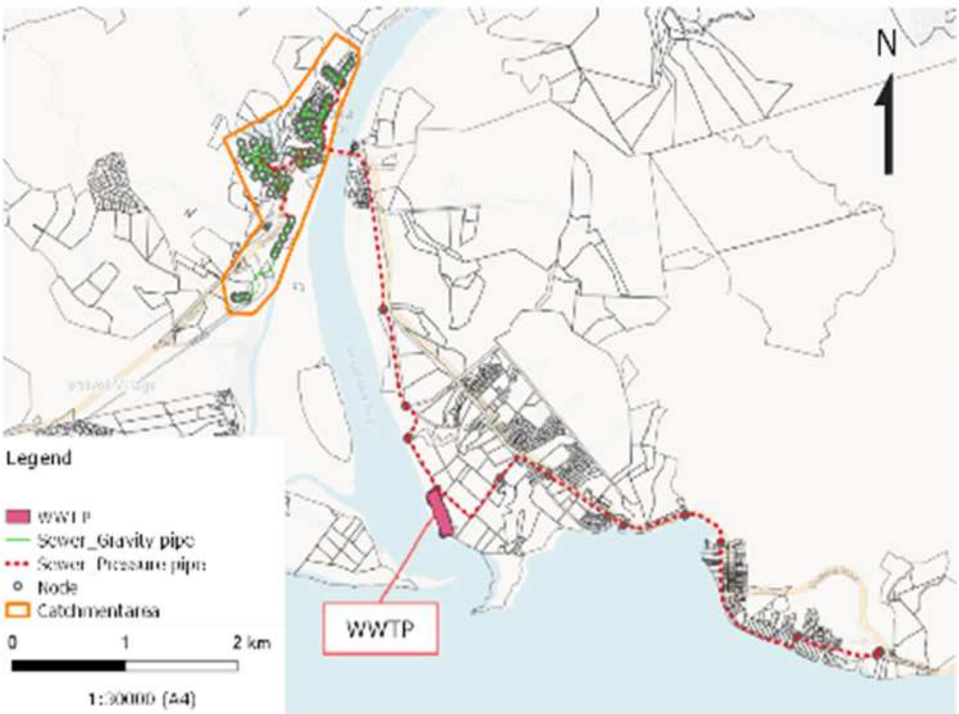
年	Influent (mg/L)						Effluent (mg/L)					
	T-SS	BOD	COD	T-N	T-P	FOG	T-SS	BOD	COD	T-N	T-P	FOG
Stand.							60	40	—	25	5	5
2014	471	290	749	8.5	4.6	172	86.2	40.5	136	5.1	3.4	43.1
2015	543	308	795	7.8	2.5	116	78.1	52.7	156	3.9	1.9	31.8
2016	589	273	909	11.2	2.6	13.7	42.0	49.2	126	9.8	1.7	6.0
2017	2240	285	655	31.7	3.1	22.2	69.9	50.4	138	16.7	2.0	10.5
2018	951	274	667	36.0	2.8	59.2	53.8	52.5	144	14.6	1.9	22.3
2019	126.9	116.4	203.6	24.5	4.8	52.2	46.8	31.6	94.5	10.8	3.0	26.7
2020	184.4	125.8	320.8	22.5	9.1	74.9	46.8	46.0	160.8	9.9	9.0	47.9
2021	133.9	129.6	258.9	20.0	8.9	120.4	69.7	47.2	117.6	8.8	6.4	49.8
Avg.* (~2018)	959	286	755	20	4	77	66	50	140	11	3	23
Avg. (~2021)	655	226	570	21	5	79	62	47	135	10	4	30

*Period unaffected by COVID -19 Pandemic
Source: Created by JET based on the data of WAF

4-1-5 Olosara WWTP (Sigatoka)

(1) Sewer Service Area

According to the 2017 census, the urban and peri-urban population of Sigatoka is 10,509. WAF records show that there are 107 households connected to the centralized treatment system. Assuming 4.5 people per household, the population connected to the sewer network is estimated to be 480.



Source: JET

Figure 4-1.8 Sewer Service area of Olosara WWTP

(2) Treatment Facilities

1) Outline of WWTP

The major features of the Olosara WWTP are outlined in **Table 4-1.8**.

Table 4-1.8 Outline of Olosara WWTP

Name	Olosara WWTP
Commencement of operation	1986
Treatment capacity	2,600 m^3/day
Inflow volume at present	Not measured
Wastewater treatment Process	Stabilization pond
Component of facility	Anaerobic pond: 1 Facultative pond: 1 Maturation pond: 1
Wastewater treatment process	Inflow → Anaerobic pond → Facultative pond → Maturation pond → Discharge
Sludge treatment process	Dredged sludge* → Mechanical dewatering → Disposal in WWTP site
Acceptance of septage	Accepted in anaerobic pond
Discharging point	Sigatoka River flowing near the WWTP

*: Dredging of pond was carried out in 2022 for the first time since the start of operation, which was 30 years ago
Source: JST as per hearing survey at WAF

Source: JET

Figure 4-1.9 Layout of Facilities in Olosara WWTP

2) Influent and Effluent Quality

Table 4-1.9 shows the annual average influent and effluent quality from 2014 to 2021.

Table 4-1.9 Water Quality of Olosara WWTP

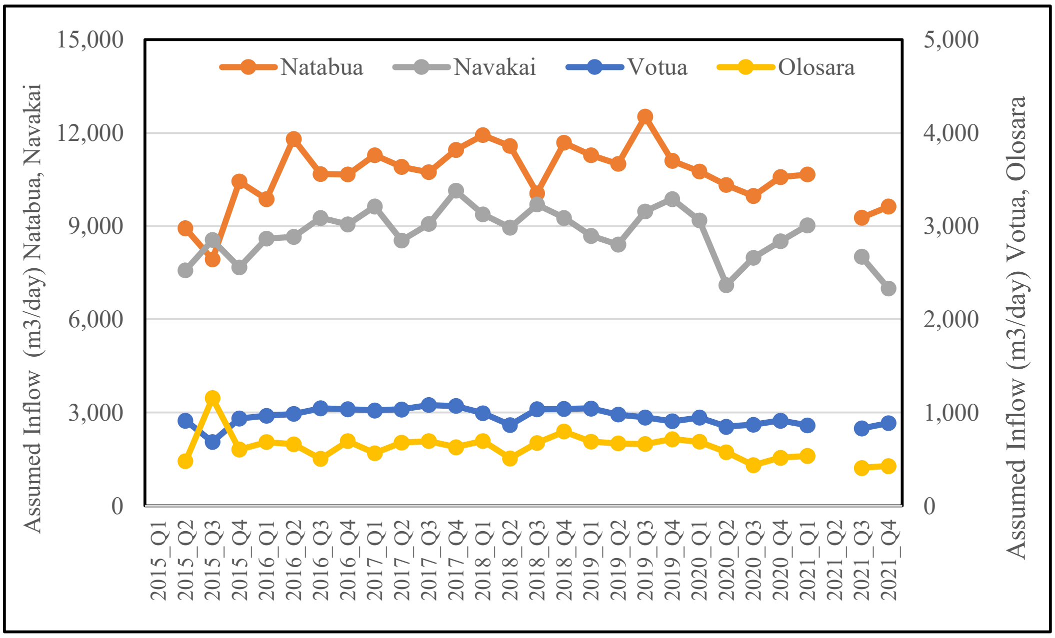
Year	Influent (mg/L)						Effluent (mg/L)					
	T-SS	BOD	COD	T-N	T-P	FOG	T-SS	BOD	COD	T-N	T-P	FOG
Stand.							60	40	—	25	5	5
2014	736	414	1220	9.1	3.4	225	78	57.2	124	4.3	1.7	39.9
2015	347	242	526	9.1	3	68.8	44.8	55.4	157	5.1	2.4	37.3
2016	437	263	550	29.8	2.5	12.4	42	41.2	135	23.5	1	7.3
2017	409	289	583	47.5	4.2	82.1	59.7	40.2	129	17.5	1.5	37
2018	512	374	873	46.4	3.3	71	49.2	54.5	142	19.9	1	18.8
2019	126.9	116.4	203.6	24.5	4.8	52.2	41.9	32.1	92.3	7.8	1.6	17.4
2020	204.9	652.5	376.7	77.9	113.4	147.2	31.8	32.5	140.9	6.5	26.2	70.9
2021	6.2	383.2	19.1	152.6	434.7	114.1	3.9	57.4	1.9	83.4	213.5	49
Avg.* (~2018)	489	317	751	29	4	92	55	50	138	15	2	29
Avg. (~2021)	348	342	544	50	72	97	44	47	116	21	32	35

*Period unaffected by COVID -19 Pandemic
Source: Created by JET based on the data of WAF

4-1-6 Projection of Influent Volume into WWTPs (Reference)

At present, no flow meters are installed at any of the four existing WWTPs. Therefore, the actual influent volume is not known. Influent volumes of each WWTP were estimated by assuming that wastewater volumes were similar to the amount of water consumed by paying customers on the WAF customer list.

Figure 4-1.10 and **Table 4-1.10** summarize the total amount of water consumed in each service area, i.e. the inflow of each WWTP. On average, around 8,800 m^3/day was consumed in the Navakai WWTP service area (Nadi), and around 11,000 m^3/day was consumed in the Natabua WWTP service area (Lautoka). The influent volume of both WWTPs has been declining since 2020, when COVID-19 became prevalent.



Source: JET

Figure 4-1.10 Assumed Inflow to Existing WWTPs

Table 4-1.10 Assumed Inflow to Existing WWTPs

Term	Assumed Inflow (m^3/day)			
	Nadi Navakai	Lautoka Natabua	Ba Votua	Sigatoka Olosara
2015_Q2	7,581	8,928	912	477
2015_Q3	8,557	7,933	686	1,155
2015_Q4	7,678	10,441	935	602
2016_Q1	8,601	9,867	966	684
2016_Q2	8,649	11,805	986	661
2016_Q3	9,265	10,677	1,046	503
2016_Q4	9,054	10,663	1,034	695
2017_Q1	9,632	11,287	1,022	565
2017_Q2	8,541	10,910	1,033	678
2017_Q3	9,066	10,735	1,082	694
2017_Q4	10,141	11,450	1,070	628
2018_Q1	9,380	11,927	994	696
2018_Q2	8,950	11,578	866	509
2018_Q3	9,692	10,062	1,036	675
2018_Q4	9,262	11,687	1,039	797
2019_Q1	8,690	11,287	1,044	690
2019_Q2	8,407	11,001	978	669
2019_Q3	9,478	12,526	948	663
2019_Q4	9,870	11,098	907	714
2020_Q1	9,186	10,765	946	687
2020_Q2	7,103	10,320	849	575
2020_Q3	7,987	9,970	871	435
2020_Q4	8,514	10,578	913	516
2021_Q1	9,026	10,661	862	535
2021_Q2	N/A	N/A	N/A	N/A
2021_Q3	8,015	9,270	829	406
2021_Q4	6,988	9,633	888	426
Average	8,743	10,656	952	628

Source: JET

This estimated influent volume does not include infiltration water, such as leakage of groundwater into the sewer pipes. Infiltration water typically accounts for about 10% of the total influent volume. On the other hand, not all water used by customers reaches the sewer network. For example, water used in watering gardens or washing cars does not directly enter the sewer network. Because Fiji has adopted a separated sewer system, most of this water is carried away in stormwater drains. Considering these competing additive and subtractive factors, the influent volume estimated using the current method is considered to be reasonably accurate.

4-1-7 Plans and Designs Recently Formulated by WAF

Plans and designs recently formulated by WAF are shown in **Table 4-1.11**. The Rakiraki Wastewater Master Plan is an effective sewerage plan that focuses on urban areas with high population densities. However, coordination with NDP is not mentioned. The IDEA process has been recommended for the facility design in all of the plans. This result is considered appropriate since WAF's Kinoya WWTP already adopts the IDEA process.

Table 4-1.11 Recently Formulated Plans and Designs

No.	Plan/Design	Year	Author	Summary
1	Rakiraki Wastewater Master Plan	June 2021	Hunter H2O	Master plan for the entire Rakiraki area.
2	Upgrading of Wastewater Treatment Plant at Natabua, Natabua WWTP Capacity Assessment Report	October 2019	GHD	Quantitative and qualitative analysis of existing treatment facilities and equipment.
3	Votua Wastewater Treatment Plant Site Condition Assessment	February 2020	Hunter H2O	Qualitative analysis of existing treatment facilities and equipment.
4	Olosara Wastewater Treatment Plant Site Condition Assessment	February 2020	Hunter H2O	Qualitative analysis of existing treatment facilities and equipment.
5	Detailed Design for Navakai wastewater treatment plant	2019	Hunter H2O	Improvement plan using IDEA process (the design plan is awaiting approval by WAF executives).
6	Option Assessment for Upgrade Works for Navakai WWTP	2017	WAF	Comparison of alternatives of treatment processes for expansion.
7	Option Assessment for Upgrade Works for Natabua WWTP	2019	WAF	Comparison of alternatives of treatment processes for expansion

Source: JET

4-2 Current Condition of Decentralized Treatment Systems

4-2-1 Domestic (Septic Tanks)

(1) Installation of Sanitation Facilities (Toilets)

Table 4-2.1 to **Table 4-2.3** show the types of sanitation facilities (toilets) and their connection types in the Western Division of Fiji, based on data from the 2017 Census.

Table 4-2.1 Installation (Connection) Conditions of Sanitation Facilities (Toilets)

Toilet Facility (Province Total)	Ba		Nadroga-Navosa		Ra		Western Division	
	Number	%	Number	%	Number	%	Number	%
Flush to piped sewer system	13,712	24.4	499	3.8	81	1.2	14,292	18.7
Flush to septic tank	35,857	63.9	9,284	70.9	4,497	63.9	49,638	65.1
Flush to pit latrine	936	1.7	348	2.7	457	6.5	1,741	2.3
Pit latrine with slab	1,818	3.2	1,333	10.2	786	11.2	3,937	5.2
Pit latrine without slab (open pit)	986	1.8	610	4.7	455	6.5	2,051	2.7
Water sealed	2,365	4.2	913	7.0	565	8.0	3,843	5.0
Shared toiled	388	0.7	69	0.5	178	2.5	635	0.8
Other	50	0.1	33	0.3	15	0.2	98	0.1
Total	56,112	100	13,089	100	7,034	100	76,235	100

Source: Created by JET based on the 2017 Population & Housing Census

Table 4-2.2 Installation (Connection) Conditions of Sanitation Facilities (Toilets) in Urban Areas

Toilet Facility (Urban Area)	Ba		Nadroga-Navosa		Ra		Western Division	
	Number	%	Number	%	Number	%	Number	%
Flush to piped sewer system	13,283	35.4	270	11.0	28	2.0	13,581	32.8
Flush to septic tank	22,622	60.2	2,093	85.4	1,209	86.6	25,924	62.6
Flush to pit latrine	300	0.8	1	0.0	27	1.9	328	0.8
Pit latrine with slab	486	1.3	30	1.2	56	4.0	572	1.4
Pit latrine without slab (open pit)	184	0.5	13	0.5	12	0.9	209	0.5
Water sealed	487	1.3	34	1.4	48	3.4	569	1.4
Shared toiled	198	0.5	9	0.4	13	0.9	220	0.5
Other	15	0.0	2	0.1	3	0.2	20	0.0
Total	37,575	100	2,452	100	1,396	100	41,423	100.0

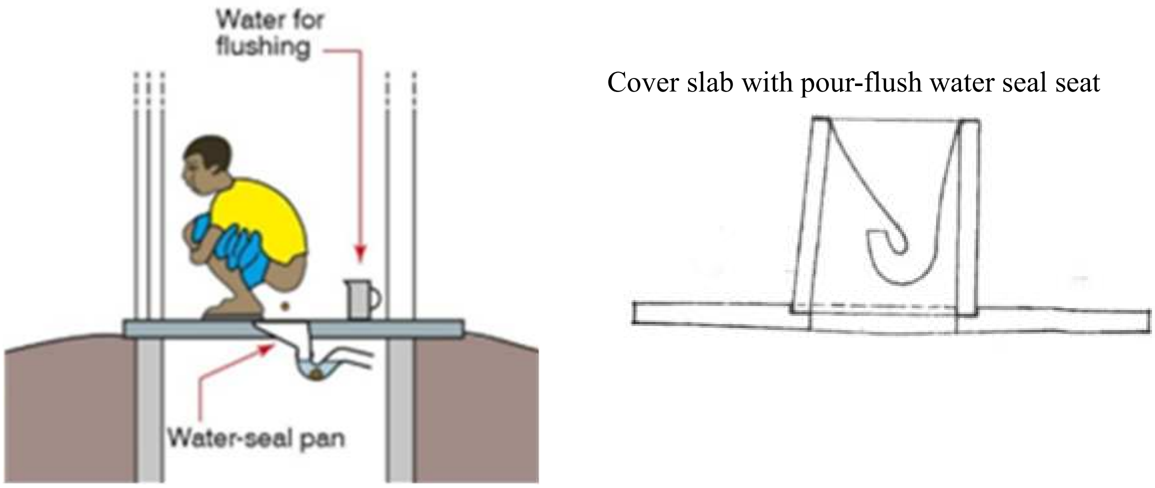
Source: Created by JET based on the 2017 Population & Housing Census

Table 4-2.3 Installation (Connection) Conditions of Sanitation Facilities (Toilets) in Rural Area

Toilet Facility (Rural Area)	Ba		Nadroga-Navosa		Ra		Western Division	
	Number	%	Number	%	Number	%	Number	%
Flush to piped sewer system	429	2.3	229	2.2	53	0.9	711	2.0
Flush to septic tank	13,235	71.4	7,191	67.6	3,288	58.3	23,714	68.1
Flush to pit latrine	636	3.4	347	3.3	430	7.6	1,413	4.1
Pit latrine with slab	1,332	7.2	1,303	12.2	730	12.9	3,365	9.7
Pit latrine without slab (open pit)	802	4.3	597	5.6	443	7.9	1,842	5.3
Water sealed	1,878	10.1	879	8.3	517	9.2	3,274	9.4
Shared toiled	190	1.0	60	0.6	165	2.9	415	1.2
Other	35	0.2	31	0.3	12	0.2	78	0.2
Total	18,537	100	10,637	100	5,638	100	34,812	100.0

Source: Created by JET based on the 2017 Population & Housing Census

According to the Fiji Bureau of Statistics, the data are in units of eating arrangement which is similar to a household. It is possible for several households to occupy a single living space. If a toilet is shared between these households, it is classified as a shared toilet even if a septic tank is used. It should also be noted that the septic tank category may include some systems such as the drum system, which do not meet National Building Code standards. The structure of a water sealed toilet is shown in **Figure 4-2.1**.



Source: Created by JET based on the 2017 Population & Housing Census

Figure 4-2.1 Water Sealed Toilet

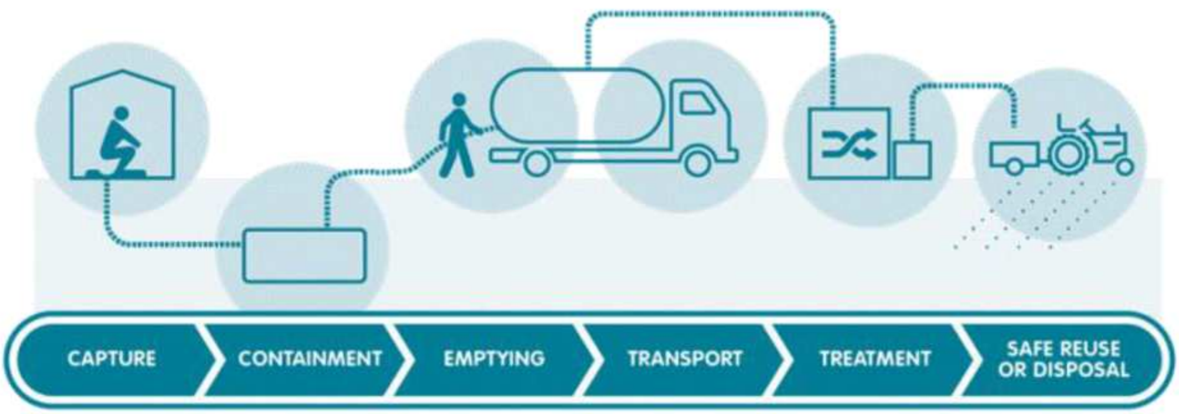
Overall, the "flush to septic tank" type toilet is the most common, accounting for over 60% of the facilities at the provincial, urban, and rural levels. On average, the percentage of the population connected to piped sewerage is less than 20%. Even in Ba Province, where the connection rate is highest, the percentage is less than 25%. WAF operates centralized treatment systems only in urban areas. In urban areas of the Western Division, the percentage connected to piped sewers is 33%. In urban areas of Ba, where the connection rate is highest, the connection rate is still only 35%. WAF does not operate any centralized treatment systems in Ra Province. However, records show that some households are connected to "piped sewer system." There is a possibility that connections to communal septic tanks are counted as "piped sewer system" connections. The interview survey with CBH clarified that "small systems" refer to village-scale systems and these including communal septic tanks and other systems of a similar scale. However, no specific details regarding installation conditions or standards have been revealed.

The data show that pit latrines without slabs (open pits), shared toilets, and other facilities that do not meet indicators defined in "Basic Sanitation Service: Use of improved facilities which are not shared with other households" established by UNICEF and WHO to meet the UN MDG goal of "Safe access to hygienic sanitation facilities" are used by more than 10% of the population, depending on the province.

According to WHO statistics, Fiji's "Population using at least basic sanitation services" is 99.16% (2020). On the other hand, the indicator of SDG 6.2.1a, "Proportion of population using safely managed sanitation services" has not been published as of May 2022. "Safely managed sanitation services" are defined as:

Safely managed sanitation service:
i) People should use improved sanitation facilities which are not shared with other households,
ii) The excreta produced should either be:
- Treated and disposed on-site.
- Stored temporarily and then emptied and transported to treatment off-site.
- Transported through a sewer with wastewater and then treated off-site, and

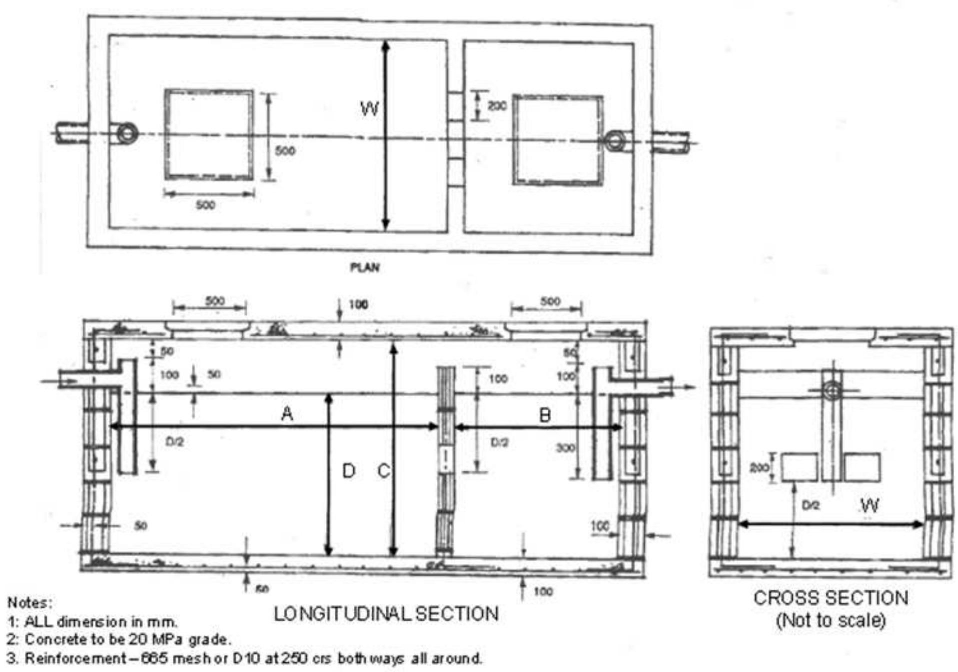
iii) Human waste needs to be safely managed across the entire sanitation service chain.



Source: WASH Discussion Paper - What do safely managed sanitation services mean for UNICEF programmes?

(2) Structure of Sanitation Facilities

The National Building Code stipulates standards for facility layout and structure for “Sanitary Plumbing and Drainage”, “Latrines for areas with no piped water supply”, “Pit latrines (dry and wet types)” and “Septic tanks for domestic use”.



Source : Fiji National Building Code

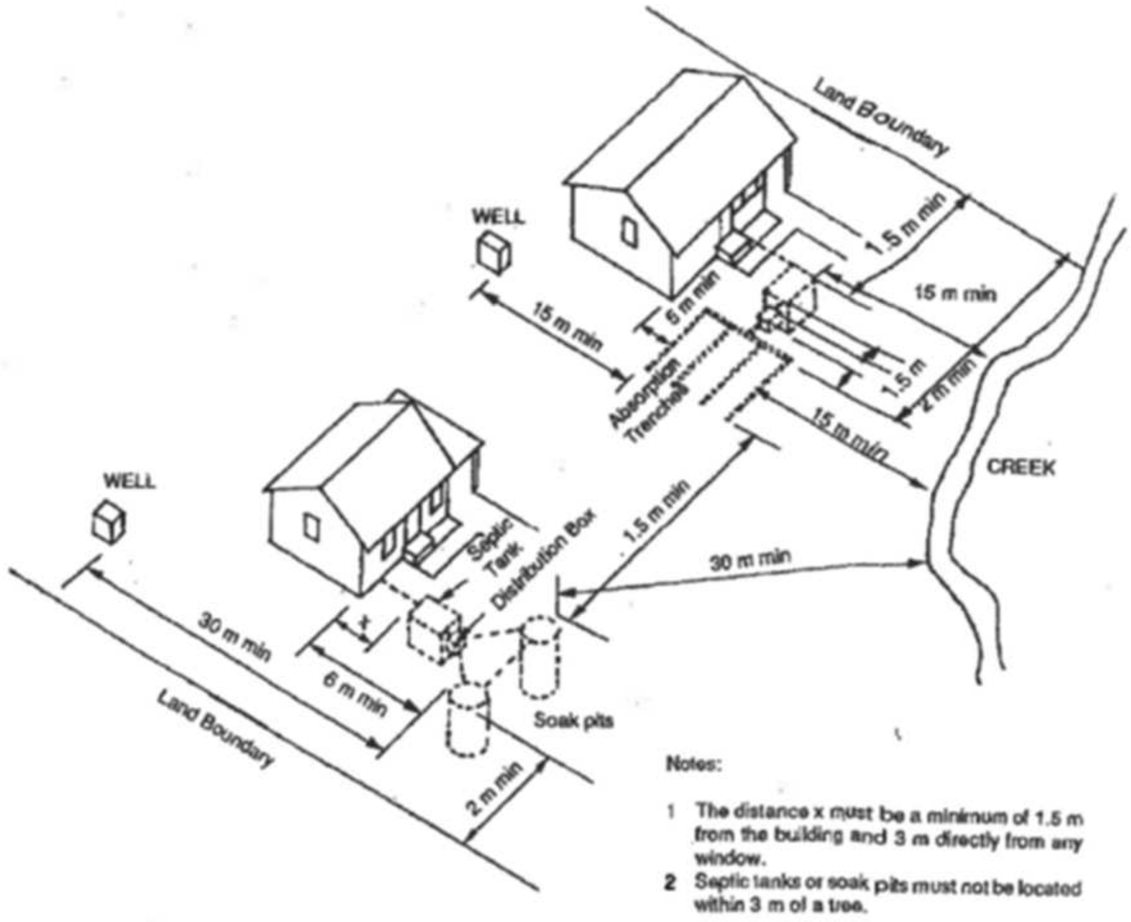
Figure 4-2.2 Standard Drawing of Septic Tank (Fiji National Building Code)

Table 4-2.4 Standard Dimensions of Septic Tanks (Fiji National Building Code)

No. of Person	Only Soil Waste（Black water only）						
	A (mm)	B (mm)	C (mm)	D (mm)	W (mm)	V (m^3)	F (m^3)
8	1000	400	1000	850	800	0.95	0.02
10	1000	600	1000	850	800	1.22	0.02
12	1000	600	1000	850	800	1.22	0.02
15	1000	600	1200	1050	800	1.34	0.03
25	1200	800	1200	1050	1000	2.10	0.05
50	1600	800	1400	1250	1000	3.00	0.06
・・・	・・・	・・・	・・・	・・・	・・・	・・・	・・・
600	4400	2400	2000	1850	2400	30.19	0.61

No. of Person	All Domestic Waste（Blackwater ＋domestic wastewater）						
	A (mm)	B (mm)	C (mm)	D (mm)	W (mm)	V (m^3)	F (m^3)
8	1400	800	1000	850	1000	1.87	0.04
10	1400	800	1200	1050	1000	2.31	0.05
12	1800	800	1200	1050	1000	2.73	0.06
15	1800	800	1200	1050	1200	3.28	0.07
25	2000	1200	1400	1250	1400	5.60	0.11
50	3200	1600	1600	1450	1600	11.14	0.22
・・・	・・・	・・・	・・・	・・・	・・・	・・・	・・・
600	9000	4800	4000	1850	5200	132.76	2.66

V= Volume of Septic Tank (working capacity), F= Volume of Aerobic Filter
Source : Fiji National Building Code



Source：Fiji National Building Code

Figure 4-2.3 Arrangement of Septic Tanks（Fiji National Building Code）

Figure 4-2.3 shows the septic tank installation layout indicated in the National Building Code. In it, a soak pit or absorption trench is provided to help the septic tank effluent permeate into the soil.

For the structure of the septic tank, reinforced concrete or reinforced blocks are generally used. In the case of a block-laid construction, block-laid side walls and baffles are built on a reinforced concrete bottom slab and impermeable lining is applied. The shape of such a tank is generally rectangular but the National Building Code also describes a cylindrical shape with an open top (including stacked cylinders with open ends).

A primary (liquefying) chamber with sufficient capacity to accumulate sludge for a “considerable period” is to be provided, in order to prevent the outflow of sludge and the blockage of permeation functions. Although it is stipulated that the tanks should be managed to maintain a retention time of 24 hours or more, there are no specific guidelines for the frequency of sludge removal (sludge bailing frequency).

The site survey held in April 2022 revealed that the use of drum systems is common in Fiji, which are counted as septic tanks. The drum system consists of two 44-gallon (200 liter) drums connected in series through holes in the top and bottom of the drums. The drums act as a septic tank consisting of two chambers. Drum systems are widely used due to their low cost and ease of installation compared to reinforced concrete tanks. However, they often do not have the capacity required by the National Building Code and lack openings for inspection and sludge removal.

Photo 4-2.1 shows the construction of a typical septic tank. **Photo 4-2.2** shows an example of a drum system. Photo (3) shows an example of a block-laid tank during construction. The example shows the internal baffles being laid before the internal wall lining is installed. This is not the recommended method of constructing a block-laid tank and this photograph is often used to demonstrate suboptimal tank constructions.


(1)


(2)

External appearance of typical Septic Tank

(3)


(4)

Construction of Septic Tank

Source：(1) JET / (2),(3),(4) KoroSan Guideline #3_On-site Household Sanitation Guidelines for Fiji (WASH Koro

Photo 4-2.1 External Appearance and Construction of Septic Tank

In this example, the vertically oriented tank (foreground) will act as the "Primary Chamber." Inspection and bailing of this tank will be possible. However, the horizontally placed "Secondary Tank" (background) cannot be inspected or bailed since there are no access points

Source : https://www.thegreywaterguide.com/

Photo 4-2.2 Construction of Drum System

Septic tanks are used in areas with piped water supply because these areas use water to flush toilets and this water must be treated before being discharged into the environment. For areas without piped water supply, the National Building Code introduces other options such as composting latrines, dry pit latrines, wet pit latrines, biogas digesters, aqua privies, and other methods.

Source: Figures provided by Fiji National Building Code. Photos taken by JET

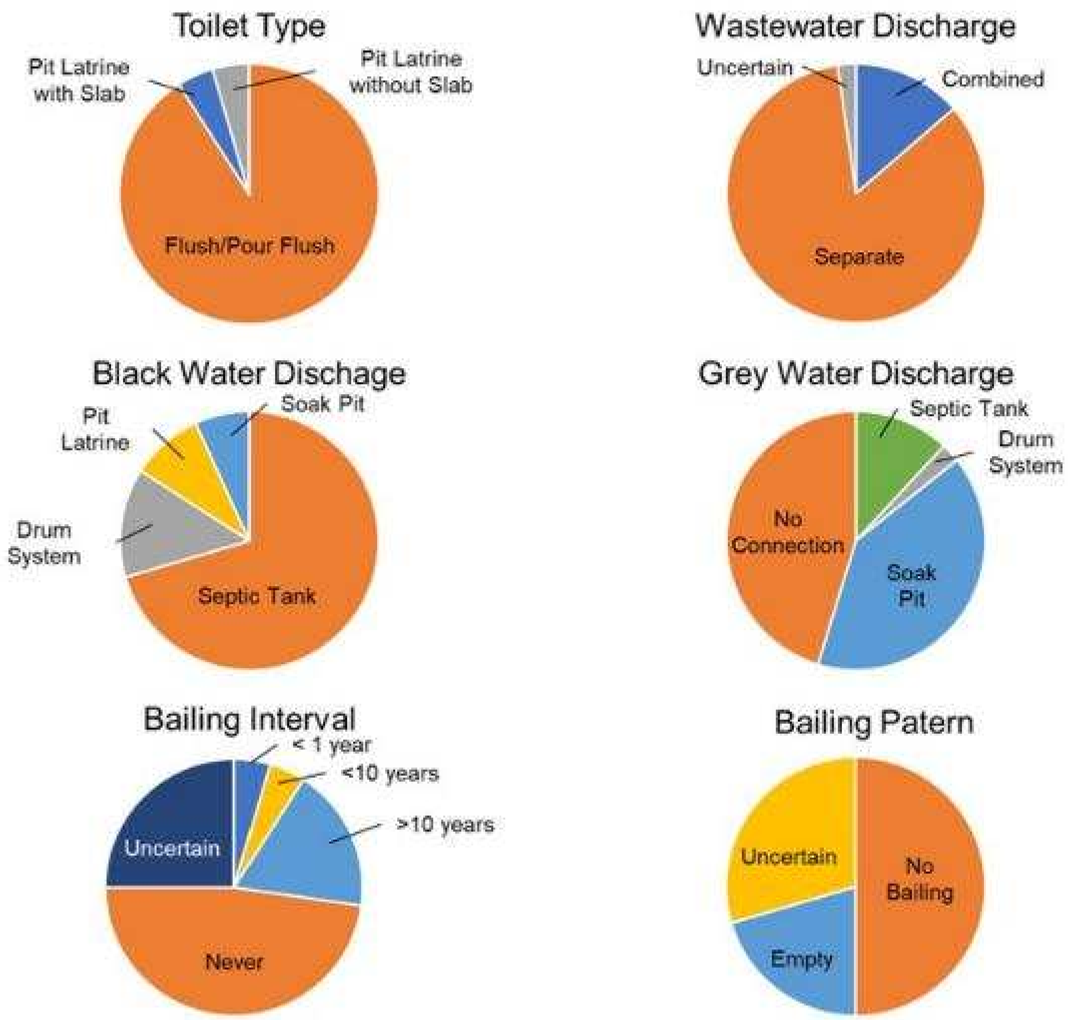
Figure 4-2.4 Pit Latrine

(3) Usage and Maintenance Conditions of Sanitation Facilities

Table 4-2.5 and **Figure 4-2.5** show the outline and results of the survey on the use and maintenance of sanitation facilities in the project area. The survey was conducted with the cooperation of the Building and Health Departments of the Provincial Council and Town Council. Whenever possible, the Building Inspector and Health Inspector accompanied the survey.

Table 4-2.5 Summary of Site Survey

District (Tikina)	Survey Period	Number of Villages / Comunities	Number oHousholds/ Buildings
Rakiraki	2022/4/9 – 13	4	18
Nadi	2022/4/14 – 19	2	12
Sigatoka	2022/4/21 - 23	3	14
Total		9	44



Source ：Created by JET based on information gathered during the interview surveys

Figure 4-2.5 Results of the Interview Survey

The survey was centered around the WAF water service area. Therefore, as **Figure 4-2.5** shows, “flush toilets (including pour flush)” were commonly used. Most of the flushed black water was treated in septic tanks (including drum systems). In most cases, grey water was not combined with black water. Grey water was treated in a separate system, either being permeated into the ground through a soak pit or being drained to the gutters without treatment.

The survey also investigated desludging frequency. When asked how often sludge was removed from their septic tanks, about half of respondents answered “never” followed by “uncertain” and “more than 10 years.” Less than 10% of those surveyed responded that they bail their septic tanks once every 10 years or less. Among them only one restaurant and one store indicated that they bail their septic tank once a year. Of those that responded “once every 10 years or more” most admitted they called the bailer only because of problems such as leaks or overflows. It is suspected that desludging is almost never done in general households.

The survey also inquired about when the septic tanks were installed. Although many responded that they did not know the installation date, those that did know indicated that installation occurred more than 20 years ago. **Photo 4-2.3** shows an example of a block-laid tank in which the outer lining has deteriorated and peeled off. It is also possible that long-term exposure to H_2S gas generated inside the tank’s anaerobic environment has deteriorated the internal lining, reducing the watertightness of the tank. In addition, when a house is built in a low-lying area, groundwater can infiltrate into the septic tank and soak pit, and issues such as the tank itself being submerged due to flooding have been reported.

Source：JET

Photo 4-2.3 Example of Deteriorated Lining

(4) Communal Septic Tank

A project to install communal septic tanks in settlements is underway in Fiji. However, the number of completed tanks, underway projects, or affected users have not been tracked. Installation of communal septic tanks are implemented by the Ministry of Housing and Community (hereinafter referred to as “MHCD”) for the formalization of informal settlements. Projects by NGOs and other donors are also being implemented. In this case, the community writes a request to MIMS, and MIMS finds an aid organization to support the project.

4-2-2 Commercial Facilities (Shops, Hotels, etc.)

Data shown in **Table 4-2.1** through **Table 4-2.3** apply only to sanitation facilities of eating arrangements (households) and do not include hotels, restaurants, and other commercial facilities. Interview surveys were conducted at several restaurants and hotels in Rakiraki, Nadi, and Sigatoka during the site surveys. The findings are summarized in the following sections.

(1) Shops and Restaurants

Interviews were conducted in shops and restaurants in Rakiraki and Sigatoka. In Rakiraki, the Rakiraki Market and Ra Province where the Rakiraki Town Council, Ra Provincial Council, and other offices are located, were surveyed. In Sigatoka, the survey was conducted near the city center where the Town Council and Provincial Council are located. Although the Olosara WWTP is located in Sigatoka, connection of households has been delayed and the survey area also has not been connected. These facilities are multipurpose facilities that are integrated with residences and are included in the results of the field survey of sanitary facilities mentioned in the previous section.

Table 4-2.6 Survey Results from Restaurants and Commercial Facilities

No.	FacilityType	Location	Number of Toilets	Treatment Facility	Number of Treatment Facilities	Greywater Treatment	Bailing Interval
1	Restaurant	Rakiraki	7	Septic Tank	1	Septic Tank	Uncertain
2	Store	Rakiraki	5	Septic Tank	1	No	< 1 year
3	Store	Rakiraki	4	Septic Tank	1	Septic Tank	Never
4	Restaurant	Rakiraki	4	Septic Tank	1	Septic Tank	Uncertain
5	Restaurant	Rakiraki	5	Septic Tank	1	Soak Pit	< 1 year
6	Restaurant	Sigatoka	5	Septic Tank	1	Soak Pit	Uncertain

Source：Interview survey by JET

(2) Hotels

Regarding hotels, interviews were conducted in Rakiraki, Nadi and Sigatoka. In Nadi and Sigatoka, large resort hotels are preferentially connected to the WAF sewerage system. The current survey focused on hotels located just outside the sewerage area. In Rakiraki, one hotel located near the city center and two resort hotels located at the tip of the peninsula were investigated. In addition, the hotel in Sigatoka was selected for the survey because it uses a large tank-type facility that seems to have been manufactured in a factory. However, this could not be confirmed because the engineer in charge was absent at the time of the survey. The hotel in Nadi is a large-scale resort hotel which has its own treatment facility (stabilization pond).

Table 4-2.7 Survey Results from Hotels

No.	Location	Capacity	Treatment Facility	Number of Treatment Facilities	Bailing Interval	Maintenance Cost (FJD/year)	Grease Trap
1	Rakiraki	6 villas	Septic Tank	2	5 years	200	Yes
2	Rakiraki	32 villas	Septic Tank	5	1 year	Uncertain	Partly
3	Rakiraki	43 rooms	Septic Tank	2	3 years	7,200	Yes
4	Nadi	60 rooms 10 villas	Stabilization Pond	1	Never	Uncertain	Yes
5	Sigatoka	20 rooms 5 villas	Septic Tank	1	Uncertain	Uncertain	Uncertain

Source：Interview survey by JET

4-2-3 Hazardous Wastewater (Factories and Hospitals)

When specific business establishments such as factories and hospitals in the sewer service area discharge hazardous wastewater into the sewerage system, the wastewater must comply with the National Liquid Trade Waste (hereinafter referred to as “LTW”) Standards described in the National Liquid Trade Waste Policy. Standards are set for 47 parameters (three of which have no numerical values) such as BOD, COD, heavy metals, and harmful substances. Some of the standard values are shown in **Table 4-2.8**.

Table 4-2.8 Discharge Standard into Sewerage System

Parameter	Standard value（mg/L）
pH	7~10
BOD	600
COD	1,500
SS	600
NH4-N	50
Grease	200
Cyanide（CN）	1
Mercury	0.03
Lead	2
Pesticides	0.01
Phenolic compound	10

Source: Schedule 3 of the Waste Disposal and Recycling Regulations of Fiji (Environment Management (Waste Disposal and Recycling) Regulations, 2007).

When a business establishment outside of the sewer service area discharges its wastewater into the environment, the wastewater must comply with Schedule-3 of the National Liquid Waste Standards of Environment Management (Waste Disposal and Recycling) Regulations 2007. Standard are set for 32 parameters such as BOD, SS, nitrogen, phosphorus, heavy metals, etc. Some of the standard values are shown in **Table 4-2.9**.

Table 4-2.9 National Liquid Waste Standards

Parameter	Standard value （mg/L）
BOD	40
SS	60
T-N	25
NH4-N	10
T-P	5
Grease	5
Cyanide（CN）	0.1
Mercury	0.02
Lead	0.05
Cadmium	0.05

Source: Schedule 3 of the Waste Disposal and Recycling Regulations of Fiji Environment Management (Waste Disposal and Recycling) Regulations, 2007.

When a business establishment installs a wastewater treatment facility in order to comply with the standards, it is necessary to get approval from the Central Board of Health of MHMS under the Public Health Act. It is also necessary to get a construction permit for the installation from the local government. The operation condition of the treatment facility will be monitored by the Department of Environment of MOWE under the Environmental Management Act 2005.

In terms of the disposal of hazardous wastes (including sludge from business establishments) in the Western Division, it was found that the hazardous wastes from hospitals are currently collected and incinerated at Lautoka Hospital.

4-3 Sludge Disposal

4-3-1 Current Status of Sewerage Sludge Disposal

(1) Excess Sludge（generated from Wastewater Treatment Plants）

Table 4-3.1 summarizes the current disposal status of excess sludge and dredged sludge generated from wastewater treatment plants.

Table 4-3.1 Current Status of Generated Sewerage Sludge in the West

WWTP (Municipality)	Treatment Process	Generated Sludge	Treatment/Disposal of Generated Sludge
Navakai (Nadi)	IDEA	Excess sludge	Aerobic digestion → Mechanical dewatering * → Sun drying → On-site disposal
Natabua (Lautoka)	Stabilization Pond	Dredged sludge	(At time of pond-dredging) Mechanical dewatering →On-site Disposal
Votua (Ba)	Stabilization Pond	Dredged sludge	(At time of pond-dredging) Mechanical dewatering →On-site Disposal
Olosara (Sigatoka)	Stabilization Pond	Dredged sludge	(At time of pond-dredging) Mechanical dewatering →On-site Disposal

* Currently not in operation due to breakdown, sludge is directly dried in the sun.
Source：Interview survey by JET

According to the designed plan, the excess sludge generated from the IDEA process at Navakai WWTP is to be aerobically digested, mechanically dewatered, sun-dried, and finally dumped within the plant's premises. In December 2021, it was reported that the sludge dewatering machine had stopped operation due to mechanical failures, and since then sludge is directly sun dried and piled up in a corner of the site for disposal. Since the disposal site lacks rubber linings, it is possible that the sludge flows out to neighboring water bodies due to rain/wind in the rainy seasons.

As for Natabua, Votua, and Olosara WWTP operating stabilization ponds, sludge dredging (which had not been carried out since the start of operation of the facility) was performed at the time of the survey; the dredged sludge was mechanically dewatered by equipment owned by the out-sourced contractor, then dumped within the premises of the WWTP (**Photo 4-3.1**). Similar to the situation in Navakai, the disposal sites are not equipped with rubber lining, and the sludge may eventually flow back into the dredged ponds, or flow into neighboring water bodies.

Source：JET

Photo 4-3.1 Dewatering of Dredged Sludge at Olosara WWTP

WAF is requesting the disposal of sludge at municipal waste dumping sites/landfills in each municipality (ex. Vunato Dumping Site of Lautoka), but due to concerns of heavy metal contamination in sewerage sludge, there are currently no waste disposal sites that accept sludge for disposal. In addition, WAF has made attempts to coordinate with the Department of Environment to secure its own sludge disposal sites, but no progress has been made.

(2) Reference: Prospects for Sludge Treatment and Agricultural Utilization at Kinoya WWTP (Suva)

At Kinoya WWTP in Suva, a portion of the excess sludge was provided to farmers as fertilizer in the past, after going through anaerobic digestion, dewatering, and sun-drying. Currently this activity has been halted, due to the concern of heavy metals and/or other hazardous substances residing in the sludge. Studies are being currently conducted to confirm the levels of heavy metal absorption to crops grown with sewerage-sludge-based fertilizers/soil conditioners.

In 2019, WAF signed a MOU with the Ministry of Agriculture (hereinafter referred to as "MOA") to utilize sewerage sludge as a biosolid resource for agriculture. The MOU was annually updated for 2020~2022; according to WAF's Liquid Trade Waste Team, MOA reported that the sludge component analyses of the Kinoya WWTP sludge showed results that the sludge could be utilized as fertilizers/ soil conditioners.

MOA plans to study various methodologies for fertilizer/soil conditioner production. Field tests using these products are also being conducted, although the experiments have been temporary halted due to some troubles occurring in the sludge treatment system of Kinoya WWTP as of September 2022.

As for WAF, a market sounding survey for sewerage sludge treatment, final disposal acceptance, and utilization was scheduled to commission in June 2022 as part of the ADB project. However, the project was not able to obtain approval from WAF's new CEO, and prospects on its implementation is unknown at this point.

4-3-2 Treatment of Septage/Sludge

(1) Collection of Septage/Sludge

In Fiji, septage/sludge collection (desludging + transport = "bailing") services are provided by private companies. These bailing companies offer services on an "on-call" basis, and there are currently nine companies (with 20 trucks in total) trucking in sludge to WWTPs in the Western Division, all registered with WAF. This includes companies that are based in areas outside the Western Division, as well as companies that specifically bail/transport sludge and liquid waste from private corporations. In Fiji, the Waste Business Permit was abolished in 2018, making it is possible to operate anywhere in the country by obtaining an Environmental Permit under the jurisdiction of the DOE.

Table 4-3.2 Sludge Collection Companies with Bases in the Western Division

Company	Base	Number of Trucks
Waste Bailers	Nadi	1
Honey Dew	Lami	4
Paradise Beverages	Lautoka	1
Waste Clear Fiji Ltd.	Nausori	1
ZAH Environment Waste Solution	Ba	2
Waste Clear West	Lautoka	4
Vinits Transport	?	3
Sudesh Transport Ltd.	Sigatoka	1
Carpenters Carry Clean	Lautoka	3

Source: JET based on WAF data

The following information was obtained from conducting interviews with three of these sludge collection companies. The information that was obtained showed high consistency with other data gathered in the site survey.

- Majority of the customers are commercial facilities and offices. Households rarely request bailing services.
- The capacity of concrete septic tanks installed in residences is 2 to 4 m^3. The drum system is often installed in rural areas. the former is bailed about once every 10 years and the latter once every five years.
- Most septic tanks treat only toilet wastewater. Grey water is discharged nearby without treatment.
- Hotels often have two septic tanks. one for toilet wastewater and another for grey water. Bailing is done once every six months to one year.
- Hotels and restaurants often have grease traps. they are cleaned once every three months. The collected oil and sludge are transported and disposed at the WWTP together along with septage.
- Bailing typically takes about one hour. However, if the sludge has solidified at the bottom, it has to be broken up and bailed, which can take about two hours.
- The cost is determined by the distance from the company’s truck base to the bailing location. The distance of the septic tank etc. from the nearest road, or where the truck is parked, does not affect the cost.
- Bailing removes the entire contents of the septic tank (sludge, scum, and sewerage, which are collectively referred to as “septage”).

(2) Treatment of Septage/Sludge

The septage/sludge collected by these companies is transported to a WWTP operated by WAF for treatment. Of the four WWTPs operated by WAF in the Western Division, the three shown in the table below accept septage. These facilities use the stabilization pond method for treatment. At Votua and Olosara WWTPs, septage/sludge is introduced directly into the anerobic ponds. At Natabua WWTP, the sludge is discharged directly into wetlands adjacent to the WWTP. The sludge input point is a natural wetland with two dumping pits. However, there is no constructed discharge point. The sludge either soaks into the ground or flows out to the ocean.

Table 4-3.3 Condition of Treatment of Septage/Sludge

Facilities that Accept Septage	Treatment Process
Natabua WWTP (Lautoka)	Sludge dumping pit
Votua WWTP (Ba)	Dump to treatment system (stabilization pond)
Olosara WWTP (Sigatoka)	Dump to treatment system (stabilization pond)

Source：JET

Location of Sludge Dumping Pit at Natabua WWTP

Sludge Dumping


Sludge Dumping Pit

Source: Google Maps, JET

Photo 4-3.2 Natabua WWTP (Lautoka)


Sludge Dumping Point

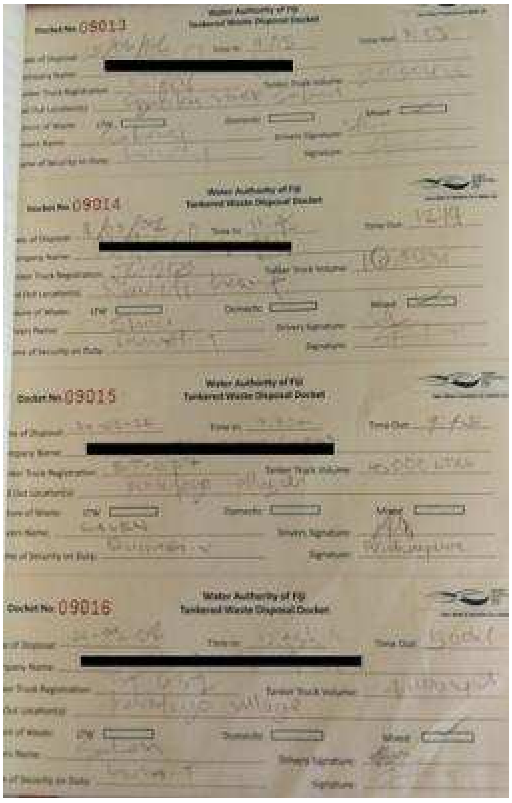

Drying Sludge Dredged from the Stabilization Pond

Source：JET

Photo 4-3.3 Dumping of Septage (Olosara WWTP)

According to the interview surveys with the private sludge collection companies, the vast majority of their customers were commercial facilities and business establishments. This was verified by checking the sludge acceptance records at Natabua and Olosara WWTPs (**Photo 4-3.4**). Based on these records, the monthly number of accepted trucks was organized by their sludge category to formulate the figures following the photo of records. It should be noted that the data used in this analysis are records from year 2019, to omit effects by the COVID-19 pandemic.

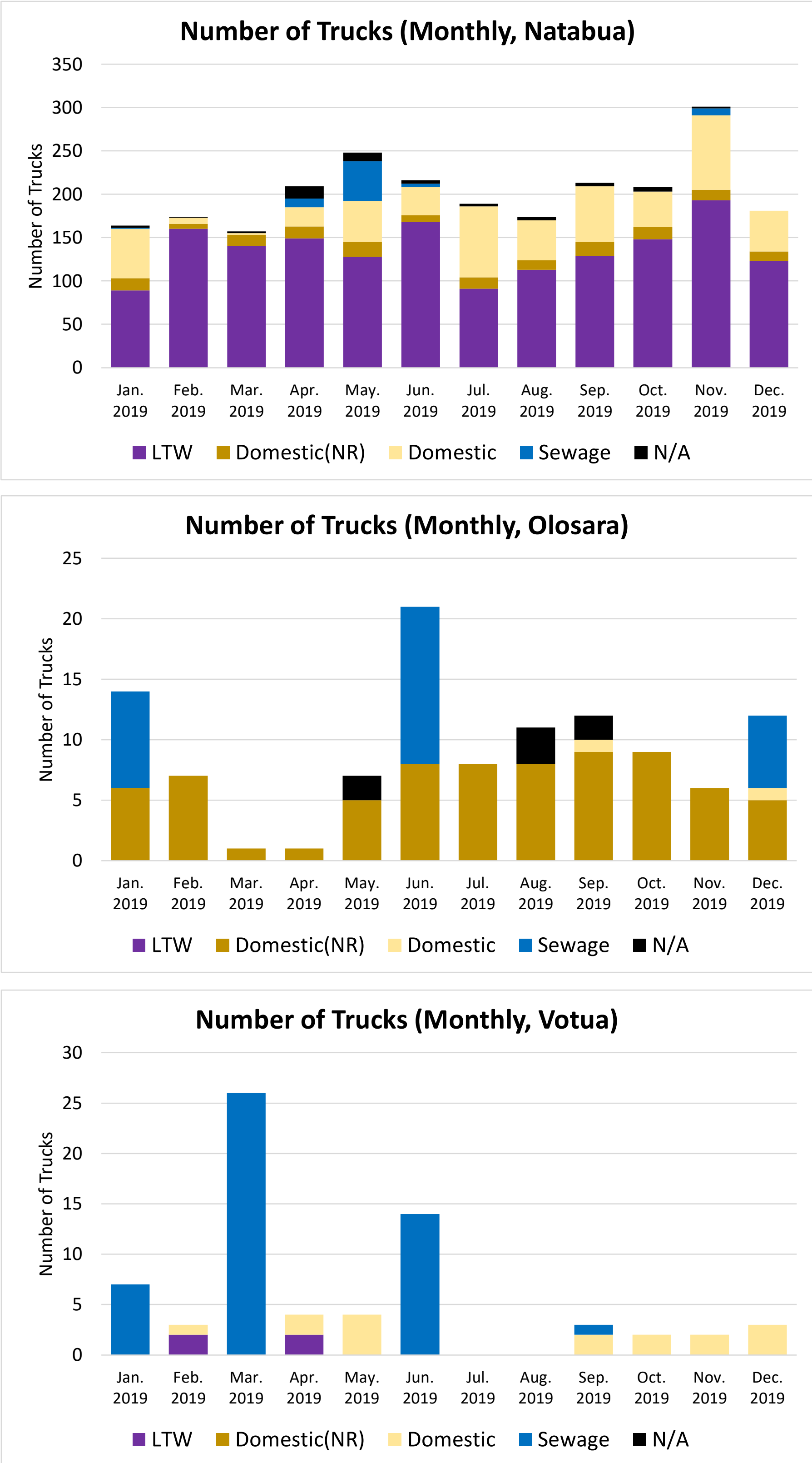
Sludge acceptance records of Natabua WWTP



Sludge acceptance tickets of Olosara WWTP

Source：JET

Photo 4-3.4 Record of Sludge Acceptance



Source: JET based on WAF data

Figure 4-3.1 Sludge Acceptance (Number of Bailing Trucks) at WAF WWTPs

The details of the sludge categories in **Figure 4-3.1** are as follows. It should be noted that the some of the data provided by WAF was incomplete, with confusions in the sludge category, which were supplemented/adjusted by JET.

LTW (Liquid Trade Waste)：Sludge that was produced by commercial/industrial activities of private corporations (industrial sludge)

Domestic (NR)：Domestic (blackwater and greywater) septage produced from Non-Residential sources (commercial and public facilities)

Domestic ：Domestic (blackwater and greywater) septage produced from residential sources (households)

Sewerage：Sludge collected from the cleaning/unclogging of sewer pipes and pumping stations

N/A：Source unknown

Results showed that 150~300 truck-loads worth of sludge is disposed at Natabua WWTP every month, which consists over 50% of LTW (industrial sludge). The remaining sludge is made up of mostly domestic septage, and the percentage of non-residential septage is limited. However, the data provided from WAF did not clearly categorize non-residential septage, and together with the interview surveys conducted with sludge collection companies, a significant portion of the collected sludge is assumed to be produced from non-domestic sources, such as hotels, restaurants, and offices.

The amount of trucked-in sludge at Olosara and Votua WWTP is small, and there is minimal acceptance of LTW to these sites. The percentage of non-residential septage is relatively high at Olosara WWTP, due to the large number of resorts/hotels not connected to WAF sewerage systems in the area. Another characteristic found from the WAF data was where sewerage sludge from a specific pumping station was continuously brought in during a span of few days; this is believed to be a result of WAF's response activities resolving incidents such as the blockage of sewer pipes and/or pumping stations.

Currently at Natabua WWTP, LTW and domestic septage are dumped into a pit which is separated from the plant's wastewater treatment system. However, in order to implement proper and safe treatment of sludge, separate handling (treatment system and tariffs) of domestic and non-domestic sludge should be considered. Ideally, the strengthening of regulations regarding industrial waste, as well as the strengthening of collection and treatment organizational structures is desirable.

(3) Reference: Definition of Liquid Waste and Responsible Agency

In the Environment Management Act 2005, liquid waste is defined as follows. In addition, the above law imposes the obligation on DOE to have the waste management and pollution control unit as management agencies for solid waste treatment and pollution control.

> "Liquid waste" means any discarded or abandoned material which maintains the physical state of continuous volume relatively independent of pressure and which takes the shape of its container at ambient temperature.
>
> Source: Environment Management Act 2005 Part 1 Preliminary [EM2] Interpretation

(1) The Department must have a unit responsible for the waste management and pollution control consisting of the following public officers –
(a) The Waste and Pollution Control Administrator; and
(b) Other public officers

(4) The functions of the unit are-
(a) to administer Part 5 (Waste management and pollution control)

Source: Environment Management Act 2005 Part 1 Preliminary [EM14] Waste management and pollution control unit

Therefore, if sludge from industrial wastewater treatment and grease trap sludge are defined as liquid waste as described above, their treatment and management will be under the control of the DOE following Fiji's laws and regulations. On the other hand, as mentioned above, these industrial sludges are currently collected with septage by private companies and delivered to WWTPs under the jurisdiction of WAF.

4-4 Sewerage Tariffs and Bailing Charges

4-4-1 Sewerage Tariffs Structure

Water and sewerage tariffs are shown in **Table 4-4.1**. The increasing block tariff system is used for household water tariff calculations in Fiji. Flat rates are applied to commercial and governmental water use. Unlike water, flat rates are applied to all users for sewerage tariff calculations. Sewerage rates are significantly lower than water rates.

Table 4-4.1 Water and Sewerage Tariffs

User	Type	Volume	Tariff (FJD/m^3)
Domestic	Water	0 - 50m^3	0.153
		51 - 100m^3	0.439
		100m^3 -	0.838
	Sewerage	Flat rate	0.200
Commercial	Water	Flat rate	1.060
	Sewerage	Flat rate	0.200
Government/ Schools	Water	Flat rate	0.529
	Sewerage	Flat rate	0.200

Source：WAF

4-4-2 Septic Tank Bailing Charges

(1) Bailing Costs

According to the interview survey with the sludge collection companies, bailing charges are determined by the distance from the truck base to the bailing location. The amount of septage collected is not considered in the billing. The customer pays the bailing company directly. **Table 4-4.2** shows the bailing costs reported by a company headquartered in Lautoka, during the interview survey for several areas of the Western Division. The costs shown are general estimates based on past data for collection at the centers of each area.

Table 4-4.2 Bailing Charges According to Interview with Company

Area	Charge for Septage Removal (FJD/Location)
Rakiraki	1,000 - 1,500
Tavua	500 - 600
Ba	300 - 330
Lautoka	200 - 250
Nadi	300 - 330
Sigatoka	500 - 600

Source：JET Interview Survey

A separate company, also headquartered in Lautoka, reported that bailing costs were 200 FJD in Lautoka, and 550 FJD in Rakiraki. These data were verified with customers using this company's services. They reported that although a single bailing request may cost over 1000 FJD, if multiple shops apply for services as a single request the costs are similar to those shown in **Table 4-4.2**. When a bailing company located in Sigatoka was surveyed, they reported that bailing in central Sigatoka would cost about 350 FJD. As can be seen, bailing costs differ greatly between regions. This large difference is a problem that must be overcome.

(2) Sludge Acceptance (Treatment) Tariffs

WAF charges 6 FJD/m^3 to accepted septage/sludge from bailing trucks. The total charge is calculated based on truck capacity and not the actual volume input into the treatment system. The weight of the trucks is not measured. If household septic tanks are 2 m^3, treatment cost would amount to 12 FJD, which is significantly less than what is charged by the sludge collection companies. This may be a factor contributing to the fact that the problem of sludge collection companies illegally dumping septage into waterways was not heard of in Fiji.

4-5 Operation and Maintenance Status of Sewerage Facilities

4-5-1 WWTPs

(1) Sludge treatment/disposal and dredging

Among the four WWTPs in the Western Division, Navakai WWTP (Nadi) adopts the IDEA treatment process which requires somewhat complicated O&M. The remaining three WWTPs adopt the stabilization pond process, with relatively simple O&M and requires little operational input.

The Natabua, Votua, and Olosara WWTPs accept septage/sludge (bailed sludge) generated in the municipal area. In Votua and Olosara WWTPs, the septage is discharged into the anaerobic pond. In Natabua WWTP, it is discharged into a pit located at the wetland within the WWTP site to avoid negative effects on overall wastewater treatment.

Treatment processes for the sewerage sludge generated at each WWTP is as shown in **Table 4-5.1**. In Navakai WWTP, the sludge dewatering machine has been out of order since at least 2019, and sludge is directly sun-dried at sludge drying beds. In Votua, Olosara, and Natabua WWTPs, the sludge accumulated in anaerobic ponds must be dredged at least once every a few years. However, due to budget shortages, dredging has just started in 2020 in Fiji by outsourcing to a New Zealand company. The dredged sludge is mechanically dewatered and landfilled at each WWTP.

Table 4-5.1 Sewerage Sludge Treatment Processes at WWTPs in the Western Division

WWTP	Municipality	Sludge treatment process
Navakai	Nadi	Aerobic digestion→Mechanical dewatering (Currently nonoperational, and directly sun-dried in drying beds instead)→Landfill in WWTP area
Natabua	Lautoka	Dredging of sludge in anaerobic ponds (implemented in 2021, for the first time in since the start of its operation in 1983)
Votua	Ba	Dredging of sludge in anaerobic ponds (No dredging since the start of operation in 1996)
Olosara	Sigatoka	Dredging of sludge in anaerobic ponds (No dredging since the start of operation in 1986. Dredging in planned for 2022)

Source: WAF

(2) O&M

O&M of WWTPs is implemented by WAF directly. Operation and daily checks are implemented in the Navakai WWTP. In the other three WWTPs only daily checks are implemented because there are almost no operation tasks to be performed for stabilization pond facilities.

The maintenance of mechanical and electrical equipment (hereinafter referred to as “M/E equipment”) of all WAF water and sewerage facilities is carried out by the M/E maintenance unit located at the Natabua WWTP (Lautoka). The number of technical officers, water fitters, and technical assistants assigned to WWTPs in the Western Division is as shown in **Table 4-5.2**.

Table 4-5.2 Staff of WWTPs in the Western Division

WWTP	Municipality	Technical Officer	Water Fitter	Technical Assistance
Navakai	Nadi	1	3	3
Natabua	Lautoka	2	2	1
Votua	Ba	1	-	-
Olosara	Sigatoka	2	-	-

Source: WAF

Water quality is also directly analyzed by WAF. WAF’s laboratory in Suva analyses BOD, SS, nitrogen, phosphorus and other items once every month.

(3) Effluent Quality

Table 4-5.3 shows the yearly compliance rate of the effluent standard for BOD (< 40 mg/L) of the existing WWTPs in the Western Division.

Table 4-5.3 Yearly Compliance Rate of BOD Effluent Standard at WWTPs in Western Division

(Units: %)

Year	Navakai (Nadi)	Natabua (Lautoka)	Votua (Ba)	Olosara (Sigatoka)
2014	45.5	16.7	63.6	27.3
2015	57.1	0	50.0	30.0
2016	22.2	40.0	42.9	54.5
2017	18.2	8.3	54.5	58.3
2018	21.4	40.0	27.3	18.2
2019	72.7	63.6	72.7	77.8
2020	88.9	70.0	50.0	80.0
2021	63.6	0	50.0	44.4

Source: WAF

As shown in the table, the compliance rate of Navakai WWTP from 2014 to 2018 was 18.2~57.1%. However, the rate improved to 72.7% in 2019. According to the survey interviews with WAF, this was because influent volume decreased due to the contraction in economic activities brought on by the influences of COVID-19. The treatment effectiveness of the WWTP increased and the effluent quality improved.

If WAF’s hypothesis is correct, it is likely that effluent quality will deteriorate once economic activities recover from COVID-19 and influent volumes increase. Hence, a WWTP with sufficient treatment capacity needs to be planned.

(4) Issues in WWTPs

Table 4-5.4 shows the issues and current status of WWTPs that were clarified in the “Information Collection and Confirmation Survey on Water and Sewerage Sector in Fiji” conducted in 2019.

Table 4-5.4 Issues and Current Status of WWTP Found in the Survey

	Issues	Period	Status
1	Municipal Sewerage M/P	2019	Plan year is old and cannot be used at 4 WWTPs.
		2022	Formulate in the JICA project.
2	Measurement of influent volume	2019	No flowmeter in WWTP, not measurable.
		2022	Flowmeters purchased but not installed, Installation time unknown.
3	Compliance rate of effluent standards	2019	Low compliance rate.
		2022	Partly improved by COVID-19, Proposal of proper treatment processes in the project.
4	Number of aerators (Navakai WWTP)	2019	Installed 4 units although 8 units were planned to be installed.
		2022	Purchased and installed 5 units.
5	Equipment trouble (Navakai WWTP)	2019	No preventive maintenance of equipment, Unable to repair defective equipment due to budget shortage.
		2022	No improvement, Training on preventive maintenance in the project.
6	O&M manuals (Navakai)	2019	No proper O&M manuals and not operated properly.
		2022	No improvement, Training on preparation of O&M manuals in the project.
7	Dredging of sludge in anaerobic pond (Natabua, Votua, Olosara)	2019	No dredging of sludge in anaerobic and facultative pond since the start of operation in 1980s.
		2022	Dredging in Natabua completed and in Olosara under preparation.
8	Improper disposal of septage (Natabua)	2019	Considering the impact on sewerage treatment, the septage received is dumped into a pit at the wetland in the WWTP site, and adverse effects on the environment is concerning.
		2022	No improvement, to be proposed in the JICA project.

Source: JET

4-5-2 Sewer Network

(1) Sewer Networks in the Western Division

Current status of sewer networks in the Western Division is as shown in **Table 4-5.5**. Although separated sewer systems were adopted in the four municipalities, in fact, infiltration/inflow during the rainy season has caused overflow of the pumping stations and complaints from residents. In Nadi and Lautoka, the number of aged pipes has increased year by year because the development of sewer networks started in 1970s to 1980s in those municipalities.

Table 4-5.5 Sewer Networks in the Western Division

Item		Nadi	Lautoka	Ba	Sigatoka
Sewer pipe	Total length (km)	129	80.5	26	16
	Gravity main (km)	32.1	26	14	10
	Pressure main (km)	38.5	34	9	5
	Pipe material	Concrete, PVC, AC, Ceramic	Concrete, DIP, AC, PVC	AC, PVC	DIP, AC, PVC
	Diameter (mm)	100~550	150~750	150~375	100~300
Pumping station	Number	40	12	8	5 (1 under construction)
	Number of pumps (per PS)	2~3	2~3	2	2~3
	Pump capacity (kW)	3~45	1.3~54	4.4~30	1.3~13.5

Source: WAF

(2) Maintenance Works

The sewer network, including pumping stations, are maintained by WAF. The main maintenance task includes clog removal in sewer pipes and pumping station facilities. These are performed based on reports from residents.

When WAF receives a report regarding pipe clogging, the member of the sewer network maintenance team visits the site and (a) tries to remove the clog by using wire drain cleaner. (b) If it cannot be removed by this method, a compressor is used. (c) If it still cannot be removed, the task is outsourced to the private sector and removed using a high-pressure washing machine.

The budget for high pressure washing machines and TV cameras was included in the 2017-2019 Strategic Plan, but they have not been purchased yet. One reason for this might be that there is a belief in WAF that it is cheaper to outsource the sewer network maintenance work to the private sector.

The sewer network maintenance team has prepared a SOP for maintenance work, but it has not been approved by WAF. Therefore, the work is currently implemented based on the experience of the staff. The number of sewer network maintenance staff is as shown in **Table 4-5.6**. They are stationed together with the staff for water supply facility maintenance in the WAF warehouses located in each municipality.

Table 4-5.6 Number of Staff for Sewer Network Maintenance in the Western Division

Municipality	Water fitter	Technical Assistant	Service Technician	Trade Assistant
Nadi	3	3	1	1
Lautoka	2	3	-	-
Ba	4	2	-	-
Sigatoka	1	1	-	-

Source: WAF

(3) Issues in Sewer Network

Issues found in sewer pipes and pumping stations in the Western Division are as shown in **Table 4-5.7**.

Table 4-5.7 Issues in Sewer Networks in the Western Division

	Issue	Status
1	Overflow from pumping stations	Four municipalities adopted the separate sewer system, but infiltration/inflow during the rainy season has caused overflow from the pumping stations and complaints from residents. It is necessary to consider measures against infiltration/inflow and provisional overflow treatment processes.
2	Maintenance works	Since WAF has no high-pressure washing machine, clog removal work has to be outsourced to a private company if they are not able to remove it themselves. This process is inefficient. It will be efficient for WAF to select either to implement the removal work by owning high pressure washing machines, or to outsource the work to private sector from the start,

Source: JET

4-5-3 Maintenance of Mechanical and Electrical Equipment

(1) Maintenance Work

For the most part, M/E equipment of the water and sewerage facilities is maintained by WAF. In the Western Division, the M/E unit shown in **Table 4-5.8** is located at Natabua WWTP site in Lautoka, and oversees maintenance of equipment of the water and sewerage facilities.

According to WAF, an equipment database is not prepared for old equipment, which makes the maintenance works difficult. Due to shortage of personnels and budget, grease and oil of the equipment is not changed. Optimal function of equipment is recovered only by repairing if after a breakdown. Therefore, the unit is demanding the increase in personnels in order to implement preventive maintenance.

The unit is headed by a technical officer, and mechanical fitters and electrical fitters etc. are assigned as shown in **Table 4-5.8**. Both technical officers have higher education in electricity and the other staff were educated at vocational training schools. Many of them have worked in WAF for more than 10 years and have ample experience.

Table 4-5.8 Numbers of Staff in the M/E Unit in the Western Division

Location	Technical officer	Mechanical fitter	Electrical fitter	Technical assistant	Graduate trainer
Natabua WWTP site	2	2	2	1	1

Source: WAF

(2) Issues in M/E Facilities

Issues found in the maintenance of M/E equipment in the Western Division are as shown in **Table 4.5-9**.

Table 4-5.9 Issues in the Maintenance of M/E Equipment in the Western Division

	Issue	Status
1	Database of M/E equipment	Database is not prepared for old equipment, which makes the maintenance works difficult. According to WAF, the new equipment has a database. Database for old equipment should be prepared based on this.
2	Preventive maintenance of equipment	Regular inspection of M/E equipment is not implemented but is repaired after it breaks down. Therefore, machines stop operation suddenly. O&M of WWTP is severely affected because there are no stand-by units. It is necessary to consider the introduction of preventive maintenance and predictive maintenance in the future. In these maintenance procedures, equipment parts are replaced on a regular basis, so it is necessary to fully recognize that the work man-hours and maintenance budget will increase, and to increase the number of staff and secure the budget.

Source: JET

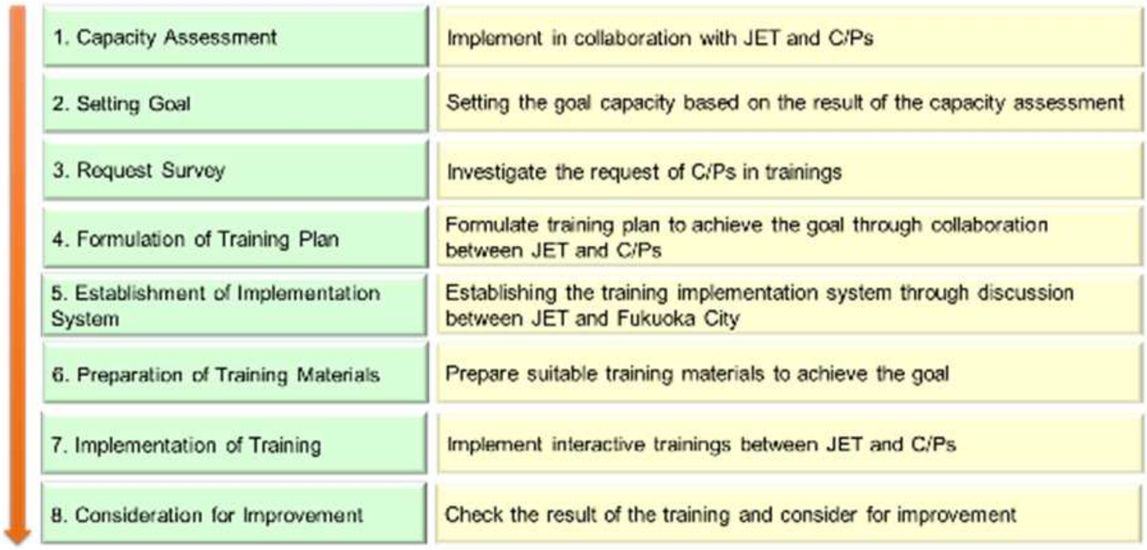
4-6 Organizational Structure and Management Capacity of Sewerage Sector of MIMS/WAF

Output-4 of the Project is "The project implementation system of the Water Authority of Fiji (WAF) and related organizations will be strengthened." To this end, the strengthening of the organizational structure of WAF and the capacity of the sewerage works management including O&M will be implemented in the

Project. Because the organizational structure depends on the scale of WWTP and the sewerage/sludge treatment process etc. which will be considered in the formulation of the Municipal Sewerage M/P.

4-6-1 Strengthening Methods

Output-4 of the project is "The project implementation system of the Water Authority of Fiji (WAF) and related organizations will be strengthened." After determining the target capacity level based on the current level, the activities of capacity development during the three years of the project will be decided by the process shown in **Figure 4-6.1.**



Source: JET

Figure 4-6.1 Process of Capacity Development

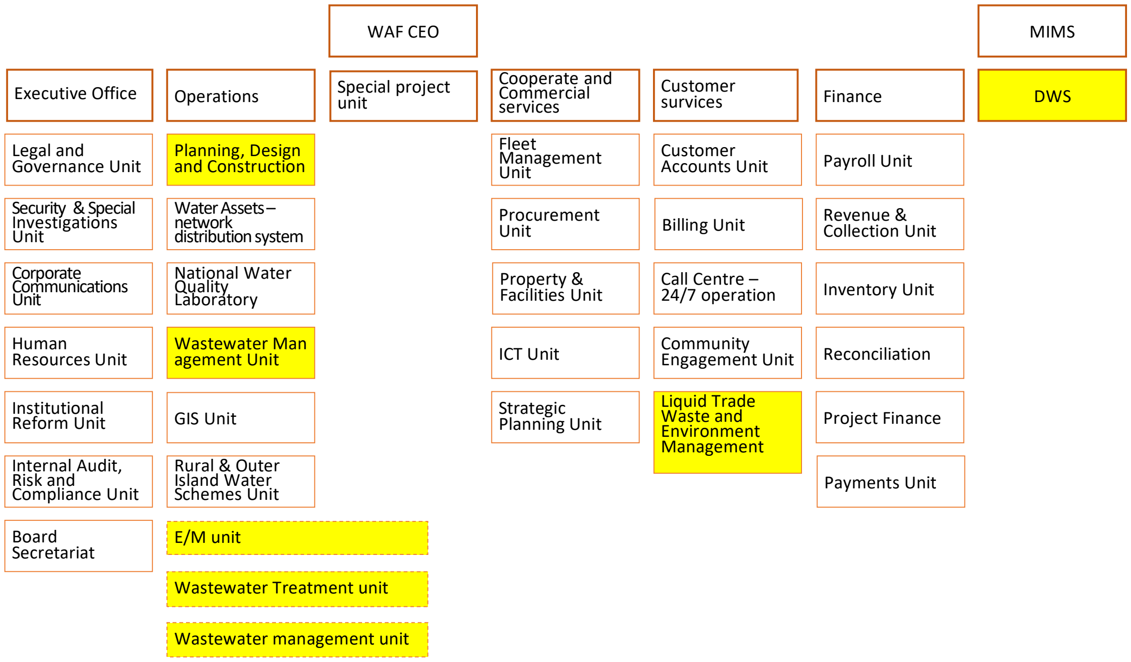
As shown in the figure,

(1) JET and C/Ps collaborate to assess the current capacity.
(2) Set the target capacity at the end of the project based on the result of the assessment.
(3) Conduct a request survey for WAF and DWS.
(4) JET and C/Ps collaborate to formulate training plan to achieve the goal.
(5) Establish a training implementation system to promote training effectively and efficiently through discussion between JET and Fukuoka City.
(6) Prepare appropriate training materials to achieve the goals.
(7) Conduct training using the training materials prepared.
(8) After the training is completed, the results of the training will be evaluated and considered for improvement, which will be used as a reference when the sewerage sector of Fiji continuously conducts training to relevant staff.

4-6-2 Capacity Assessment

(1) Assessment Method

Figure 4-6.2 is the organization chart of MIMS and WAF. The organizational units shown in yellow are related to the sewerage works and capacity assessment was implemented in those units.



*MIMS before organizational restructuring; current Ministry of Public Works, Meteorological Services and Transport (MPW)
Source: JET

Figure 4-6.2 Organizational Units Implemented Capacity Assessment

Table 4-6.1 shows the main tasks of those units.

Table 4-6.1 Main Tasks of Organization Units Implemented the Capacity Assessment

Organization		Unit			Main tasks
1	MIMS*	DWS			Promotion of water supply and sanitation projects in rural areas. Technical evaluation of decentralized treatment facilities.
2	WAF	Operation Department	Planning/Design/Construction		Planning/design of water and sewerage project, Supervision of WAF's own budget projects.
3			WAF Western	Wastewater Treatment	O&M of sewer networks and WWTPs.
4				Mechanical/Electrical	Maintenance of M/E equipment in water and sewerage facilities.
5		Customer Service Department	Liquid Trade Waste Management		Monitoring and guidance of liquid trade waste.

MIMS: before organizational restructuring; current MPW
Source: JET

JET selected the ten parameters shown in **Table 4-6.2** as the capacities required for implementing sewerage works.

Table 4-6.2 Capacity Assessment Parameters

Assessment Parameter	
1	Organizational structure
2	Budget
3	Materials
4	Activities for capacity development
5	Understanding of relevant knowledge
6	Environmental measure
7	Health and safety
8	Implementation of tasks
9	Communication
10	Capacity strengthening measures

Source: JET

(2) Result of Capacity Assessment

The results of the capacity assessment are as follows.

1) DWS

Table 4-6.3 shows the summary of the capacity assessment of DWS.

Table 4-6.3 Capacity Assessment of DWS

Assessment parameter		Result
1	Organizational structure	✧ Four staff are for sewerage works. However, one seat has been vacant. One more member was reduced due to COVID-19.
2	Budget	✧ DWS is in charge of promoting water and sanitation facilities in rural areas. The budget has been reduced due to the austerity caused by the COVID-19, and various plans have been delayed.
3	Materials	✧ DWS does not have an operations division and does not own materials.
4	Activities for CD	✧ No activity has been made for the capacity development (hereinafter referred to as "CD") of staff.
5	Understanding of relevant knowledge	✧ DWS has implemented technical approval for many decentralized treatment processes and has knowledge in that field.
6	Environmental measure	✧ Environmental measures are being implemented under the guidance of MWWE when implementing water and sanitation projects in rural areas.
7	Health and safety	✧ DWS does not have an operation division and does not implement H&S training.
8	Implementation of tasks	✧ Due to lack of budget caused by COVID-19, many projects have been delayed. ✧ DWS is promoting the introduction of the communal septic tank in some villages in rural areas. ✧ There is a trial introduction plan of Johkasou, but the plan is delayed due to COVID-19. ✧ DWS has given technical approval for 11 decentralized treatment processes over the last five years.
9	Communication	✧ DWS provides resident briefing meetings when implementing water and sanitation projects in rural areas.
10	Capacity strengthening measures	✧ DWS has some degree of knowledge and experience in promotion of sanitation in rural areas and in technical approval of decentralized treatment facilities. Therefore, it is appropriate for DWS to strengthen its policy and technical capacities by obtaining information on laws, standards, O&M of the Japanese decentralized treatment process (Johkasou).

Source: JET

2) Planning/Design/Construction

Table 4-6.4 shows the summary of the capacity assessment of the Planning/Design/Construction Unit of WAF.

Table 4-6.4 Capacity Assessment of the Planning/Design/Construction Unit of WAF

Assessment parameter		Result
1	Organizational structure	✧ Currently, the number of staff is 23 of which 12 are upper technical officers such as civil and mechanical engineer, etc. ✧ The number of staff is chronically insufficient. However, due to the impact of COVID-19, the budget was reduced, and the amount of work decreased, so the number of staff appears sufficient currently. ✧ The turnover rate is currently high.
2	Budget	✧ Budget to handle the amount of the current works is secured.
3	Material	✧ The unit does not have an operations division and does not own materials. Staff computers are out of date.
4	Activities for CD	✧ A few staff trainings have been implemented yearly. (Training contents are unknown.)
5	Understanding of relevant knowledge	✧ Especially new staff have low level understanding in related laws and standards. ✧ Knowledge in sewerage planning is insufficient due to lack of experience.
6	Environmental measure	✧ EIA is indispensable in the implementation of sewerage projects and is always carried out. ✧ Resident briefing meetings at the planning stage are held when necessary.
7	Health and safety	✧ In the planning of sewerage project, sufficient attention is paid to safety measures for sewerage facilities. ✧ Safety measures for local residents during construction work are being tackled as an essential item.
8	Implementation of tasks	✧ Sewerage planning/design works are not always carried out with clear goals. ✧ The records of consultations with related organizations are properly prepared and preserved. ✧ Regular meetings have been held with consultants and contractors.
9	Communication	✧ Good relationships are always maintained with relevant organizations.
10	Capacity strengthening measures	✧ According to WAF, many staff lack knowledge because they have no actual experience in sewerage planning. ✧ Therefore, conducting M/P formulation and pre-F/S implementation in collaboration with JET in the project will be a great opportunity for them to obtain experience and expertise.

Source: JET

3) Wastewater Treatment (Sewer Network Maintenance)

Table 4-6.5 shows the summary of the capacity assessment of the sewer network maintenance of WAF Western.

Table 4-6.5 Capacity Assessment of the Sewer Network Maintenance of WAF Western

Assessment parameter		Result
1	Organizational structure	✧ 10 water fitters, nine technical assistants, a service technician and a trade assistant are assigned for sewer network maintenance in WAF Western. Most staff do not have higher education and do not have qualifications. They obtained relevant knowledge by gaining experience in WAF and participating to short-term external training programs. Most have 10 years or more experience in their works. ✧ Due to shortage of staff, only clog removal of sewer pipes is carried out and sewer pipe inspection cannot be implemented.
2	Budget	✧ Due to budget shortage, both personnel and equipment are insufficient.
3	Materials	✧ No TV camera for sewer pipe inspection and jet washer for pipe cleaning. ✧ Own only wire type pipe cleaners, compressors, and vehicles for transportation.
4	Activities for CD	✧ On-site technology has been handed down from seniors to juniors by tacit knowledge. ✧ SOP for on-site works was formulated, but it has not been approved (reason unknown).
5	Understanding of relevant knowledge	✧ Staff have some degree of experience and expertise in sewer network maintenance because they have cleared many pipes, which occurs every day. However, they have no knowledge in pipe inspection by TV camera and pipe cleaning by jet washer because they don't have the equipment.
6	Environmental measure	✧ Staff contribute to the protection of the surrounding environment by prompt cleaning of sewer pipes upon notification from residents.
7	Health and safety	✧ At the maintenance site, traffic cones are set, and traffic control is carried out. ✧ Staff have not received safety training other than confined space training.
8	Implementation of tasks	✧ Prompt cleaning is implemented for removing clogging in sewer pipes and pumping stations. ✧ Some pipe cleaning works must be outsourced to a private company in the Western Division which has jet washers. There is only one such company, so the response is frequently delayed.
9	Communication	✧ Work reports are created although there is no standard format. ✧ WAF has begun to prepare a database of maintenance of sewer pipes and pumping stations.
10	Capacity strengthening measures	✧ WAF has carried out maintenance on many sewer pipe facilities and has a certain level of experience and expertise. Therefore, it will be useful for WAF to get some ideas for improving current maintenance works through learning about the maintenance works carried out in Japan.

Source: JET

4) Wastewater Treatment (O&M of WWTPs)

Table 4-6.6 shows the summary of the capacity assessment of the O&M of WWTPs of WAF Western.

Table 4-6.6 Capacity Assessment of the O&M of WWTPs of WAF Western

Assessment Parameter		Result
1	Organizational structure	✧ Six technical officers, five water fitters, and four technical assistants are assigned for O&M of WWTPs in WAF Western. Since the Votua WWTP in Ba and the Olosara WWTP in Sigatoka are managed by patrol monitoring, only one or two technical staff are assigned. ✧ Most staff do not have higher education and do not have qualifications. They obtained relevant knowledge by gaining experience in WAF and participating to short-term external training programs.
2	Budget	✧ Due to budget shortage, the sludge dewaterer in Navakai WWTP has been out of order without any repair for at least four years. Only five aerators in the IDEA tank, of which there should be eight, are in operation. ✧ Sludge which has settled in the anaerobic ponds of the three WWTPs that use the stabilization pond process has not been dredged out for nearly 30 years due to budget shortage. Typically, dredging is required once every few years. (Sludge dredging in Natabua WWTP was implemented in 2020 and that in Olosara WWTP will start in 2022.)
3	Materials	✧ The minimum equipment and consumables such as chemicals required for O&M are secured.
4	Activities for CD	✧ On-site technology has been handed down from seniors to juniors by tacit knowledge. ✧ Technical training has not been implemented.
5	Understanding of relevant knowledge	✧ Three WWTPs that use the stabilization pond process have very few operational requirements, so little knowledge of wastewater treatment is required. ✧ At Navakai WWTP, the equipment necessary for analyzing activated sludge and DO concentration required for the operation of IDEA is not prepared, and the staff lack knowledge about the operation.
6	Environmental measure	✧ When complaints about odors are received from local residents, deodorant chemicals are dosed to the inlet of WWTP.
7	Health and safety	✧ Staff have not received safety training other than confined space training. ✧ Training is needed because the staff have little knowledge of health and safety.
8	Implementation of tasks	✧ On-site inspections are conducted daily, and operation reports are prepared. ✧ Although the operation conditions such as the aeration and settling time of IDEA tank and the excess sludge withdrawal time have been set, the conditions have not been adjusted according to the effluent quality. ✧ O&M manuals and SOP are not prepared. ✧ Due to various factors such as insufficient oxygen supply due to the failure of the aerator and insufficient removal of sludge due to the failure of the sludge dewaterer, it is difficult to improve effluent quality.
9	Communication	✧ WWTPs respond promptly to complaints from local residents. ✧ O&M condition and equipment troubles are reported to the management level of WAF Western constantly.
10	Capacity strengthening measure	✧ WWTP does not have O&M manuals and SOPs, and staff involved in O&M lack knowledge about wastewater treatment. Therefore, it is necessary to acquire knowledge through technical training and to provide guidance on how to create manuals and SOPs.

Source: JET

5) Mechanical and Electrical Maintenance

Table 4-6.7 shows the summary of the capacity assessment of the M/E maintenance of WAF Western.

Table 4-6.7 Capacity Assessment of the Mechanical and Electrical Maintenance of WAF Western

Assessment parameter		Result
1	Organizational structure	✧ Mechanical and electrical unit has been set up in the WAF Western area to implement maintenance of equipment in water and sewerage facilities. Total of nine staff including two technical officers, two mechanical fitters, and two electrical fitters are assigned. Both of the technical officers have higher education in electricity, but the others studied at vocational training schools. Most of the staff have been in WAF for more than 10 years and have a lot of experience. ✧ Preventive maintenance of equipment is not implemented due to short of personnel. The unit is requesting the increase of staff from nine to sixteen.
2	Budget	✧ Procurement of spare parts necessary for maintenance and repair is delayed or unavailable due to budget shortage.
3	Materials	✧ Due to budget shortage, only the minimum necessary equipment and materials are prepared.
4	Activities for CD	✧ Technology regarding maintenance and repair of equipment has been handed down from seniors to juniors by tacit knowledge. ✧ Technical training has not been implemented.
5	Understanding of relevant knowledge	✧ The technical officer level recognizes the importance of preventive maintenance, but since they have no experience in implementing it, they do not know how to implement it ✧ Staff have repaired pumps and aerators, and it is considered that they have some degree of skill and experience.
6	Environmental measure	✧ No particular measures have been taken.
7	Health and safety	✧ Only confined space safety training has been conducted. No other efforts have been made regarding health and safety in mechanical and electrical works.
8	Implementation of tasks	✧ Corrective maintenance (i.e. response for trouble) of M/E equipment in water and sewerage facilities in WAF Western is implemented. ✧ Database of equipment introduced recently is created. However, it is not prepared for most of the equipment. ✧ Work reports are created although there is no standard format.
9	Communication	✧ No special external communication is required. ✧ The work report is prepared and submitted to the upper level.
10	Capacity strengthening measure	✧ Since the staff have no experience in implementing preventive maintenance, they do not know how to implement it. Therefore, it will be useful to obtain suggestion from the trainings on how to carry out maintenance work of mechanical and electrical equipment in sewerage facilities in Japan.

Source: JET

6) Liquid Trade Waste Management

Table 4-6.8 shows the summary of the capacity assessment of the liquid trade waste (hereinafter referred to as "LTW") management of WAF Western.

Table 4-6.8 Capacity Assessment of the Liquid Trade Waste Management of WAF Western

Assessment parameter		Result
1	Organizational structure	✧ The unit is under the customer service department and has eight staff. Two of them are in charge of the Western Division and are stationed at the WAF Western office in Lautoka to monitor and instruct factories and businesses under its purview.
2	Budget	✧ Due to budget shortage, the wastewater quality monitoring of small-scale businesses, which had been carried out before, has been stopped.
3	Materials	✧ Equipment and materials necessary for sampling of wastewater are available.
4	Activities for CD	✧ No training has been conducted.
5	Understanding of relevant knowledge	✧ The unit provides guidance for high concentration LTW exceeding the discharge standards and has certain degree of experience and expertise. ✧ The unit request to learn about laws, regulations, standards, penal regulations, and actual guidance methods for LTW in Japan through training.
6	Environmental measure	✧ Not especially implemented.
7	Health and safety	✧ Staff have not received safety training other than confined space training.
8	Implementation of tasks	✧ The wastewater from 11 factories (large and medium scale) discharging to the sewerage system in the Western Division is monitored regularly (usually every three months, and high-concentration wastewater is monitored monthly). ✧ The staff of the LTW unit collect water samples at the factory and send it to the WAF laboratory in Suva for water quality analysis. The results are sent to the LTW unit who present it to the factory and provide improvement guidance as necessary. (Currently, the National Liquid Trade Waste Policy's surcharges and penalties have not been approved by the Parliament, so surcharges for high-concentration wastewater cannot be collected and penalties such as suspension of discharge are not imposed.)
9	Communication	✧ Many companies have responded to the improvement of their wastewater through continuous guidance by the LTW unit, and the effect of the guidance is fully demonstrated. ✧ The unit also handles complaints from residents in the vicinity of the factories regarding wastewater.
10	Capacity strengthening measure	✧ The "National Liquid Trade Waste Policy – for Discharges to Wastewater System Owned and Operated by Water Authority of Fiji" was established based on the "Fiji National Liquid Waste Management Strategy and Action Plan" prepared by UN in 2007. As such, the history of LTW management is relatively new. Therefore, the LTW unit staff want information on the laws, standards, and actual regulation methods related to the LTW management in Japan.

Source: JET

(3) Setting Goals

Based on the results of the capacity assessment, discussions were held with the C/Ps, and the target capacities for each sewerage works field at the end of this project were set as shown in **Table 4-6.9**.

Table 4-6.9 Target Capacities at the End of the Project

Field		Target capacity
1	Sewerage works management	✧ Management level of WAF and DWS understands the management policies and processes of sewerage works of Japan through discussions with the Japanese municipality.
2	Planning/Design	✧ Staff in planning/design of WAF understand the formulation procedure of Municipal Sewerage M/P through collaborative works with JET and start to formulate the M/P.
3	Project management	✧ Staff of the special project WAF share information with JET and learn the issues in implementing sewerage projects in foreign countries and use this knowledge as a reference for implementing their own projects.
4	O&M of sewerage facilities	
1)	Maintenance of sewer systems	✧ Sewer network maintenance staff understand the procedures of inspection, cleaning, and repair of the sewer system, and understand how to formulate SOPs for them. ✧ Sewer system maintenance staff recognize the danger of sewer system maintenance work and implement the work safely.
2)	O&M of WWTPs	✧ Operation staff understand the basics of sewerage and sludge treatment technology. ✧ Operation staff understand how to formulate O&M manuals, SOPs and checklists for treatment facilities and start to formulate them. ✧ Operation staff recognize the danger of operation work and implement the work safely.
3)	Maintenance of M/E equipment	✧ Maintenance staff of M/E equipment understand the meaning of preventive maintenance of equipment and how to formulate maintenance plans of equipment. ✧ Maintenance staff of M/E equipment recognize the danger of M/E works and implement the work safely.
5	Liquid trade waste (LTW)	✧ Staff of liquid trade waste unit understand the laws, regulations, and standards of LTW in Japan. ✧ Staff of liquid trade waste unit understand how LTW is regulated in Japan.
6	On-site sanitation	✧ Staff of DWS and planning/design unit of WAF understand the laws, regulations, and standards of on-site sanitation in Japan. ✧ Staff of DWS and planning/design unit of WAF understand the functions and efficiency of on-site sanitation processes.

Source: JET

(4) Request Survey

In consultation with JET and C/Ps, the request from the Fiji side regarding the implementation of the training was confirmed. The results are shown in **Table 4-6.10**.

Table 4-6.10 Request from WAF for Training

	Field	Request
1	Maintenance of sewer systems	➢ Sufficient experience in maintenance of sewer systems. Requested introduction of maintenance of sewer systems in Japan for reference in future work. ➢ WAF has begun to provide safety training for the works in confined space but requested training on a wide range of other health and safety topics.
2	O&M of WWTP	➢ Fitters and Technical Assistants who actually carry out O&M in WWTPs have very limited knowledge about sewerage and requested introduction to basic knowledge about sewerage. ➢ O&M manuals and SOPs are not prepared at WWTPs. Requested guidance on how to prepare them.
3	Maintenance of M/E equipment	➢ All mechanical and electrical equipment is handled by corrective maintenance. ➢ Requested the introduction of preventive maintenance implementation methods in Japan.
4	LTW management	➢ WAF monitors the LTW discharged into the sewer system and provides improvement guidance to factories with high concentration wastewater, but experience and expertise are insufficient. Requested for introduction of LTW regulations in Japan.
5	Procurement	➢ "The Detail Design Survey for the Project for Formulation of Wastewater Treatment Master Plan in Western Division" conducted from 2020 to 2021, found that WAF takes a long time to procure goods, which was considered to be a problem. Since it was proposed to add the procurement issue in the staff training program, the necessity of the training was confirmed again in the request survey. As a result, it was found that WAF recognizes that there are following two reasons for the delay in procurement. i) Most of the procurement goods are imported. Since the market in Fiji is small, domestic agents do not keep large inventory. Therefore, time is required to import items after the need is verified and contracts are made. ii) Although it is possible to make direct contracts with overseas manufacturers, they often do not want to participate in bidding. WAF is considering the following to improve the situation. ➢ Procurement in water supply and sewerage projects by overseas funds is carried out based on the fund's own procurement policy, and no problems have occurred. ➢ Due to the above, no training on procurement is required.
6	Sewerage project management	➢ Regarding project management, "preliminary and actual management", "schedule management" and "procurement management" were proposed as training topics. However, Field (3) above states that procurement management training is not required. Instead, WAF requested the introduction of case studies in other countries regarding "stakeholder management," including coordination with related organizations.

Source: JET

The above requests will be reflected in the training program and training materials developed in this Project.

(5) Training Implementation System

For the CD on the management of sewerage works and O&M of sewerage facilities, it is effective to ask for the cooperation of a Japanese municipality that is actually implementing sewerage works in Japan.

In Fiji, Fukuoka City carried out the "Project to Support Reducing Unaccounted for Water Control on NADI/LAUTOKA Regional Water Supply in Fiji" from 2013 to 2016 as a JICA Partnership Program, and the "Project to Support Strengthening Water Supply Service on NANDI/LAUTOKA Regional" from 2018 to 2022. There is a strong connection between WAF and Fukuoka City. In addition, the Road and Sewerage Bureau of Fukuoka City was a member of the survey team in the "Fiji Western Region Sewerage Master Plan Formulation Project Detailed Plan Formulation Survey" conducted in 2020 and has sufficient knowledge and information about the sewerage works in Fiji. **Table 4-6.11** shows the role-sharing between JET and Fukuoka City in the implementation of the training programs.

Table 4-6.11 Role-sharing between JET and Fukuoka City in the Implementation of Training

Content	JET	Fukuoka City
Expert Subject	Planning/design of sewerage project. Project management.	Management of sewerage works. O&M of sewerage facilities.
Roles	Implementation of training of expert subjects. OJT in Fiji.	Implementation of on-line training of expert subjects. Acceptance of training in Japan.

Source: JET

As shown in the table, Fukuoka City will carry out activities as lecturers in lecture-style training and as an institution that accepts training in Japan.

(6) Formulation of the Training Plan

1) Training Program

Based on the capacity assessment and the request survey, JET repeated discussions with DWS and WAF and prepared the training program (draft) in **Table 4-6.12**.

Table 4-6.12 Training Program (draft)

Training Category		Program		Training Method	Target
1	Sewerage Works Management	Management of Sewerage Works		Info. Sharing	Management level of DWS and WAF
2	Planning/ Design	Planning		Info Sharing OJT	Planning and design staff of WAF (and DWS)
		Sewer Networks Design			
		WWTP Design			
3	Project Management	Budget Management		L&D	WAF Staff related to water and wastewater projects
		Schedule Management			
		Stakeholder Management			
4	O&M of sewerage facilities	Sewerage and Sludge Treatment Technology	Wastewater treatment	L&D	Staff of WAF Western relating to O&M of sewerage works
			Sludge treatment		
			Effluent quality management		
		Maintenance of ME Equipment	Maintenance plan and procedures	L&D	
			Instruction of plan and Procedures	OJT	
		Maintenance of Sewer Networks	Maintenance plan and Procedures	L&D	
			Instruction of plan and Procedures	OJT	
		O&M of WWTP	O&M plan of WWTP	L&D	
			Daily inspection of WWTP	L&D, OJT	
			Water quality analysis	L&D, OJT	
		Health and Safety	Health and safety plan	L&D, OJT	
			Risk management	L&D, OJT	
			Emergency response	L&D, OJT	
5	Liquid Trade Waste	Laws, Regulations		L&D	Staff of Customer Service Department
		Regulation procedures		L&D	
6	On-site sanitation	On-site sanitation system (Johkasou)	Laws, Regulation and Standards	L&D	Management level of DWS (and WAF)
			O&M	L&D	
		Farm village drainage works in Japan	Planning and design	L&D	
			O&M	L&D	

Source: JET

2) Implementation Methods of Trainings

Trainings of each Training Category will be conducted with attention to the items shown in **Table 4-6.13**.

Table 4-6.13 Items to Pay Attention in the Training

Category	Items to pay attention to
1	Sewerage works management training is targeted towards management level of DWS and WAF with reporting on the current state of sewerage works in Japan, transition to corporate accounting, asset management, etc. After that, Japanese and Fijian side will exchange opinions and share information.
2	Planning and design of sewerage works training is mainly targeted towards WAF staff in charge of planning and design. However, DWS staff are also in charge of decentralized treatment projects, so they will be added as necessary. Fukuoka City will provide information on sewerage planning, sewer pipe design, and WWTP design in Japan, and then exchange opinions with the Fiji side to share the information. In M/P formulation and Pre-F/S implementation, JET will collaborate while providing information through OJT to improve capacity.
3	Project management training will be carried out by JET who have experience in project management overseas.
4	O&M of sewerage facilities training is mainly targeted towards WAF staff in charge of O&M of sewerage facilities. Technical knowledge of each program is provided by Fukuoka City and shared by exchanging opinions. JET will support the creation of O&M manuals, SOPs etc. by OJT. Regarding health and safety, JET will give advice on risk management, etc. while conducting on-site safety patrols, and improve the capacity of WAF staff through open discussion and exchange.
5	Regulations for LTW training is mainly targeted towards the staff of the Customer Service Department of WAF and staff of WWTP that receive LTW effluent. Fukuoka City will provide information on laws and regulations related to LTW in Japan, actual regulations and guidance methods, and share knowledge by exchanging opinions.
6	Decentralized treatment system works training is mainly targeted towards staff in DWS that are responsible over the works, but since there is a possibility that WAF will formulate small-scale sewerage projects in the future, staff of WAF in charge of planning and design will also be added. Fukuoka City will provide information on the planning and O&M of the Johkasou projects and the rural agricultural community drainage projects in Japan and will share knowledge by exchanging opinions.

Source: JET

Lectures and exchange of opinions will generally be conducted online. The implementation method is shown in **Table 4-6.14**.

Table 4-6.14 Implementation Method of Online Training

	Implementation items	Person in charge
1	Preparation of lecture materials (Japanese)	Fukuoka City
2	Translation of materials into English	JET
3	Preparation of Fiji side materials (English) (if necessary)	WAF
4	Translation of Fiji side materials into Japanese	JET
5	Lecture (by using English materials)	Fukuoka City, JET
6	Exchange of opinions (by using Japanese interpreter)	Fukuoka City, JET, WAF

Source: JET

3) Training in Japan

A training session in Japan, hosted by Fukuoka City, was held as a part of the CD program. The training will include an introduction to sewerage works of Fukuoka City and discussion sessions with staff during visits to various facilities. Factories that manufacture Johkasou, sludge dewatering machines, and other

Japanese technologies that can be deployed in Fiji were also be visited.

4) JICA knowledge co-creation program

Furthermore, the JICA Knowledge Co-Creation Program (KCCP) is effective due to its intensive nature, and trainees are able to gain perspectives of a wide range of issues and solutions from countries other than Japan and Fiji, which is important for the discovery and learning processes and is expected to be an effective training method. For this reason, training session for the five topics shown in **Table 4-6.15** will be considered in discussion with JICA, C/P organizations and the latest status of KCCP.

Table 4-6.15 JICA Knowledge Co-Creation Programs (KCCP) (draft)

No	JICA KCCP Topics	Scheduled trainees
1	Water Environment Administration	DWS sewerage planning management staff, WAF management staff
2	Operation and Maintenance of Sewerage System	WAF sewerage O&M management staff
3	Sewerage and Urban Drainage Management	DWS, WAF planning and design management staff
4	On-Site Wastewater Treatment System	DWS and WAF C/Ps for this Project, Ministry of Medical Services, Central Health Bureau staff (authority to approve combined sewer systems)
5	Practice of Environmental and Social Considerations for Investment Project Financing	MIMS*, WAF environmental and social considerations staff DOE staff working with ESCs

* MIMS: before organizational restructuring; current MPW
Source: JET

(7) Implementation status of training

In accordance with the training program shown in **Table 4-6.12,** the first training on 20, April 2022 to the second training on 28 July 2024, two on-line trainings were implemented. The outlines of each training results are shown below.

1) The First training "Sewerage Works Management"

The training on sewerage works management was held on 20, April 2022 for the management level staff of DWS and WAF. The outline of the training is as shown in **Table 4-6.16**.

Table 4-6.16 Outline of the Training for Sewerage Works Management

Subject	The 1st On-line Training "Sewerage Works Management"
Date	20, April 2022 10:00-12:00 (JST) 13:00-15:00 (FJT)
Venue	WAF Central, WAF West, WAF North, DWS, Fukuoka City, JICA Global Environment Department
Participants	DWS 2, WAF 25, JICA Global Environment Department 2, JICA Fiji Office 2, JET 3
Agenda	1.Opening remarks (JICA Global Environment Department, WAF, Road and Sewerage Department of Fukuoka City) 2. Explanation of training implementation method Source: JET 3. Sewerage works management in Japan (Fukuoka City) 4. Sewerage works management in Fiji (WAF) 5. Discussion 6. Closing remarks (WAF)
Outline	This training program was conducted in collaboration with WAF and the Road and Sewerage Department of Fukuoka City. The topic of the first training was "Sewerage works management." 1. Sewerage works management in Japan (Fukuoka City) ✧ Introduction of the history and relevant laws of sewerage works in Japan ✧ Introduction of the effective methods for reduction of expenditure and increase of revenue to solve the issues of sewerage works 2. Sewerage works management in Fiji (WAF) ✧ Introduction of the history of WAF, and the outline of sewerage facilities pipes managed by WAF ✧ Introduction of the current situation/issues and the measures planned by WAF
Discussion	1. Infiltration/inflow ✧ WAF is implementing a 5-year project for mitigation of infiltration/inflow from June 2021. Through the training, Fukuoka City will share with WAF their knowledge regarding infiltration/inflow in rainy weather. 2. Training for health/safety and emergency response ✧ Fukuoka City will provide training on health/safety and emergency response regarding the aged pipe collapse that occur frequently in Fiji for targeting staff of WAF and general public. 3. Initiatives for Climate Resilience ✧ Climate change resilience has begun to be considered in the design of sewerage facilities, etc. throughout Fiji, including WAF. ✧ In Japan, the urban inundation measure plan by sewerage has been revised to a plan that takes into account the effects of climate change, and the national guidelines have been revised to promote planned advance disaster prevention. 4. Sludge treatment plan ✧ In Fiji, there is no standard for final disposal and utilization of sludge. Some examples of utilization of sewerage sludge in Fukuoka City were introduced.

Source: JET

2) The second training “Sewerage Planning and design”, “Sewerage Treatment Plant Design”

On 19, July 2022, the training on "Sewerage Planning" and "Sewer Pipe Design" was held, but due to an occurrence of a collapsed sewer pipe, staff in charge attended to deal with the trouble, and participants of the training were small, so the training was held again on July 27.

And on 28, July, training on "Sewerage Treatment Plant Design (Mechanical), (Electrical), (Civil)" was held. The outline is shown in **Table 4-6.17** and **Table 4-6.18**.

Table 4-6.17 Outline. of the Training on Sewerage Planning and Sewer Pipe Design

Subject	The second on-line training “Sewerage planning and sewer pipe design
Date	19, July 2022 10:00-12:30（JST）、13:00-15:30 (FJT) 27, July 2022 14:00-16:45（FJT）Retraining (due to small number of participants on 19th caused by attending to sewer pipe trouble)
Venue	WAF Central, WAF West, Fukuoka City, (retraining wad by JET)
Participants	WAF staff in charge of planning/design
Agenda	1. Sewerage Planning (Fukuoka City) 2. Sewer Pipe Design (Fukuoka City) 3. WAF Wastewater Project Updates (WAF)
Contents	1. Sewerage planning *Introduction to basic knowledge about sewerage in Japan *Outline of sewerage planning *Formulation of master plan 2. Sewer pipe design *Setting conditions for sewer pipe design *Things to consider in design *Manholes *Selecting construction methods 3. WAF Wastewater Project Updates (WAF) *Current status of WAF sewerage projects *Introduction to various rules and standards in WAF *Introduction to flagship projects (capital investment) *Capital investment track record *Implementation of planning and design *Planning and design/on-site issues
Q&A	Main questions from WAF 1. Sewerage planning *How to calculate the planned sewerage volume *How to measure the actual inflow sewerage volume *How to calculate the tourism wastewater volume *Funding sources for storm water management in Japan 2. Sewerage pipeline design *Current status of pressure pipe usage in Japan *Infiltration condition of storm water in Japan 3. Main questions from Fukuoka City *Current status of training in Fiji *Position of the M/P to be formulated in this project *Securing a budget to realize the M/P

Source: JET

Table 4-6.18 Outline of the Training on Sewerage Treatment Plant Design(Mechanical), (Electrical), (Civil)

Subject	The second on-line training "Sewerage Treatment Plant Design (Mechanical), (Electrical), (Civil)"
Date	28, July 2022 10:00-13:00（JST）、 13:00-16:00 (FJT)
Venue	WAF Central, WAF West, Fukuoka City
participants	WAF staff in charge of planning and design
Agenda	1. Sewerage design and supervision/mechanical (Fukuoka City) 2. Sewerage design and supervision/electrical (Fukuoka City) 3. Sewerage design and supervision/civil works (Fukuoka City)
Contents	1. Sewerage design and supervision/mechanical *Sewerage treatment process *Machinery and equipment for each facility in a WWTP 2. Sewerage design and supervision/electrical *Configuration and overview of electrical equipment *Electrical equipment for each facility in a WWTP *Introduction to FORViS (remote monitoring system) in Fukuoka City 3. Sewerage design and supervision/civil works *Role and structure of sewerage system *Setting planned sewerage volume *Configuration of pumping station *WWTP
Q&A	Main questions from Fiji regarding the lecture 1. Mechanical *Treatment processes of collected sludge in Japan *Use of pretreatment in the disinfection process of treated wastewater *Types of sludge dewatering machines in Japan *Odor control measures at WWTPs *Sludge incineration temperature *Using digestion gas for incineration *Removal of harmful components from digestion gas 2. Electrical *Contents of the FORViS system *Receiving voltage at WWTPs in Japan *Capacity of emergency power generation equipment 3. Civil engineering *Consideration of infiltration water in pump station design *Methods for improving the sedimentation efficiency of the primary sedimentation tank *How to set the sodium hypochlorite dosage

Source: JET

4-7 Financial Status of WAF

4-7-1 Government Budget for WAF

Budget to WAF is stated in the **Table 4-7.1** below. The government budgets operating funds and capital investment funds and puts them into WAF every year. Sales revenue to customer is not the financial resource for business operations in both the water supply and wastewater businesses, but the government budget is the basis for WAF business operations.

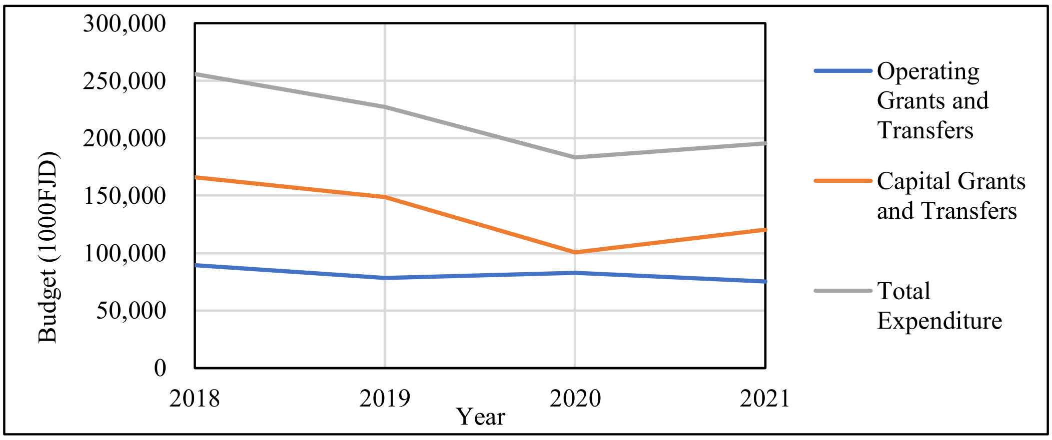
Table 4-7.1 Budget from the Government for WAF

(Units: million FJD)

Budget year	2017-2018	2018-2019	2019-2020 estimate	2020-2021 estimate
Operating Grants and Transfers	89,577.3	78,401.5	82,506.7	75,138.7
Capital Grants and Transfers	166,226.2	148,640.3	100,512.6	120,255.1
Total Expenditure	255,803.6	227,041.7	183,019.3	195,393.8
Major Cap Expenditure for Wastewater				
Water source / water treatment plant	14,700.0	33,700.0	30,685.2	24,500
Wastewater Collection System	54,000.0	51,700.0	25,182.3	4,800
WWTP expansion	19,200.0	18,600.0	10,550.0	7,300
Sewer network expansion	14,000.0	20,400.0	10,317.9	4,500

Source：FIJI National Budget Estimate 2020-2021

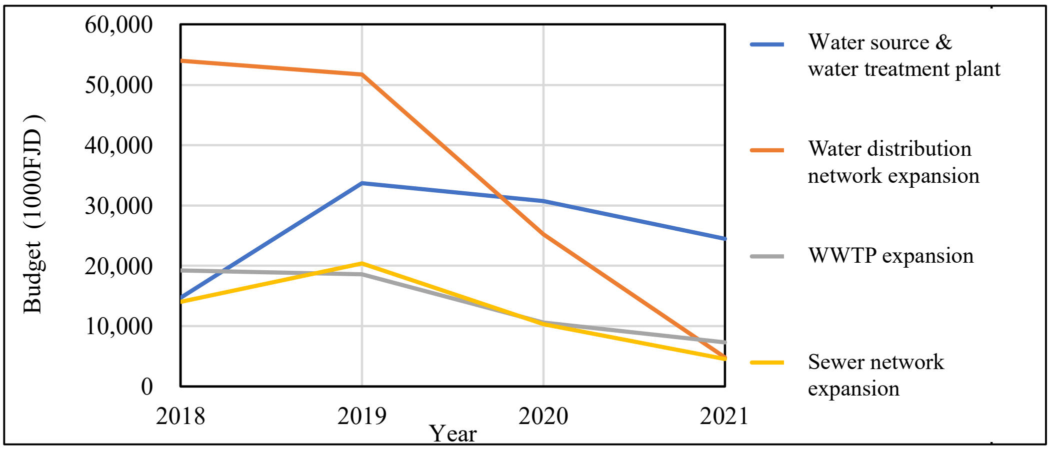
The trends in the total budget, capital costs, and operating costs for WAF is stated in the **Figure 4-7.1**. It can be seen that the reduction in capital costs will cover the reduction in the budget, since operating costs, including staff salaries and customer service, cannot be significantly reduced.



Source：JET

Figure 4-7.1 Trends of WAF Budget

The budget situation is shown in **Figure 4-7.2**. Among the capital costs, the largest amounts are water source/water treatment plant expansion, water distribution system improvement in the water supply business, wastewater treatment plant expansion and sewerage pipeline network expansion in the wastewater business. Except for the expansion of water sources and water treatment plants, the budget decreased significantly. For example, the budget for expansion of WWTPs in 2020-2021 decreased by 60% from 2018 to 2019.



Source : JET

Figure 4-7.2 Trends in the CAPEX for Major Wastewater-Related Items

4-7-2 Financial Statements of WAF

The WAF financial statements up to 2017 are shown below. Financial statements from 2018 onwards will be provided after the audit is completed.

(1) Income Statement

Audited income statement is shown in the **Table 4-7.2** below.

Table 4-7.2 WAF Income Statement

(Units: FJD)

Year	2015	2016	2017
Revenue	87,329,457	72,071,657	78,899,685
Other Income	22,497,780	49,326,460	48,747,566
Total Revenue	109,827,237	121,398,117	127,647,251
Personnel expenses	(19,515,199)	(26,026,267)	(33,950,443)
Operating expenses	(62,452,610)	(94,936,223)	(98,732,047)
Operating Profit before depreciation and amortization	27,859,428	435,627	(5,035,239)
Depreciation & amortization	(58,300,576)	(59,288,328)	(56,892,377)
Finance Income	50,315	103,454	154,410
Loss for the period	(30,390,833)	(58,749,247)	(61,773,206)
Total comprehensive (loss) for the year	(30,390,833)	(58,749,247)	(61,773,206)

Source : WAF Annual Report 2017

Only government subsidies are recorded as income in the above income statement, and water supply sales, which should be the original revenue, are not recorded as income but are deposited in the government integrated fund account. It is not possible to grasp the profit and loss that reflects the profitability status of the WAF water and sewerage business in this accounting procedure. Therefore, it is necessary to grasp the profit and loss situation excluding government subsidies.

First, the amount of water and sewerage business sales charged to water and sewerage users is shown in **Table 4-7.3**.

Table 4-7.3 Sales for Water and Wastewater

(Units: FJD)

Year	2015	2016	2017
Water	29,125,910	36,959,496	40,357,604
Wastewater	3,284,743	4,649,850	4,143,910
Other fees such as new connection and repairing charge	1,541,856	3,042,419	3,434,807
Total Water and Wastewater Revenue	33,952,509	44,651,765	47,936,321

Source：Created by JET based on WAF Annual Report 2017

Next, if government subsidies are excluded from sales and the above water and wastewater sales are replaced with income, the operating income excluding depreciation is shown in **Table 4-7.4**.

There is no profit from the original water and wastewater business, and the operating loss 84 million FJD in year 2017.

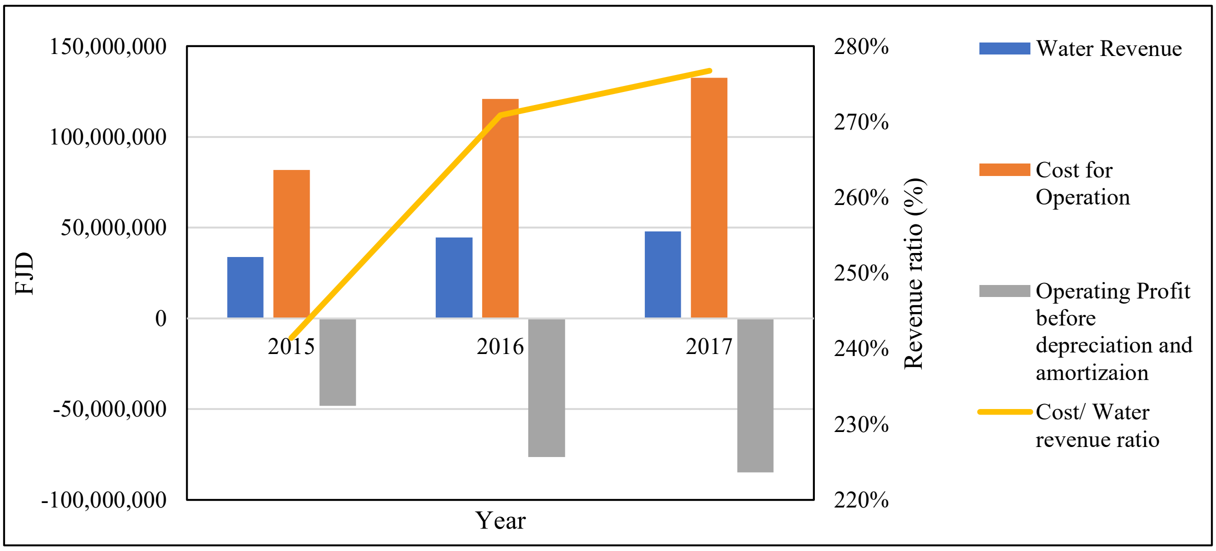
Table 4-7.4 Income for Water and Wastewater, excluding subsidy

(Units: FJD)

Year	*2015*	*2016*	*2017*
Water and wastewater revenue	33,952,509	44,651,765	47,936,321
Personnel expenses	(19,515,199)	(26,026,267)	(33,950,443)
Operating expenses	(62,452,610)	(94,936,223)	(98,732,047)
Operating Profit before depreciation and amortization	(48,015,300)	(76,310,725)	(84,746,169)

Source：Created by JET based on WAF Annual Report 2017

Sales revenue do not cover operation and maintenance costs. Expenses in 2017 far exceeded sales, with an expense ratio of over 250% to sales (**Figure 4-7.3**).



Source : JET

Figure 4-7.3 Operating Income, Expenses, Operating Loss, and Operating Expense Ratio

(2) Balance Sheet

The Audited Balance Sheet is shown in the **Table 4-7.5** below.

Table 4-7.5 WAF Balance Sheet

(Units: FJD)

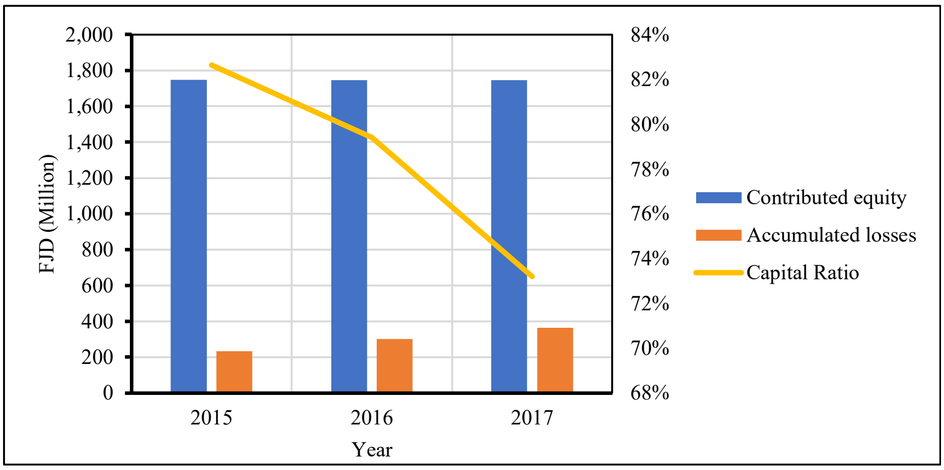
Year	2015	2016	2017
Non-current assets			
Property, plant and equipment	1,761,711,340	1,746,069,527	1,769,830,071
Intangible asset	823,273	967,501	825,440
Total non-current assets	1,762,534,613	1,747,037,028	1,770,655,511
Current assets			
Cash and cash equivalents	35,464,433	34,241,532	62,578,916
Trade and other receivables	12,235,959	6,818,766	22,246,585
Inventories	16,565,503	28,939,985	31,273,648
Held-to-maturity investments	50,000,193	1,323,742	1,326,710
Other assets and prepayments	1,513,407	887,838	922,430
Total current assets	70,779,495	72,211,863	118,348,289
Total assets	1,833,314,108	1,819,248,891	1,889,003,800
Equity			
Contributed equity	1,747,699,848	1,746,452,278	1,746,440,815
Accumulated losses	(232,852,610)	(301,827,102)	(363,600,308)
Total equity	1,514,847,238	1,444,625,176	1,382,840,507
Current liabilities			
Obligations under finance lease	422,551	91,458	
Trade and other payables	15,268,669	18,820,909	28,938,966
Provision for employee entitlements	683,010	775,140	405,078
Deferred revenue - capital grant		47,512,310	43,891,010
ADB funded grant		1,613,149	3,807,243
Total current liabilities	16,374,230	68,812,966	77,042,297
Non-current liabilities			
Obligations under finance lease	88,350		
Deferred revenue – capex grant	231,992,329	239,025,086	365,701,621
ADB funded grant	70,011,961	66,785,663	63,419,376
Total non-current liabilities	302,092,640	305,810,749	429,120,997
Total liabilities	318,466,870	374,623,715	506,163,294
Total equity and liabilities	1,833,314,108	1,819,248,891	1,889,003,800

Source：WAF Annual Report 2017

Equity capital is capital contributed by the government, while short-term liabilities in debt items are accounts payable and deferred revenue government subsidies, and fixed liabilities are deferred revenue government subsidies and ADB donations. There is no private external borrowing in the debt item.

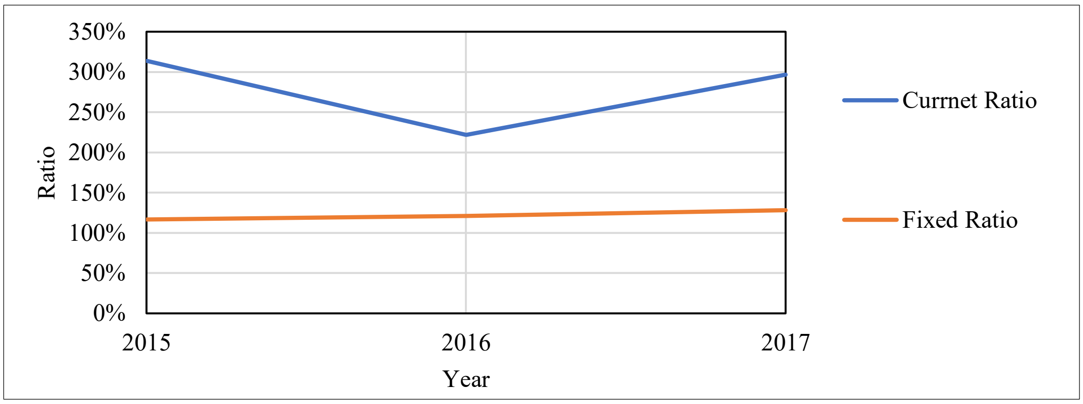
The ratio of equity capital, cumulative loss, and stock balance is shown in **Figure 4-7.4** and **Figure 4-7.5**.

The capital adequacy ratio is over 70%, but the cumulative deficit is increasing every year, so the capital adequacy is on a downward trend. However, due to the effect of capital input by government subsidies, the quick ratio is 200% or more, and it means much higher than the level that is generally considered safe in the short term. On the other hand, the fixed ratio is over 100%, meaning that the company's fixed assets are greater than its equity capital. This means that the company's long-term fixed assets are not being covered by its equity capital alone.



Source：JET

Figure 4-7.4 Changes of Equity Capital, Cumulative Loss, and Equity Ratio



Source：JET

Figure 4-7.5 Changes of Quick Ratio and Fixed Ratio

(3) Cash Flow

The Audited Cash Flow is stated in **Table 4-7.6** below.

Table 4-7.6 Cash Flow

(Units: FJD)

Year	2015	2016	2017
Operating activities			
Receipts of Government Revenue	31,257,761	36,753,022	45,673,267
Receipt from Government Grant & Other Income	54,918,804	72,071,657	78,899,685
Payment to suppliers and employees	(71,842,149)	(92,628,548)	(140,218,285)
Payment to Government – Consolidated Fund Account	(31,257,761)	(36,753,022)	(45,673,267)
Net cash flows used in operating activities	(16,923,345)	(20,556,891)	(61,318,600)
Investing activities			
Receipt from Government – capital grant	116,500,872	104,576,413	169,576,635
Receipt from rural entities – rural projects	441,560	3,738	
Payments for property, plant and equipment	(80,284,187)	(84,606,430)	(79,983,603)
Net cash flows from investing activities	36,658,245	19,973,721	89,593,032
Financing activities			
Repayment of finance lease	(377,710)	(419,443)	(91,458)
Proceeds from interest income	50,315	103,454	154,410
Net cash flows from/ (used in) financing activities	(327,395)	(315,989)	62,952
Net increase/(decrease) in cash and cash equivalents	19,407,505	(899,159)	28,337,384
Cash and cash equivalents on 1 January	16,056,928	35,140,691	34,241,532
Cash and cash equivalents on 31 December	35,464,433	34,241,532	62,578,916

Source：WAF Annual Report 2017

Since government subsidies are included in both operating and investment cash flows in the above table, the original cash flows of the water business cannot be grasped. Therefore, the **Table 4-7.7** shows the business and investment cash flows excluding government subsidies. The amount of negative cash flow is almost the same as the budget for WAF recorded annually by the government. The necessity cash flow required for the project is maintained by the government budget.

Table 4-7.7 Operating and Investment Cash Flow

(Units: FJD)

Year	2015	2016	2017
Total Water and Wastewater Revenue	33,952,509	44,651,765	47,936,321
Payment to suppliers and employees	(71,842,149)	(92,628,548)	(140,218,285)
Payments for property, plant and equipment	(80,284,187)	(84,606,430)	(79,983,603)
Adjusted Cash flow from operation and investment	(118,173,827)	(132,583,213)	(172,265,567)

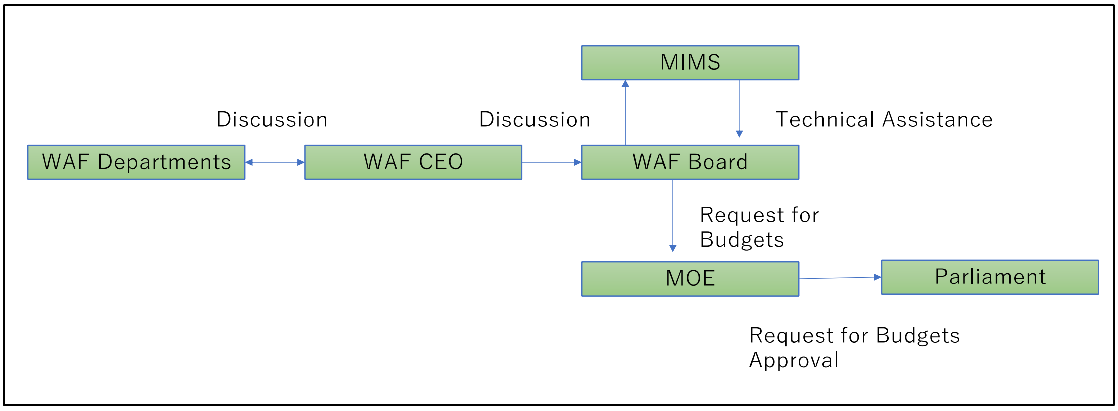
Source：Created by JET based on WAF Annual Report 2017

4-7-3 Budget for Wastewater

(1) Budget approval process

WAF's project budget for implementing all public water and wastewater projects in Fiji depends entirely on national budget allocations. Therefore, as shown in **Figure 4-7.6**, the annual budget approval process was selected by discussing the budget request of each WAF department with the CEO, consulting with the

WAF board of directors, obtaining approval, and submitting it to the Ministry of Economy. After that the budget is consulted to the parliament. Budgets approved by the parliament can only be enforced with the approval of the WAF's board of directors.



*MIMS: before organizational restructuring; current MPW
*MOE: before organizational restructuring; current MOF
Source: JET

Figure 4-7.6 Budget Approval Process of WAF

(2) Budget of year 2017

The WAF 2017 budget according to the annual report is shown in **Table 4-7.8**. The total budget is 217 million FJD, of which the budget for sewerage-related capital investment is 33 million FJD. The budget ratio for capital investment and 27% for operating budget. The amount of capital investment in the wastewater business accounts for 15% of the total budget (**Figure 4-7.7**).

Water	74,938,423
Wastewater	33,184,000
Others Operation Budget	58,993,825
Rural Schemes	30,254,877
Meter Replacement	14,119,200
Free Water Tanks	5,875,000
Total	**217,365,325**

Table 4-7.8 WAF 2017 Budget
Source : Created by JET based on 2017Annual Report

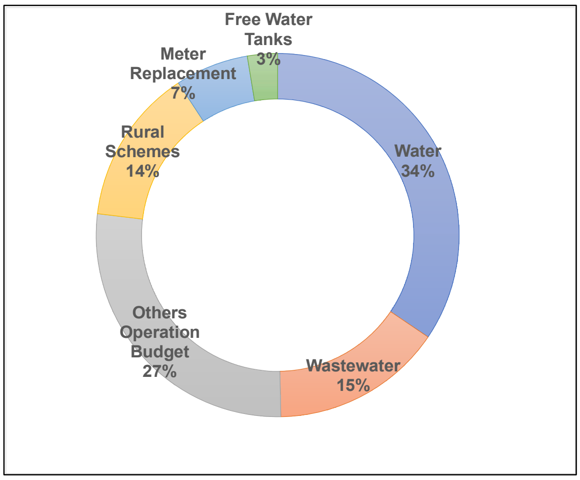


Figure 4-7.7 WAF2017 Budget Allocation
Source : Created by JET based on 2017Annual Report

(3) Budget of year 2018～2022

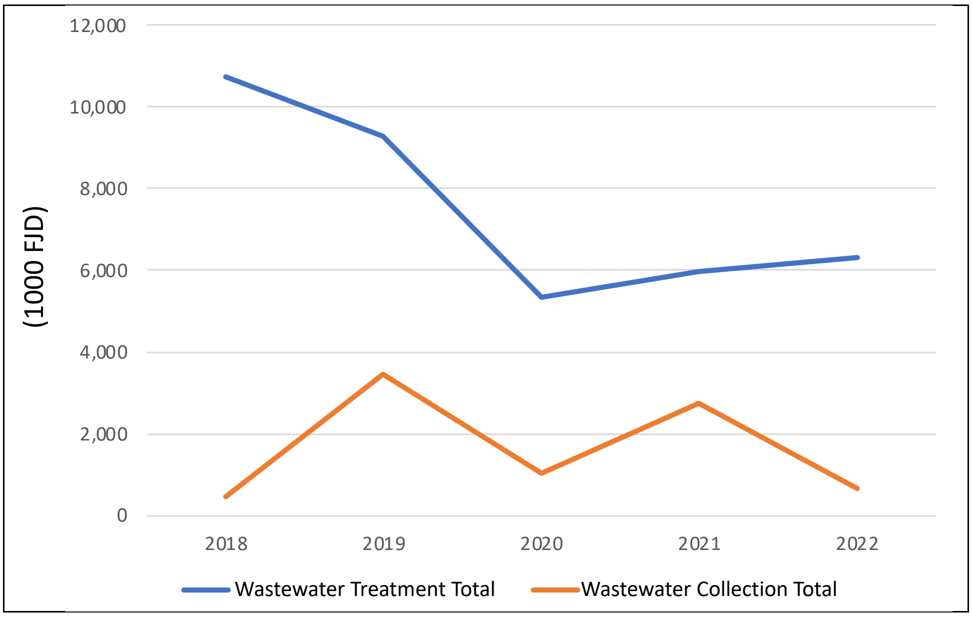
The wastewater budgets for 2018-2022 based on WAF internal materials are shown in **Table 4-7.9** and **Figure 4-7.8**. Reflecting the decrease in the capital cost budget for WAF from the government, the budget for distribution is flat and budget for treatment facility is reduced.

Table 4-7.9 WAF Wastewater Budget 2018～2022

(Units:1000 FJD)

Year	2018	2019	2020	2021	2022
Wastewater Treatment					
Wastewater Consolidation Works	6,213	5,281		5,966	
Feasibility Study for new plant	2,030	0			
Desludging	1,543	2,158			
Wastewater Treatment	937	1,844			6,300
Package Plant Works			4,710		
Rollover Works			630		
Wastewater Treatment Total	10,723	9,283	5,340	5,966	6,300
Wastewater Collection					
Sewer Network Extensions		1,460			
Upgrading Wastewater Pumping Station	462				
Rollover Project		2,000			
Construction			1,039		
Improving Sewer Network				2,742	675
Wastewater Collection Total	462	3,460	1,039	2,742	675

Source：Created by JET based on WAF data



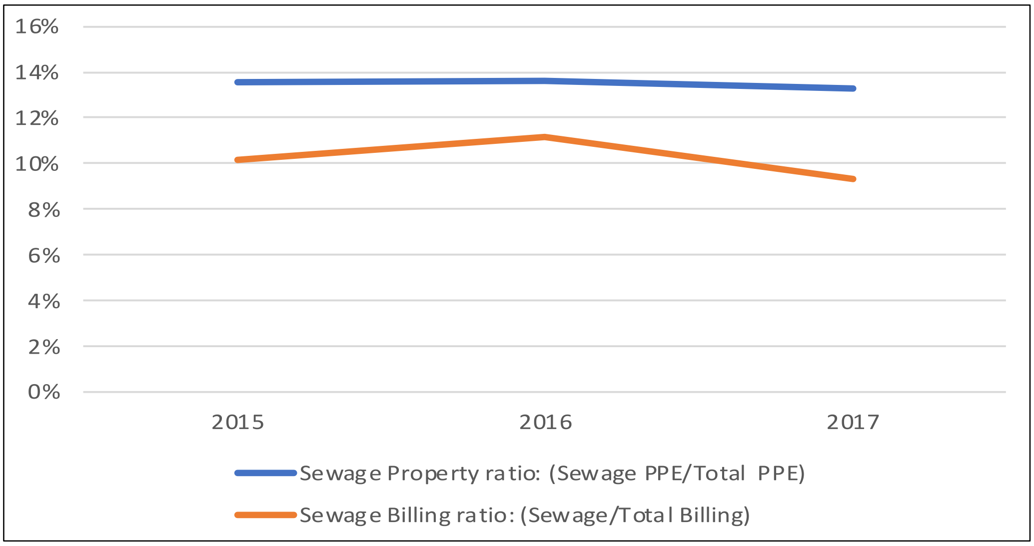
Source：Created by JET based on WAF data

Figure 4-7.8 Budget for Wastewater Treatment and Distribution 2018～2022

4-7-4 Profitably of Wastewater Business

(1) Wastewater Assets and Revenue Ratio on WAF

The wastewater business from 2015 to 2017 accounts for 14% of tangible fixed assets, according to the 2017 financial statements, In addition, wastewater revenue account for about 10% of sales (**Figure 4-7.9**). It can be estimated that the impact of the wastewater business on WAF finance performance is 10 to 20% of the total WAF business.



Source：JET

Figure 4-7.9 Ratio of Wastewater Business Accounts for Fixed Assets and Revenue of WAF

(2) Wastewater Revenue, Customer Connections and Average Payment by each Customer Segment

The wastewater sales revenue (FJD/year) and the number of connections by customer sector are shown in **Table 4-7.10**.

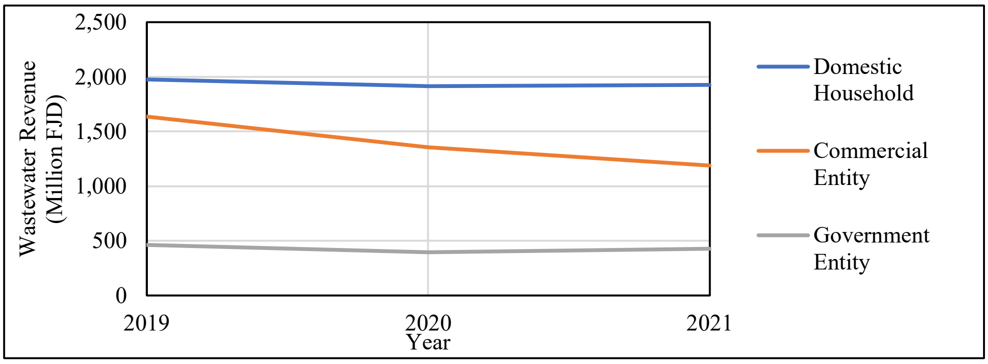
Sales revenue to domestic households are almost flat, but sales to commercial entity have declined significantly since 2020; it shows the impact of the recession caused by COVID-19 clearly. Sales to government entity picked up in 2021, but sales to commercial companies decreased by 28% from 2019, showing no recovery (**Figure 4-7.10**). In terms of the sales ratio by customer segment, commercial entity accounted for 40% in 2019, but decreased to 34% in 2021 (**Figure 4-7.11**).

Table 4-7.10 Wastewater Sales Revenue and Connections by Customer Segment

(Units: FJD/year)

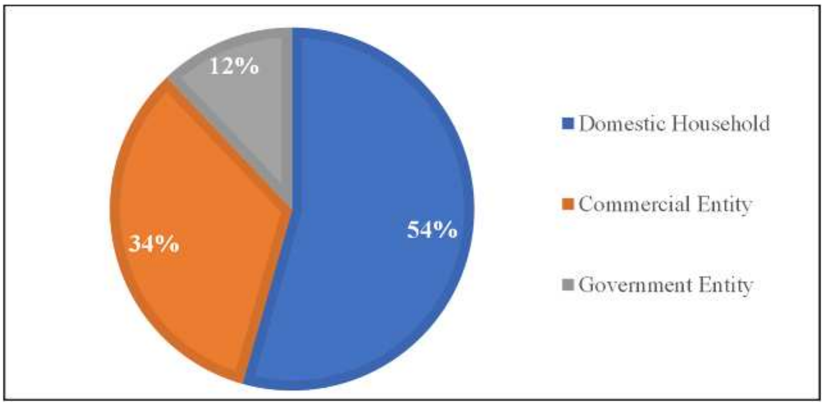
Year	2019	2020	2021
Wastewater Revenue (FJD/yr)			
Domestic Household	1,976,059	1,914,655	1,925,772
Commercial Entity	1,635,419	1,355,312	1,186,820
Government Entity	461,012	393,022	426,795
Total Revenue	4,072,491	3,662,989	3,539,387
Wastewater Connection (FJD/yr)			
Domestic Household	26,944	26,917	27,523
Commercial Entity	4,952	4,868	4,910
Government Entity	553	587	611
Total Connection	32,449	32,372	33,044

Source：Created by JET based on WAF data



Source：JET

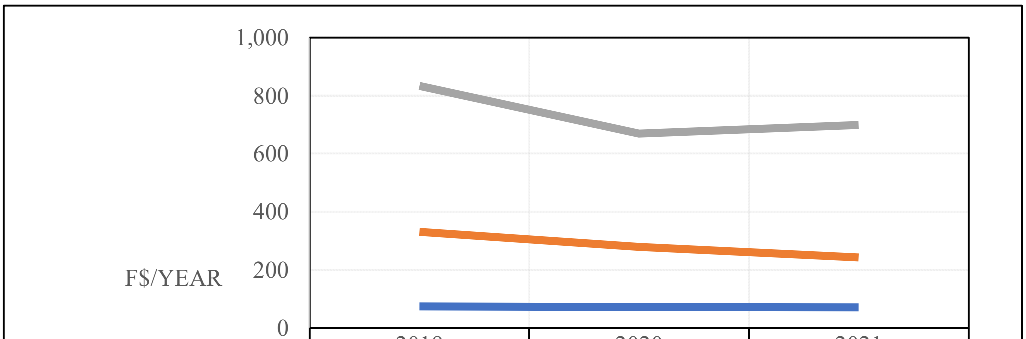
Figure 4-7.10 Wastewater Sales Revenue by Customer Segment



Source：JET

Figure 4-7.11 Sales Ratio by Customer Segment (Year 2021)

The trends in the average payment amount by customer segment in **Figure 4-7.12** below. Average annual payment for domestic households is about 70 FJD, which is constant without being affected by economic fluctuations. In contrast, payment from commercial entity have fallen 27% since 2019.



	2019	2020	2021
Domestic Household	73	71	70
Commercial Entity	330	278	242
Government Entity	834	670	699

Source：JET

Figure 4-7.12 Trends of Wastewater Payment by Customer Segment

(3) WAF Estimated Operating Income by Wastewater

The operating income (2019-2021) estimated from the revenue and expenses of the wastewater business is shown in the **Table 4-7.11**.

Wastewater sales revenue is accounted by the WAF, however, most of the expenses are not calculated separately among water and wastewater. For accounting cost, only materials related to wastewater treatment are calculated as wastewater costs, on the other hand, maintenance costs such as labor costs and operating costs are not distinguished among water and wastewater. Therefore, referring to the past published financial statements, it is estimated by the method that personnel expenses are 60% of sales and maintenance expenses including material costs are 200% of sales, and revenue from 2019 to 2021 is calculated. The government subsidies are excluded from sales.

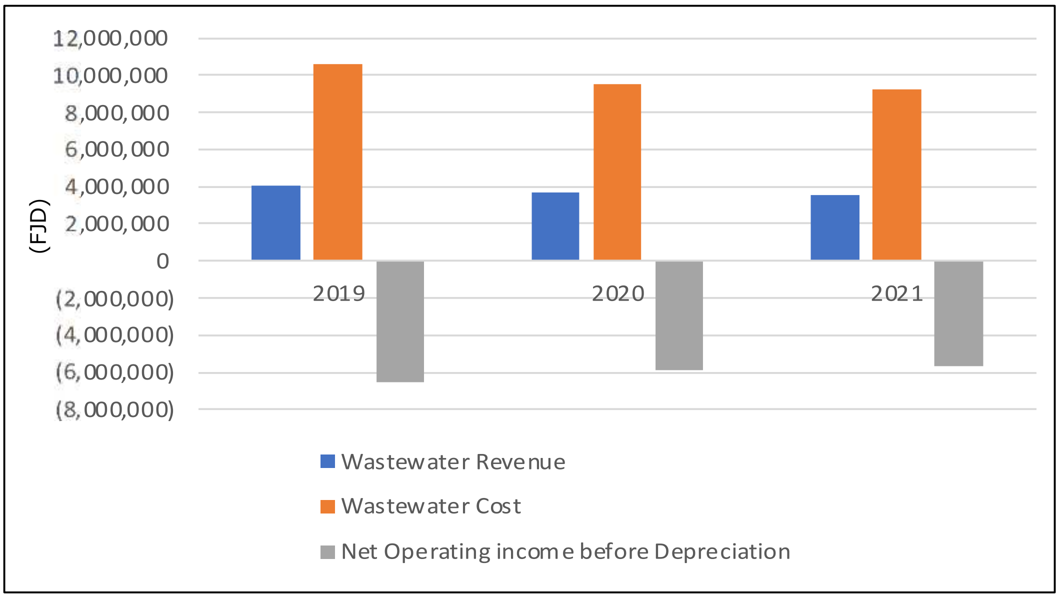
Since the official financial statements have not been released since FY2018, this is an estimated operating income, but the operating loss might continue by the current tariff charges are expected to continue (See **Figure 4-7.13**）.

Table 4-7.11 Estimated Operating Income of Wastewater

(Units: FJD)

	Year	2019	2020	2021
Wastewater Charges (FJD)	: Domestic	1,976,059	1,914,655	1,925,772
	: Commercial	1,635,419	1,355,312	1,186,820
	: Government	461,012	393,022	426,795
Wastewater Revenue (FJD)		4,072,491	3,662,989	3,539,387
Operation Cost related to materials (FJD)		1,100,889	959,165	1,108,178
Other Operation Cost (FJD)		7,044,093	6,366,812	5,970,596
Personnel Cost (FJD)		2,443,495	2,197,793	2,123,632
Wastewater Cost (FJD)		10,588,476	9,523,771	9,202,406
Net Operating income (Loss) before Depreciation		**(6,515,985)**	**(5,860,782)**	**(5,663,019)**

Source：JET



Source : JET

Figure 4-7.13 Estimated Operating Income of Wastewater (Year 2019 – 2021)

4-7-5 Summary of WAF Financial Status

- Sales of water and wastewater do not cover O&M expenses. Since the collection rate of sales is as high as 95% (2017), the low-price setting is the reason why the income cannot cover the expenses, and the loss is recorded every year. The production cost of water is about 1.00 FJD/m^3 according to WAF's finance dept, the operating loss increases as the sales volume increases since the current water and sewerage tariffs are much lower than the production cost. Even if the current non-revenue water rate of 30% improves to zero, the operating loss will continue.
- Subsidies for WAF from the government budget are the cornerstone of capital investment and operating funds. Since the current policy of the Fijian government is to operate the water and sewerage business with a subsidy budget, it is necessary for the Ministry of Economy to continue its commitment to support WAF.
- The financial statements obtained up to 2017, do not show the impact of COVID-19 on WAF management yet. Since the current business situation cannot be grasped from the data of five years old, WAF need to provide the latest financial data. It is due to the delay in auditing by the Office of the Auditor General according to WAF management, and it is not a WAF's issue, such as the accounting processing method.
- According to the Ministry of Economy, one of WAF's supervisory body, WAF will continue to be a government-owned business entity, but it is not expected to be financially dependent on the government budget forever. WAF is expected to become financially independent based on sales of water to customers and, become an independent institution. To that end, raising water tariffs is recognized as an important option for WAF to improve profitability.
- The financial statements and budget documents do not clearly distinguish between water and wastewater maintenance costs. It is necessary to calculate the capital cost and maintenance cost of the

wastewater operation, that is required for this master plan, and analyze the level of sewerage tariffs that cover these costs and generate financially sustainable profits.

4-7-6 Reference Tariff calculated by Affordable to Pay (ATP)

(1) The Current Tariff of Wastewater

The current tariff of wastewater is as shown in **Table 4-4.1**, the water supply rate for domestic households is 0.15~0.83 FJD/m^3, 1.06 FJD/m^3 for commercial use. Tariff for wastewater rate is 0.20 FJD/m^3 for both household and commercial use. Tariff rates have not been revised since 2000. According to local newspapers, WAF has frequently asked the government to raise prices in recent years in order to improve business and reduce operating loss.

The application fee for new connections the WAF sewer network is 70 FJD per new connection. The cost of connecting from the household to the pipe is borne by the user, and there is no government subsidy. The cost is equivalent to 270 FJD per meter of connecting pipe.

(2) Reference Tariff calculated by Affordable to Pay: (ATP)

The user's Affordability to Pay (hereinafter referred as "ATP") can be calculated using the World Bank's simple benchmark. In the wastewater sector, the benchmark of 2% of household disposable income[6] is used as the payable amount.

- ATP of Wastewater = 2% of disposable income= <u>368 FJD/year</u>

  In this formula;
    - Average household disposable income = Average household income – taxes and social security costs
    - Average household disposable income = 26,249 FJD [7]
    - Income tax on households, social guarantee tax, etc.

      = average household income 26,249 FJD x 30%[8] =7,847 FJD

- Tariff calculated by ATP = The current tariff x [ATP÷disposable income] = <u>1.05 FJD/m^3</u>

  In this formula;
    - ATP= 368 FJD
    - Current annual payments for wastewater per household [9] = 70 FJD
    - ATP ÷ Current annual payment for wastewater per household = 5.25
    - The current tariff = 0.20 FJD/m^3

As mentioned above, the wastewater tariff charge calculated from ATP is <u>1.05 FJD/m^3</u>, which is about five

[6] Estimated by the World Bank and the United Nations from past research and business experience, it is often used as a benchmark for WTP in practice.
[7] FBOS: 2019-2020 Household Income and Expenditure Survey
[8] Income tax, corporate tax rate is 20%, Welfare tax rate is around 10% in Fiji
[9] Calculated by dividing the paid amount of wastewater sales of domestic households by the number of connections.

times the current tariff. According to the past survey by WAF, the water production and supply cost is 1.00 FJD/m^3, and the tariff cicurated by ATP exceeds this water originating cost.

CHAPTER 5 Centralized and Decentralized Treatment Systems

5-1 Summary of Planning Factors

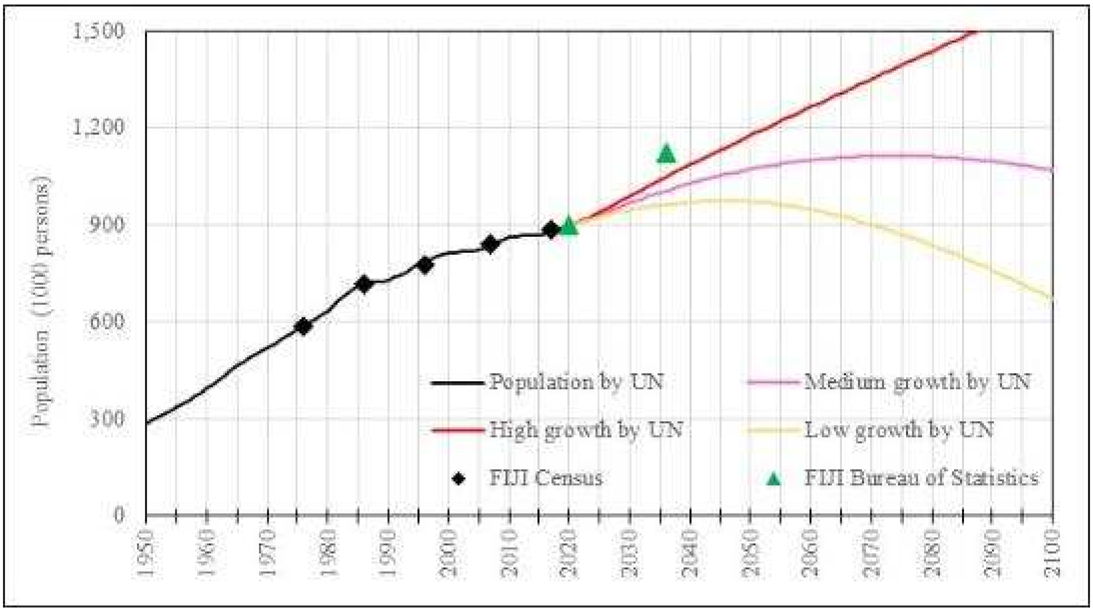
5-1-1 Target Year

The target year of this M/P is 2036, in line with the National Development Plan.

5-1-2 Future Population

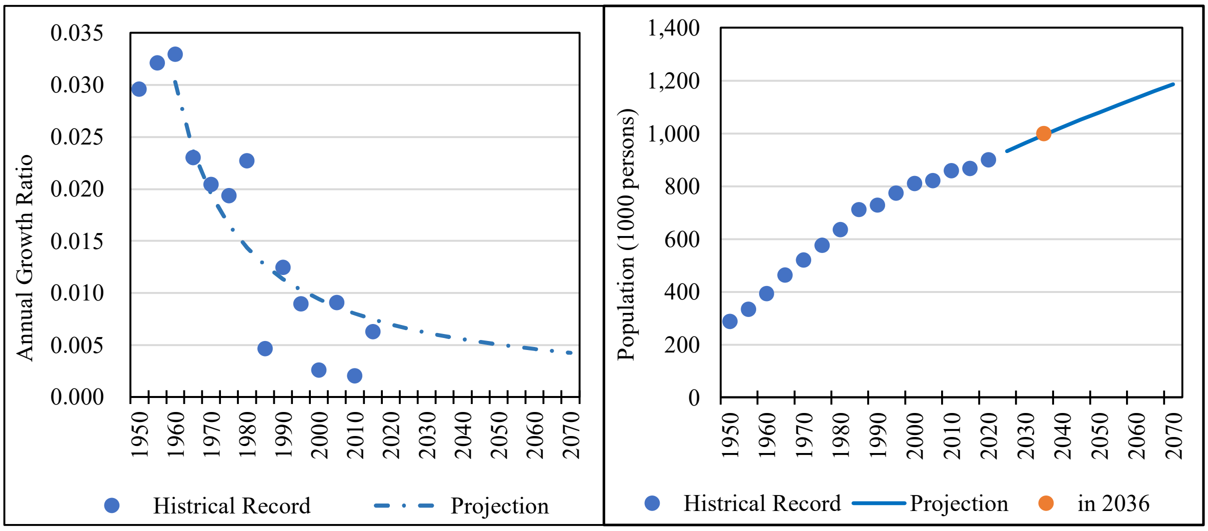
(1) Future Population of Fiji

The National Development Plan estimates that the total population of Fiji will exceed 1,100,000 in the future. According to latest estimates by the Fiji Bureau of Statistics, the population in 2036 is estimated to be 1,120,000. This value exceeds the "High growth" population forecasts published by the United Nations (**Figure 5-1.1**) and includes large growth factors in addition to what is seen the population growth trends of the past. **Figure 5-1.2** shows that the population growth ratio is markedly decreasing. Considering the declining population growth rate, the population of Fiji in 2036 is estimated to be about 1 million. This value is roughly in line with the "Medium growth" scenario estimate of the United Nations.



Source: Created by JET based on data from Fiji Bureau of Statistic and UN

Figure 5-1.1 Past Population of Fiji and Population Forecast



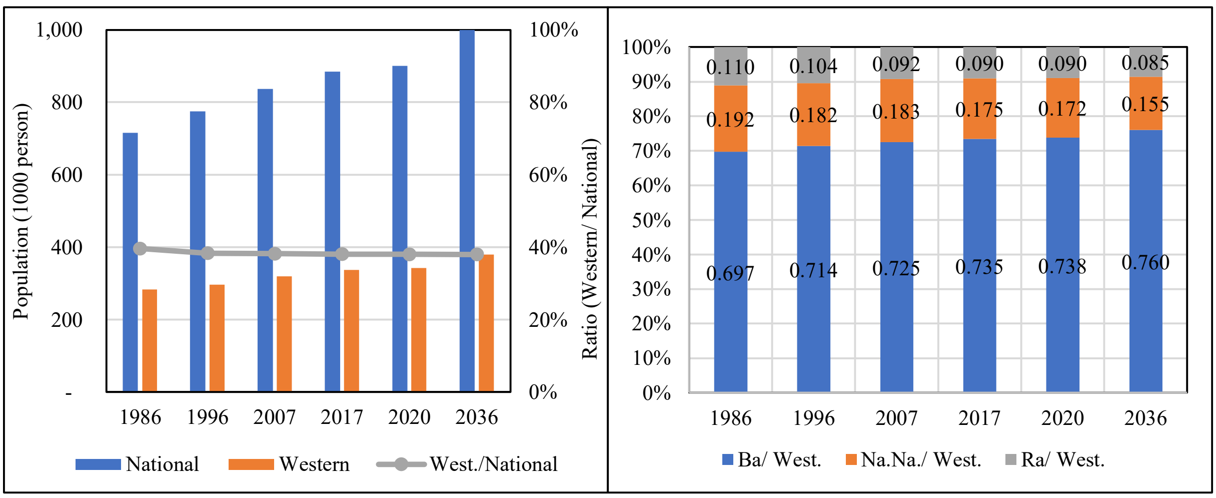
Source: Fiji Bureau of Statics, JET

Figure 5-1.2 Population Forecast Based on Historical Data

(2) Populations of Divisions and Provinces

Figure 5-1.3 shows a comparison of the national population to that of the Western Division over the years. As can be seen, the population of the Western Division has consistently been about 38% of the national population. Assuming that the Western Division will account for 38% of the national population in 2036, the population of the Western Division is forecast to be 380,000 people, with the national population predicted to be 1,000,000.

Trends of provincial population ratios shows a slight increase in Ba Province and slight decreases in Ra and Nadroga-Navosa Provinces. This trend is expected to continue in the future. Based on existing trends, the population ratios of Ba, Nadroga-Navosa, and Ra in 2036 are expected to be 76.0%, 15.5%, and 8.5%, respectively. **Table 5-1.1** shows the population of the Western Division, including the population of previous years, as well as provincial populations.



Source: Fiji Bureau of Statics, JET

Figure 5-1.3 Population Comparison of the Western Division and Provinces

Table 5-1.1 Population Forecast of the Western Division and Provinces

Year	National	Western Division		Ba Province		Nadroga-Navosa Province		Ra Province	
	Population	Population	Percentage	Population	Percentage	Population	Percentage	Population	Percentage
1986	715,375	283,349	39.6%	197,633	69.7%	54,431	19.2%	31,285	11.0%
1996	775,077	297,184	38.3%	212,197	71.4%	54,083	18.2%	30,904	10.4%
2007	837,271	319,611	38.2%	231,760	72.5%	58,387	18.3%	29,464	9.2%
2017	884,887	337,041	38.1%	247,685	73.5%	58,940	17.5%	30,416	9.0%
2020	901,000	342,700	38.0%	252,900	73.8%	59,100	17.2%	30,700	9.0%
2036	1,000,000	380,000	38.0%	288,800	76.0%	58,900	15.5%	32,300	8.5%

Source: Fiji Bureau of Statics

(3) Populations of Urban, Peri-Urban, Rural Areas

Table 5-1.2 shows the urban, peri-urban, and rural populations of the provinces of the Western Division. The urban area mostly coincides with the city and town boundaries established by each city/town[10]. As of 2017, roughly 25% of the entire population resided in urban areas. The peri-urban area, where development is yet to take place, accounts for about 30% of the population. The remaining 45% of the population is distributed throughout the rural areas.

The Fiji Bureau of Statistics expects the population distribution in urban, peri-urban, and rural areas to be 31%, 43%, and 26%, respectively, in 2036. This pattern denotes an expectation of population migration towards urban areas in the future. This M/P adopts the same population distribution; urban, peri-urban, and rural populations for planning are set as shown in the bottom half of **Table 5-1.2**.

Table 5-1.2 Urban, Peri-Urban and Rural Populations by Province

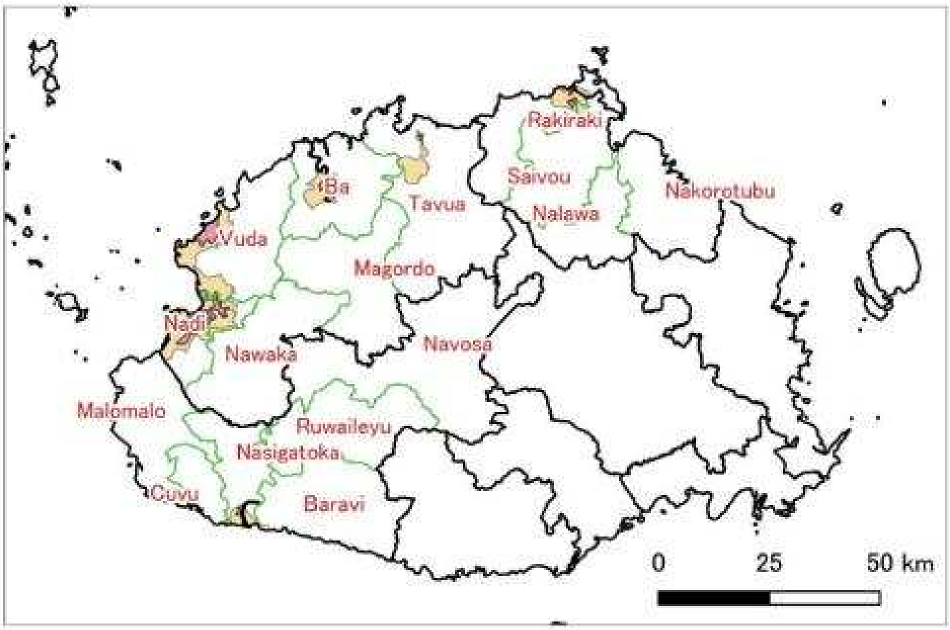
	Province / Category	Ba	Nadroga-Navosa	Ra	Total	Distribution Ratio
2017	Urban	81,662	1,533	1,672	84,867	25.2%
	Peri-Urban	85,145	8,976	4,292	98,413	29.2%
	Rural	80,878	48,431	24,452	153,761	45.6%
	Sub-Total	247,685	58,940	30,416	337,041	100.0%
	Ratio	73.5%	17.5%	9.0%	100%	
2036	Urban	113,800	1,900	2,100	117,800	31.0%
	Peri-Urban	143,400	13,400	6,600	163,400	43.0%
	Rural	31,600	43,600	23,600	98,800	26.0%
	Sub-Total	288,800	58,900	32,300	380,000	100.0%
	Ratio	76.0%	15.5%	8.5%	100%	

Source: Fiji Bureau of Statics, JET

(4) Population of Districts (Tikina)

In Fiji, provinces are further subdivided into Districts (Tikinas) (see **Figure 5-1.4**). Census data are gathered at the district level. District-wise populations for 2036 were determined using district-wise population ratios of 2017. The results are shown in **Table 5-1.3**. Because the urban and peri-urban populations are expected to increase, populations of districts with only rural areas are expected to decrease.

[10] Current Town Boundary in Nadi is a part of the Urban area. Future town boundary is planned to expand up to Urban area.



Source: Fiji Bureau of Statics, JET

Figure 5-1.4 The Three Provinces of the Western Division and Its Districts

Table 5-1.3 Population Forecast by District

Province	District (Tikina)	Population 2017				Population 2036			
		Total	Urban	Peri-Urban	Rural	Total	Urban	Peri-Urban	Rural
Ba	Ba	39,372	6,405	9,441	23,526	36,020	8,930	19,900	7,190
	Magodro	4,806			4,806	4,810			4,810
	Nadi	59,717	29,016	29,422	1,279	86,380	40,440	45,550	390
	Naviti *	2,910			2,910	2,910			2,910
	Nawaka	16,121		8,406	7,715	16,510		14,160	2,350
	Tavua	23,269	1,194	7,616	14,459	18,900	1,660	12,830	4,410
	Vuda	99,264	45,047	30,259	23,958	121,040	62,770	50,960	7,310
	Yasawa *	2,226			2,226	2,230			2,230
	sub-total	247,685	81,662	85,145	80,878	288,800	113,800	143,400	31,600
Ra	Nakorotubu	4,392			4,392	4,240			4,240
	Nalawa	4,932			4,932	4,760			4,760
	Rakiraki	13,908	1,672	3,949	8,287	16,170	2,100	6,070	8,000
	Saivou	7,184		343	6,841	7,130		530	6,600
	sub-total	30,416	1,672	4,292	24,452	32,300	2,100	6,600	23,600
Nadroga-Navosa	Barava	8,332		628	7,704	7,880		940	6,940
	Cuvu	7,264			7,264	6,540			6,540
	Malolo *	3,211			3,211	2,890			2,890
	Malomalo	15,484			15,484	13,930			13,930
	Nasigatoka	14,338	1,533	8,348	4,457	18,370	1,900	12,460	4,010
	Navosa	5,106			5,106	4,600			4,600
	Ruwailevu	4,430			4,430	3,990			3,990
	Vatulele *	775			775	700			700
	sub-total	58,940	1,533	8,976	48,431	58,900	1,900	13,400	43,600
Western Division		337,041	84,867	98,413	153,761	380,000	117,800	163,400	98,800

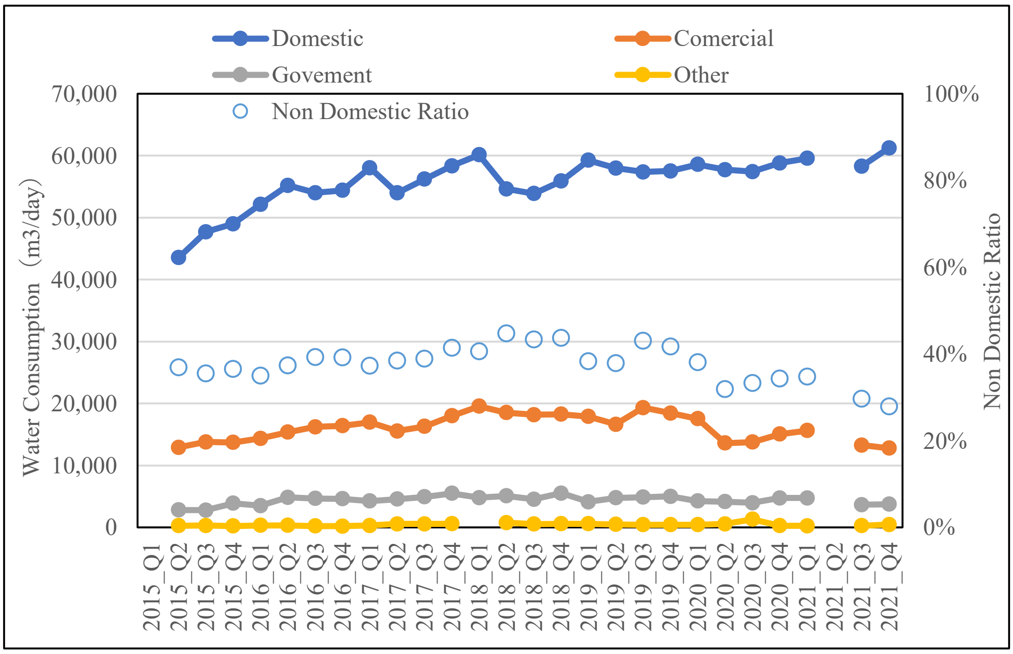
*Italics**: Located on islands other than Viti Levu.
Source: Fiji Bureau of Statistics, JET

5-1-3 Unit Water Consumption

(1) Past Trends

Currently, WAF provides water supply services to six cities/towns in the Western Division. **Figure 5-1.5** shows the revenues from water consumption for every quarter since 2015.

- Domestic water consumption showed a slight increasing trend until the onset of COVID-19, and consumption has been flat since.
- Commercial water consumption showed similar increasing trends until the onset of COVID-19. Consumption has decreased since the start of COVID-19, and the commercial water ratio (commercial water consumption/domestic water consumption) has also clearly decreased.
- Due to the above, although there are no issues with the latest consumption values, 2019 values should be used to accurately model water consumption patterns.



Source: WAF

Figure 5-1.5 Revenue Water Consumption Trends by Sector (Total of Six Municipalities)

1) Domestic Water Unit Consumption Flow

Table 5-1.4 shows the amount of domestic revenue water in the first quarter of 2021. Assuming that the population per connection is 4.5 people/household, the unit consumption flow for domestic water ranges from 190 to 250 L/day/person, and the average of the six cities/towns is 236 L/day/capita. Currently, WAF has set domestic water consumption at 220 L/day/capita and the sewerage recovery rate at 90%. This is not significantly different from the average of the six municipalities shown in **Table 5-1.4**. The value currently specified by WAF will be adopted for planning.

Table 5-1.4 Domestic Revenue Water Flow

Municipality	Domestic Revenue Water Flow		Number of Connections	Users per Connection	Consumption per User
	(m^3/3 months)	(m^3/day)	(Connection)	(Capita/Connection)	(L/day/capita)
Nadi	1,993,236	22,147	19,713	4.5	0.250
Lautoka	1,778,871	19,765	17,436	4.5	0.252
Ba	677,151	7,524	8,321	4.5	0.201
Tavua	237,936	2,644	2,841	4.5	0.207
Rakiraki	154,442	1,716	2,006	4.5	0.190
Sigatoka	399,114	4,435	4,564	4.5	0.216
Total	5,240,750	58,231	54,881	4.5	0.236

Source: WAF

2) Non-Domestic Ratio

Non-domestic sewerage is wastewater from businesses (including hospitals and schools), government offices, etc. Since there is a wide variety of types of services, such as stores and restaurants, it is difficult to estimate the water consumption of each establishment. Therefore, the amount of non-domestic sewerage is estimated by multiplying the volume of domestic water consumption by the non-domestic ratio.

Table 5-1.5 shows revenue water flow by category in 2019. The non-domestic ratio in the municipalities included in this M/P is in the range of 15% to 60%. The ratio is highest in Nadi and Lautoka where airports, hotels, and other commercial facilities are concentrated.

Table 5-1.5 Revenue Water Flow in each Municipality (2019 data)

No	Category		Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka	Remark
1	Commercial	m^3	22,110	19,648	7,042	2,596	1,869	4,797	
2	Domestic	m^3	8,007	5,895	1,363	202	371	2,274	
3	Government	m^3	801	2,535	471	218	174	529	
4	Other	m^3	352	37	123	0	6	1	
5	Total	m^3	31,271	28,114	8,999	3,016	2,420	7,601	1+2+3+4
6	Non-domestic ratio	%	41.4	43.1	27.8	16.2	29.5	58.5	(2+3+4) /1

Source: WAF

The non-domestic ratio of the six municipalities were rounded to establish the values for planning as shown in **Table 5-1.6**.

Table 5-1.6 Non-Domestic Ratio in each Municipality

Municipality	Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka
Non-domestic ratio (%)	40	45	30	20	30	60

Source: JET

(2) Infiltration Water Volume

The design flow must include water that leaks into the pipes from joints and other leakage points. The Rakiraki Sewerage M/P formulated in 2019 used a value of 10% of the total as infiltration water volume. This is a generally agreed upon value used in Japan and other countries. This M/P will also adopt 10% of the total as the infiltration water volume for planning.

(3) Summary of Unit Wastewater Flow

The unit wastewater flows to be used in planning are summarized in **Table 5-1.7**.

Table 5-1.7 Summary of Unit Wastewater Flow

Item	Unit	Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka
Domestic water usage (Uniform)	L/day/capita	220	220	220	220	220	220
Return Ratio	%	90	90	90	90	90	90
Domestic wastewater unit flow (Uniform)	L/day/capita	200	200	200	200	200	200
Non-domestic ratio	%	40	45	30	20	30	60
Infiltration ratio	%	10	10	10	10	10	10

Source: JET

5-2 Examination of the Service Area

5-2-1 Goals for Centralized Treatment Systems

The target area needs to be selected so that 70% of the population will have access to centralized treatment by the target year. As described in **Table 5-1.1**, the population of the Western Division in 2036 is expected to be 380,000. Therefore, 266,000 people will need to have access to centralized treatment systems. The remaining 114,000 people will need to have access to onsite methods of wastewater treatment.

Due to the extensive expansion of service area required to meet these goals, the target area needs to be selected so that priority of project implementation is clear and so that the project can be executed efficiently and economically.

5-2-2 Topics to be Considered

Considerations when selecting the service area for centralized treatment systems are listed below, in order of importance.

a) City/town boundaries set by municipalities which denote the city centers
(“Urban” areas as defined by the Bureau of Statistics).

b) Densely populated areas in the Peri-Urban area.

c) Areas already receiving water supply services.

d) Areas planned to receive water supply service.

Regarding a), city/town boundaries are areas where the city/town plan active development in the future. Sewerage services in these areas are necessary for the new buildings to comply with building codes, and for other reasons.

Regarding b), water consumption in areas with water supply is generally higher than in areas lacking water supply. At the same time, there is an advantage in that usage tariffs can be easily collected in these areas.

Regarding c), many development plans and projects exist outside of the areas defined in a). These areas are included in water supply development plan and sewerage services should also be included.

5-2-3 Selection of the Service Area

The population of areas under consideration that meet all of the requirements outlined in Section **5-2-2** exceeds 70%. **Table 5-2.1** shows the population targeted for centralized treatment systems in each district. Figure 5-2.1 to **Figure 5-2.3** show the areas.

Table 5-2.1 Population Using Centralized/Decentralized Treatment Systems in each District

Province	District (Tikina)	Centralized Treatment System				Decentralized Treatment System			
		Total	Urban	Peri-Urban	Rural	Total	Urban	Peri-Urban	Rural
Ba	Ba	31,200	8,930	18,900	3,370	4,820	-	1,000	3,820
	Magodro	0	-	-	-	4,810	-	-	4,810
	Nadi	80,870	40,440	40,430	-	5,510	-	5,120	390
	Naviti *	0	-	-	-	2,910	-	-	2,910
	Nawaka	9,960	-	9,960	-	6,550	-	4,200	2,350
	Tavua	13,100	1,660	10,140	1,300	5,800	-	2,690	3,110
	Vuda	107,870	62,770	45,100	-	13,170	-	5,860	7,310
	Yasawa *	0	-	-	-	2,230	-	-	2,230
	sub-total	243,000	113,800	124,530	4,670	45,800	0	18,870	26,930
Ra	Nakorotubu	0	-	-	-	4,240	-	-	4,240
	Nalawa	0	-	-	-	4,760	-	-	4,760
	Rakiraki	7,100	2,100	4,620	380	9,070	-	1,450	7,620
	Saivou	0	-	-	-	7,130	-	530	6,600
	sub-total	7,100	2,100	4,620	380	25,200	0	1,980	23,220
Nadroga-Navosa	Barava	940	-	940	-	6,940	-	-	6,940
	Cuvu	430	-	-	430	6,110	-	-	6,110
	Malolo *	0	-	-	-	2,890	-	-	2,890
	Malomalo	0	-	-	-	13,930	-	-	13,930
	Nasigatoka	14,530	1,900	12,460	170	3,840	-	-	3,840
	Navosa	0	-	-	-	4,600	-	-	4,600
	Ruwailevu	0	-	-	-	3,990	-	-	3,990
	Vatulele *	0	-	-	-	700	-	-	700
	sub-total	15,900	1,900	13,400	600	43,000	0	0	43,000
Western Division		266,000	117,800	142,550	5,650	114,000	0	20,850	93,150

*Italics**: Located on islands other than Viti Levu.
Source: Fiji Bureau of Statistics, JET

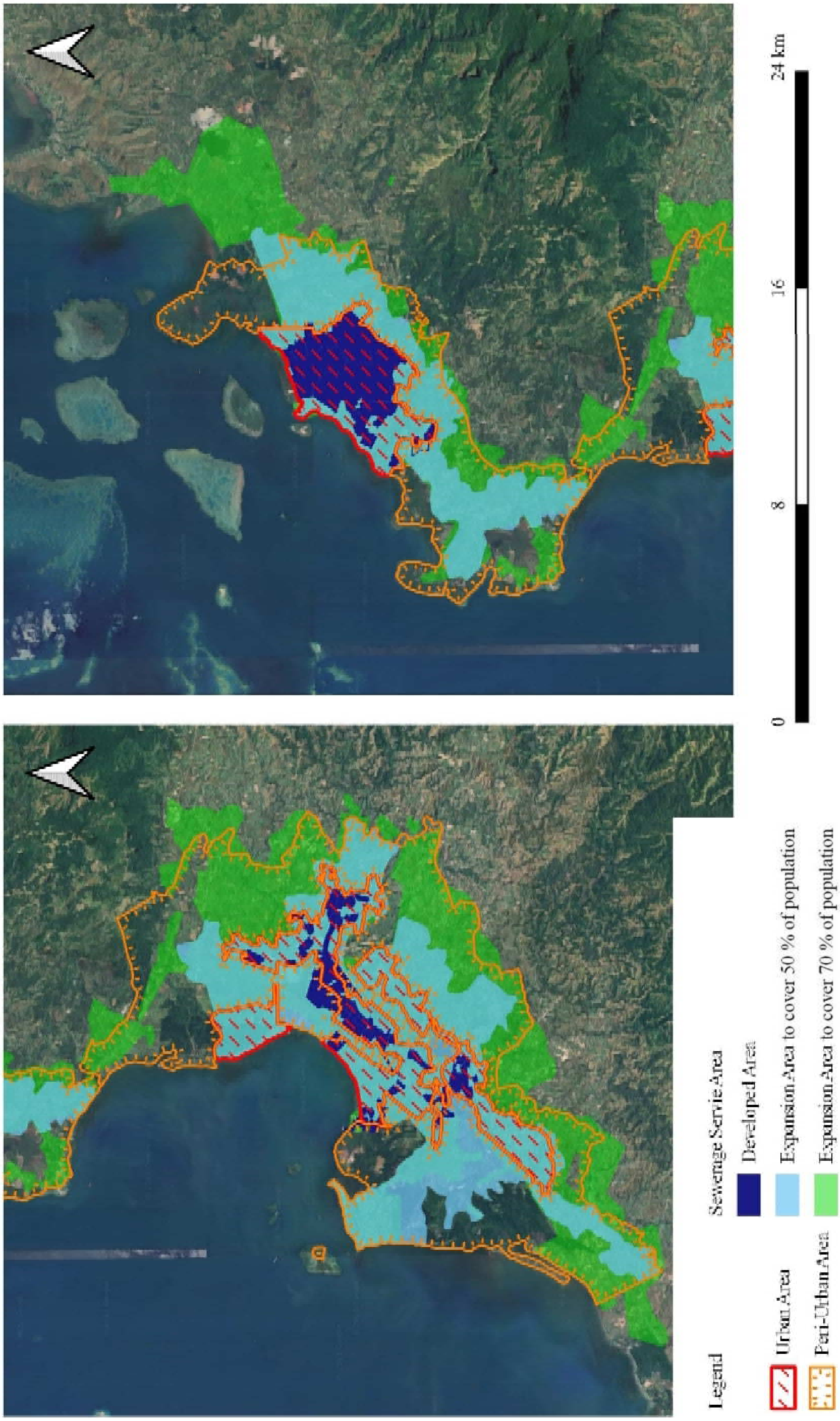


Figure 5-2.1 Proposed Service Areas (Nadi, Lautoka)

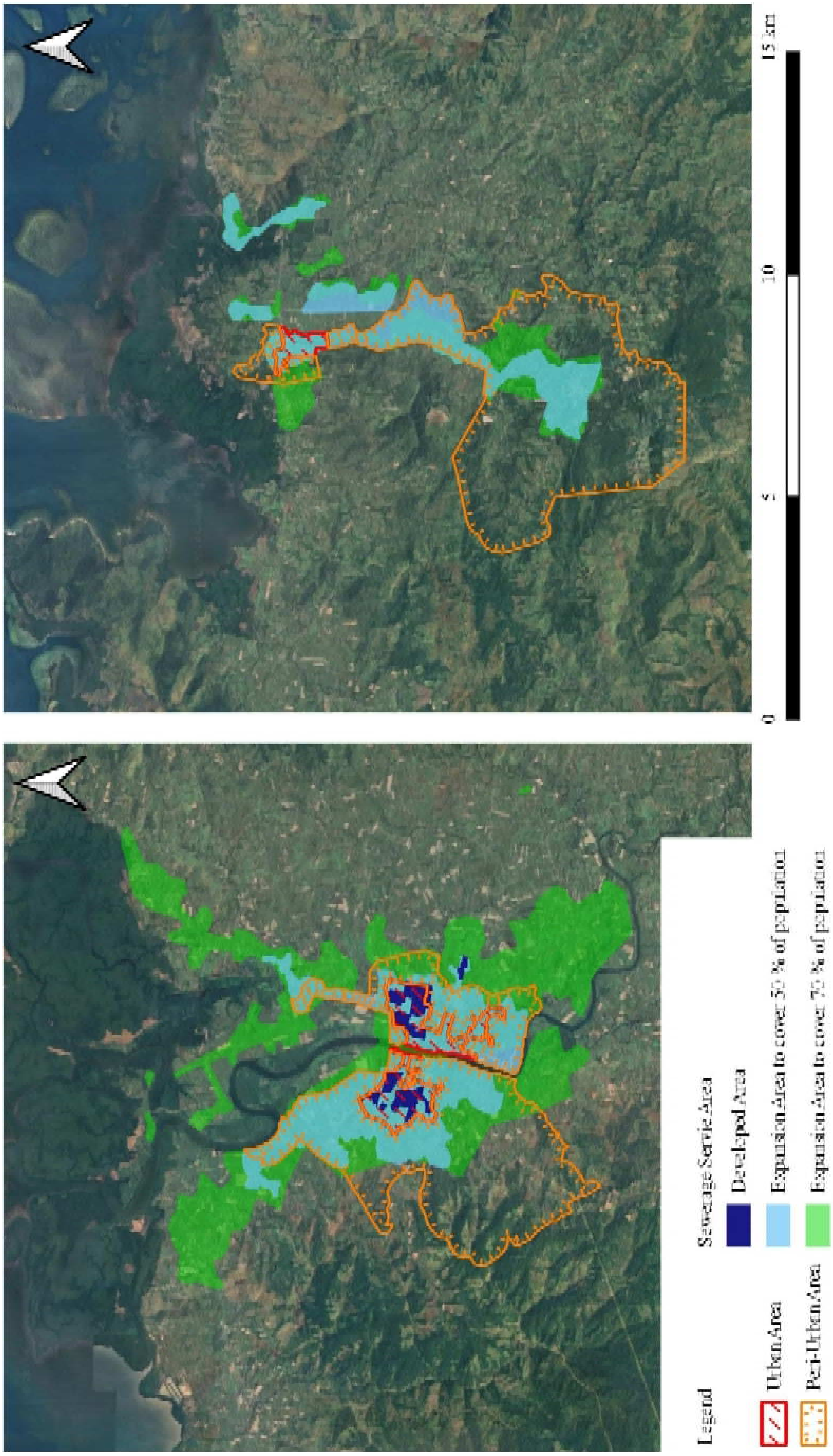


Figure 5-2.2 Proposed Service Areas (Ba, Tavua)

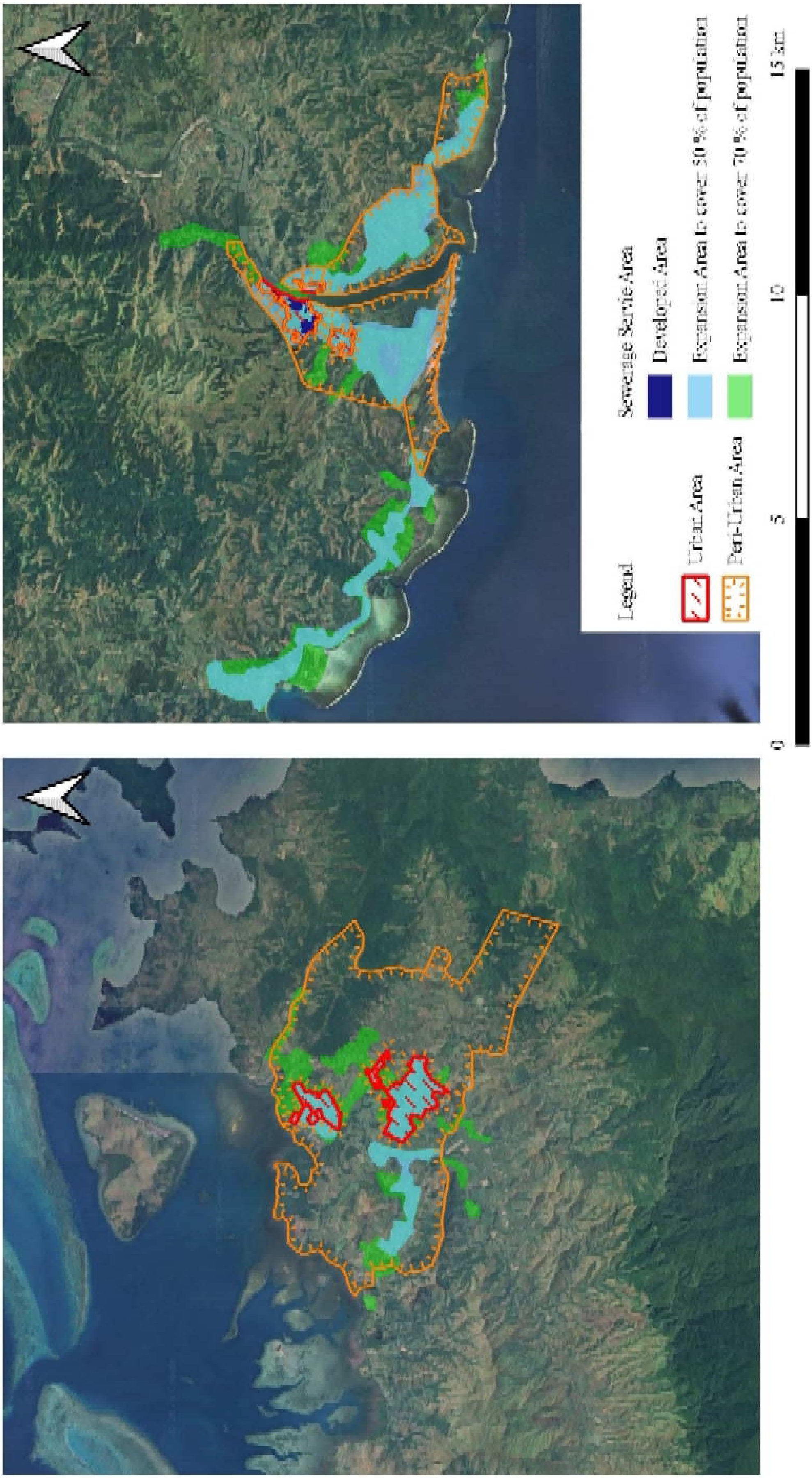


Figure 5-2.3 Proposed Service Areas (Rakiraki, Sigatoka)

5-2-4 Estimated Wastewater Flow

The amount of sewerage expected to be generated in the proposed service area outlined in **5-2-3** is shown in **Table 5-2.2**. If one treatment facility is constructed in each city, the scale of those facilities will be as shown in **Table 5-2.2**. The daily average treatment volume ranges from 2,000 to 32,000 m^3/day.

Table 5-2.2 Estimated Scale of WWTPs

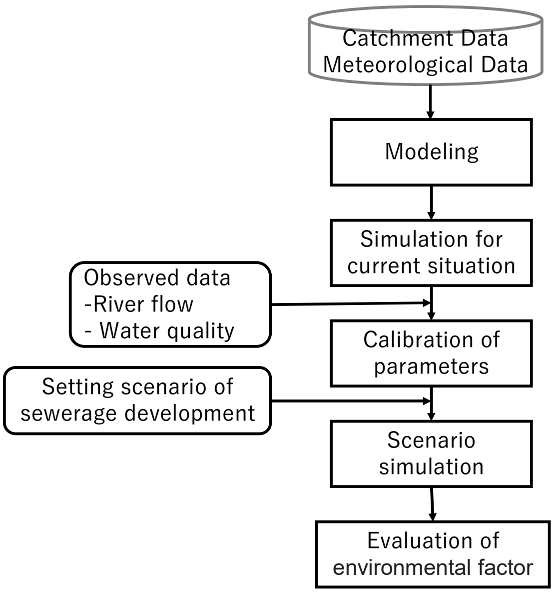
No	Item	Unit	Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka
1	Population		101,600	97,100	31,200	13,100	7,100	15,900
2	Water Consumption	m^3/capita/day	0.220	0.220	0.220	0.220	0.220	0.220
3	Return Ratio	%	90	90	90	90	90	90
4	Unit wastewater Flow	m^3/capita/day	0.200	0.200	0.200	0.200	0.200	0.200
5	Domestic Flow	m^3/day	20,320	19,420	6,240	2,620	1,420	3,180
6	Non-Domestic Ratio	%	40	45	30	20	30	60
7	Non-Domestic Flow	m^3/day	8,128	8,739	1,872	524	426	1,908
8	Generated Wastewater	m^3/day	28,448	28,159	8,112	3,144	1,846	5,088
9	Infiltration ratio	%	10	10	10	10	10	10
10	Infiltration water	m^3/day	2,845	2,816	811	314	185	509
11	Total Inflow ADWF	m^3/day	31,293	30,975	8,923	3,458	2,031	5,597
12	Total Inflow PDWF	m^3/day	62,586	61,950	17,846	6,917	4,061	11,194
13	Total Inflow PWWF	m^3/day	156,464	154,875	44,616	17,292	10,153	27,984

Source: JET

5-2-5 Estimated Water Quality Improvements due to Expansion of Wastewater Treatment

(1) Outline of the Simulation

The impacts to water quality of waterways from the implementation of this project was simulated and evaluated. The evaluation procedure is shown in **Figure 5-2.4**.



Source: JET

Figure 5-2.4 Evaulation Method

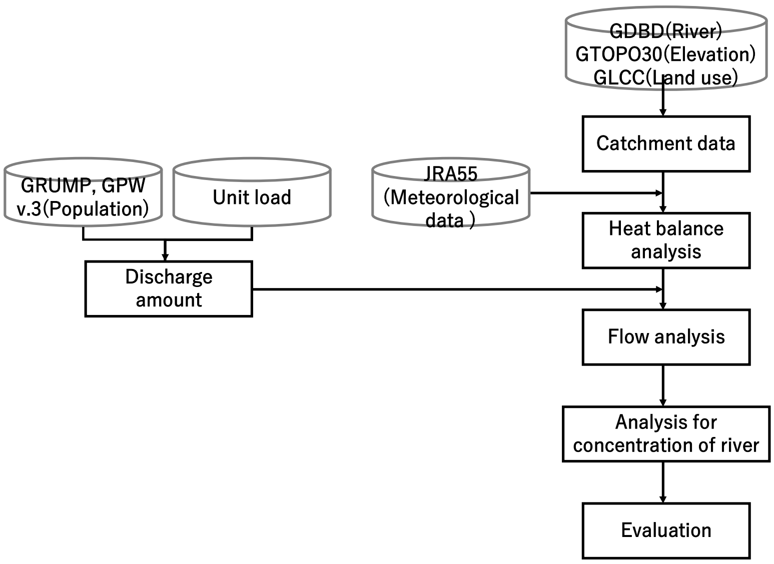
The AIST-SHANEL International Prototype Model was used. Analysis was done using unsteady state analysis using a distributed model. The target basin was divided into a 1 km mesh, and river channels were assigned to the mesh for analysis. Global data was used to create the analysis model. The outline of the model and the data used are shown in **Table 5-2.3**. The configuration of the simulation model is shown in **Figure 5-2.5**. Basin data and meteorological conditions were set based on the published global data and river flow and river water concentrations were simulated.

Table 5-2.3 Model Outline and Input Data

Model Outline	
Analysis Method	Unsteady state analysis using a distributed model
Time resolution	1 Day
Spatial resolution	1 km

Global Data	
Waterways data	Hydro 1K
Elevation data	GTOPO30
Land use data	GLCC
Population data	GPW v4
Meteorological data	JRA55

Source: JET



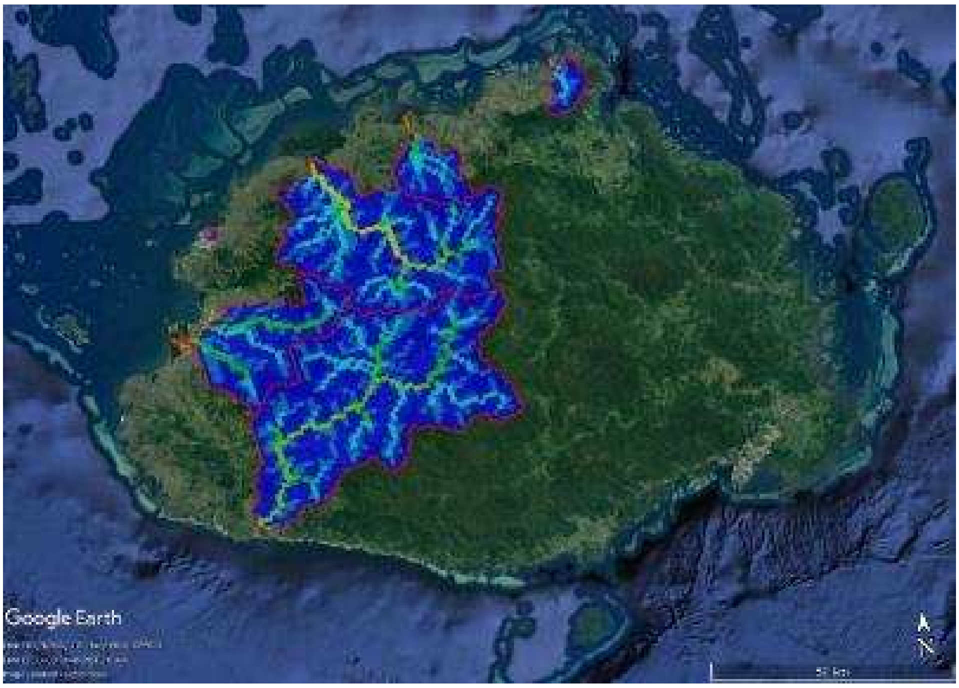
Source: JET

Figure 5-2.5 Structure of the Simulation Model

(1) Creating the Basin Data

1) Waterways Data

The flow direction mesh data published by the United States Geological Survey (hereinafter referred to as "USGS") was converted from the Hydro1k database to the waterflow line mesh data, and river channel data was created. The area distribution of the river network is shown in **Figure 5-2.6**.



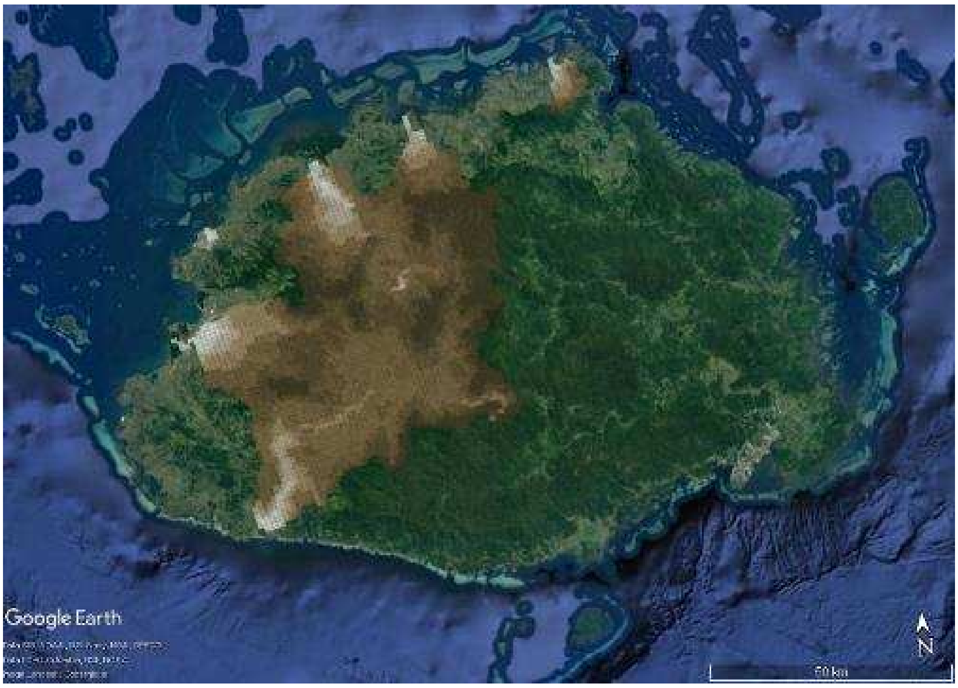
Source: JET

Figure 5-2.6 Waterways of the Target Area

2) Elevation Data

The USGS collected and integrated elevation data from DEM-owned institutions around the world to create the GTOPO30 elevation model. The data was downloaded from Earth Explorer

(http://earthexplorer.usgs.gov/), provided by USGS. The target year is 1996.



Source: JET

Figure 5-2.7 Elevations of the Target Area

3) Land Use Data

The Global Land Cover Characterization (hereinafter referred to as "GLCC") Version 2, also a global database made available by the USGS, is a land use database created from land use data collected by Advanced Very High-Resolution Radiometer (hereinafter referred to as "AVHRR") satellites from April 1992 to March 1993. The data was downloaded from Earth Explorer (http://earthexplorer.usgs.gov/), provided by USGS. The GLCC categorizes land use as one of 24 types. These were redefined as shown in **Table 5-2.4** with reference to the Hydro-BEAM model, of Kyoto University.

Table 5-2.4 Redefinition of Land Use

No.	Land use	Definition				
		Urban	Moutain and Forest	Cropland -field	Cropland	Water body
1	Urban and Built-Up Land	○				
2	Dryland Cropland and Pasture				○	
3	Irrigated Cropland and Pasture			○		
4	Mixed Dryland/Irrigated Cropland and Pasture			○		
5	Cropland/Grassland Mosaic				○	
6	Cropland/Woodland Mosaic				○	
7	Grassland				○	
8	Shrubland				○	
9	Mixed Shrubland/Grassland				○	
10	Savanna		○			
11	Deciduous Broadleaf Forest		○			
12	Deciduous Needleleaf Forest		○			
13	Evergreen Broadleaf Forest		○			
14	Evergreen Needleleaf Forest		○			
15	Mixed Forest		○			
16	Water Bodies					○
17	Herbaceous Wetland					○
18	Wooded Wetland					○
19	Barren or Sparsely Vegetated	○				
20	Herbaceous Tundra		○			
21	Wooded Tundra		○			
22	Mixed Tundra		○			
23	Bare Ground Tundra					○
24	Snow or Ice					○
99	Interrupted Areas					
100	Missing Data					

Note) "No." means the data set No. in GLCC

Source: JET

4) Population Data

The Gridded Population of the World (hereinafter referred to as "GPW") Version 4 is a database of population density distribution published by the National Aeronautics and Space Administration (hereinafter referred to as "NASA"). Since the latest population distribution in Fiji is based on the 2007 census, the latest 2017 total population was used to correct the 2007-2017 population growth rate by multiplying population of all of the meshes by the population growth rate.

5) Pollution Analysis Model

Multiple phenomena such as advection, diffusion, decomposition, sedimentation, denitrification, elution, and sequestration contribute to the natural purification action of rivers, but it is difficult to model all of these complex phenomena accurately. Since the unit rates and surface source loads are also given as approximates, all phenomena other than advection and diffusion are collectively defined as the natural decomposition rate for analysis.

6) Setting Unit Pollution Load

Since the unit pollution load of Fiji is unknown, Japanese values were used to form the basis of the values for Fiji. The Japanese average was used as the unit pollution load of gray water in Fiji. Taking into consideration pollution removal rates of septic tanks, the unit pollution load of black water was set as shown in **Table 5-2.5**. The unit wastewater flow was set as 200 L/day/ capita.

Table 5-2.5 Setting of Unit Pollution Load

Item	Septic Tank Removal Rate	Breakdown (g/day/capita)		Total (g/day/capita)
		Black Water	Grey Water	
BOD	50%[11]	9.00	40.00	49.00
COD	50%[11]	5.00	18.00	23.00
SS	85%[12]	3.00	24.00	27.00
T-N	70%[11]	2.70	4.00	6.70
T-P	80%[11]	0.18	0.50	0.68

Source: Guideline for River basin wised Overall Sewerage Development Plan, January 2015.

(2) Model Verification and Calibration

1) Meteorological Conditions

For meteorological data (rainfall, atmospheric pressure, temperature, specific humidity, wind speed, etc.), the Global Long-Term Reanalysis JRA-55 conducted by the Japan Meteorological Agency and the Central Research Institute of Electric Power Industry was used. The target year was 2021, when the discharge and water quality observations were carried out.

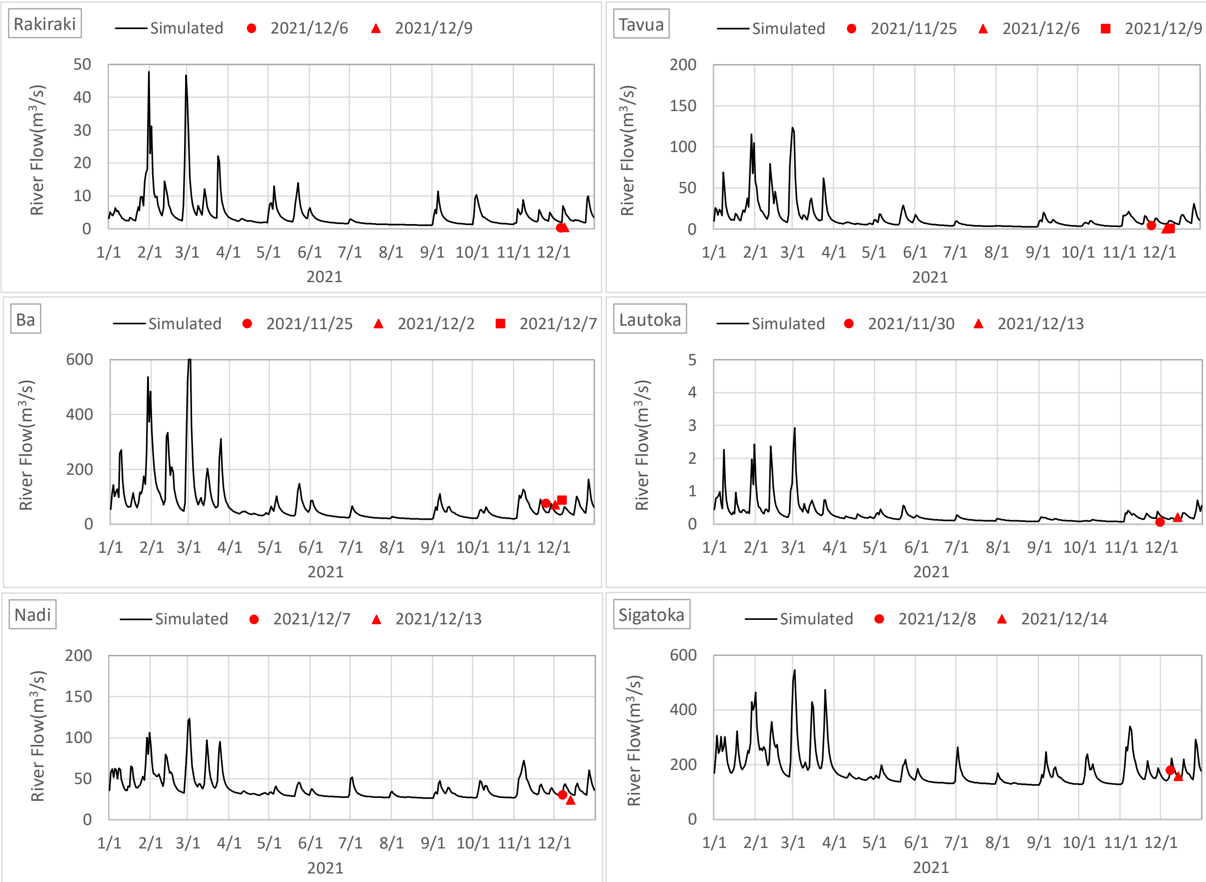
2) Observation Points

The observation points will be the same as those of the river flow and water quality surveys described in Section 3-4.

3) Flow Rate Calibration

As a result of the calibration, porosity was set to 10% for Rakiraki, Tavua, Ba, and Lautoka on the northern side of Viti Levu Island: porosity was set to 0.22% for Nadi and Sigatoka on the western side of Viti Levu Island. As shown in **Figure 5-2.8**, the results correspond well with observed values and reproducibility is sufficient.

[11] National Institute for Land and Infrastructure Management, Study on the development of low-cost type new sewerage system suitable for developing countries.
[12] Ryuichi SUDO; Technical problems in household wastewater treatment, Journal of Environmental Conservation Engineering

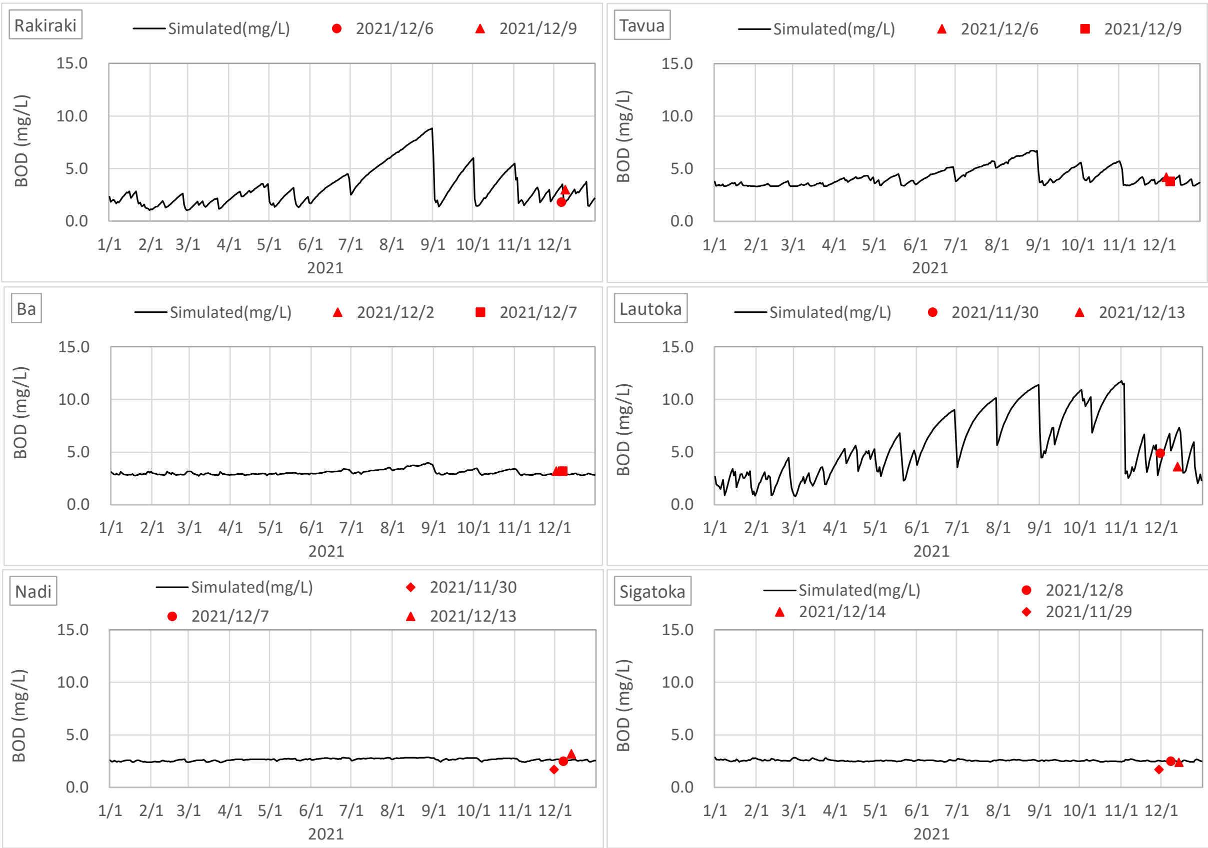


Source: JET

Figure 5-2.8 Flow Rate Calibration

4) Water Quality Calibration

Figure 5-2.9 shows a comparison of observed and analyzed values after BOD calibration. The observed value can be reproduced by calibrating the coefficient of runoff.



Source: JET

Figure 5-2.9 Comparision of Observed Data and Simulation Data

(3) Effects of Centralized Treatment System Development

1) Meteorological Conditions

For the meteorological data, the average yearly data was used. As shown in **Table 5-2.6**, data from 2013 will be adopted as it is the year in which the annual precipitation and average temperature over the past 10 years are the closest to typical values (1991-2020 average values). As with current analyses, values from JRA-55 were used for the analysis.

Table 5-2.6 Annual Precipitation and Average Temperature of Nadi

Monthly rainfall (mm)

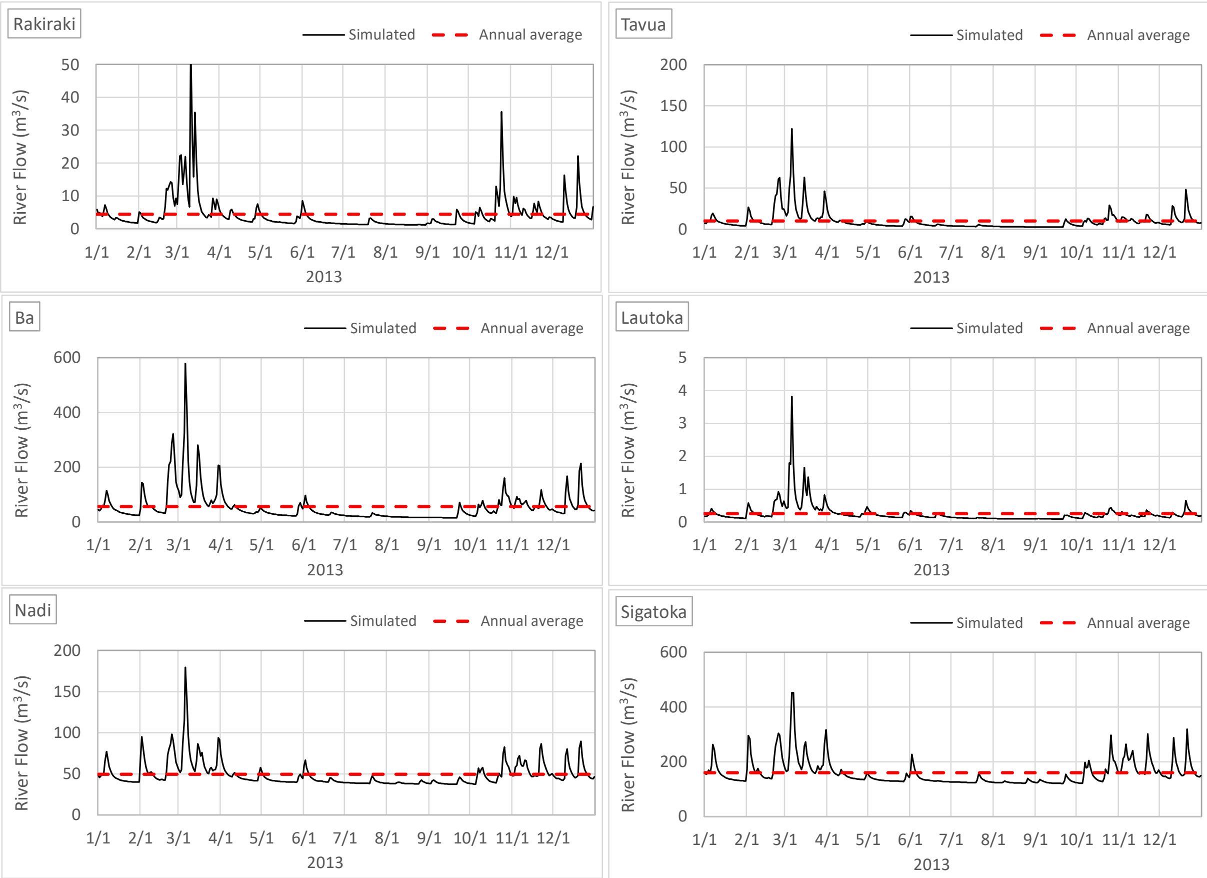
Month	30 year Average	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	368	960	88	402	206	227	314	335	402	78	539
2	348	574	465	244	347	427	787	530	85	122	333
3	358.7	694	342	137	154	324	510	413	—	785	309
4	193.2	235	104	117	95	500	49	344	324	177	63
5	100.8	37	116	134	—	21	55	110	—	156	122
6	58.9	312	125	1	15	28	—	53	58	29	42
7	49.4	33	6	13	16	13	21	1	65	60	9
8	64.3	66	11	0	40	197	61	6	20	17	5
9	67.8	211	155	8	63	7	4	42	90	51	71
10	87.9	104	119	37	25	165	28	173	133	149	41
11	133.1	122	239	89	29	123	139	—	48	145	242
12	222.3	199	258	124	182	270	202	100	202	170	373
Annual value	2052.4	3547	2028	1306	1172	2302	2170	2107	1427	1939	2149
Difference *		1494.6	24.4	746.4	880.4	249.6	117.6	54.6	625.4	113.4	96.6

* 30year average - anuual value

Source: JET

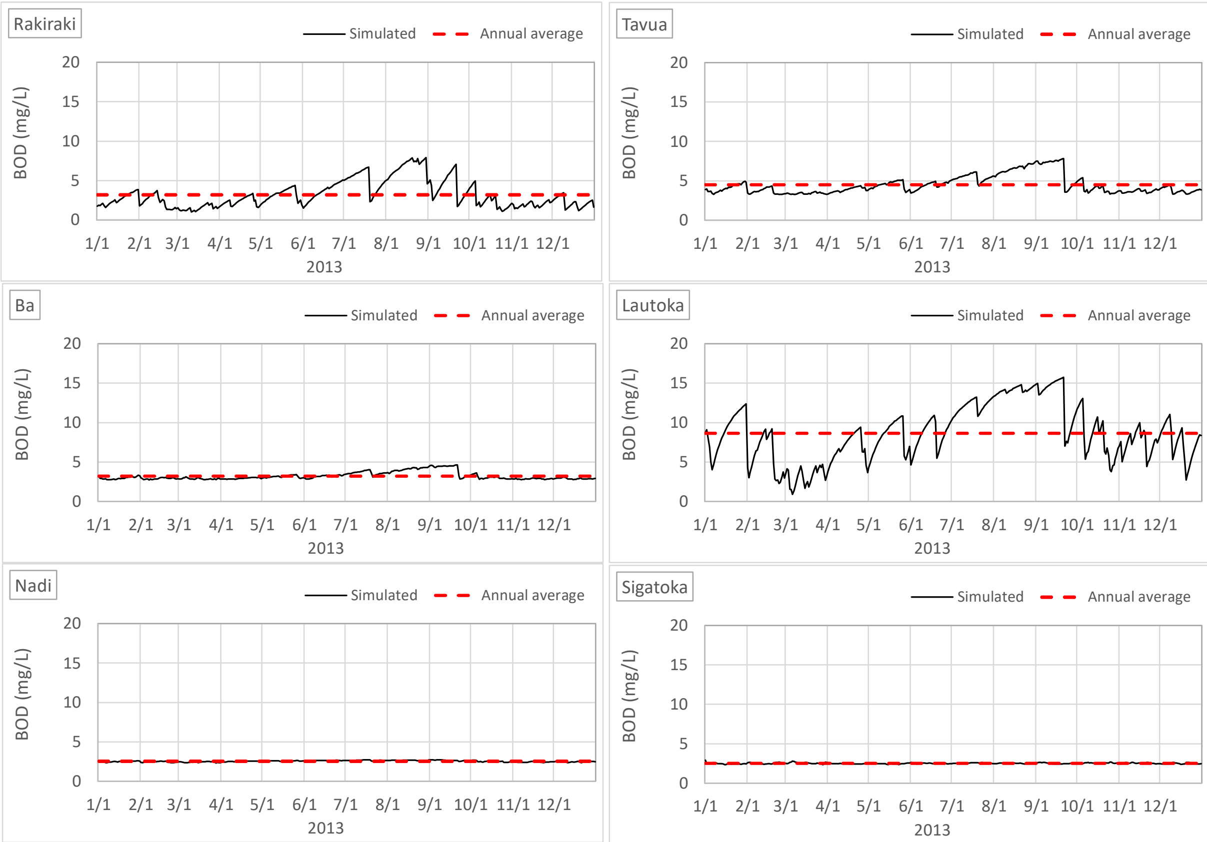
2) Analysis of Current Conditions

Hydrographs of the most downstream points of each water system are shown in **Figure 5-2.10**. Daily variations in BOD concentration are shown in **Figure 5-2.11**. Annual average values of river flow and BOD concentration are shown in **Table 5-2.7**.



Source: JET

Figure 5-2.10 Hydrograph



Source: JET

Figure 5-2.11 BOD Concentration

Table 5-2.7 Annual Average Flow Rate and BOD

Basin Name	Most Downstream Point		Observation Point	
	Flow rate (m^3/s)	BOD (mg/L)	Flow rate (m^3/s)	BOD (mg/L)
Rakiraki	4.42	3.19	4.20	3.21
Tavua	9.97	4.49	9.86	4.54
Ba	56.04	3.22	53.05	3.14
Lautoka	0.26	8.64	0.20	6.68
Nadi	49.34	2.55	33.69	2.68
Sigatoka	160.13	2.51	159.00	2.53

Source: JET

3) Scenario Analysis

Several scenarios were simulated to evaluate the impacts of the new WWTPs on BOD.

i) Selection of Target Area

The proposed sewerage area is as shown in Figure 5-2.1 to **Figure 5-2.3**. The model mesh that coincides with this area was set as the sewerage area.

ii) Evaluation Scenario

The following two effluent standards were used as scenario cases.

Table 5-2.8 Examination Cases

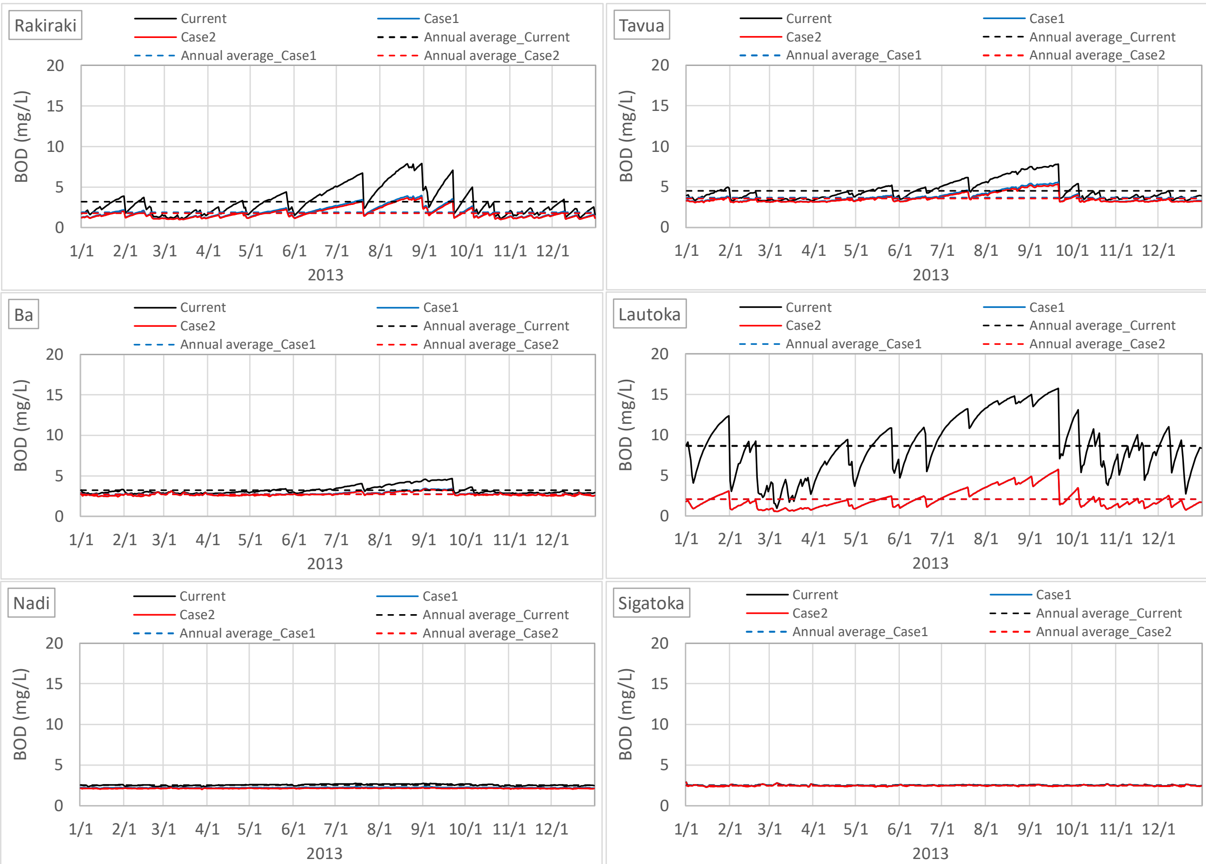
	WWTP Effluent BOD (mg/L)	Comments
Case1	40	Required for general discharge
Case2	20	Required for discharge into Significant Ecological Zones

Source: JET

iii) Results

Daily variations in BOD at the downstream end of the observed rivers are shown in **Figure 5-2.12**. The annual average BOD concentration is shown in **Table 5-2.9**. Although the effluent quality was different between Case 1 and Case 2, BOD concentration downstream was mostly the same. Comparing the results with the current condition of undeveloped wastewater treatment, river water quality improvement tends to be high in Rakiraki, Tavua and Lautoka, where the basin area is small, and the river flow rate is small.

Sigatoka, which is part of a large basin with good water quality, sees a smaller improvement effect of on river water quality. On the other hand, for Lautoka and Rakiraki, which have a relatively small basin areas and poor water quality, river water quality can be improved by about 15 to 50%.



Source: JET

Figure 5-2.12 Comparison of BOD After Implementation (Most Downstream End)

Table 5-2.9 Average Annual BOD Concentraion for Each Case (Most Downstream End)

Basin Name	Average Annual BOD Concentration (mg/L)		Improvement
	Current	Case1	(%)
Nadi	2.55	2.21	13.3
Lautoka	8.64	2.05	76.3
Ba	3.22	2.76	14.3
Tavua	4.49	3.66	18.5
Rakiraki	3.19	1.88	41.1
Sigatoka	2.51	2.48	1.2

Source: JET

5-3 Planning of Sewerage Facilities

5-3-1 Wastewater Treatment Process

(1) Effluent Water Quality

As listed in **Table 5-3.1**, Fiji has two types of effluent water quality standards: the General standards and the Significant Ecological Zone (hereinafter referred to as "SEZ") standards, which has stricter conditions. The application of SEZ standards is not defined for specific water areas/water bodies, but are designated by the DOE, which examines the topography and environmental characteristics around the discharge point of each proposed site.

Table 5-3.1 Effluent Water Quality Standards

Parameter	Units	Concentration	
		General	Significant Ecological Zone
pH	pH	7-9	7-9
BOD5	mg/L	40	20
SS	mg/L	60	30
Fecal coliforms	CFU/100mL	400	200
TN	mg/L	25	10
Ammonia	mg/L	10	5
TP	mg/L	5	2

Source：Schedule 3 of the Waste Disposal and Recycling Regulations of Fiji (Environment Management (Waste Disposal and Recycling) Regulations, 2007).

Regarding the application of effluent water quality standards, DOE provided the below information in the meeting held on July 2022:

- SEZ standards are applied to effluents which discharge to coastal areas with delicate environmental characteristics.
- In the case of Lautoka's Natabua WWTP, General standards apply since the effluent is discharged 1.2 km away from the coast.

Therefore, in this report both the General and SEZ standards will be considered as the WWTP's target effluent water quality, and organized into the following two cases.

(Case 1) Applies SEZ standards to all WWTP, perceiving the possibility of tightened environmental regulations (Strictest Case)

(Case 2) Apply General/SEZ standards based on the scale of outflow water bodies

Based on discussions with WAF, the application standards are set as follows:

Table 5-3.2 Setting Effluent Standards

Water Body WWTP discharges to	Applied Standard	Notes
Ocean/Bays/Coastal Areas	General	Apply General standards to large-scale water bodies such as coastal areas/bays, where the influence of effluents is less susceptible.
Rivers/Streams	SEZ	Apply SEZ standards to small-scale water bodies such as rivers and streams, where the influence of effluents could be relatively large.
WWTPs to be built in the future	SEZ	For the case of Rakiraki and Tavua, where WWWTPs are yet to be built, apply SEZ standards for safekeeping.

Source: JET

Considering with above (Case 1) and (Case 2), the setting of effluent standards for each WWTP are summarized as follows:

Table 5-3.3 Setting Effluent Standards for each WWTP

WWTP (Municipal)	Outflow Water Body	Effluent Standard	
		Case 1	Case 2
Navakai (Nadi)	Nadi River	SEZ	SEZ
Natabua (Lautoka)	Ocean (1.2 km out to sea)	SEZ	General
Votua (Ba)	Waterway in mangrove thicket	SEZ	SEZ
Tavua	Undecided	SEZ	SEZ
Rakiraki	Undecided	SEZ	SEZ
Olosara (Sigatoka)	Mouth of Sigatoka River	SEZ	General

Source: JET

(2) Comparison of Treatment Process Options

As shown earlier in **4-1-1,** currently three WWTPs in the Western Division operate stabilization ponds for its wastewater treatment. If maintenance (sludge dredging of ponds) is properly and regularly carried out, the effluent can comply with the General standards. Therefore, if a large site area can be secured for the WWTP, and if the General Standard applies for the discharge area, the stabilization pond method can be considered as a low construction/O&M cost option.

If the above conditions are not met (such as: limited availability of land, SEZ Standards requirement of the discharge area), mechanical treatment processes using many electromechanics equipment, such as conventional activated sludge process will be applied. **Table 5-3.4** lists some treatment processes that area adopted in Japan.

Table 5-3.4 Seven Treatment Processes Adopted in Japan

Processing method	Features	Main Design Standards	Effluent Quality
Conventional Activated Sludge Process	Medium ~ Large scale WWTP (10,000m^3/day and larger) Most popularly adopted method. Many mechanical assets needing regular maintenance.	MLSS concentration：1500~2000 mg/L HRT：6～8 hrs	10mg/L＜BOD≦15mg/L With coagulants, T-P≦1mg/L
Pure Oxygen Activated Sludge Process	Applies pure oxygen aeration to enable high organic load and high MLSS concentrations.	MLSS concentration：3000~4000 mg/L HRT：1.5～3 hr	Same as Conventional Activated Sludge Process
Oxidation Ditch Process (OD)	Primary settling tank not needed. Mechanical aeration under low-organic load conditions allows relatively easy O&M with few mechanical assets requiring regular maintenance.	MLSS concentration：3000~4000 mg/L HRT：24 hrs (Check HRT needed for nitrification based on ASRT calc.) Aerobic: Anoxic time ratio =1：1	Same as Conventional Activated Sludge Process (+ Nitrogen removal) (+ Phosphorus removal with coagulants)
Extended Aeration Process	Primary settling tank not needed. Limits/controls amount of excess sludge by keeping organic load low. Difference between OD is the directional flow of water (OD: circular channel, EA: one-way channel) Few mechanical assets requiring regular maintenance	MLSS concentration：3000~4000 mg/L HRT：24 hrs (Check HRT needed for nitrification based on ASRT calc.) Aerobic: Anoxic time ratio 1：1	Same as Conventional Activated Sludge Process (+ Nitrogen removal)
Sequential Batch Reactor Process (SBR)	A single tank performs inflow, reaction, sedimentation, and discharge. The system needs to be frequently operated to perform each function.	Two types: Low-load SBR and High-load SBR.	Same as Conventional Activated Sludge Process (+ Nitrogen removal)
Trickling Filter Process	The trickling filter is filled with 3~5 mm media, where a layer of microorganisms (biofilm) grows on. When wastewater trickles down between the media, the microorganisms break down organic matter/takes in SS. No final sedimentation tank is needed. There is no final settling basin, and the captured SS and grown microorganisms are removed by washing back to the first settling basin. Overgrown microorganisms are washed and off and removed back to the primary settling tank.	Media size：3~5 mm Media thickness：2~3 mm BOD load：4 BOD-kg/(m^3・day) or lower Filtering Speed：25 m/day and below	Same as Conventional Activated Sludge Process
Contact-Aeration Process	Air is blown from the bottom of the media submerged in the wastewater to form a layer of microorganisms (biofilm) on its surface. Organic matter is broken down by bringing wastewater into contact with the biofilm, Fine SS particles tend to flow out of the final sedimentation tank.	BOD loading：0.3 BOD-kg/(m^3・d) or lower	Same as Conventional Activated Sludge Process

Source: Created by JET based on Japan Sewerage Works Agency “Fundamental Design Guideline” (2004), “Small-scale Treatment Plant Design Guideline (Draft)” (March 1991), Japan Sewerage New Technology Organization “Aerobic Trickling Filter Process Technical Manual 1994 edition,” and Japan Sewerage Association “Sewerage Facility planning / design guidelines and explanations Part 2 2009 edition”

As shown in **4-5-1**, considering the current levels of WWTP maintenance, easily maintainable treatment processes are more desirable for Fiji. **Table 5-3.5** summarizes the required maintenance levels and application of each method in Japan's small-scale municipalities. Out of the seven options, the OD process and Extended Aeration process can be picked out as methods highly applicable in Fiji. Since the Extended Aeration process's design standards and functions are similar to that of the OD process, this report will consider the OD process, which has a larger number of adopted cases in Japan.

The IDEA process, which has already been adopted for Kinoya WWTP and improved design of Navakai WWTP (Nadi), is a modified method of the SBR method. It required a larger number of mechanical assets, but the WAF staff's onsite maintenance experience at Kinoya WWTP can utilized for operations in the West.

Therefore, of the above seven treatment processes, the OD process and the IDEA process will be considered as mechanical treatment processes options in this report.

Table 5-3.5 Evaluation Based on O&M Requirements and Past Application Cases in Japan

Treatment Process	Evaluation	Results
Conventional Activated Sludge Process	• Large number of mechanical assets requiring regular maintenance	Not applicable
Pure Oxygen Activated Sludge Process	• O&M of specialized mechanical assets (oxygen generator, liquid nitrogen tanks, etc.) required	Not applicable
Oxidation Ditch Process (OD)	• Relatively few number of mechanical assets and easy O&M • Large case number of small-scale municipalities that adopted OD process	Applicable
Extended Aeration Process	• Similar to the OD process, relatively few number of mechanical assets and easy O&M	Applicable
Sequential Batch Reactor Process (SBR)	• Complicated maintenance • System and mechanical assts need to be operated based on a strict time schedule • Valves must be inspected frequently	Not applicable
Trickling Filter Process	• Number of mechanical assets per trickling filter is small, but requires many small-size trickling filters as the influent amount increases; as a result, the number of assets grow large, leading to complicated maintenance • Difficult to control/stabilize water quality due to the peeling/dropout of biofilm on media surface • Not many facilities have adopted Trickling Filter methods in Japan in the past	Not applicable
Contact-Aeration Process	• Similar to the Trickling Filter Process, the number of mechanical assets per basin is small, but with the increase in influent amount the number of basins/assets increase, becoming more difficult to manage • Not many facilities have adopted Trickling Filter methods in Japan in the past	Not applicable

Source：JET

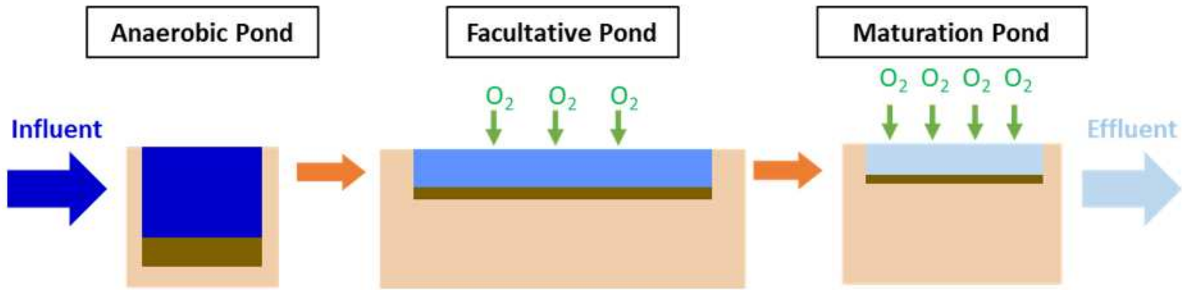
From the above examination results, this study will consider the following four treatment processes based on the current situation of wastewater treatment in Fiji and the past application cases in Japan.

Table 5-3.6 Treatment Process to be Examined in the Study

Treatment Process	Outline/Applicable Conditions	Effluent Quality
Stabilization Pond (SP)	• Currently adopted at Natabua, Olosara, Votua WWTP • Requires large site area and application of General standards for effluent water quality	General
Aerated Lagoon (AL)	• Smaller land requirement compared to Stabilization Pond • Requires large site area and application of General standards for effluent water quality	General
IDEA Process (IDEA)	• Currently adopted at Kinoya WWTP. • Adopted in the detailed design project for Navakai WWTP • Apply if available site area is limited and/or if SEZ standards apply for effluent water quality	General & SEZ
Oxidation Ditch Process (OD)	• One of Japan's standard mechanical treatment processes, and is highly applicable in Fiji • Apply if available site area is limited and/or if SEZ standards apply for effluent water quality	General & SEZ

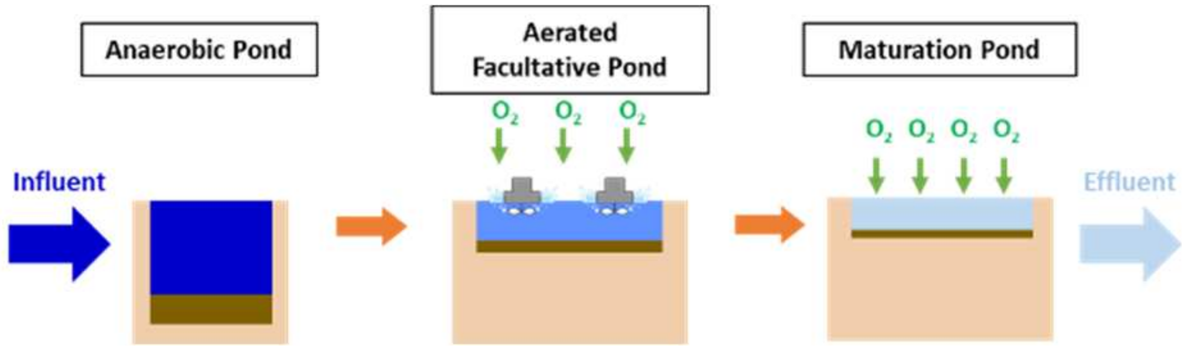
Source：JET

The schematic flow for each treatment process is shown as follow.



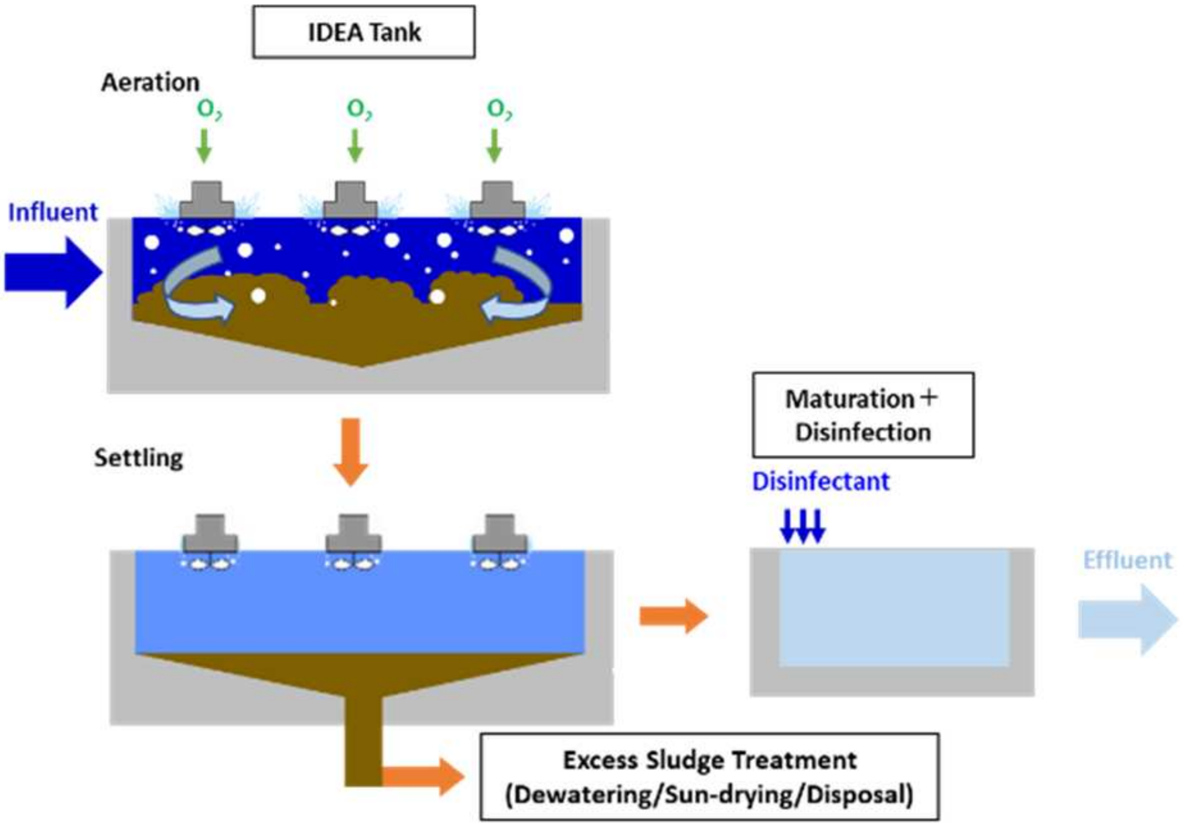
Source：JET

Figure 5-3.1 Schematic Flow of Stabilization Pond Process



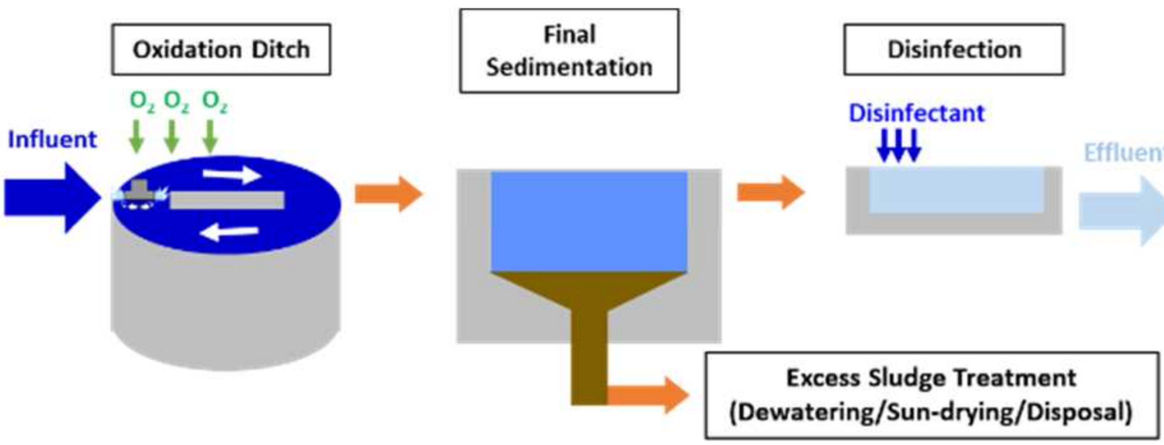
Source：JET

Figure 5-3.2 Schematic Flow of Aerated Lagoon Process



Source：JET

Figure 5-3.3 Schematic Flow of IDEA Process



Source：JET

Figure 5-3.4 Schematic Flow of OD Process

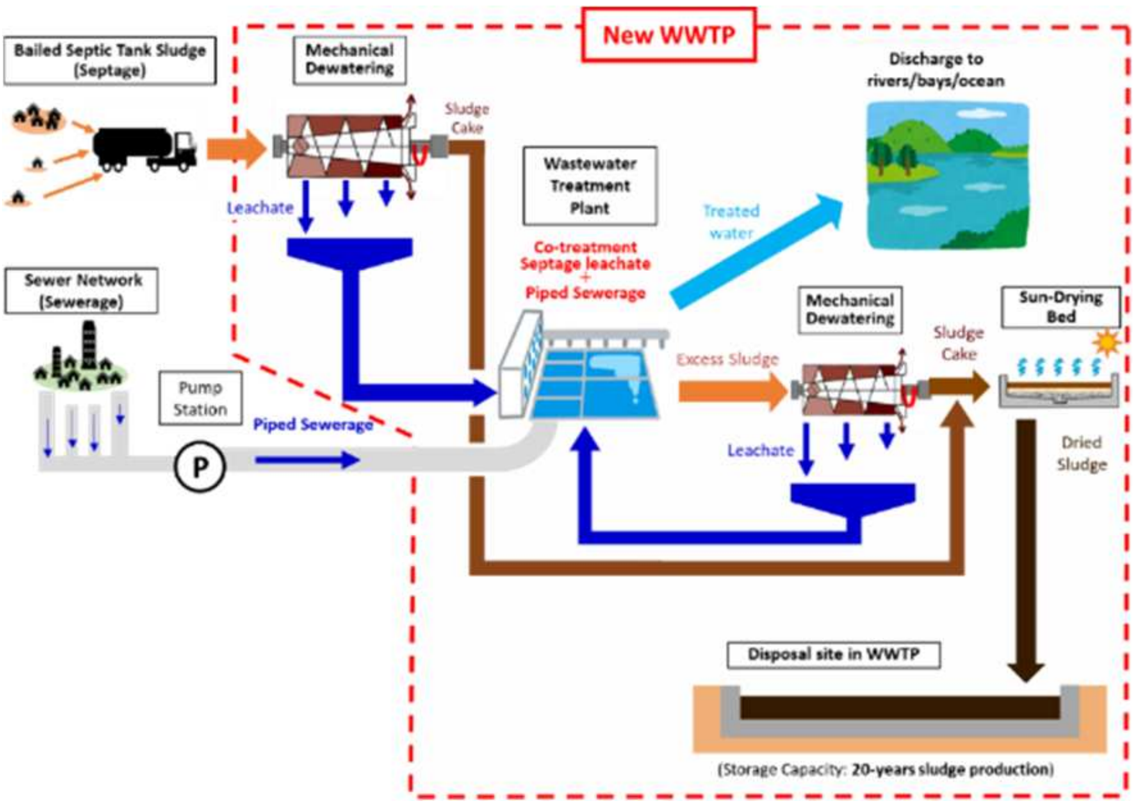
(3) Preconditions for the Examination/Selection Process

The capacity calculation of each treatment process was formulated to find the estimated site area required for the treatment plant. The preconditions for the calculations are as listed below. As for the IDEA process, due to the fact that its capacity calculation formulas are not open to the public due to patent restrictions, area estimations were computed based on the estimated retention time of each basin. (See **APPENDIX 5-2** for details).

1) Setting the Treatment Target Wastewater

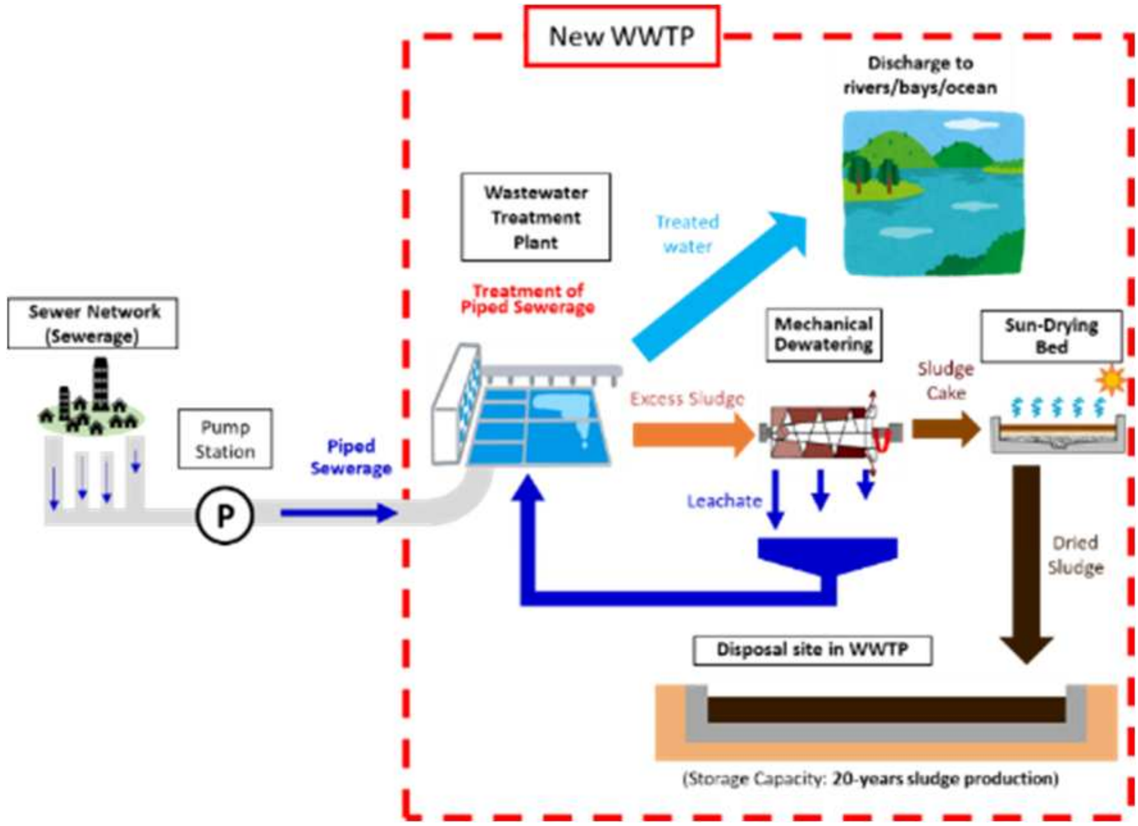
The target wastewater to be treated at the WWTPs was set to be "inflow of sewerage from pipelines" (hereinafter referred as "pipeline sewerage"), and "domestic septage collected by bailing trucks" (hereinafter referred as "septage" or "domestic septage")

Septage is expected to be accepted at three locations: Natabua, Rakiraki, and Olosara WWTP. Septage is to be received in the septage receival tanks, then directly dewatered by dewatering machines. The leachate will be co-treated with pipeline sewerage, whereas the sludge cakes are sun-dried then stored (landfilled) within the WWTP premises. The schematic flow of WWTPs is as shown below.



Source : JET

Figure 5-3.5 Schematic Flow of WWTPs accepting Septage



Source：JET

Figure 5-3.6 Schematic Flow of WWTPs only accepting Piped Sewerage

2) Influent Flow

The influent flow of each WWTP is organized as below.

Table 5-3.7 Influent Flow of WWTPs

Target Sewerage	Flowrate (m^3/day)	Navakai (Nadi)	Natabua (Lautoka)	Votua (Ba)	Tavua	Rakiraki	Olosara (Sigatoka)
Total Influent (Pipeline Sewerage + Domestic Septage)	Average Daily	32,000	31,000	9,000	4,000	3,000	6,000
	Maximum Daily	35,200	34,100	9,900	4,400	3,300	6,600
	Maximum Hourly	63,000	62,000	18,000	7,000	5,000	12,000
	Peak Wet Weather	157,000	155,000	45,000	18,000	11,000	29,000
Domestic Septage	Average Daily Quantity	0	21	0	0	12	11

Source：JET

3) Influent Water Quality

The influent water quality of each WWTP is shown below. Of the six WWTPs, Navakai, Rakiraki, and Olosara accept domestic septage that is bailed and trucked into the plant. Compared to the amount of pipeline sewerage (few thousand~tens of thousands m^3/d), the amount of septage trucked in is very small (at most 11~21 m^3/d, average daily quantity). After examination it was concluded that even when leachate from the dewatered septage is co-treated, the influent water quality did not change from the water quality of the pipeline sewerage (refer to **APPENDIX 5-2**). Therefore, the above mentioned three WWTPs will also adopt the water quality that is listed in **Table 5-3.8**.

Table 5-3.8 Influent Water Quality and Water Temperature

BOD (mg/L)	TSS (mg/L)	T-N (mg/L)	T-P (mg/L)	COD (mg/L)	Temp. (℃)
360.0	485.0	70.0	9.0	792	20.0

Source：JET

4) Sludge Storage

Since there are currently no disposal sites/landfills that accept sewerage sludge, sludge storage sites for excess sludge and dredged sludge (and for some WWTPs, dewatered domestic septage sludge) were considered in the facility layout/footprint calculations. The calculations assumed that the storage sites will contain 20 years' worth of sludge produced from the WWTP.

(4) Facility Layout Examination/Required Site Area

The capacity calculation of each treatment process for each WWTP was done, then used to compute a rough estimate of the facility layout and required site area (For details of the capacity calculation, refer to **APPENDIX 5-3～5**). The approximate site area for each study case is organized in **Table 5-3.9**. As a result of the examinations, in either case the area required for sludge storage was very large. However, if final disposal sites (landfills) start accepting sewerage sludge, and/or if the utilization of sewerage sludge (fertilizer/soil conditioner production) as mentioned in **4-3-1** is promoted in Fiji, the footprint requirement of sludge storage could be reduced.

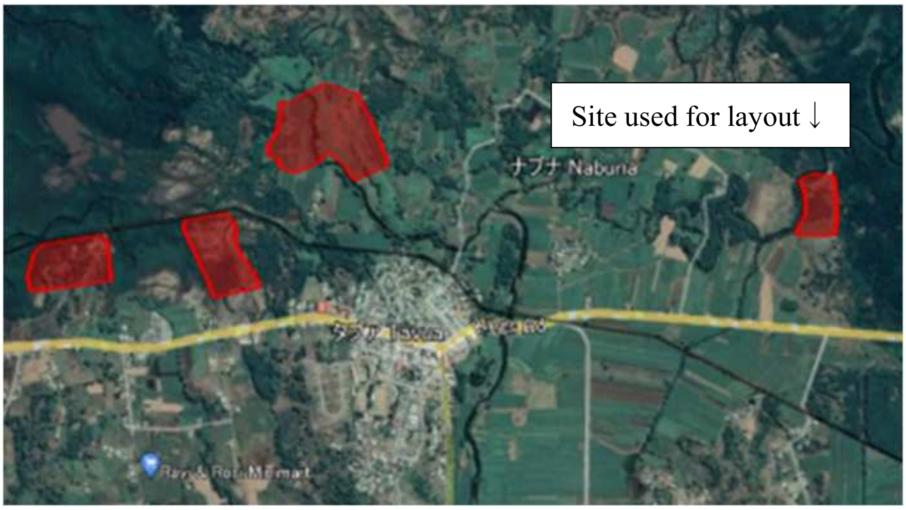
Table 5-3.9 Required Site Area Estimate of each WWTP/Treatment Process

WWTP (Municipality)	Acceptance of Septage	Treatment Process* 1	Target Effluent Quality Std.	Estimated Area (ha)	Area for Sludge Storage (ha)
Navakai* 2 (Nadi)	None	Stabilization Pond	General	73.3	4.2
		AL	General	49.8	4.2
		OD / IDEA	General/SEZ	20.5	11.5
Natabua (Lautoka)	Accept	Stabilization Pond	General	72.5	4.2
		AL	General	49.2	4.2
		OD / IDEA	General/SEZ	22.7	11.8
Votua (Ba)	None	Stabilization Pond	General	31.1	1.5
		AL	General	19.3	1.5
		OD / IDEA	General/SEZ	8.2	3.4
Tavua	Accept	Stabilization Pond	General	8.8	0.5
		AL	General	6.4	0.5
		OD / IDEA	General/SEZ	4.0	1.6
Rakiraki	Accept	Stabilization Pond	General	8.3	0.9
		AL	General	6.3	0.9
		OD / IDEA	General/SEZ	4.1	1.5
Olosara (Sigatoka)	None	Stabilization Pond	General	13.9	1.2
		AL	General	11.5	1.2
		OD / IDEA	General/SEZ	6.7	2.8

* 1 The site area of the IDEA process is assumed to be almost the same as that of the OD process.
* 2 Since Navakai WWTP is currently being treated by the IDEA process, the stabilization pond and AL process were omitted from the examination

As for the OD process, the new treatment facilities were laid out next to the existing treatment facilities, so wastewater treatment can be continued during the construction period. After switching to the OD process, the site of the current treatment plant will be treated as landfill for sludge and/or as a site for facility expansions after 2036.

Since there are no existing WWTPs in Tavua and Rakiraki, the facility layout is shown at the following sites, which are candidate sites. As for Rakiraki, the boundary line of the candidate site was not specified, so it was estimated from the bird's-eye view and the result of on-site surveys.



Source：JET

Figure 5-3.7 Estimated Candidate sites for Tavua WWTP

Source : Created by JET, based on "Greater Easter Division Rakiraki Wastewater Master Plan"(Water Authority of Fiji)

Figure 5-3.8 Candidate Site for Rakiraki WWTP

The facility layout of each study case is shown below.

Source : JET

Figure 5-3.9 Navakai WWTP (Nadi): OD

Source: JET

Figure 5-3.10 Natabua WWTP (Lautoka): Stabilization Pond

Source: JET

Figure 5-3.11 Natabua WWTP (Lautoka): AL

Source: JET

Figure 5-3.12 Natabua WWTP (Lautoka): OD

Source: JET

Figure 5-3.13 Votua WWTP (Ba): Stabilization Pond

Source: JET

Figure 5-3.14 Votua WWTP (Ba): AL

Source: JET

Figure 5-3.15 Votua WWTP (Ba): OD

Source: JET

Figure 5-3.16 Tavua WWTP: Stabilization Pond

Source: JET

Figure 5-3.17 Tavua WWTP: AL

Source: JET

Figure 5-3.18 Tavua WWTP: OD

Source: JET

Figure 5-3.19 Rakiraki WWTP: Stabilization Pond

Source: JET

Figure 5-3.20 Rakiraki WWTP: AL

Source: JET

Figure 5-3.21 Rakiraki WWTP: OD

Source: JET

Figure 5-3.22 Olosara WWTP (Sigatoka): Stabilization Pond

Source: JET

Figure 5-3.23 Olosara WWTP (Sigatoka): AL

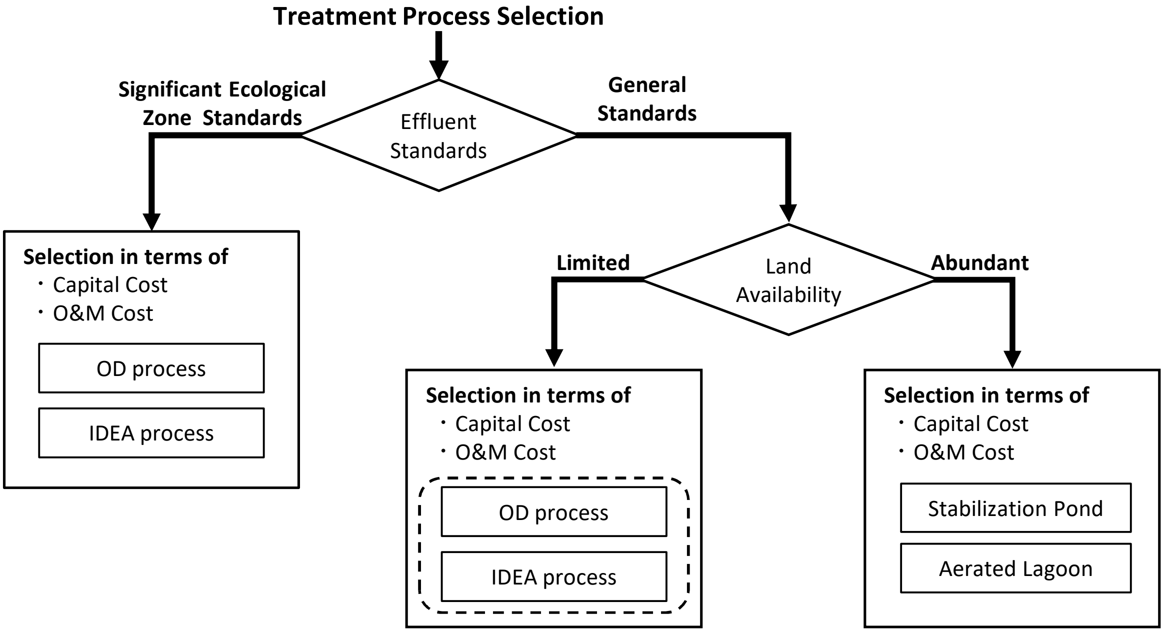
Source：JET

Figure 5-3.24 Olosara WWTP (Sigatoka): OD

(5) Selection of Applicable Treatment Processes

Figure 5-3.25 shows the treatment process selection flow for each WWTP. The first criterion is the effluent quality standard; if the SEZ standards apply, then the OD or IDEA process will be adopted. From these two processes, construction costs and maintenance costs will be examined in detail and narrowed down by the Municipal Sewerage M/P.

If the General effluent quality standards apply, the treatment process will depend on the availability of land. As mentioned earlier in **(4)**, the site area requirement varies for each treatment process and each WWTP, so the possibilities of land acquisition around the existing sites/candidate sites must be looked into.



Source：JET

Figure 5-3.25 Selection Flow of WWTP Treatment Processes

The availability of land acquisition is unknown at this point. Therefore, the treatment process of each municipality's WWTP was selected based on the effluent standards (see **5-3-1 (1)** for details). The results for (Case 1: SEZ standards for all WWTPs) and (Case 2: Standards chosen based on scale of discharging water body) are listed as follows.

Table 5-3.10 (Case 1) Required Site Area Estimation

WWTP (Municipality)	Acceptance of Septage	Target Effluent Quality Std.	Treatment Process*1	Estimated Area (ha)	Area for Sludge Storage (ha)
Navakai※2 (Nadi)	None	SEZ	OD / IDEA	20.5	11.5
Natabua (Lautoka)	Accept	SEZ	OD / IDEA	22.7	11.8
Votua (Ba)	None	SEZ	OD / IDEA	8.2	3.4
Tavua	Accept	SEZ	OD / IDEA	4.0	1.6
Rakiraki	Accept	SEZ	OD / IDEA	4.1	1.5
Olosara (Sigatoka)	None	SEZ	OD / IDEA	6.7	2.8

*1: When the influent nitrogen concentration is set as70mg/L, the area of the OD/IDEA process is estimated to be about the same
Source：JET

Table 5-3.11 (Case 2) Required Site Area Estimation

WWTP (Municipality)	Acceptance of Septage	Target Effluent Quality Std.	Treatment Process*1	Estimated Area (ha)	Area for Sludge Storage (ha)
Navakai※2 (Nadi)	None	SEZ	OD / IDEA	20.5	11.5
Natabua (Lautoka)	Accept	General	Stabilization Pond	72.5	4.2
			AL	49.2	4.2
			OD / IDEA	22.7	11.8
Votua (Ba)	None	SEZ	OD / IDEA	8.2	3.4
Tavua	Accept	SEZ	OD / IDEA	4.0	1.6
Rakiraki	Accept	SEZ	OD / IDEA	4.1	1.5
Olosara (Sigatoka)	None	General	Stabilization Pond	13.9	1.2
			AL	11.5	1.2
			OD / IDEA 法	6.7	2.8

*1: When the influent nitrogen concentration is set as70mg/L, the area of the OD/IDEA process is estimated to be about the same
Source：JET

(6) Final Disposal of Sludge

As mentioned earlier in **4-3-1**, currently there are no final disposal sites (landfills) that accept sewerage sludge. In addition, standards for the acceptance of sludge to disposal sites are yet to be determined/established by the Department of Environment

However, as the land acquisition requirement shown earlier, the dumping and storage of sludge within WWTP sites is an impractical option; the securement of outside final disposal sites and/or recycling of sludge is a critical matter. Therefore, coordination must be made with the Department of Environment and Ministry of Agriculture on the establishment of sludge disposal/recycling standards, as well as the development and gazetting of related legislations.

Once the acceptance of sludge at outer facilities are secured, the WWTPs will dewater and sun-dry sludge, which will then be trucked out to final disposal sites and/or sludge recycling facilities. In addition, to ensure that the content of hazardous substances (ex. heavy metals) is below standards, regular sampling and testing of sludge will be a mandatory requirement.

5-3-2 Sewer Network

In the sewerage areas set in **5-2**, a site survey was conducted in consideration of the topographical conditions and the existing sewerage facilities in the four service areas (Nadi, Lautoka, Ba and Sigatoka). In the existing sewerage service areas such as Nadi, Lautoka, Ba and Sigatoka area, the new sewer pipelines were laid separate of the existing pipelines; the new sewer pipelines were designed to connect the expanded sewerage service areas to the proposed wastewater treatment plant. In addition, like the existing sewer network, many pumping stations are required. Due to the topographical conditions, it is difficult to collect sewerage by gravity flow in all service areas.

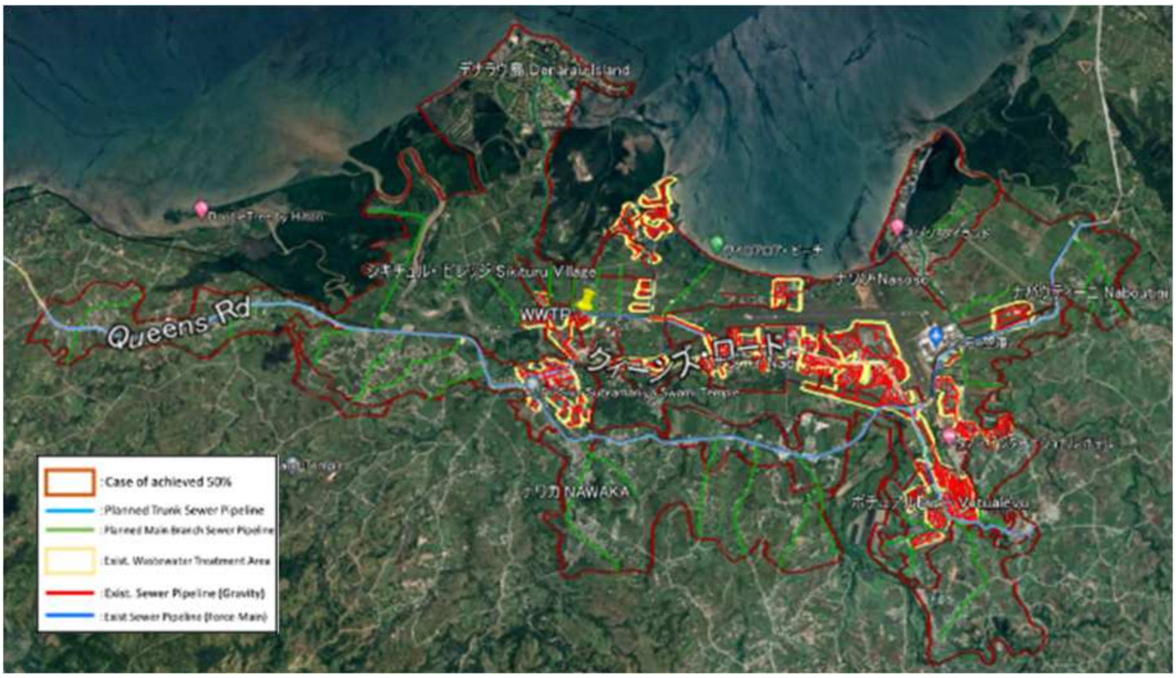
The facility scale (pipeline length) of the trunk and the main branch sewer pipelines in the proposed areas

(Case of achieved 50%) is shown in **Table 5-3.12**. In addition, the schematic pipeline of each sewerage service area is shown through **Figure 5-3.26** to **Figure 5-3.31**.

Table 5-3.12 Length of Sewer Pipeline (Case of achieved 50%)

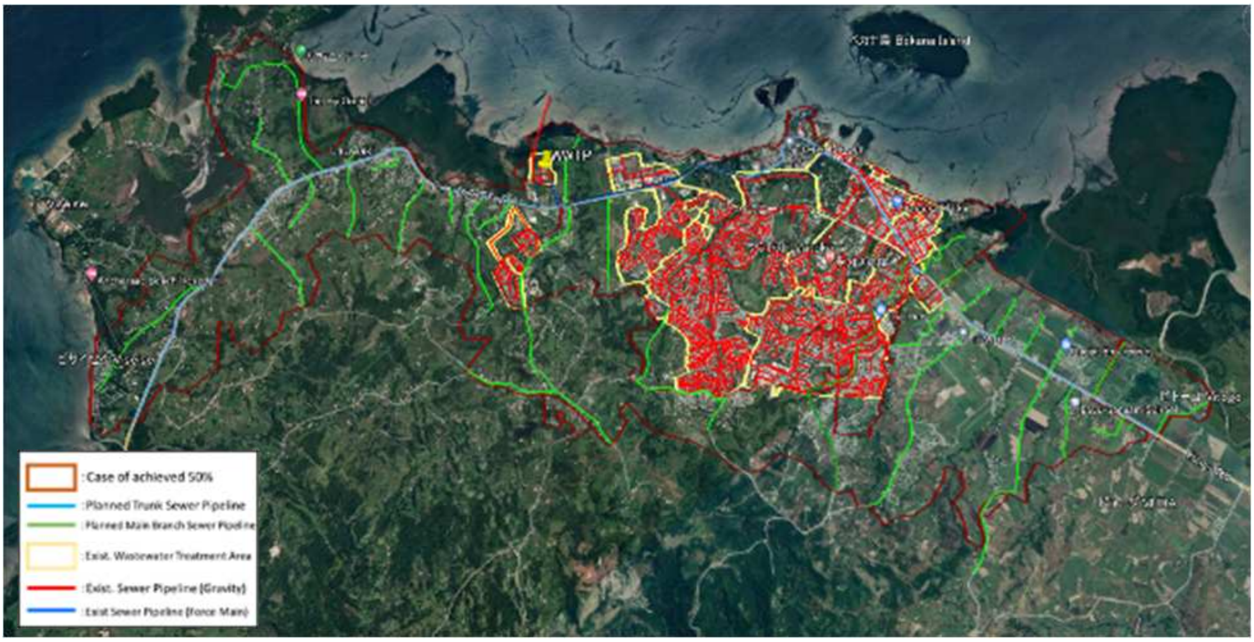
Service Area	Unit	Trunk Sewer Pipeline	Main Branch Sewer Pipeline
Nadi	km	30.9	53.9
Lautoka	km	17.7	42.3
Ba	km	16.4	17.9
Tavua	km	7.2	12.1
Rakiraki	km	8.2	5.1
Sigatoka	km	22.1	11.5

Source：JET



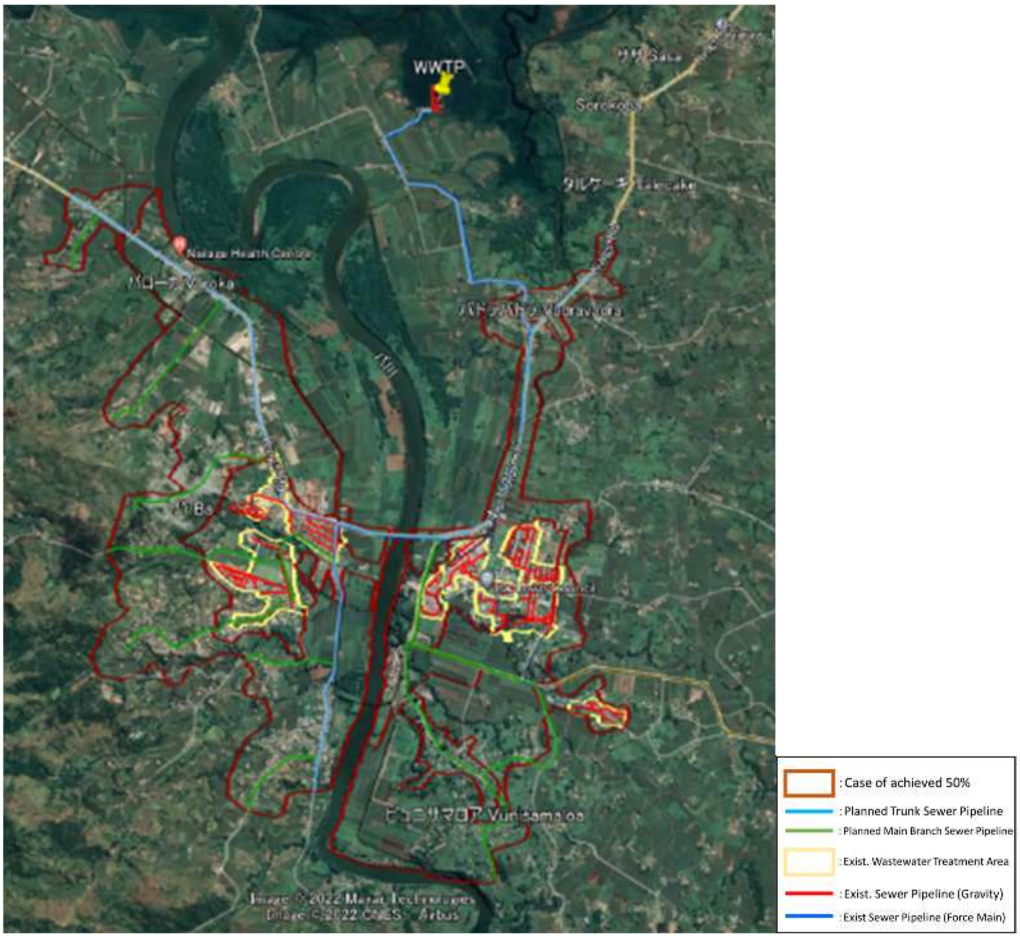
Source: JET

Figure 5-3.26 Schematic Sewer Network Plan (Case: 50% Achievement in Nadi)



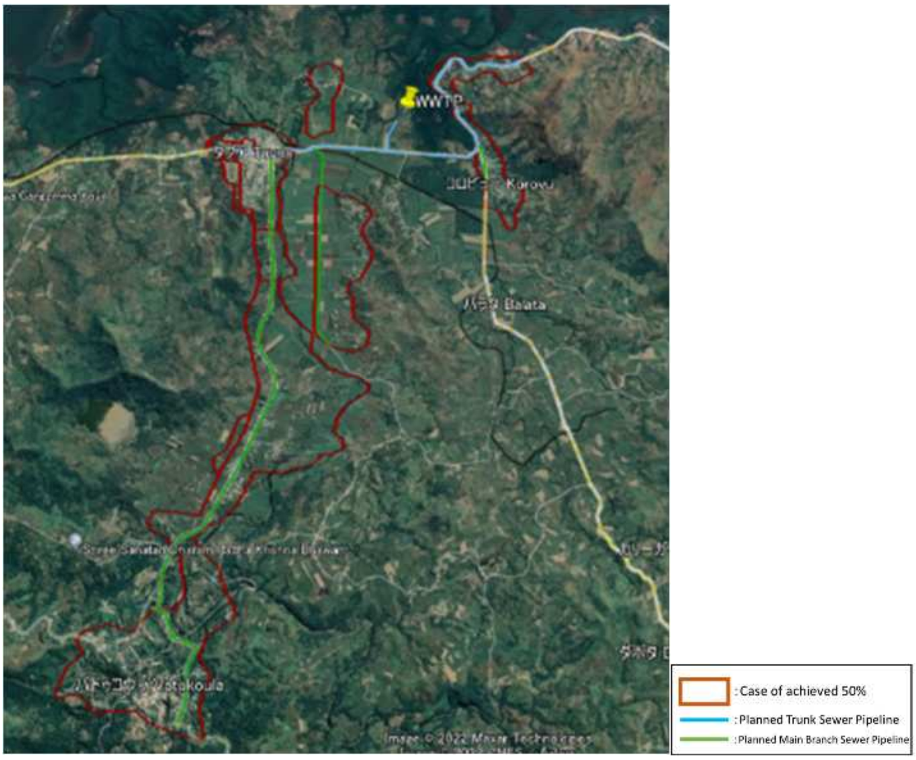
Source: JET

Figure 5-3.27 Schematic Sewer Network Plan (Case: 50% Achievement in Lautoka)



Source: JET

Figure 5-3.28 Schematic Sewer Network Plan (Case: 50% Achievement in Ba)



Source: JET

Figure 5-3.29 Schematic Sewer Network Plan (Case: 50% Achievement in Tavua)

Source: JET

Figure 5-3.30 Schematic Sewer Network Plan (Case: 50% Achievement in Rakiraki)

Source: JET

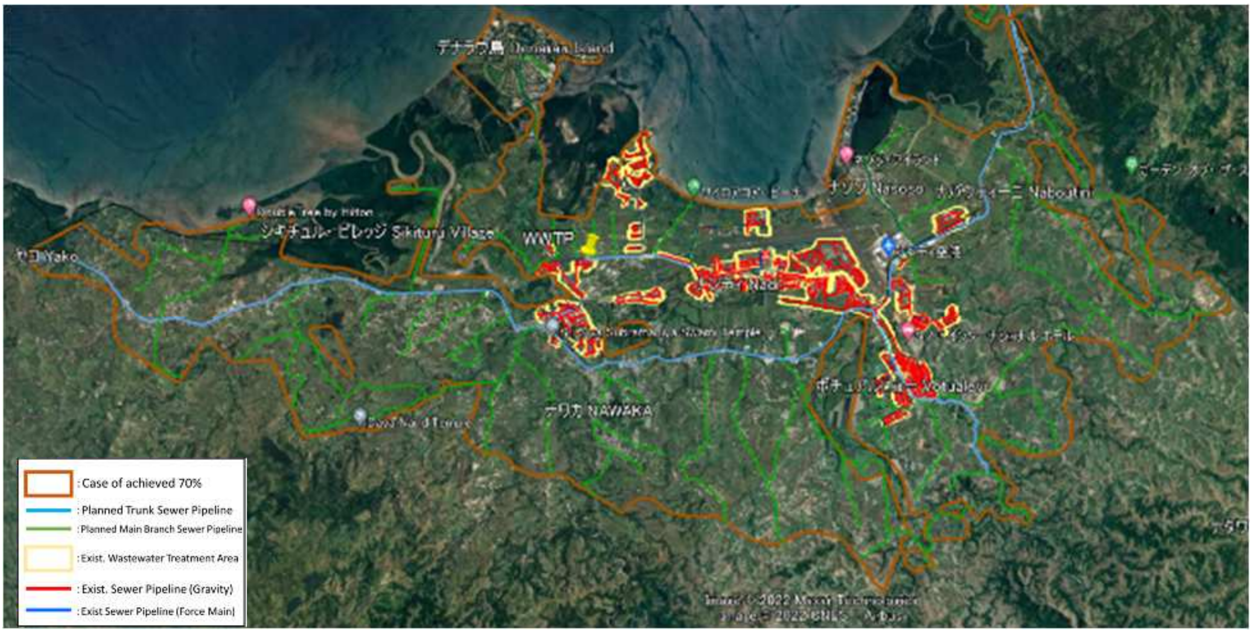
Figure 5-3.31 Schematic Sewer Network Plan (Case: 50% Achievement in Sigatoka)

The facility scale (pipeline length) of the trunk and the main branch sewer pipelines in the proposed areas (Case of achieved 70%) is shown in **Table 5-3.13**. In addition, the schematic pipeline of each sewerage service area is shown in **Figure 5-3.32** to **Figure 5-3.37**.

Table 5-3.13 Length of Sewer Pipeline (Case of achieved 70%)

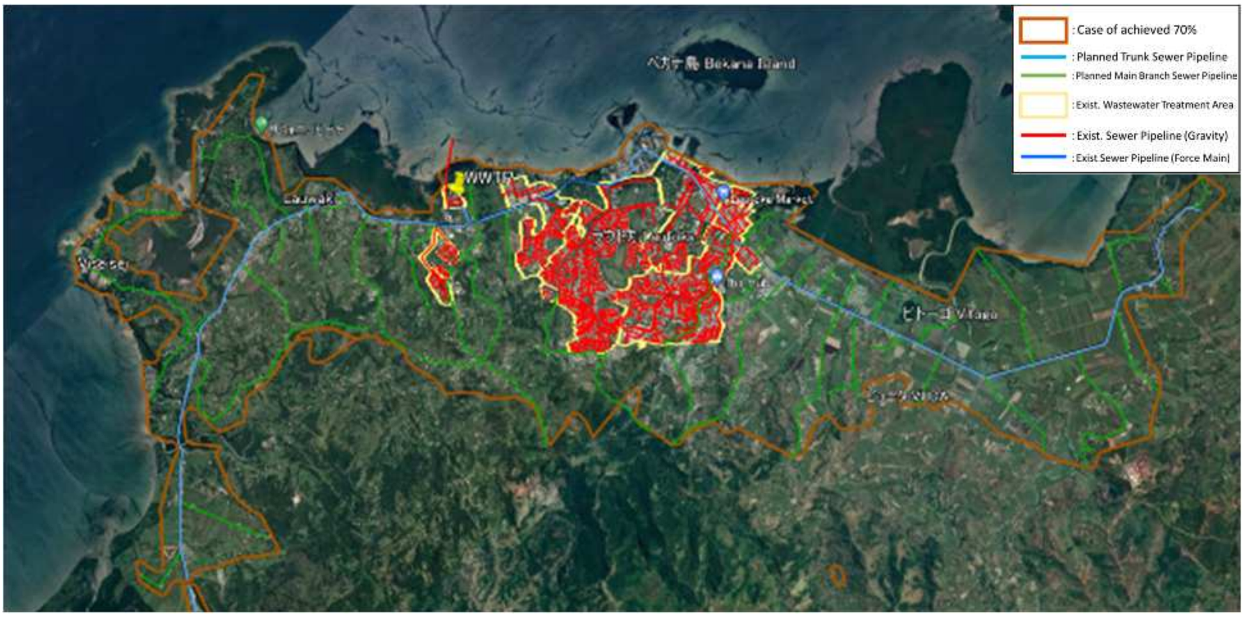
Service Area	Unit	Trunk Sewer Pipeline	Main Branch Sewer Pipeline
Nadi	km	37.1	113.3
Lautoka	km	27.3	86.9
Ba	km	27.0	56.7
Tavua	km	8.5	18.1
Rakiraki	km	12.6	14.7
Sigatoka	km	22.1	21.1

Source: JET



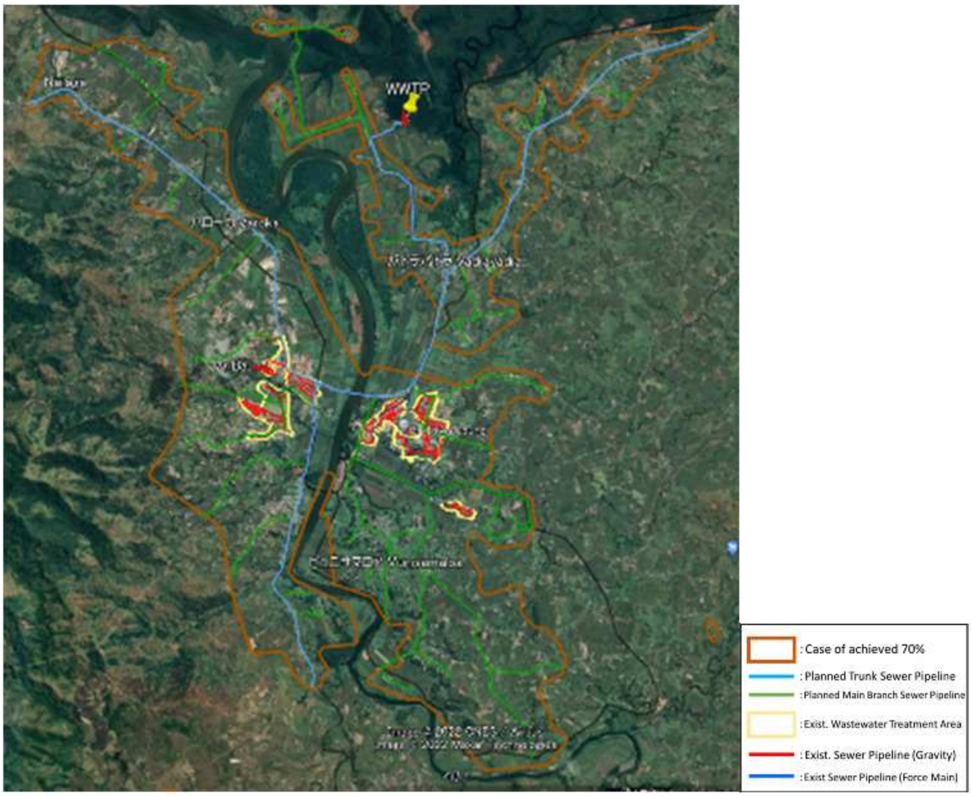
Source: JET

Figure 5-3.32 Schematic Sewer Network Plan (Case: 70% Achievement in Nadi)



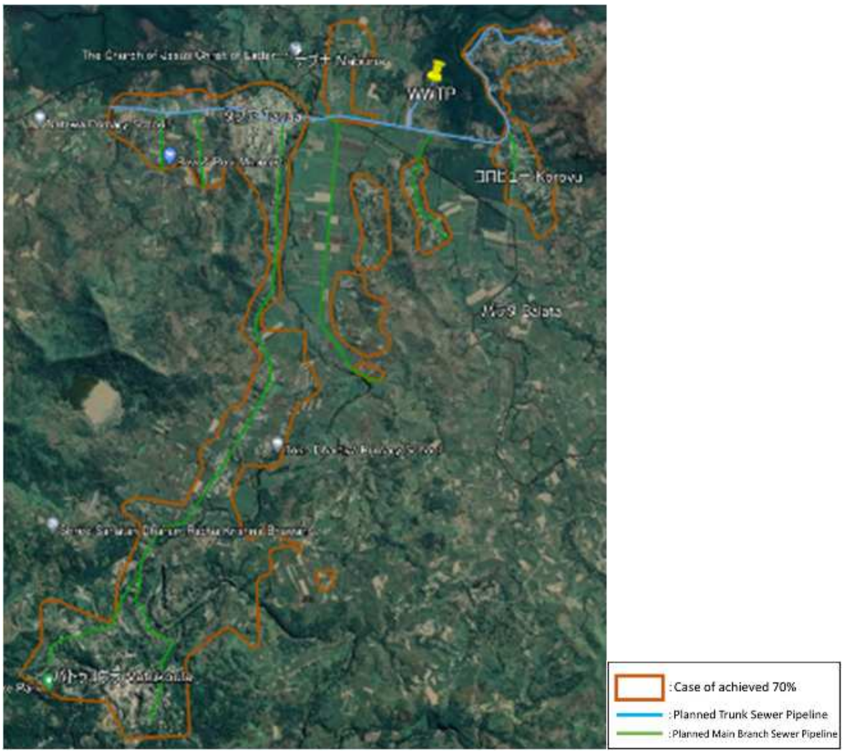
Source: JET

Figure 5-3.33 Schematic Sewer Network Plan (Case: 70% Achievement in Lautoka)



Source: JET

Figure 5-3.34 Schematic Sewer Network Plan (Case: 70% Achievement in Ba)



Source: JET

Figure 5-3.35 Schematic Sewer Network Plan (Case: 70% Achievement in Tavua)

Source: JET

Figure 5-3.36 Schematic Sewer Network Plan (Case: 70% Achievement in Rakiraki)

Source: JET

Figure 5-3.37 Schematic Sewer Network Plan (Case: 70% Achievement in Sigatoka)

5-3-3 Estimation of Construction Cost and O&M Cost

(1) Precondition of Cost Estimation

The approximate scale of the facilities required to achieve the NDP is determined in **5-3-1** and **5-3-2**. The Regional Wastewater M/P does not have the outline design for each facility, and the accuracy of the cost estimation is not high compared to the project cost estimation that will be implemented in the Municipal Sewerage M/P in Phase 2. The construction cost calculated here indicates the approximate scale of the construction cost to achieve the NDP.

The preconditions for calculating the construction cost are as follows.

- For basic civil engineering works, the construction cost will be estimated by multiplying the approximate quantity by the approximate unit price.
- The unit price of Fiji will be used as a reference for the main items of civil engineering work, and the unit price that is difficult to obtain will be adopted with reference to the examples of Japan and third countries.
- Mechanical and electrical costs are calculated based on the ratio of civil engineering costs and mechanical and electrical costs in Japan.
- The land acquisition cost for the WWTP was calculated based on the unit price of land in Fiji in accordance with MOE's comments. However, since the unit price of land varies greatly depending on the type of land for WWTP's site, etc., the land acquisition cost calculated here is scheduled to change in the Phase 2.
- Approximate unit prices are before the COVID-19 pandemic and 2022 Russian invasion to Ukraine.
- Consultant fees are not included.
- Price escalation and physical contingency are not included.

(2) Construction Cost of WWTPs

Based on the capacity calculation of each treatment process examined in **5-3-1** above, the construction cost was estimated by assuming the approximate quantity of civil engineering works. **Table 5-3.14** shows the construction costs of the IDEA/OD process which is the most expensive method, and the stabilization pond method which is the least expensive method.

Table 5-3.14 Construction Cost for each WWTP and each Treatment Process

WWTP (Municipality)	Treatment Process	Design Flow (m^3/day)	Construction Cost (million JPY)	Construction Cost (million FJD)
Navakai (Nadi)	Stabilization Pond	35,200	12,100	179
	OD / IDEA		20,500	303
Natabua (Lautoka)	Stabilization Pond	34,100	12,000	177
	OD / IDEA		19,800	293
Votua (Ba)	Stabilization Pond	9,900	4,260	63
	OD / IDEA		7,030	104
Tavua	Stabilization Pond	4,400	1,620	24
	OD / IDEA		3,170	47
Rakiraki	Stabilization Pond	3,300	1,280	19
	OD / IDEA		2,360	35
Olosara (Sigatoka)	Stabilization Pond	6,600	2,230	33
	OD / IDEA		4,730	70

*1 FJD ＝ 67.55JPY (April 2024)
Source: JET

Table 5-3.15 shows construction costs including land acquisition costs required for each treatment process shown in **Table 5-3.9**. Since the collected land unit cost varies from 20 to 110 FJD/m^2, the average of 65 FJD/m^2 was used for cost estimation. Since the stabilization pond method requires a large footprint, the cost difference between the OD/ IDEA becomes smaller when considering the land cost, but it will not be reversed.

Table 5-3.15 Construction Cost for each WWTP and each Process (with Land Acquisition Cost)

WWTP (Municipality)	Treatment process	Construction Cost		Land Acquisition Cost		Total	
		(mil. JPY)	(mil. FJD)	(mil. JPY)	(mil. FJD)	(mil. JPY)	(mil. FJD)
Navakai (Nadi)	Stabilization Pond	12,100	179	3,240	48	15,300	227
	OD / IDEA	20,500	303	878	13	21,300	316
Natabua (Lautoka)	Stabilization Pond	12,000	177	3,170	47	15,100	224
	OD / IDEA	19,800	293	1,010	15	20,800	308
Votua (Ba)	Stabilization Pond	4,260	63	1,350	20	5,610	83
	OD / IDEA	7,030	104	338	5	7,360	109
Tavua	Stabilization Pond	1,620	24	405	6	2,030	30
	OD / IDEA	3,170	47	203	3	3,380	50
Rakiraki	Stabilization Pond	1,280	19	338	5	1,620	24
	OD / IDEA	2,360	35	203	3	2,570	38
Olosara (Sigatoka)	Stabilization Pond	2,230	33	608	9	2,840	42
	OD / IDEA	4,730	70	270	4	5,000	74

*1 FJD ＝ 67.55JPY (April 2024)
Source: JET

(3) O&M Cost for WWTPs

O&M cost of the WWTPs was estimated using Japanese cost function curve as shown in **Table 5-3.16**.

Table 5-3.16 O&M Cost for each WWTP and each Process

WWTP (Municipality)	Treatment process	Design Flow (m^3/day)	O&M Cost (million JPY/ yr)	O&M Cost （1000 FJD/ yr）
Navakai (Nadi)	Stabilization Pond	35,200	104	1,544
	OD / IDEA		239	3,540
Natabua (Lautoka)	Stabilization Pond	34,100	103	1,529
	OD / IDEA		234	3,460
Votua (Ba)	Stabilization Pond	9,900	39	582
	OD / IDEA		118	1,740
Tavua	Stabilization Pond	4,400	19	281
	OD / IDEA		74	1,090
Rakiraki	Stabilization Pond	3,300	16	229
	OD / IDEA		62	920
Olosara (Sigatoka)	Stabilization Pond	6,600	26	379
	OD / IDEA		93	1,380

*1 FJD ＝ 67.55JPY (April 2024)
Source: JET

(4) Construction Cost and O&M Cost for Sewer Network

Construction cost for sewer network is estimated based on the length of the sewer pipes shown in **5-3-2** and the average unit price per meter shown in the Rakiraki Wastewater M/P (**Table 4.1-11**) as a reference. Since actual unit O&M cost for sewer network (FJD/m sewer pipe) is not available in Fiji, the unit maintenance cost per meter in Japan is applied. **Table 5-3.17** shows the construction and O&M costs of sewer systems.

Table 5-3.17 Construction Cost and O&M Cost of Sewer Network in each Municipality

WWTP (Municipality)	Sewer Pipeline Length （km）	Construction Cost (mil. JPY)	Construction Cost (mil. FJD)	O&M Cost (mil. JPY/yr)	O&M Cost （1000 FJD/yr）
Navakai (Nadi)	1,731	96,100	1,423	94	1,384
Natabua (Lautoka)	1,042	57,800	856	56	833
Votua (Ba)	587	32,600	483	32	470
Tavua	170	7,970	118	9	136
Rakiraki	130	6,150	91	7	104
Olosara (Sigatoka)	235	13,000	193	13	188

*1 FJD ＝ 67.55JPY (April 2024)
Source: JET

(5) Construction Cost and O&M Cost for Pumping Stations

Since outline design of sewer network is not implemented in the Regional Wastewater M/P, the number and capacity of pumping stations are assumed based on the number of existing facilities in Fiji. Since there are 12 pumping stations for the total sewer length of 158 km in Lautoka, it is assumed that one pumping station will be required per 13 km of sewer pipes. **Table 5-3.18** shows the construction and O&M costs of pumping stations.

Table 5-3.18 Construction Cost and O&M Cost of Pumping Stations in Each Municipality

WWTP (Municipal)	No. of Pumping Stations	Construction Cost (mil. JPY)	Construction Cost (1000 FJD)	O&M Cost (mil. JPY/yr)	O&M Cost （1000 FJD/yr）
Navakai (Nadi)	133	3,270	48,454	303	4,489
Natabua (Lautoka)	80	1,970	29,162	183	2,702
Votua (Ba)	45	1,110	16,440	70	1,039
Tavua	13	321	4,746	20	300
Rakiraki	10	247	3,651	16	231
Olosara (Sigatoka)	18	445	6,587	28	416

*1 FJD ＝ 67.55JPY (April 2024)
Source: JET

5-4 Prioritization of Sewerage Development and Implementation Schedule

5-4-1 Evaluation Items for Determining the Priority Cities

(1) Selection of Evaluation Criteria

The evaluation criteria for selecting the priority city are the four criteria and seven sub-criteria shown in **Table 5-4.1** (Sub-criteria 1: Population is listed as reference, but not adopted in the evaluation). The two following points were also taken into consideration.

- Prioritization should be evaluated from multiple points of view.
- Data of each city/town can be used or can be collected.

Table 5-4.1 Critera and Sources of Data for Prioritizing the Six Cities/Towns

Main Criteria	Sub Criteria	Sources of Data
Population	Population	Bureau of Statistics
	Population density	Bureau of Statistics
Sanitation	Ratio of waterborne disease	Ministry of Health and Medical Services
Urban development	No. of hotels	Fiji Hotel & Tourism Association
	Amount of water usage (non-domestic)	WAF
Water environment	Current river water quality	Site survey by JET
	Estimated future river water quality	Estimated by JET

Source: JET

Table 5-4.2 describes some details of each criterion.

Table 5-4.2 Description of the Critera

Main Criteria	Description
Population	Since the Regional Wastewater M/P aims to provide 70% of the population access to centralized treatment systems, as set out in the National Development Plan, population is the most significant criterion. The population of urban and peri-urban areas in each city and town, which are the main target areas for sewerage development, should be included in the total. Since sewerage systems already exist in some cities/towns, the population without sewerage access must be estimated. For effective planning, population density should also be considered.
Sanitation	The prevalence of water-borne diseases is an indicator of hygiene. This item is needed as a measure of the contribution of sewerage facilities to public health and sanitation.
Urban development	Tourism is a major industry in the Western Division. The number of hotels will be used as an indicator of the scale of the tourism industry. In addition, commercial water consumption is also an important indicator of the scale of industrial activities in the region. Therefore, commercial water volume will also be used in the evaluation.
Water environment	Water quality near each city/town will be used as an indicator of the current water environment. Also, in order to demonstrate the effects of sewerage development, simulations of water quality after the development of the treatment plants will be used as an evaluation item.

Source: JET

Tariff collection rate was also planned to be used as an evaluation item. However, it was discovered that city/town-wise data is not available. Moreover, WAF’s overall tariff collection rate is 95%, suggesting that differences in tariff collection rates between cities/towns is not significant. Therefore, this item was dropped from the evaluation criteria.

Table 5-4.3 shows the criteria for each city/town for the data that can be collected.

Table 5-4.3 Criteria

	Sub-Criteria	Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka
1	Population (persons)	71,048	71,573	15,846	8,810	5,964	10,509
1'	Non-sewered population (persons)	55,186	42,593	12,656	8,810	5,964	10,028
2	Population density (persons/ ha)	5.1	11.3	5.1	3.0	1.7	5.7
3	Ratio of waterborne disease (%)	2.34	0.81	0.47	0.65	0.52	1.47
4	No. of hotels (hotels)	76	19	0	1	2	18
5	Amount of water usage (non-domestic) (1000 m^3/day)	9.2	8.5	2.0	0.4	0.6	2.8
7	Current river water quality (BOD mg/L)	2.6	8.6	3.2	4.5	3.2	2.5
8	Estimated future river water quality (BOD mg/L)	2.2	5.2	2.8	3.7	1.9	2.5

Data Source
1: Fiji Bureau of Statistics; Number of persons in "urban" & "peri-urban" areas in Census 2017
1': Above 1 - Number of customers connected to "Sewer" x 4.5
2: Fiji Bureau of Statistics; Area of "urban" & "peri-urban" in Census 2017
3: Central Board of Health
4: Fiji Bureau of Statistics; Number of hotels in "urban" & "peri-urban".
5: WAF; Categorized revenue water.
7: JET: Results from River flow measure and Water quality analysis
8: JET: Results of simulation calibrated based on result of River flow measure and Water quality analysis

Source: JET

(2) Weighting of the Evaluation Criteria

The priority of project implementation is quantified and evaluated by weighting and scoring each evaluation item. The analytic hierarchy process (hereinafter referred to as "AHP") is used to determine the weight of each criterion. AHP makes paired comparisons between each of the evaluation items (comparing the importance of each criterion to every other criterion one-by-one) to arrive at a weight of each criterion.

The paired comparison survey was conducted by questionnaire and administered to WAF staff (10 general staff and 6 managerial staff). Of the collected responses, those with high consistency indexes indicating unreliable results were excluded. AHP data was aggregated from the remaining nine questionnaires. The results are given in **Table 5-4.4**.

Items with the highest and lowest weights are shown in **Table 5-4.5**. The results reveal that "urbanization" and "population" are weighted highly.

Table 5-4.4 Questionnaire Results

Respondent	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	sum	Combined Weight
POPULATION	0.323		0.696			0.147	0.234	0.234	0.300	0.220				0.176		0.096	2.425	0.269
SANITATION	0.149		0.088			0.293	0.234	0.234	0.300	0.146				0.289		0.073	1.807	0.201
URBAN DEVELOPMENT	0.448		0.081			0.262	0.359	0.172	0.100	0.508				0.247		0.390	2.567	0.285
WATER ENVIRONMENT	0.080		0.135			0.298	0.172	0.359	0.300	0.126				0.289		0.441	2.201	0.245
																	sum	Combined Weight
Population	0.500		0.167			0.125	0.167	0.500	0.500	0.500				0.500		0.100	3.058	0.340
Population Density	0.500		0.833			0.875	0.833	0.500	0.500	0.500				0.500		0.900	5.942	0.660
Cases of waterborne disease	1.000		1.000			1.000	1.000	1.000	1.000	1.000				1.000		1.000	9.000	1.000
No. of hotels (hotels)	0.500		0.167			0.500	0.500	0.100	0.667	0.750				0.333		0.500	4.017	0.446
Non-domestic water usage	0.500		0.833			0.500	0.500	0.900	0.333	0.250				0.667		0.500	4.983	0.554
Current river water quality	0.200		0.167			0.500	0.750	0.500	0.333	0.500				0.500		0.143	3.593	0.399
Future River water quality	0.800		0.833			0.500	0.250	0.500	0.667	0.500				0.500		0.857	5.407	0.601
Consistency Index	0.13	0.49	0.07	0.23	0.17	0.11	0.11	0.11	0.00	0.06	0.23	0.77	0.36	0.02	0.38	0.13		

Source: JET

Table 5-4.5 List of Weights

Main Criteria	Weight	Sub-criteria		Weight	Points
Population	0.269	1	Non-sewered population	0.34	9.1
		2	Population density	0.66	17.8
Sanitation	0.201	3	Cases of waterborne disease	1.00	20.1
Urban Development	0.285	4	No. of hotels	0.45	12.7
		5	Non-domestic water usage	0.55	15.8
Water environment	0.245	6	Current river water quality	0.40	9.8
		7	Estimated future river water quality	0.60	14.7
	1.000				100

Source: JET

(3) Point Allocation Method

Priority is evaluated by evaluating the six target cities/towns on a 100-point scale. To set the numerical values for each city/town, the highest value of the criteria was set as "V", and the points were divided into the following three ranges.

Range		Allocation
Value > 2/3V	:	100 %
2/3V > Value > 1/3V	:	65 %
1/3V > Value	:	30 %

Table 5-4.6 shows the scores of each criterion for each of the six cities/towns.

Table 5-4.6 Point Allocations for Each City/Town

Criteria	City	Range	Points	
1. Non-sewered Population V=55,186 2/3V=37,000 1/3V=18,000	Nadi	55,186 > 2/3V	9.1 point x 100%	9.1 point
	Lautoka	42,593 > 2/3V	9.1 point x 100%	9.1 point
	Ba	1/3V > 12,656	9.1 point x 30%	2.7 point
	Tavua	1/3V > 8,810	9.1 point x 30%	2.7 point
	Rakiraki	1/3V > 5,964	9.1 point x 30%	2.7 point
	Sigatoka	1/3V > 10,028	9.1 point x 30%	2.7 point
2. Population Density V=11.3 2/3V=7.5 1/3V=3.8	Nadi	2/3V > 5.1 > 1/3V	17.8 point x 65%	11.5 point
	Lautoka	11.3 > 2/3V	17.8 point x 100%	17.8 point
	Ba	2/3V > 5.1 > 1/3V	17.8 point x 65%	11.5 point
	Tavua	1/3V > 3.0	17.8 point x 30%	5.3 point
	Rakiraki	1/3V > 1.7	17.8 point x 30%	5.3 point
	Sigatoka	2/3V > 5.7 > 1/3V	17.8 point x 65%	11.5 point
3. Waterborne disease prevalence V = 2.34 2/3V = 1.55 1/3V = 0.78	Nadi	2.34 > 2/3V	20.1 point x 100%	20.1 point
	Lautoka	2/3V > 0.81 > 1/3V	20.1 point x 65%	13.1 point
	Ba	1/3V > 0.47	20.1 point x 30%	6.0 point
	Tavua	1/3V > 0.65	20.1 point x 30%	6.0 point
	Rakiraki	1/3V > 0.52	20.1 point x 30%	6.0 point
	Sigatoka	2/3V > 1.47 > 1/3V	20.1 point x 65%	13.1 point
4. Number of Hotels V=76 2/3V = 51 1/3V = 25	Nadi	76 > 2/3V	12.7 point x 100%	12.7 point
	Lautoka	1/3V > 19	12.7 point x 30%	3.8 point
	Ba	1/3V > 0	12.7 point x 30%	3.8 point
	Tavua	1/3V > 1	12.7 point x 30%	3.8 point
	Rakiraki	1/3V > 2	12.7 point x 30%	3.8 point
	Sigatoka	1/3V > 18	12.7 point x 30%	3.8 point
5. Commercial Water Consumption V= 9.2 2/3V = 6.1 1/3V = 3.1	Nadi	9.2 > 2/3V	15.8 point x 100%	9.1 point
	Lautoka	8.5 > 2/3V	15.8 point x 100%	9.1 point
	Ba	1/3V > 2.0	15.8 point x 30%	2.7 point
	Tavua	1/3V > 0.4	15.8 point x 30%	2.7 point
	Rakiraki	1/3V > 0.6	15.8 point x 30%	2.7 point
	Sigatoka	1/3V > 4.7	15.8 point x 30%	2.7 point
6. Current Water Quality V=8.6 2/3V = 5.8 1/3V = 2.9	Nadi	1/3V > 2.6	9.8 point x 30%	2.9 point
	Lautoka	8.6 > 2/3V	9.8 point x 100%	9.8 point
	Ba	2/3V > 3.2 > 1/3V	9.8 point x 65%	6.4 point
	Tavua	2/3V > 4.5 > 1/3V	9.8 point x 65%	6.4 point
	Rakiraki	2/3V > 3.2 > 1/3V	9.8 point x 65%	6.4 point
	Sigatoka	1/3V > 2.5	9.8 point x 30%	2.9 point
7. Future Water Quality (Improvement Rate) V=0.41 2/3V = 0.27 1/3V = 0.14	Nadi	1/3V > 0.13	14.7 point x 30%	4.4 point
	Lautoka	0.40 > 2/3V	14.7 point x 100%	14.7 point
	Ba	2/3V > 0.14 > 1/3V	14.7 point x 65%	9.6 point
	Tavua	2/3V > 0.18 > 1/3V	14.7 point x 65%	9.6 point
	Rakiraki	0.41 > 2/3V	14.7 point x 100%	14.7 point
	Sigatoka	1/3V > 0.01	14.7 point x 30%	4.4 point

Source: JET

5-4-2 Project Implementation Prioritization

Table 5-4.7 shows the prioritization of the six cities/towns in the Western Division for project implementation based on the prioritization criteria, weight of each criterion, and point allocation described above. Lautoka scores high in all criteria and stands out compared to the other cities/towns.

Based on the above, the Lautoka and Nandi were selected as target municipalities the Municipal Sewerage M/P.

Table 5-4.7 Points Allocated to Each City/Town and Prioritization

	Sub-Criteria	Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka
1'	Non-sewered population (persons)	9.1	9.1	2.7	2.7	2.7	2.7
2	Population density (persons/ ha)	11.6	17.8	11.6	5.3	5.3	11.6
3	Prevalence of waterborne disease	20.1	13.1	6.0	6.0	6.0	13.1
4	No. of hotels (hotels)	12.7	3.8	3.8	3.8	3.8	3.8
5	Amount of water usage (Non-domestic) (1000 m^3/day)	15.8	15.8	4.7	4.7	4.7	4.7
7	Current river water quality (BOD mg/L)	2.9	9.8	6.4	6.4	6.4	2.9
8	Estimated future river water quality (BOD mg/L)	4.4	14.7	9.6	9.6	14.7	4.4
	Total	76.6	84.1	44.8	38.6	43.7	43.3
	Rank	2	1	3	6	4	5

Source JET

5-4-3 Overall Implementation Schedule

Considering that only 20% of the population currently has access to centralized treatment systems, increasing this to 70% in the 10 or so years (i.e. until 2036) as stated in the National Development Plan will be a significant challenge. In this light, two implementation schedules are proposed.

- Case1: Complete construction of all facilities by 2036.
- Case2: Implement the project city by city, based on implementation priority.

Table 5-4.8 shows the conditions when considering the implementation schedule. Individual projects, including the F/S survey, will be started in 2025, after the completion of this current project. It is assumed that the detailed design and construction work will be carried as a loan project. The time required to complete individual house connections is included in the schedule.

Table 5-4.8 Contents for Schedule Evaluation

Item	Duration
- Feasibility Study	1 year
- Consultant Selection	1 year
- Detailed Design	1 year
- Contractor Selection (Tender Assistant)	1 year
- Construction (Nadi, Lautoka, Ba)	5 years
- Construction (Tavua, Rakiraki, Sigatoka)	4 years
- House connection	3 years

Source: JET

Table 5-4.9 shows the overall project schedule based on implementation priority and the above evaluation conditions.

Case 1 requires all construction work, including house connections, to be completed by 2036, which means that the construction period of six municipals will simultaneously overlap for three years. This schedule is considered unrealistic due to the huge project cost requirement and traffic congestion during the construction period.

In Case 2, the construction periods of each municipal are not overlapped, so it is assumed that the municipal in the Western Division will be completed in 2053, 17 years later than in 2036. In 2036, 34% of the population will have access to the centralized treatment system.

Although the schedule for Fiji as a whole, including the Central and Northern Divisions, is not yet decided, the schedule in Case 2 is adopted as the proposed schedule for this Regional Wastewater M/P.

Table 5-4.9 Overall Implementaion Schedule

Case 1: Achieving the target until 2036

Municipal	Priority	Outline	2020'						2030'										2040'										2050'			
			4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3
Lautoka	1	WWTP: 31,000 m3/day Population: 97,100																														
Nadi	2	WWTP: 32,000 m3/day Population: 101,600																														
Ba	3	WWTP: 9,000m3/day Population: 31,200																														
Rakiraki	4	WWTP: 2,100m3/day Population: 7,100																														
Sigatoka	5	WWTP: 5,600m3/day Population: 15,900																														
Tavua	6	WWTP: 3,500m3/day Population: 13,100																														
Access to Centralized (%)			19	19	19	19	19	19	19	19	19	24	41	58	70																	

F/S, Consultant selection, D/D, T/A   Construction   House Connection

Case 2: Developing the sewerage area one municipal by one

Municipal	Priority	Outline	2020'						2030'										2040'										2050'			
			4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3
Lautoka	1	WWTP: 31,000 m3/day Population: 97,100																														
Nadi	2	WWTP: 32,000 m3/day Population: 101,600																														
Ba	3	WWTP: 9,000m3/day Population: 31,200																														
Rakiraki	4	WWTP: 2,100m3/day Population: 7,100																														
Sigatoka	5	WWTP: 5,600m3/day Population: 15,900																														
Tavua	6	WWTP: 3,500m3/day Population: 13,100																														
Access to Centralized (%)			19	19	19	19	19	19	19	19	19	24	30	34	34	34	42	49	56	56	56	58	59	61	61	63	64	66	66	67	69	70

F/S, Consultant selection, D/D, T/A   Construction   House Connection

5-5 Examination of Decentralized Treatment Systems

5-5-1 Goals for Decentralized Treatment Systems

“Population with access to decentralized treatment systems” will be calculated by subtracting the number of people with sewerage connections from the total population in each District (Tikina), in line with the centralized treatment systems planned in the Regional Waster M/P. The target year of the Regional Wastewater M/P has been set as year 2036, which is also the target year for the National Development Plan, so the target year for decentralized treatment systems will also be set as 2036. Apart from this project, Fiji is also working to meet SDG targets by 2030. Therefore, year 2030 is set is intermediate target year for the current project.

- ➢ Regional Wastewater M/P preparation: 2021
- ➢ Intermediate target year: 2030 (SDGs target year)
- ➢ Regional Wastewater M/P target year: 2036

Based on a comprehensive development policy that includes both centralized and decentralized treatment objectives, the goal for decentralized domestic wastewater treatment system is set as follows:

GOAL: Increase access to centralized or decentralized treatment system to 70% of the Wester Division’s population by 2036.

※ The access ratio of centralized treatment systems is the ratio of population connected to centralized treatment systems vs. the total population.

※ The access ratio of decentralized treatment systems is the “proportion of population using safely managed sanitation services” as defined in SDGs indicator 6.2.1a.

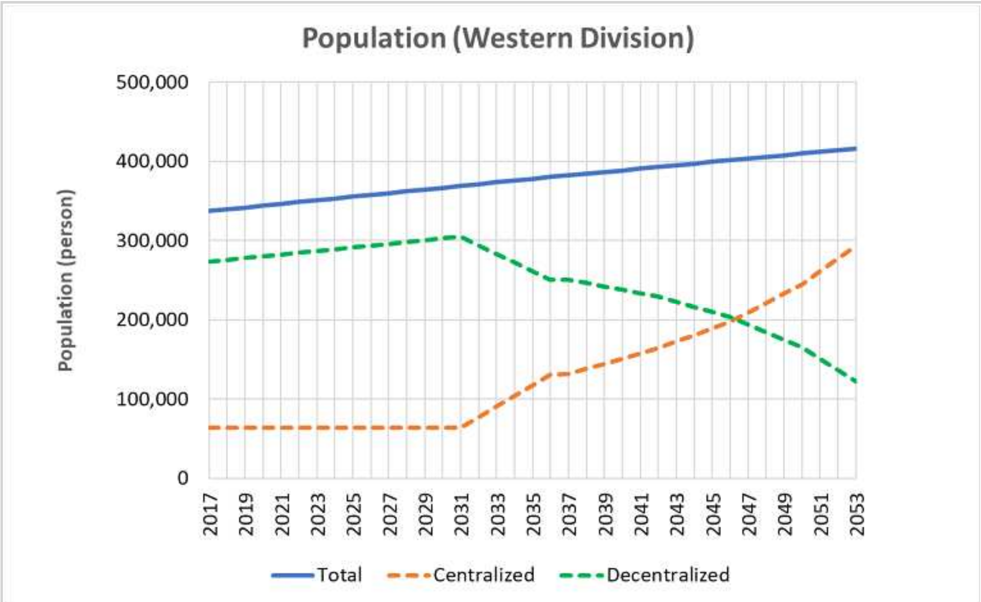
In Fiji, the management and statistics related to decentralized treatment systems are not clear. For this project, the “proportion of population using safely managed sanitation services” as indicated in the SDGs will be defined as “fecal sludge from on-site facilities (such as septic tanks) is safely extracted, transported, and treated at a treatment facility off-site.”

Efforts to ensure and expand regular septic tank desludging will continue past 2037. To this end, the target population receiving service of centralized treatment systems and “safely managed sanitation system” by year 2053 will be set to 90%. The target population percentage of regular septic tank desludging (“population with regular septic tank cleaning”/ “total population receiving decentralized treatment systems”) will be determined per Tikina, considering their bailing/collection efficiency.

According to the field surveys conducted in this project, most septic tanks are stand-alone tanks that treat only blackwater. From the perspective of safe treatment of domestic water, including combined greywater and blackwater, as indicated in SDGs 6.3, the installation of combined septic tanks and Johkasou is required. However, this point will not be addressed here and will be an issue for the Government of Fiji to address in the future.

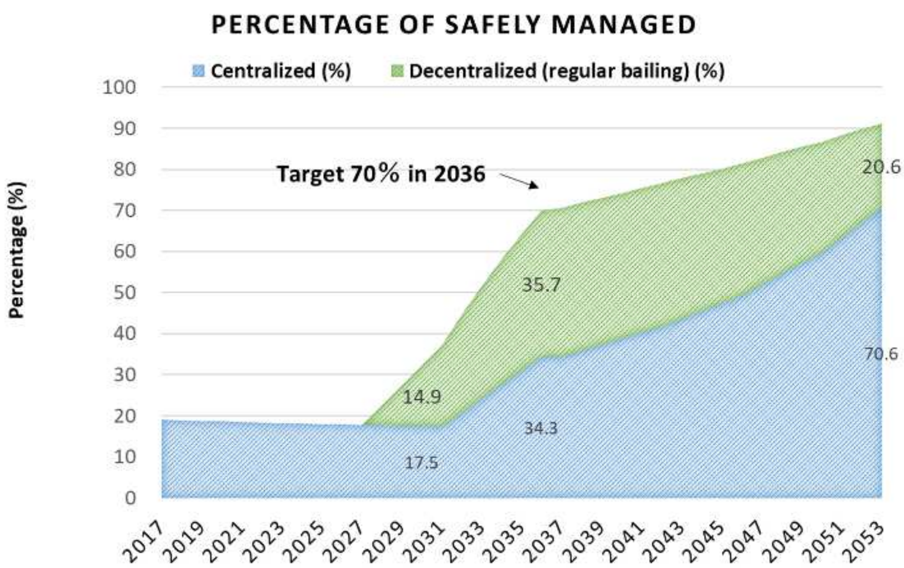
5-5-2 Target Population for Decentralized Treatment Systems

Figure 5-5.1 and **Figure 5-5.2** show trends of population targeted for decentralized treatment systems and "safely managed sanitations services" defined above.



Source: JET

Figure 5-5.1 Forecast of Population with Access to Decentralized Treatment System



Source: JET

Figure 5-5.2 Forecast of Population Ratio with Access to "Safely Managed Sanitation Services"

5-5-3 Calculation of Septage Volume

(1) Septage Volume

Septage volume is calculated as follows:

$$Vd = \frac{P}{N} \times \frac{Vt}{T}$$

Where Vd = Septage generation volume (m^3/year)
P = Bailing population (people)
N = Population per facility (people/facility)
Vt = Average bailing volume (m^3)
T = Average bailing interval (years)

(2) Classification of Sanitation Facilities

The population census of Fiji categorizes sanitation facilities into one of “septic tank” or “latrine and others.” However, fields surveys conducted in this project discovered that other systems such as drum systems and soakage pits were used in a significant number of cases. Hearing surveys revealed that pit latrines were much more common before the year 2000 but many of them were converted to septic tanks during Water Supply and Hygiene (hereinafter referred to as “WASH”) project activities. This trend of increase septic tank adoption is expected to continue, and this project will assume that those not connected to centralized treatment systems will have septic tanks and that these tanks will be subject to intermittent bailing.

Those connected to small-scale collective treatment systems such as “communal septic tanks” will be counted as decentralized (septic tank) treatment population. The volume of septage generated from non-residential sources such as hotels, restaurants, and commercial facilities will be calculated by multiplying the residential septage volume of the area by the “commercial water rate.”

(3) Target Collection Population

Based on the target population of decentralized treatment systems described above, the target population was with the following considerations:

- The target population was set so that the population covered by “safely managed sanitation services” (sum of population serviced by “centralized treatment systems,” and “regularly desludged septic tanks,”) will reach 70% by 2036, and 90% by 2053
- A preparation period of five years from 2023 will be given and activities related to regular desludging of septic tanks will start from 2028.
- he target population of regular septic tank desludging will be determined per District, as listed in **Table 5-5.1**. For the years between 2036 and 2053the implementation percentage will be determined by linear interpolation.

Table 5-5.1 Target Population for Regular Desludging per District (Tikina)

District Category	Conditions	District (Tikina)	Target Population (%)	
			2036	2053
A	• District has urban zone • Close by to WWTP and/or truck base of bailing company	Vuda, Nadi	65	80
B	• Located along major highways (Kings Rd.、Queens Rd.) • District has urban zone and/or clustered villages	Ba, Nawaka, Tavua, Rakiraki, Saivou, Baravi, Cuvu, Malomalo, Nasigatoka	60	80
C	• Area between District Category B and D	Ruwailevu	30	60
D	• Located in Viti Levu Island • District with villages scattered in the mountainous area	Magodro, Nakorotubu, Nalawa、Navosa	0	30
E	• Remote islands	Naviti, Yasawa, Malolo, Vatulele	0	0

Source : Created by JET

(4) Number of Users per Septic Tank

Based on population data and the number of decentralized treatment systems, the population per toilet facility was calculated as shown in **Table 5-5.2**. Although the fraction of people using certain systems differs between regions, the population per toilet facility is nearly constant at 4.3 to 4.6 people per system. Based on these results, the population per septic tank is set at 4.5.

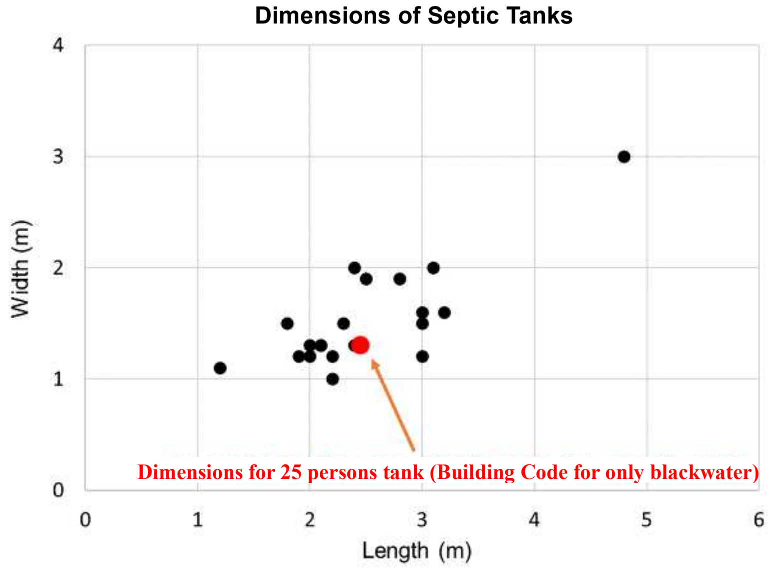
Table 5-5.2 Population per Septic Tank

Area	Population, Facilities	Ba	Nadroga-Navosa	Ra	Western Division
Total	A. Population	247,708	58,931	30,434	337,071
	B. Number of Toilet Facilities	56,112	13,089	7,034	76,235
	C. Residents per Facility (A/B)	4.4	4.5	4.3	4.4
Urban	A. Population	165,411	10,293	5,987	181,691
	B. Number of Toilet Facilities	37,575	2,452	1,396	41,423
	C. Residents per Facility (A/B)	4.4	4.2	4.3	4.4
Rural	A. Population	82,297	48,638	24,445	155,380
	B. Number of Toilet Facilities	18,537	10,637	5,638	34,812
	C. Residents per Facility (A/B)	4.4	4.6	4.3	4.5

Source : Created by JET, based on Fiji Housing and Population Census 2017

(5) Septic Tank Volume

External dimensions of septic tanks verified in field surveys, and those calculated from standard drawings assuming 150 mm concrete block thicknesses (**Table 5-5.3**), are shown in **Figure 5-5.3**. This comparison shows that, in the case of a single-purpose (blackwater only) septic tank, the size is adequate to serve 25 people (2.1 m^3).



Source: JET

Figure 5-5.3 Results of Septic Tank Survey (External Dimensions)

Table 5-5.3 Standard Septic Tank Dimensions (Fiji National Building Code)

No. of Person	Only Soil Waste						
	A	B	C	D	W	V (m^3)	F (m^3)
8	1000	400	1000	850	800	0.95	0.02
10	1000	600	1000	850	800	1.22	0.02
12	1000	600	1000	850	800	1.22	0.02
15	1000	600	1200	1050	800	1.34	0.03
25	1200	800	1200	1050	1000	2.10	0.05
50	1600	800	1400	1250	1000	3.00	0.06

No. of Person	All Domestic Waste						
	A	B	C	D	W	V (m^3)	F (m^3)
8	1400	800	1000	850	1000	1.87	0.04
10	1400	800	1200	1050	1000	2.31	0.05
12	1800	800	1200	1050	1000	2.73	0.06
15	1800	800	1200	1050	1200	3.28	0.07
25	2000	1200	1400	1250	1400	5.60	0.11
50	3200	1600	1600	1450	1600	11.14	0.22

V= Volume of Septic Tank (Working Capacity), F= Volume of Aerobic Filter
Source: Fiji National Building Code

The tank size prescribed in the Build Code is quite small when compared to the standards of Australia and New Zealand (**APPENDIX 5-6**) as well as volumes calculated using methods described by the WHO (**APPENDIX 5-7**). Furthermore, since the use of combined septic tanks that treat both blackwater and greywater will become more widespread in the future, the effective per unit capacity will be set as 2.0 m^3 for this project.

When desludging (bailing) septic tanks, it is common practice for about 1/3 of the contents to be left in the tank to preserve some population of effective microorganisms and maintain treatment functionality of the tank. However, interview surveys revealed that the entire contents of the tank are removed in Fiji during bailing. Therefore, the amount of sludge removed is assumed to be the effective tank volume.

(6) Bailing Interval

Interview surveys revealed that septic tank bailing (desludging) is done on an on-call bases and it is common for 10 years or more to pass between bailing. Although the Building Code cautions that "if the tank is not cleaned out at frequent interval, the sludge will eventually be scoured from the tank and clog the outlet drain, the absorption trench or soil and aerobic filter where provided," parameters such as bailing intervals based on tank volumes are not given.

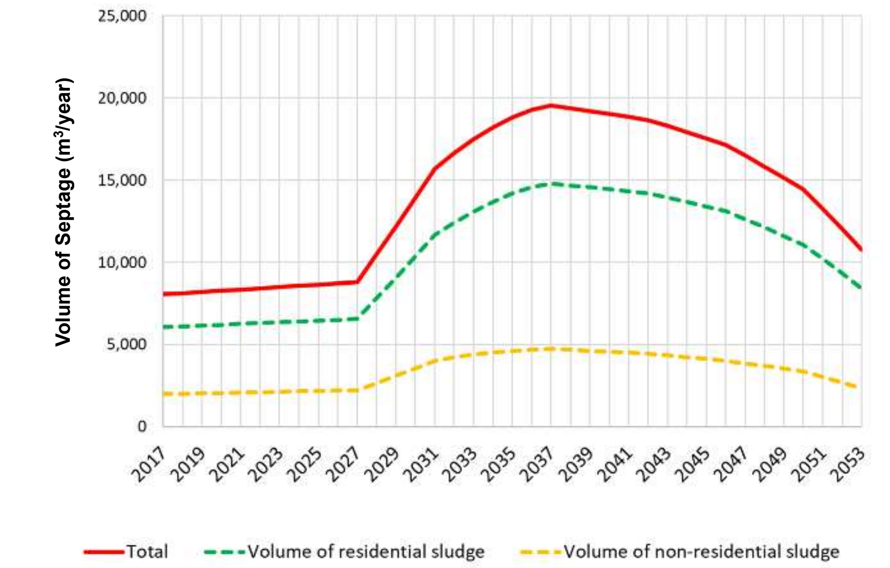
Septic tank design is based on the accumulation of sludge and scum over a given time interval, bailing intervals, and required retention time, as shown in **APPENDIX 5-7** The bailing interval of two to five years is common, and maintenance standards and guidelines are established in each country as shown in **APPENDIX 5-8**.

If tanks are not bailed at appropriate intervals (for example, if a tank is not bailed for a very long time) sludge and scum accumulate and start filling up the tank, reducing the effective volume in the tank, and the retention time required for effective wastewater treatment will not be ensured. As a result, inadequately treated sewerage will be discharged from the tank, causing clogging of the infiltration tank, contaminating public waters with contaminants and pathogens. In addition, the accumulated sludge can become caked at the bottom of the tank, making the bailing work difficult. According to interviews with bailing contractors, breaking up and extracting caked sludge can take up to two to three hours. On the other hand, when the withdrawal interval is short (less than 1 year), the anaerobic digestion of sludge does not progress sufficiently.

Based on the above, a bailing interval of five years will be established for this project. The rest will be on an on-call basis, with assumed bailing frequency of once every 20 years. "20 years" is considered to be the usable lifetime of a septic tank, including the body, internal lining, piping, infiltration tank, etc.; each septic tank is assumed to be bailed at least one time during its service life. Various service lives of 15-40 years or 20-30 years can be found in literature. This is heavily dependent on the surrounding environment, materials, maintenance conditions, and other factors. Bailing period of five years will be applied to the equivalent population of hotels and other commercial facilities.

(7) Sludge Volume

The sludge volume calculated based on the above settings for the Western Division is shown in **Figure 5-5.4**.



Source: JET

Figure 5-5.4 Forecast of Septage Volume in the Western Division

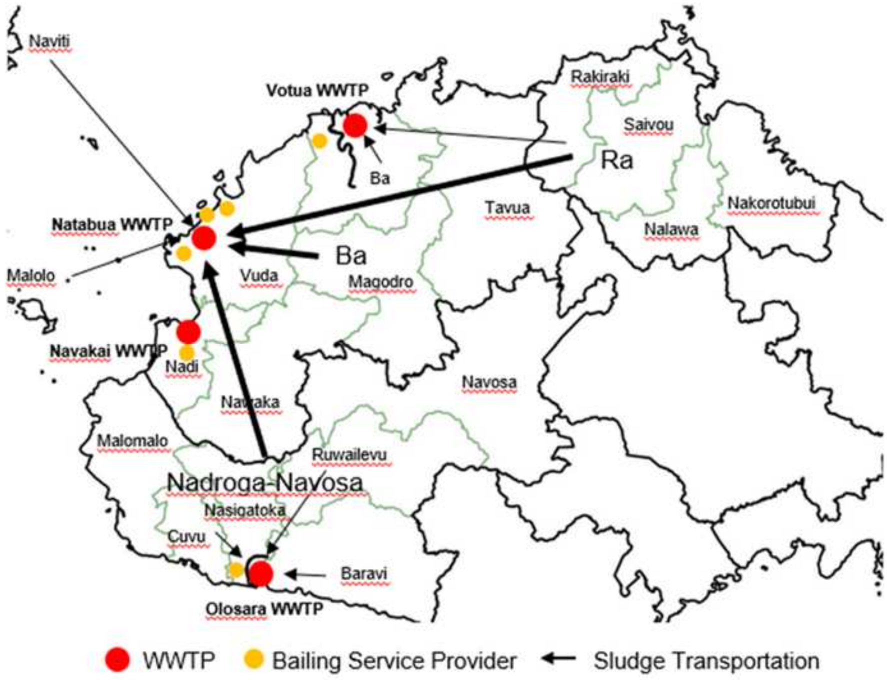
5-5-4 Collection of Septage

(1) Current Conditions

Septage is currently collected by private companies. The collected septage is transported to Votua (Ba), Natabua (Lautoka), or Olosara (Sigatoka) WWTP for final treatment. At Votua and Olosara WWTPs, septage is introduced directly into the anerobic ponds. At Natabua WWTP, the sludge is dumpeddirectly into a pit located in the wetlands close to the stabilization pond.

Figure 5-5.5 shows the sludge transport routes together with the locations of the WWTPs and headquarters of the private desludging companies. The transport route was estimated based on interviews with the contractors and information such as the sludge discharge sources provided by WAF.

Currently, a majority of the bailed sludge (not only domestic septage, but also including LTW), is transported to Natabua WWTP. WAF records verifies this; the sludge includes significant volumes of sludge from Ra and Sigatoka. This may be attributed to the fact that many LTW dischargers and bailing company bases are concentrated around Lautoka and Nadi. Another possible factor is the fact that the sludge treatment (direct dumping) at Natabua WWTP is independent of the wastewater treatment system, and there are few restrictions on the volume and the properties of incoming sludge. This uneven distribution of disposal destinations is a factor in widening the regional disparities in bailing fees.



Source: JET

Figure 5-5.5 Current Sludge Transport Routes

(2) Future Conditions

Currently, a majority of the bailed septage is transported to and treated at Natabua WWTP. Bailing charges are high in areas that are far away, such as in Ra Province where Rakiraki is located. One possible solution to this issue is to establish a septage treatment facility in the Ra Province area to reduce the transportation cost burden. Advantages and disadvantages of alternatives, including the current situation, are summarized in **Table 5-5.4**. As a sidenote, the commissioning of new WWTPs in Rakiraki and other municipalities are expected by 2053, but since the starting influent flow of these WWTPs will be limited, the acceptance of bailed septage to these plants will not be considered here.

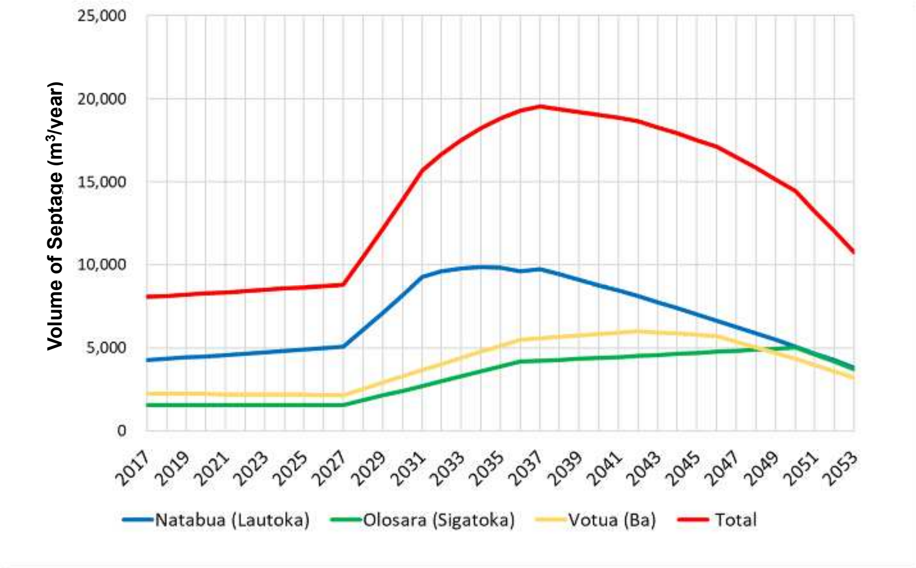
Table 5-5.4 Comparison of Alternative Septage Collection Plans

Alternative		Description (Pros and Cons)
1	Use all three WWTPs for septage treatment as is currently done, but increase the amount treated at Votua WWTP.	(Advantages) ・ Transportation distance of septage collected in Ra Province and Votua will be decreased (Disadvantages) ・ There is only one bailing company (two trucks) near Votua WWTP, so increased bailing and transport capacity is needed. ・ Development priority of the area around Votua WWTP is low, and increase of treatment capacity of the plant is not expected soon.
2	A new septage treatment facility will be constructed in Ra Province, and septage treatment will be carried out here, Natabua WWTP, and Olosara WWTP.	(Advantages) ・ Transportation distance of septage collected in Ra Province and Votua will be decreased (Disadvantages) ・ There are no bailing companies in Ra Province. Therefore, strengthening of private bailing companies or implementation as a public service is required. ・ Construction of a new septage treatment facility is required. Land must be acquired, water quality of the discharge point will be impacted, and construction and operations costs will be incurred. The Fiji side is reluctant to get behind this option.
3	Increase treatment capacity at Natabua WWTP, and treat septage at Natabua and Olosara WWTPs (Votua WWTP will remain as a backup option).	(Advantages) ・ The treatment capacity of Natabua WWTP is large compared to other facilities. Septage acceptance capacity is also higher than that of other WWTPs. ・ Many bailing companies are located near Natabua WWTP. They will not need to establish new truck bases close to new treatment facilities. ・ Development priority of the area around Natabua WWTP is high and treatment capacity improvements are expected to be implemented with high priority. (Disadvantages) ・ Septage transportation distance for Ra Province and Votua will increase. ・ Reducing tariff discrepancies between regions will become difficult.

Source: JET

In “Alternative 1,” septage is accepted at Votua, Natabua, and Olosara WWTPs, as in the present situation. Of these, septage from Ra Province some parts of Ba Province (Ba and Tavua) will be transported to and treated at Votua WWTP, thereby shortening the transportation distance. **Figure 5-5.6** shows trends in the annual volumes of septage accepted by each WWTP, and **Table 5-5.5** shows calculated results of mixed septage ratio at peak years for each WWTP. Note here that the mixed septage ratio is calculated based on the treatment capacity of existing facilities.

At Votua WWTP, the contamination rate of effluent sewerage was about 2.2% at its peak (2042), and was about 1.2% even in 2030, immediately after the start of regular desludging. When septage is introduced into the wastewater treatment process, problems such as an increase in nitrogen (ammonia) in the treated water, associated increases in BOD (N-BOD), COD, and coloration may occur. In the case of Japan, the guideline for mixed human waste/sewerage ratio is 1% of the amount of sewerage inflow. For this reason, in order to accept septage, it is necessary to pre-treat the septage and increase the treatment capacity of the WWTP. However, the development priority of the target service area low, and timely capacity enhancement cannot be expected.



Source: JET

Figure 5-5.6 Annual Septage Volume Treated at WWTPs (Alternative 1)

Table 5-5.5 Volume/Mixed Ratio of Septage brought to WWTPs (Alternative 1)

WWTP	Treatment Capacity	Volume of Septage	Mixed Septage Ratio (Septage/Treatment Cap.)
Natabua	8,200 m^3/day	~ 10,400 m^3/year (42 m^3/day), 2034	0.5%
Votua	1,100 m^3/day	~6,100 m^3/year (24 m^3/day), 2042	2.2%
Olosara	2,600 m^3/day	~5,200m^3/year (21 m^3/day), 2050	0.8%

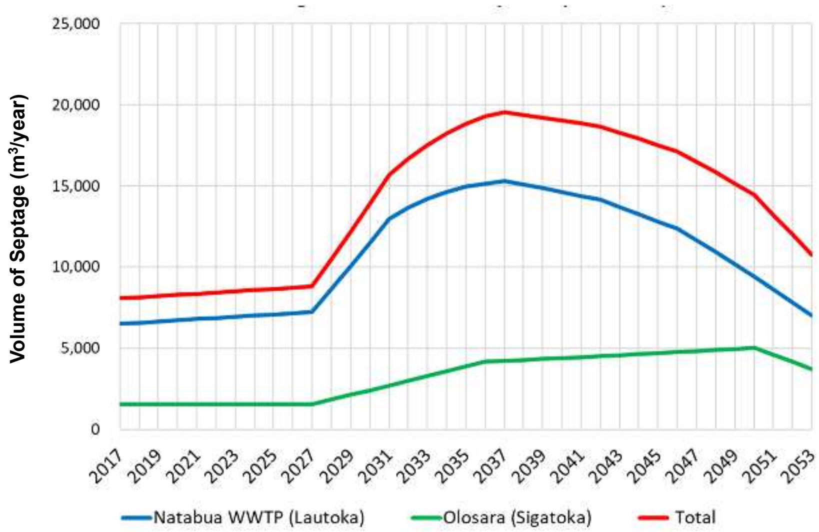
※The daily septage volume is calculated based on 250 operation days per year

Source: JET

“Alternative 2” aims to reduce the collection and transportation cost by establishing a new septage treatment facility in Ra Province, treating septage from Ra Province and Tavua of Ba Province. **APPENDIX 5-9** shows the results of a review of “Alternative 2”.

Analysis shows that the total amount of septage that can be collected in the area is comparatively limited, even when Tavua in Ba Province is included, and it is expected that the efficiency of collection and transportation in dispersed villages in Ra Province will be low. For this reason, there are concerns about the profitability for bailing contractors, and it is expected that strong involvement from the public sector, including the construction of the septage treatment facilities, will be necessary. The Fijian side is showing reluctance for this plan.

In “Alternative 3,” septage from Ra and Ba Provinces is transported to Natabua WWTP, and septage from Nadroga-Navosa is transported to Olosara WWTP. **Figure 5-5.7** shows changes in the annual volumes of septage accepted by each WWTP, and **Table 5-5.6** shows calculated results of septage contamination rate at peak year for each WWTP.



Source: JET

Figure 5-5.7 Annual Septage Volume Treated at WWTPs (Alternative 3)

Table 5-5.6 Volume/Mixed Ratio of Septage brought to WWTPs (Alternative 3)

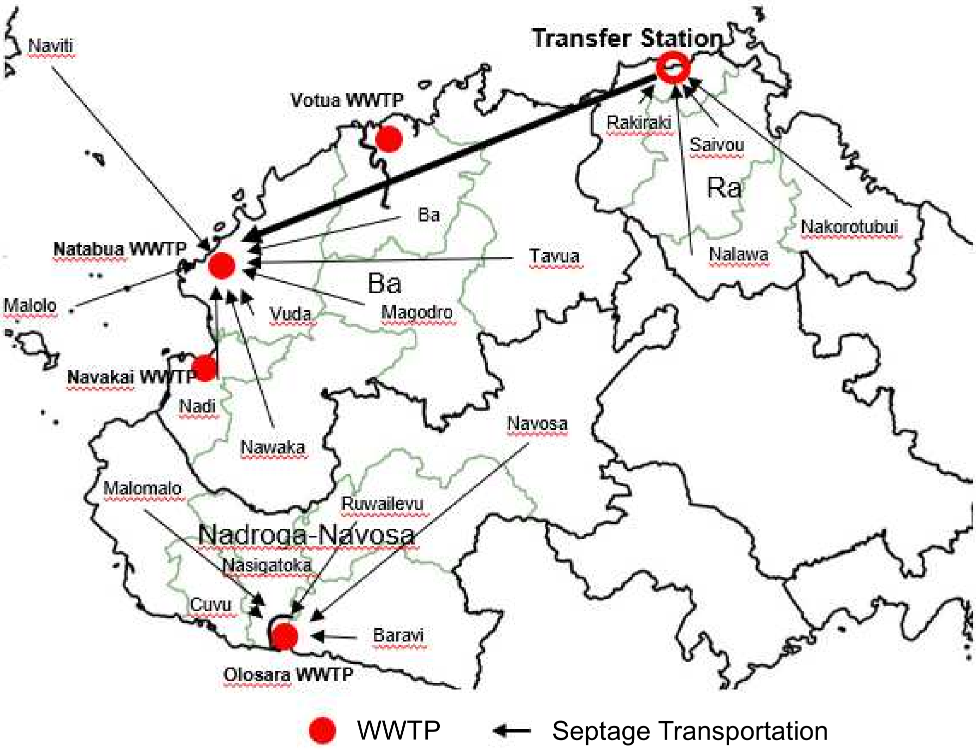
WWTP	Treatment Capacity	Volume of Septage	Mixed Septage Ratio (Septage/Treatment Cap.)
Natabua	8,200 m^3/day	~15,700m^3/year (63 m^3/day), 2037	0.8%
Olosara	2,600 m^3/day	~5,200m^3 year (21 m^3/ day), 2050	0.8%

※Daily septage volume is calculated based on 250 operation days per year
Source: JET

Regarding Natabua WWTP, if only septage is accepted, the mixed septage ratio will remain less than 1% even at peak times, even with the existing facility. Therefore, septage acceptance is considered feasible at the current WWTP.

Currently, however, a large volume of LTW is combined with septage and treated (directly dumped) into a pit at the wetlands in Natabua WWTP. The treatment effectiveness is unknown, and it is not appropriate to continue this method. Regarding the handling of LTW, legal frameworks and responsible agencies are unclear. Such regulatory frameworks and implementation agencies should be clarified and separate treatment of septage/LTW should be carried out. In addition, when septic tank septage is dumped into a wastewater treatment facility that uses activated septage, there is a concern that the SRT will decrease due to the high TSS in the septage, it is desirable to carry out a so-called “co-treatment,” in which septage is dewatered, and the leachate is treated with raw sewerage (pipeline sewerage) in the wastewater treatment system

In “Alternative 3,” the difference in bailing fees in remote areas continues to be a problem. It is conceivable to improve efficiency and reduce transportation costs by establishing a septage transfer station, transporting septage to the WWTP using a larger truck. **Figure 5-5.8** shows an image of the septage transportation route using the transfer station. This plan will need to consider public subsidies or redistribution of burdens between regions (cross-subsidy).



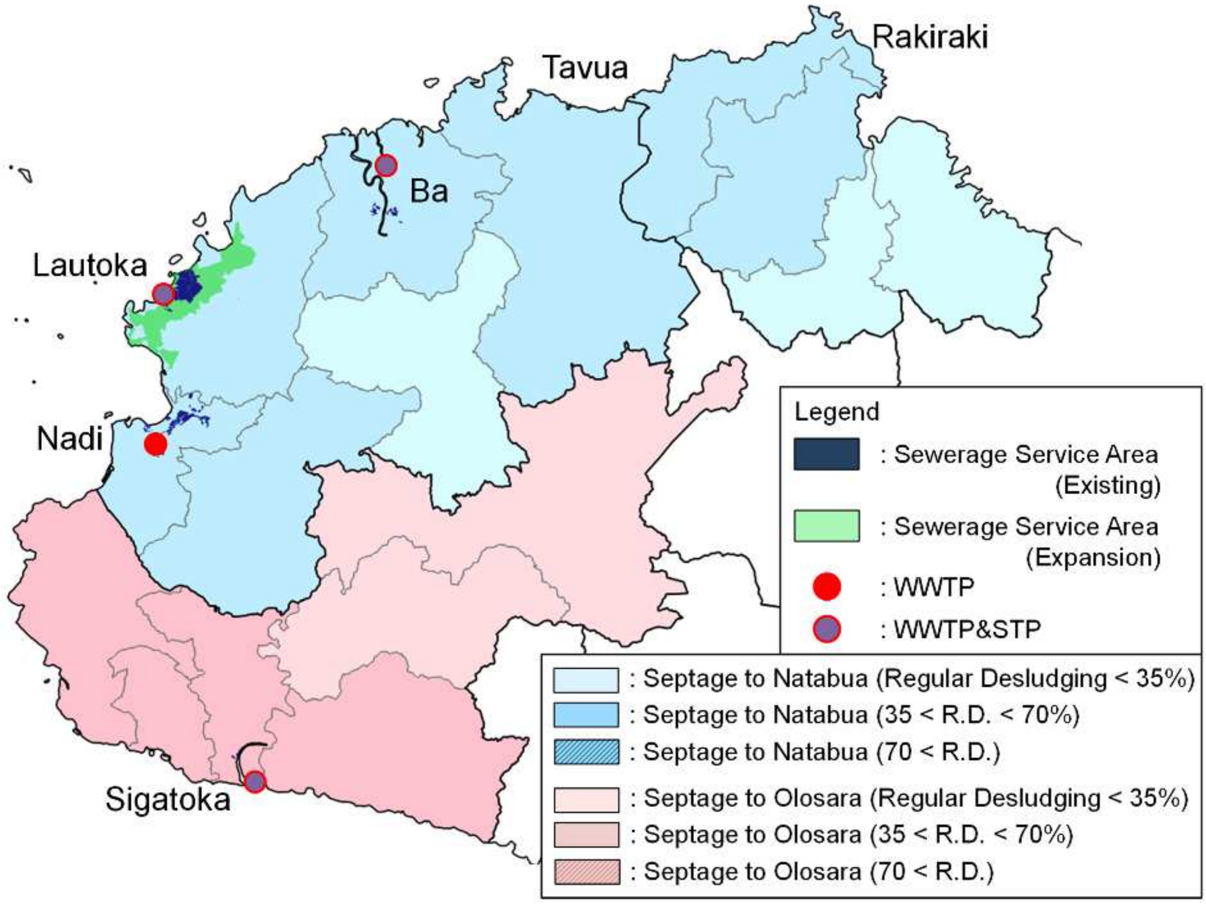
Source: JET

Figure 5-5.8 Septage Transport Routes using a Transfer Station

5-6 Overall Plan of Wastewater Treatment

As a summary of the study of the centralized and decentralized treatment system, the development status in 2036 and 2053 and each major index are shown in this section.

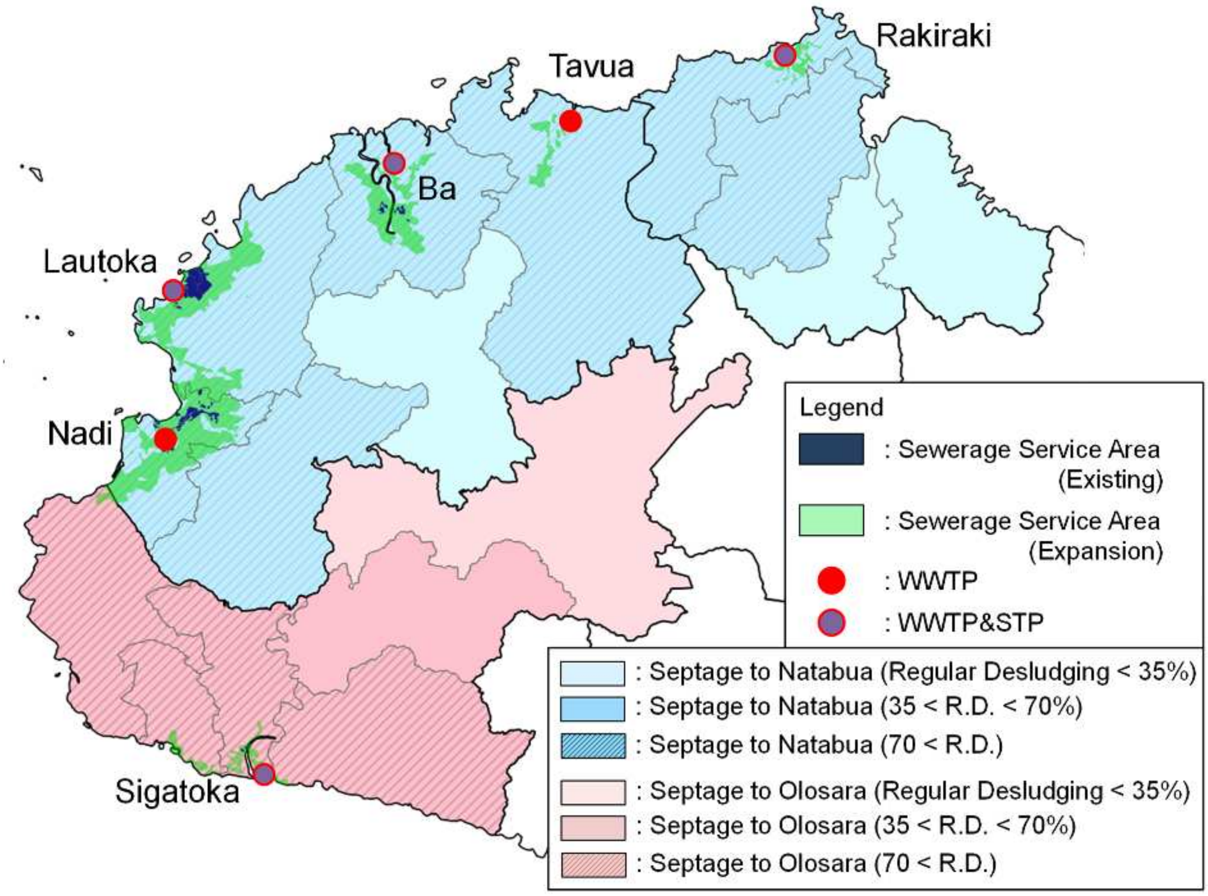
As for the situation in 2036, as shown in **Figure 5-6.1**, the expansion of the Lautoka sewerage system will be completed, and the access ratio to the centralized treatment system will improve to 34%. In line with this, as a leveling up of decentralized treatment systems, the rate of regular desludging from septic tank will be increased to 36%, and the access ratio of safely managed sanitation services will reach to 70%. Septage generated in Ba and Ra province will be collectively treated at the new treatment facility in Natabua WWTP (Lautoka).



Source: JET

Figure 5-6.1 Wastewater Treatment Status in 2036

Figure 5-6.2 shows the situation in 2053 when the development of sewerage system is expected to be completed. With the sewerage system expansion in the 6 municipalities in the Western Division is completed, the access ratio to centralized treatment systems will reach 70% of the population, achieving the National Development Plan goal.



Source: JET

Figure 5-6.2 Wastewater Treatment Status in 2053

CHAPTER 6 Environmental and Social Considerations

6-1 Project Components Related to Environmental and Social Impacts

A purpose of environmental and social considerations in the Master Plan stage is to examine the environmental and social implications as early as possible and take into account their impacts in decision making for individual project planning. Doing so the significant environmental and social impacts can be avoided and minimized in the development stage. In the Regional Wastewater M/P, environmental and social considerations are implemented by applying the principles of Strategic Environmental Assessment (hereinafter referred to as "SEA") to formulate a comprehensive wastewater treatment M/P including on-site and off-site treatment for improvement of wastewater treatment in the Western Division of Fiji. Specifically, this M/P identifies important environmental and social items to be considered by scoping based on available data and information and sets up evaluation methods. In addition, possible development scenarios for a WWTPs in each city/town are analyzed on a preliminary basis.

After the formulation of the Regional Wastewater M/P, as the Municipal Sewerage M/P and Pre-F/S of priority projects materialize, the targets for environmental and social considerations will be gradually narrowed down, and the contents of the evaluation items will be become more detailed. With such a process in mind, the scoping results and evaluation methods in this M/P stage should not be directly used, but referred at the subsequent plans and individual projects. Environmental and social consideration process such as EIA (including scoping) must be redone, taking into account the nature of the plans and projects.

Possible project components at this M/P stage are shown in **Table 6-1.1**. The target areas and current situation of the existing facilities are referred to in **Chapter 3**.

Table 6-1.1 Possible Project Components at the Regional Wastewater M/P Stage

Category	Project Component Facility	Note
Off-site	WWTP	Construction and expansion with or without land acquisition
	Pumping station	Construction and expansion with or without land acquisition
	Sewer network	New construction of sewer pipelines connecting to WWTPs (main sewers, sub-main sewers, collecting sewers, etc.), rehabilitation of main and sub-main sewers
	Sludge recycling plant	Construction of a sludge recycling plant
On-site	On-site wastewater treatment facility	Implementation of house/communal treatment facilities: septic tank, Johkasou etc.
	Septage treatment/recycling facility	Construction of a septage treatment/recycling facilities

Source：JET

6-2 Environmental and Social Baselines

6-2-1 Natural Environment

Viti Levu, a volcanic island with a mountain area in the center, is classified in a rainy tropical climate. The southern, eastern and central parts of the island experience annual rainfall of 3,000-5,000 mm, covered with rainforests, while the western part only has rainfall less than 2,000 - 3,000 mm with shrub-mixed savanna fields. The monthly average temperature in the Western Division is 23℃(July) at the lowest, and 27℃ (January) at the highest. Mangrove forests are often observed along the coastline of the island, and only 16% of the areas in the island, including hills, deltas, and coastal plains are available as arable land.

6-2-2 Water Resources

There are many rivers and creeks in Viti Levu, as well as lakes and freshwater wetlands inside the island. The large precipitation and the natural forests lead to plenty of water resources together with rich groundwater reservoirs. Major cities/towns in the Western Division utilize the surface water for regular water use including tap water and industrial/irrigation water, while small communities often use groundwater in addition. Such surface water usage is not well coordinated, so sometimes a conflict among this usage occurs. Rivers and creeks are also used on a daily basis for recreational purposes such as swimming and fishing by the surrounding communities.

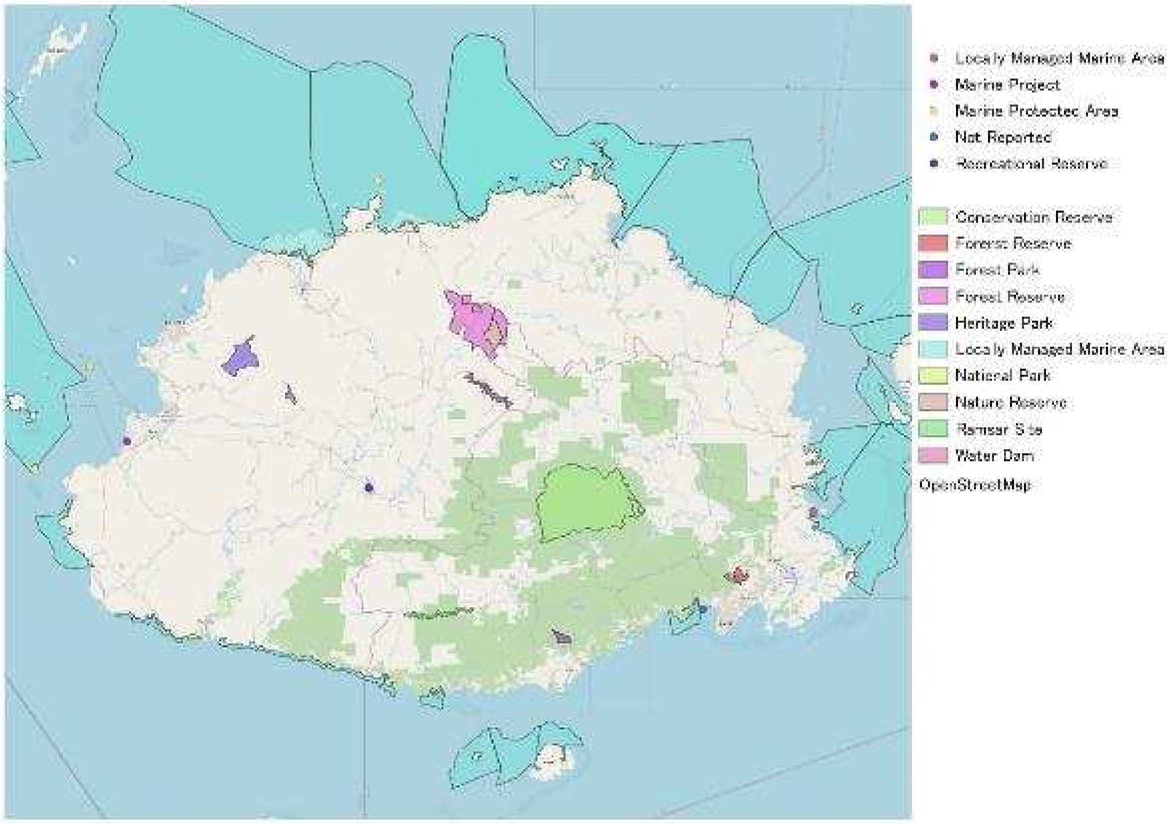
6-2-3 Floods

In Fiji, flooding occurs every year after heavy rain during the rainy season, sometimes even during the dry season. Floods and inundation locally occur in the Western Division are mostly caused by poor drainage systems; land development is also an associated factor. In particular, the Nadi River watershed is recently experiencing more floods impacting structures and agricultural products possible due to degradation of vegetation in the upstream area and land development in the downstream area. The government of Fiji, supported by JICA and other donors, is currently preparing the Nadi River Flood Control Project.

6-2-4 Designated Areas for Conservation of Nature and Cultural Heritages

(1) Protected Area

In Fiji, protected areas are designated by various organizations such as the National Protected Areas Committee, Locally Managed Marine Area (hereinafter referred as "LMMA") Network, Birdlife International, and Ministry of Forest, and most of the protected activities involve local communities. According to World Database on Protected Areas (hereinafter referred as "WDPA"), there are currently 146 protected areas, including 117 marine protected areas and 26 terrestrial protected areas. **Figure 6-2.1** shows protected areas in Viti Levu.



Source: Prepared by JET based on WDPA dataset (www.protectedplanet.net)

Figure 6-2.1 Protected Areas in Viti Levu

1) National Park

Sigatoka Sand Dune National Park, located on the estuary of Sigatoka River, is the only National Park in Fiji, and is a very popular tourist spot.

2) Marine Protected Area

Of Fiji’s entire marine protected areas, 103 areas are designated as LMMAs.[13]. LMMAs are designated based on traditional fishing areas (coastal areas including coastlines and mangrove stands, traditionally called as Qoliqoli Areas) managing the coastal area based on the traditional management structure and knowledge of communities utilizing the area. In the Western Division, the coastal areas from the east of Lautoka to Rakiraki, and the areas near Sigatoka are designated as LMMAs.

3) Terrestrial Protected Area

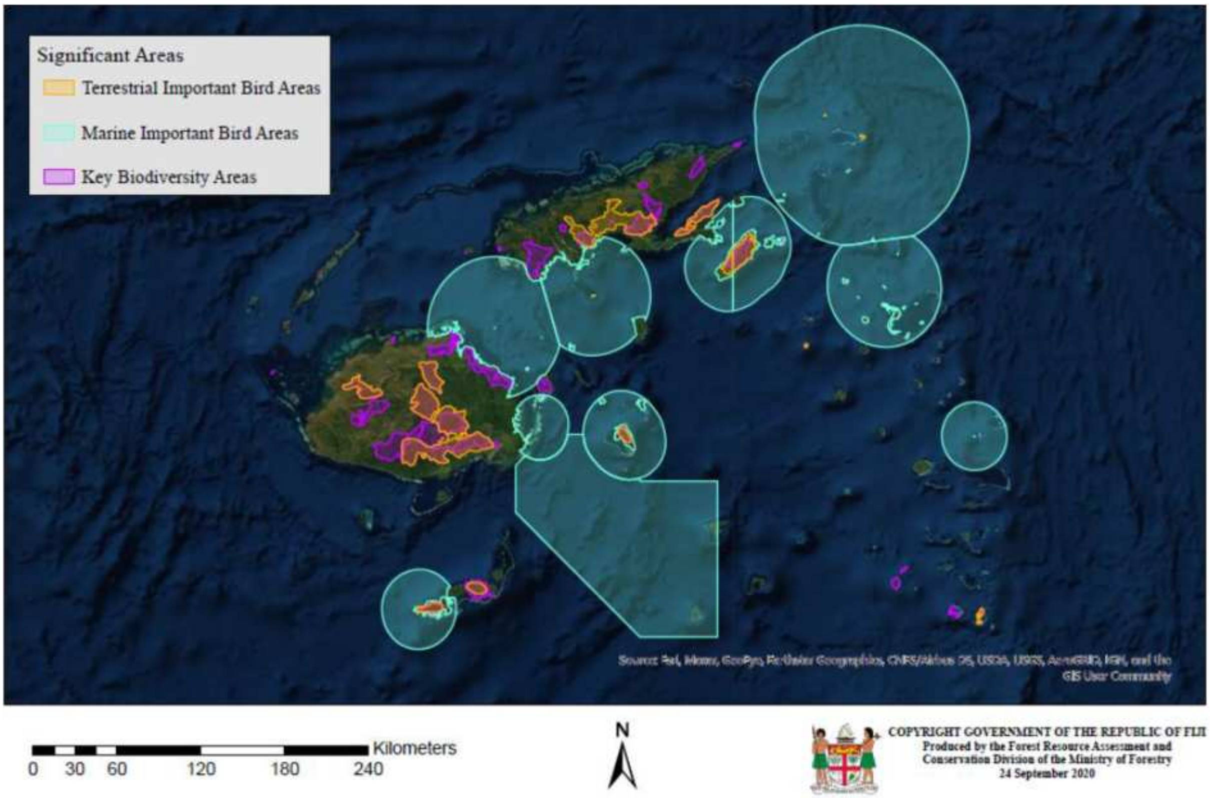
Most of the terrestrial protected area in the Western Division are located in the mountain region.

4) Key Biodiversity Area (KBA) and Important Bird Area (IBA)

In addition to the protected areas mentioned above, there are Key Biodiversity Areas (hereinafter referred as “KBAs”), and Important Bird Area (hereinafter referred as “IBAs”) identified by international standards

[13] Locally Managed Marine Area (LMMA) is an international networking initiative in Asia-Pacific, established since 2000 to work together with communities, NGOs, governments, and researchers for promoting food security and livelihoods, and for managing coastal resources.

(**Figure 6-2.2**). Terrestrial IBAs of Viti Levu are found in the mountain region, while IBAs are located at the eastern coastline of the island after Rakiraki. KBAs are found at the northeastern coastline and the mountainous region.



Source: Fiji's 6th National Report to the Convention on Biological Diversity 2014-2020

Figure 6-2.2 KBAs and IBAs in Fiji

6-2-5 Biodiversity[14]

Fiji has rich forest biodiversity with highland and lowland forests as well as mangroves in the coastal intertidal zone. The mangrove area in Fiji is the third largest among all Oceanian Island countries; however, the area shows a decreasing trend from 43,650 ha in 1991 to 43,650 ha in 2007, possibly caused by urbanization, tourism development, waste disposal, and wastewater. 90% of the mangrove forests are grown in the southeastern and northeastern coastlines of Viti Levu, especially near Rewa, Ba, and Nadi Rivers, and Labasa River Delta of Vanua Levu. Mangrove forest degradation is causing destruction of the vulnerable ecosystem, leading to loss of important habitats, difficulty of local people's mangrove use, malfunction of mangrove's filtration system, and loss of carbon sinks as a mitigation measure against climate change.

DOE drafted the mangrove management plan in 2003, but it has never been approved as an official document, resulting in no comprehensive policies of mangrove protection for a long time. Currently, the Mangrove Conservation and Management Regulations are under preparation by DOE and expected to be

[14] National Biodiversity Strategy and Action Plan for Fiji 2020-2025

issued in late 2022. According to DOE, at the development stage of projects, the first priority is to avoid mangrove forests or any other vulnerable areas. However, depending on the situation mangrove offsets (e.g. 6 mangrove plantations per 1 cutting) and compensations may be accepted in the project EIA for mangrove protection.

6-2-6 Socio-economic Situation

Socio-economic situation in Fiji and in Western Division is shown in **Table 6-2.1**. Lautoka and Nadi in Western Division are the largest cities after the Capital Suva, so the socio-economic level is close to the average of Fiji. However, the agricultural population and the poverty rate are slightly higher than the average. The unemployment rate is low at 7.4%, but it does not take into account daily wage and temporary workers, so the real rate is assumed higher. Women tend to be unemployed compared to men.

Table 6-2.1 Socio-economic Situation in Fiji and in Western Division

Parameters	Fiji	Western Division
Population Urban Rural	864,132 477,500 (55.3%) 386,632 (44.7%)	330,434 176,498 (53.4%) 153,936 (46.6%)
Population age structure Age 0-14 Age 15-64 Age 65+	 29.3% 64.6% 6.1%	 28.4% 65.2% 6.4%
Male-headed households	80.9%	81.3 %
Household members	4.3 people/household	4.1 people/household
Poverty rate (rate less than the national poverty line*) Urban Rural	258,053 (29.9% of the population) 97,602 (20.4% of the urban population) 160,450 (41.5 % of the rural population)	106,988 (32.4% of total population in the division) 41,206 (23.3 % of the urban population in the division) 65,782 (42.7 % of the rural population in the division)
Average income per household Urban Rural	$26,248.6 $30,500.7 $20,738.1	— $28,107.7 $20,318.0
Unemployment rate Male Female	7.4% 5.1% 11.7%	—

* A single national poverty line was set at $2,179.39 per adult equivalent (AE) per year, or $41.91 per AE per week.
Source: Fiji Bureau of Statistics, Household Income and Expenditure Survey Main Report 2019-2020 (2021).

6-2-7 Ethnic Groups

Fiji's ethnic groups consist of native Fijian, known as iTaukei (62.0%), Indo-Fijian (34.2%) which immigrated during the British colonial era, and other groups (3.8%) including Rotuman, other Oceanian, and Chinese (FBS, 2021). English is spoken as a common language, and Fijian and Hindi are also used. Christianity is popular among iTaukei people while Hindu among Indo-Fijian. The poverty rate of iTaukei is highest, occupying more than 70% of the total poverty population (**Table 6-2.2**).

Table 6-2.2 Poverty Rates in Fiji (By Ethnic Groups)

Contents	iTaukei	Indo-Fijian	Other Groups
Population	535,554 (62.0%)	295,326 (34.2%)	33,251 (3.8%)
Population of the poor (Poverty rate: less than the national poverty line*)	192,977 (36.0%)	58,933 (20.0%)	6,143 (18.5%)
Percentage of the total poor population	74.8%	22.8%	2.4%

Source: Fiji Bureau of Statistics, Household Income and Expenditure Survey Main Report 2019-2020 (2021).

In Fiji, iTaukei's land rights have been protected by the constitution and laws even before the independence of the nation in 1970 and managed collectively by iTaukei Land Trust Board (TLTB). Similarly, hunting, fishing, harvesting of wild fruits and vegetables in iTaukei land, and marine resource use and fishing in coastal area and mangrove forests where iTaukei people have been traditionally using, are also protected by the Forest Decree and Fisheries Act.

6-3 Environmental and Social Consideration System and Organization

6-3-1 Environmental Laws and Regulations

Table 6-3.1 shows major environmental laws, regulations, and related documents of Fiji. The Environmental Management Act 2005 is the first integrated regulatory framework of environmental sector in Fiji, and states principles on sustainable use and development of natural resources, and importance of the environmental management through the country. Based on this act, Environment Management (EIA Process) Regulations and Environment Management (Waste Disposal and Recycling) Regulations were formulated. In addition, currently the Mangrove Conservation and Management Regulations is under preparation.

Table 6-3.1 Environmental Laws, Regulations and Related Documents in Fiji

Name	Summary
EIA Guidelines 2008 (revised 2012)	It is similar to what appears in the Environment Management (EIA Process) Regulations, but is more specific and states the process step by step in a simpler format and language. The latest version of the guidelines was revised and issued in 2012 as the 2nd edition.
Environment Management (EIA Process) Regulations 2007	This regulation outlines main components of the EIA process and provides the EIA procedures.
Environment Management (Waste Disposal and Recycling) Regulations 2007	The purpose of Waste Disposal and Recycling Regulations 2007 is to prevent the pollution of the environment by controlling the discharge of solid and liquid waste, emissions of polluting gases, and handling storage/disposal of wastes and hazardous substances generally. The regulations states that development sites need waste permits for discharging significant amounts of liquid waste into waters/emission of air pollution. For liquid waste, frequency of effluent quality analysis, and the effluent quality standards (General and Significant Ecological Zone) are also stated.
Environmental Management Act 2005	This is an act for the protection of the natural resources, for the control and management of developments, and for waste management and pollution control, in addition to the regulatory framework of EIA process. The act also states the establishment of a National Environment Council and DoE's roles and responsibilities.
Endangered and Protected Species Act 2002 (amended 2017)	The act regulates and control the international trade, domestic trade, possession, and transportation of species protected under Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The amended 2017 act adds non-CITES species to be protected.

Source: JET

6-3-2 Environmental Policies, and Plans

Major national environmental policies and plans are shown in **Table 6-3.2**.

Table 6-3.2 National Environmental Policies and Plans in Fiji

Category	Document
Waste	• National Liquid Trade Waste Policy 2017 • Clean Environment Policy 2019
Biodiversity	• Integrated Coastal Zone Management Framework 2011 • Mangrove Management Plan 2013 (Draft) • National Biodiversity Strategic Action Plan 2020-2025 • National Ocean Policy 2020-2030
Forest protection	• Fiji Forest Policy Statement 2007
Land use	• Rural Land Use Policy of Fiji 2002
Gender	• National Gender Policy 2014
Indigenous group	• iTaukei Affairs Strategic Development Plan 2018-2023

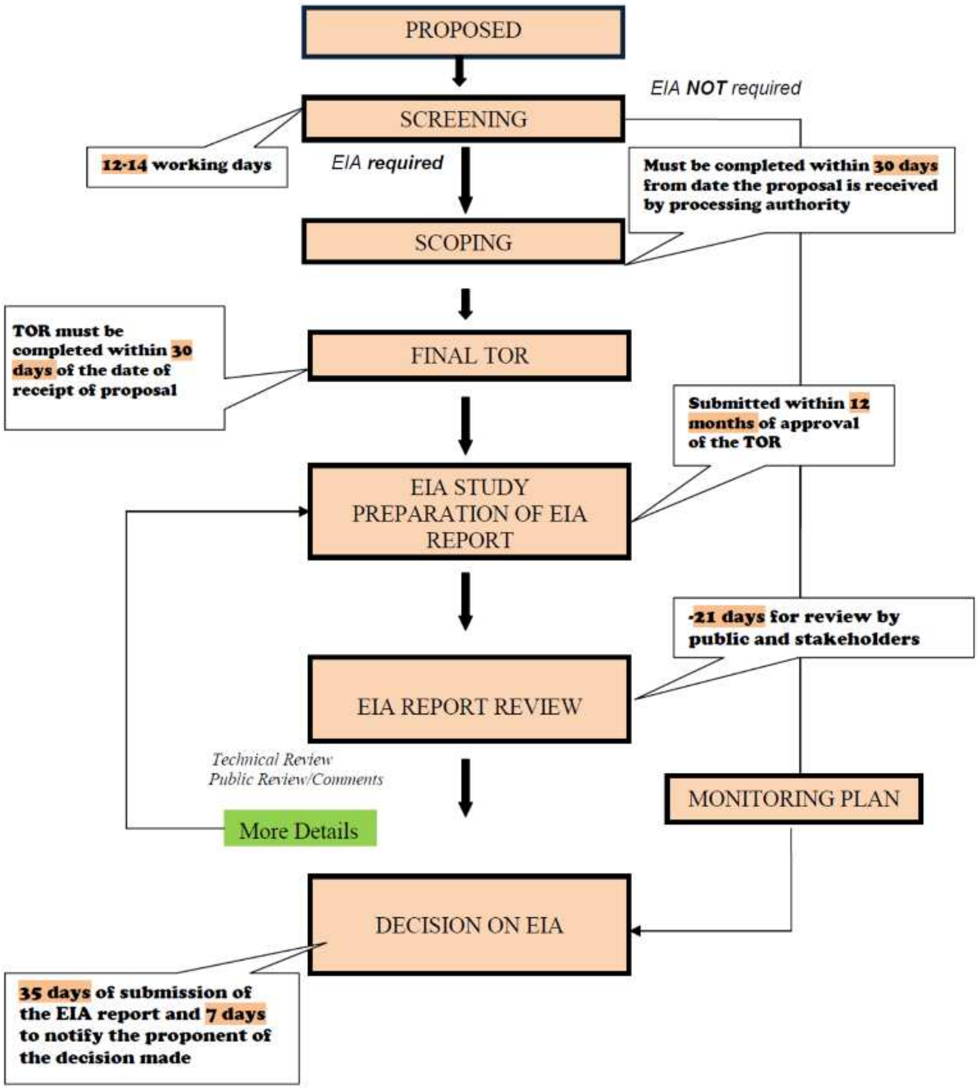
Source: JET

6-3-3 Organizations in Environmental Sector

The environmental governance of Fiji is responsible for DOE of MOWE. The Environmental Management Act states roles and responsibilities of DOE, and currently EIA Unit, Waste and Pollution Control Unit, and Resource Management Unit work on each environmental topic. The Western Division Office of DOE is located in Nadi.

6-3-4 EIA Process

Projects that are required for EIA is listed in Schedule 2 of the Environmental Management Act. Sewerage related projects fall in "(q) a proposal for the construction of a landfill facility, composting plant, marine outfall or wastewater treatment plant," and therefore requires obtaining EIA approval. DOE prepared EIA Guidelines in 2008 (revised in 2012) to explain in detail about EIA procedures. EIA must be conducted by a DOE-registered consultant. **Figure 6-3.1** shows the EIA process flow.



Source: Environmental Impact Assessment Guidelines 2012

Figure 6-3.1 EIA Process in Fiji

6-3-5 Strategic Environmental Assessment (SEA)

There are no regulations that stipulates implementation of SEA in Fiji. The EIA guidelines only defines a project as “a development activity or proposal which has or is likely to have an impact on the environment. This encompasses polices, plans and programs or strategic environmental assessment (SEA) as well as technology and other categories of activities.” The “Strategic Plan 2020-2024” developed by MOWE neither mentions about SEA, nor any plans for its implementation. According to an interview with DOE, it was confirmed that DOE is responsible only for the EIA procedures at the project stage, and not for SEAs.

However, the following past projects in Fiji have implemented SEAs. The “Secretariat of the Pacific Regional Environment Program” (hereinafter referred to as “SPREP”) prepared the “Strategic Environmental Assessment – Guidelines for Pacific Island Countries and Territories,” promoting SEA implementation for Pacific region countries for decision-making during policy/program/plan development stages.

- Ministry of Forestry (2019), FCPF Readiness Project, Fiji. Strategic Environmental Social Assessment (SESA)
- JICA (2016), The Project for The Planning of the Nadi River Flood Control Structures Final Report, Volume 2 Main Report, Part 1: Master Plan Study
- ADB (2003), A Strategic Environmental Assessment of Fiji’s Tourism Development Plan

6-3-6 Policies and Activities related to Climate Change

Climate change vulnerability of Fiji is a serious concern; increasingly extreme weather events such as draught and heavy rain are heavily affecting people’s lives and infrastructure. It is also pointed out that rising sea levels would bring more floods, coastal erosion, and salt intrusion, and increase risks during a high tide.[15]

The Government of Fiji submitted Nationally Determined Contribution in 2026 in accordance with Paris Agreement and stated the target as “Zero GHG emission by 2050.” Other climate change related documents have been prepared related to the target as shown below.

- Green Growth Framework 2014
- National Climate Change Policy 2018-2030 (The first version in 2012)
- Low Emission Development Strategy 2018-2050
- Climate Relocation of Communities Trust Fund Act 2019
- Climate Change Act 2021

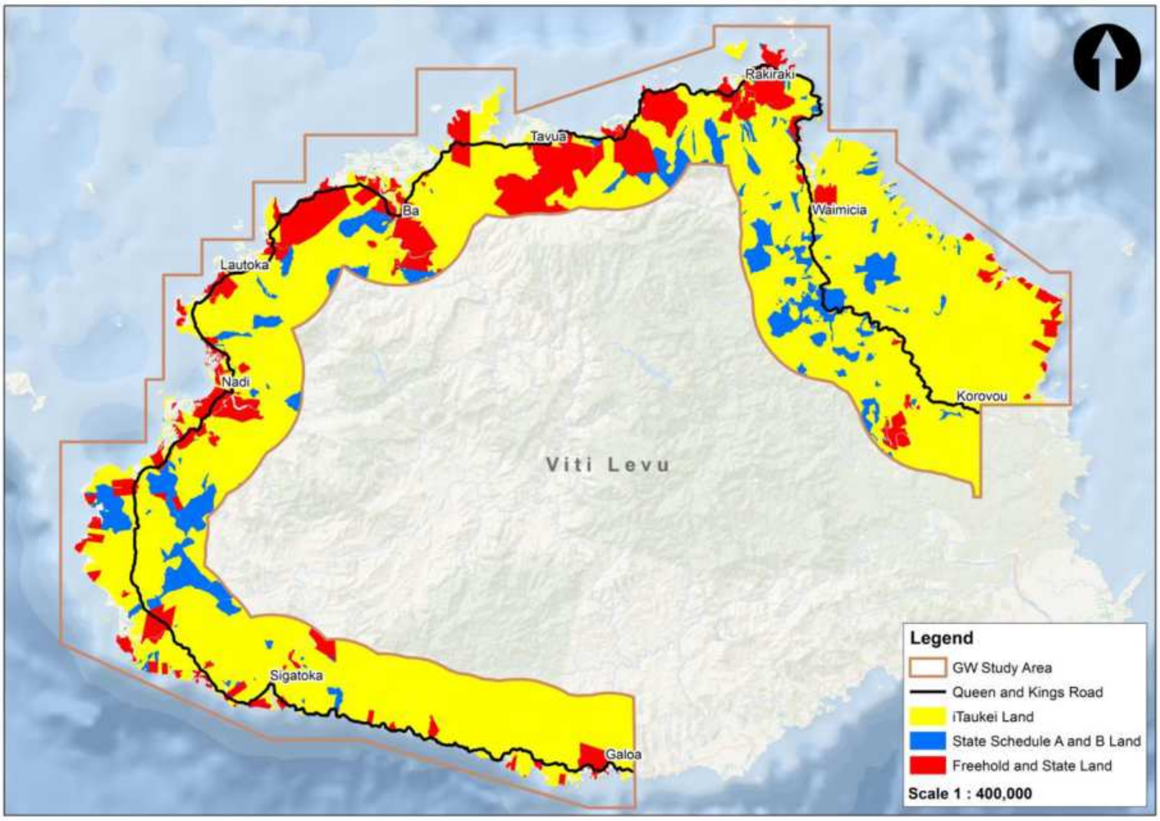
According to the documents above, wastewater and sludge recycling is proposed as climate change related activities in the sewerage sector. WAF has not yet prepared any policy documents related to climate change,

[15] World Bank Group. Climate Risk Country Profile, Fiji (2021)

but a vulnerability assessment was conducted in the past.

6-3-7 Regulatory Framework on Land Acquisition and Resettlement

Land ownership in Fiji is generally classified into 3 categories: iTaukei land, freehold land, and state/crown land. As shown in **Figure 6-3.2**, iTaukei land occupies 83% of the western part of Viti Levu (including the Western Division). Most of the urban area is public or freehold land, but it is only 17% of the entire areas.



Source: Regional Land Release Plan for the Greater West and Coastal Region 2019-2039

Figure 6-3.2 Land Ownership Classification of Western Viti Levu

Table 6-3.3 shows laws and regulations related to land acquisition. The Constitution of Fiji does not allow expropriation of land, and made iTaukei land non-transferrable, except for public use. In case of land acquisition by the government, any land and related rights must be compensated; the State Acquisition Lands Act states the details of its regulations and procedures.

Table 6-3.3 Laws and Regulations Related to Land Acquisition

Categories	Laws
Common	• Constitution of Fiji 2013 • State Acquisition of Lands Act 1940 (amended 1970)
iTaukei Land	• iTaukei Lands Act 1905 • iTaukei Land Trust Act 1940
Freehold Land	• Land Sales Act 1974 (amended 2014)
Public Land	• State Land Act 1945

Source: JET

Land acquisition methods by each land type are summarized below.

(1) iTaukei Land

All iTaukei land belongs to iTaukei community groups such as “Tokatoka” (Family), “Mataqali” (family group), “Yavusa” (tribe), and “Vanua” (independent kingdom), and is located near each community. Otherwise, it becomes iTaukei Reserve. iTaukei land can be leased to non-iTaukei people for development purposes in short-term or long-term through TLTB, who manages all iTaukei land on behalf of iTaukei owners. The Government of Fiji has classified people who live in iTaukei land without proper TLTB process as informal settlers. The informal settlements are now problematic in many cities and municipalities. In case of iTaukei land acquisition, the land users can be generally compensated as agreed with TLTB; however, the informal settlers may not be eligible to receive such a compensation.

(2) Freehold Land

In accordance with Land Sales Act, freehold land can be purchased, transferred, or leased. However, there are some restrictions for non-Fijian personnels and companies who want to purchase the land.

(3) State/Crown Land

In addition to onshore land, all costliness (lands lying lower than the high tide line), and bottom sediment of waterbodies are classified as state/crown (public) land. State/crown land is not for sale but can be leased by Department of Land (hereinafter referred to as “DOL”) of MOLMR. Under the existing regulatory system, mangrove forests, which are located in the intertidal coastal line, is categorized as “State/Crown land” so these areas are allowed to change its land use by DOL under the regulations. However, the EIA clearance related to the land use change has to be obtained in advance. It is noteworthy that the Mangrove Conservation and Management Regulations shall be considered for such a development once it is enacted.

6-4 Scoping

In order to select important environmental and social items related to wastewater treatment, scoping analysis is conducted as follows, considering the possible project components and environmental and social baseline information. At this M/P stage, it is very difficult to evaluate impacts in detail since specific project components, together with spacial and temporal conditions, have not been decided yet. Therefore, the general impact levels are assumed at this time based on general information of the regional characteristics and facilities.

Table 6-4.1 Scoping (Regional Wastewater Stage)

Cat.		Items	Result	Reasons
Social Env.	1	Involuntary Resettlement and Land Acquisition	X	**Planning / Construction:** The construction of any facilities may associate with involuntary resettlement or land acquisition, depending on land availabilities. **Operation:** Involuntary resettlement or land acquisition is not expected.
	2	Local Economy		According to Fiji's regulations, the building-to-land ratio depends on water and sewerage connectivity. Therefore, it is expected that sewerage reticulation development vitalizes local economy and facilitates citizen's settlement (including informal settlers).
	3	Land Use		Land use pattern by the government and private sector in the service area may be changed to a more efficient pattern, based on the contents of the Municipal Sewerage M/P.
	4	Social Institutions		The M/P include WAF and other related organization's organizational capacity improvement. Overall sewerage management capacity in Fiji will be improved though the activity.
	5	Existing Social Infrastructure and Services	X	**Construction:** Construction of a facility may involve traffic disturbance: Specifically, when constructing sewer lines that is buried under roads, restriction of user's access may occur, such as de-tour, and temporary blocking. Power, gas, water lines may be impacted by the construction work as well. **Planning / Operation:** Sewerage service area expansion as a public service, as well as proper on-site treatment, is expected.
	6	Indigenous Peoples	X	**Planning / Construction / Operation:** Construction and expansion of the treatment facility may cut down mangroves and reclaim mudflats, and it is possible that neighboring native people cannot fully use their inherited areas, or such areas are diminished.
	7	Poverty	X	**Planning / Construction / Operation:** There are informal settlements in the outskirts of the city/towns in Western Division (especially in Sigatoka, Lautoka, and Nadi). At the Municipal Sewerage M/P stage, these informal settlements have to be taken into account by discussing with local governments.
	8	Misdistribution of Benefit and Damage	X	**Planning / Construction / Operation:** Although the Regional Wastewater M/P covers all area of the division, misdistribution of benefit, such as sewerage service -served areas versus non-serviced areas, and beneficiary people versus adversely affected people, may affect economic balance in the division.
	9	Cultural Heritage	X	**Planning / Construction / Operation:** There may be traditional sites etc. in iTaukei land. Construction of a facility may involve disturbance to such sites, including its relocation and access restrictions.
	10	Local Conflict of Interest	X	**Planning / Construction / Operation:** The Regional Wastewater M/P considers 6 city/towns for sewerage areas. Depending on development priority, there may be local conflict of interest within the Western Division.
	11	Water Use	X	**Planning / Construction:** Construction work may temporarily affect water environment that neighboring people use. **Operation:** It is expected that better quality of discharged water by the WWTP installation and proper on-site facility management result in improvement of the water environment.

Cat.		Items	Result	Reasons
	12	Sanitation and Infectious Diseases (HIV/AIDS)		It is expected that improvement of wastewater treatment in the Western Division will improve sanitary environment and reduce risks of infectious diseases.
	13	Gender / Children's right		Adverse impacts on gender and children's rights are not expected.
	14	Landscape	X	**Planning / Construction / Operation:** The Western Division is a famous tourist destination, so facility designs, and construction work need to be considered.
	15	Work environment / accidents	X	**Planning / Construction / Operation:** Work environment for construction and operation staffs, as well as countermeasures for accidents need to be considered.
Natural Env.	16	Topography and Geographical Features	X	**Planning / Construction:** Soil erosion may occur at tilted land, so depending on development characteristics and location, topography and geographical features need to be considered. **Operation:** No impacts on topography and geographical features are expected.
	17	Hydrology	X	**Planning / Construction / Operation:** The area is vulnerable to cyclones and monsoonal floods, windstorms, high tides etc., so the facility planning need to take these into account.
	18	Protected area / Biodiversity	X	**Planning / Construction / Operation:** In the coastal area of the Western Division, there are many ecologically important habitat areas such as mangroves, mudflats, and coral reefs. Some of them are designated as protected areas. These areas may be affected by effluents from the construction work, and the facility operation.
	19	Climate change	X	**Planning / Construction / Operation:** Impacts of climate change such as rising sea levels and heavier rain may lead to shortage of the wastewater treatment capacity, and more flood and inundation. Sludge generated by the treatment process generate methane gas.
Pollution Control	20	Air pollution	X	**Construction:** Suspended dust and gas emission from the construction machinery are generated during a certain period of time. **Operation:** No impacts on air quality are expected.
	21	Water pollution	X	**Construction:** Downstream area of the construction site may be temporarily affected by turbid water from the construction work. **Operation:** It is expected that the WWTP installation and proper on-site facility management result in improvement of the effluent water quality.
	22	Soil and groundwater Contamination	X	**Construction:** Soil and groundwater contamination may happen caused by oil leakage etc.
	23	Waste	X	**Construction:** Waste soil and materials are generated during construction. **Operation:** Sludge/septage from the treatment facilities need to be treated properly.

Cat.		Items	Result	Reasons
	24	Noise and Vibration	X	**Construction:** Noise and vibration are generated from construction work and machinery. **Operation:** Pumps and motors of the facilities may generate noise and vibration.
	25	Ground Subsidence		No ground subsidence is expected.
	26	Offensive Odor	X	**Construction:** When rehabilitating existing WWTPs, offensive odor may be generated due to disturbance of the facilities. **Operation:** Offensive odor may be generated from the WWTPs, but improvement of the odor issues is expected with the proper facility installation and operation.
	27	Bottom Sediment	X	**Construction:** Bottom sediment of the rivers and coastal area may be disturbed temporarily due to construction of an offshore outfall and discharge pipes. **Operation:** The bottom sediment quality in water bodies may be improved together with the better effluent water quality.

Source: JET

6-5 Important Environmental and Social Items and Study Methods

Based on the scoping results, the important environmental and social items to be considered in the Municipal Sewerage M/P stage and project stage and their study methods (draft) are summarized in **Table 6-5.1**.

Table 6-5.1 Important Environmental and Social Items and Study Methods (Draft)

Cat.		Items	Study Contents	Study Methods (draft)
Social Env.	1	Involuntary Resettlement and Land Acquisition	・ Necessity of land acquisition and involuntary resettlement, and its scale (when necessary, an abbreviated resettlement action plan (ARAP) has to be prepared)	・ Laws and regulations on land acquisition and resettlement ・ Case studies of similar sewerage-related projects ・ Aerial photos of the target area ・ Land use ・ Onsite survey to find/record any presence/types of buildings/structures within and nearby the site ・ Census and socio-economic survey, asset inventory etc. for the ARAP in accordance with the national regulations and World Bank's OP4.12
	2	Existing Social Infrastructure and Services	・ Impacts on road access by the construction work ・ Impacts on social infrastructure and services (power, gas, water etc.)	・ Review on construction details such as construction components, methods, period, location, and area etc. ・ Review on traffic volumes, the surrounding situations of the site-by-site surveys and interviews ・ Review on locations of social infrastructures (power, gas, water) by site surveys and interviews
	3	Indigenous Peoples	・ Impacts on lifestyles and livelihood of indigenous people around the site	・ Socio-economic survey at nearby communities ・ Identification of indigenous people's important sites and their situation of utilization by site surveys and interviews ・ Stakeholder meetings and focus group meetings
	4	Poverty	・ Consideration on informal settlements ・ Impacts on the poor who are affected by land acquisition and resettlement	・ Confirmation on locations of informal settlements by site visit and interviews ・ census and socio-economic survey ・ Study on lifestyle and living conditions of the poor and informal settlers ・ Stakeholder meetings and focus group meetings
	5	Misdistribution of Benefit and Damage	・ Impacts by sewerage area set-up ・ Impacts on affected people around the project areas	・ Socio-economic survey at nearby communities ・ Site visit and interviews ・ Stakeholder meetings

Cat.		Items	Study Contents	Study Methods (draft)
	6	Cultural Heritage	• Impacts on cultural heritages near the project site	• Document review • Identification of indigenous people's cultural heritages by site visit and interviews • Stakeholder meetings
	7	Local Conflict of Interest	• Potential that local conflict of interest among the city/towns, and among communities occurs	• Interviews • Stakeholder meetings
	8	Water Use	• Water use situation near and downstream of the WWTP discharge point • Impacts during construction and operation	• Review on construction details such as construction components, methods, period, location, and area etc. • Review on the effluent discharge plan (volume, quality, and a location to discharge it) • Document review • Study on water use situation near the discharge point of a treatment facility, and downstream by site visit and interviews
	9	Landscape	• Locations of tourist spots (hotel etc.) • Landscape nearby the site	• Site visit • Review on construction details such as construction components, methods, period, location, and area etc.
	10	Work environment / accidents	• Occupational health and safety measures	• Laws and regulations related to occupational health and safety • WAF's documents related to occupational health and safety measures • Case studies of similar wastewater treatment projects (contract documents with contractors etc.)
Natural Env.	11	Topography and Geographical Features	• Impacts on topography and geographical features associated with the construction work	• Review on construction details such as construction components, methods, period, location, and area etc. • Site visit
	12	Hydrology	• Occurrence of floods, inundation, and high tides	• Document review • Site visit and interviews
	13	Protected area / Biodiversity	• Location of the protected areas and ecologically important areas	• Document review • Site visit and interviews • Review on construction details such as construction components, methods, period, location, and area etc. • Review on the effluent discharge plan (volume, quality, and a location to discharge it)

Cat.		Items	Study Contents	Study Methods (draft)
	14	Climate change	・ Fiji's climate change policies and plans in sewerage sector ・ Greenhouse gas emissions from the project ・ Impacts to the project by climate change	・ Document review and interviews ・ Amount of sludge generation and treatment process ・ Estimation of CO2 emission from the project
Pollution Control	15	Air pollution	・ Ambient air quality ・ Environmental standards of Fiji, Japan and other countries, WHO standards ・ Locations of residential areas, schools and hospitals ・ Impacts by the construction work	・ Document review and air quality measurement (if necessary) ・ Site visit and interviews ・ Review on construction details such as construction components, methods, period, location, and area etc.
	16	Water pollution	・ Ambient water quality at an effluent receiving water body and nearby ambient water ・ Environmental standards of Fiji, Japan, and other countries, and WHO standards	・ Document review and air quality measurement (if necessary) ・ Site visit and interviews ・ Review on construction details such as construction components, methods, period, location, and area etc. ・ Planned volume and quality of the effluent ・ Simulation on the effluent dispersion and water quality (if necessary)
	17	Soil and Groundwater Contamination	・ Measures against oil spillage during construction	・ Review on construction details such as construction components, methods, period, type of the machinery, operation and storage locations etc.
	18	Waste	・ Disposal methods of construction waste ・ Amount of sludge generation and treatment process	・ Interviews with related organizations ・ Case studies of similar sewerage-related projects
	19	Noise and Vibration	・ Fiji's environmental standards ・ Distances between the sources to residential areas, hospitals, and schools ・ Impacts by the construction work	・ Document review ・ Site visit and interviews ・ Review on construction details such as construction components, type of the machinery, operation periods and locations etc.
	20	Offensive Odor	・ Distances between odor sources to residential areas, hospitals, and schools ・ Impacts by the construction work	・ Review on construction details such as construction components, methods, period, location, and area etc. ・ Site visit and interviews ・ Case studies of similar wastewater treatment projects
	21	Bottom Sediment	・ Effluent discharge locations and its surrounding environment ・ Impacts by the construction work	・ Document review ・ Site visit and interviews ・ Review on construction details such as construction components, methods, period, location, and area etc.

Source: JET

6-6 Alternative Analysis

6-6-1 Not Implementing the Project

This M/P's target is to achieve the National Development Plan's goal to "provide access to centralized treatment systems for 70% of the Fijian population by 2036." The M/P builds a framework of wastewater treatment development for the city/towns of the Western Division, showing areas of the centralized or decentralized treatment system service areas, necessary development methodologies and schedules, and so on. Without the strategic implementation of wastewater treatment which is described in this M/P, the NDP target for 2036 will not be achieved.

6-6-2 Development Scenarios in the Regional Wastewater M/P

The development scenarios for each city/town will be detailed in the next phase, the Municipal Sewerage M/P. In the Regional Wastewater M/P, taking into account the wastewater treatment capacity demands to rise in the future, alternative development scenarios were formulated based on the expansion/new construction of WWTPs. These scenarios were analyzed and compared from environmental and social aspects. Utilization of the analysis results in the Municipal Sewerage M/P will make better and more reliable decision making/mitigation/minimization measures/facility designs to ensure proper implementation of environmental and social considerations.

Currently, among the 6 major city/towns in the West, 4 city/towns (Lautoka, Nadi, Ba, and Sigatoka) have existing centralized treatment systems, while the other 2 towns (Tavua and Rakiraki) have no such system nor septage treatment facilities. Therefore, the development scenarios of each city/town for the treatment facilities are set as below.

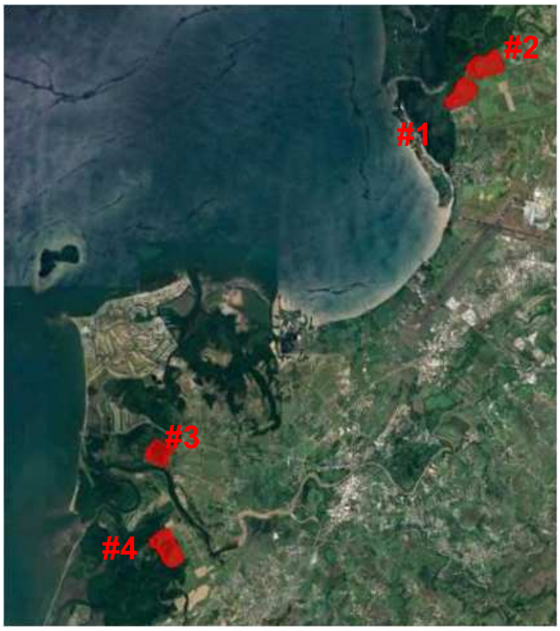
- Scenario a: Expansion of existing WWTP (including land acquisition)
- Scenario b: Construction of new WWTP

In Scenario b, four priority city/towns are analyzed with several facility site alternatives: Lautoka and Nadi that immediately need more capacity for the existing treatment facilities; Rakiraki and Tavua that have no treatment facilities. The candidate sites for Scenario b are shown in **Figure 6-6.1**. The sites for Rakiraki are referred to Rakiraki M/P, while the sites for other 3 city/towns are selected from the aerial map considering the following criteria.

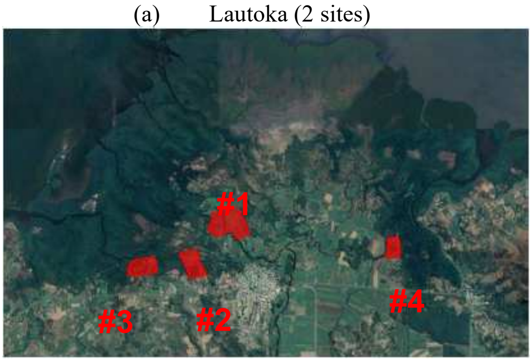
1. Close to a water body for effluent discharge
2. Relatively close to an urban area
3. Large enough to construct a treatment facility
4. Downstream of a watershed

It should be noted that these candidate sites are initial selections, and therefore have to be discussed in detail in the Municipal Sewerage M/P together with related organizations and local governments.

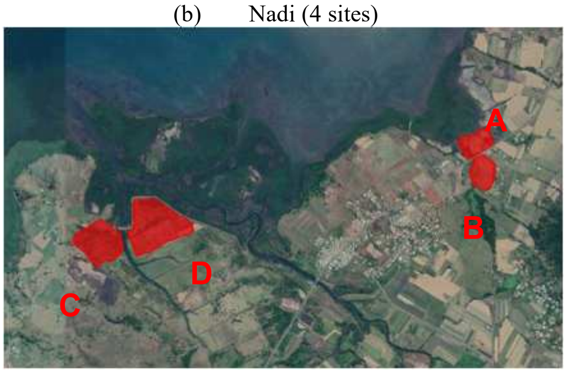
(a) Lautoka (2 sites)



(b) Nadi (4 sites)



(c) Tavua (4 sites)



(d) Rakiraki (4 sites)

Source: JET

Figure 6-6.1 Candidate Construction Sites for New WWTPs

6-6-3 Analysis Methods

Scenario a (expansion of existing WWTPs) and Scenario b (construction of new WWTPs) are analyzed at each city/town to the extent possible, by looking at the following aspects that vary from site to site, based on available information, site visits, and interviews.

[Environmental]
- Site and adjacent area
- Floods
- Biodiversity and geological features of nearby coastal area

[Social]
- Lifestyle and livelihood of neighbors
- Land tenure and its use

6-6-4 Analysis Results and Scenario Evaluation

The analysis results and scenario evaluation of Scenario a (expansion of existing WWTPs) and Scenario b (construction of new WWTPs) in each city/town are summarized as follows.

(1) Lautoka

Lautoka is a center of trade, business, and services in the Western Division. The sugar business is the main component of its economy; Local private businesses are also thriving, such as agriculture, small enterprises, and labor supply. There are approximately 770 households with 4,461 people living within the 1 km radius from Natabua WWTP.

The analysis results and scenario evaluation are shown in **Table 6-6.1**.

Table 6-6.1 Analysis Results and Scenario Evaluation in Lautoka

Items	Scenario a (existing: Natabua WWTP)	Scenario b (new WWTP)	
		Site #1	Site #2
Site and adjacent area	North / East: 2 communities (Saru and Taiperia) 150-500 m northeast, and agricultural fields/mangroves in the other areas South: Private business West: Community 400 m west, and mangroves in the other areas	Site: Mangroves with a creek North: Mangroves East: Mangroves across Vitogo River, and a community (Vitogo) in 700 m east South: Agricultural fields, and a several communities (Lovu etc.) in 200m south West: Mangroves	Site: Mangroves/agricultural fields North: Mangroves/agricultural fields East: Mangroves/agricultural fields, and a community (Naviyago) 250 m east South: Mangroves across Vitogo River, and a community (Vitogo) in 200m south West: Mangroves
Lifestyle and livelihood of neighbors	Mangroves are very important for people in Taiperia (an informal settlement) as a food, resource and disaster protection (high tide, Tsunami, windstorm, coastal erosion etc.).	Adjacent to Naviyago, there is a historically and culturally important area (called Koromakawa) for Naviyago people, and a community farm along the site boundary. Mangroves may be also very important for their livelihood.	
Floods	Floods have occurred twice in 2017.	In 2012, Vitogo River overflowed due to heavy rain and an earthquake, and it resulted damaged assets/human casualties As a long-term impact, the land degradation and damaged houses caused resettlement of people.	
Biodiversity and geological features of nearby coastal area	Mangrove stands are found northward to westward of the site, its width ranging 300m ~ 1.5 km from the inland Shallow water with the depths of 8-27.5m stretches out across the tidal mudflat. The Yasawa Island Group is found to the north, along with a plethora of smaller islands and reef systems that largely protect this area from open ocean swells.	Mangrove stands are found from the north to northwest of the sites, known as Naivala Island, stretching out 1.5km to seaward. Vitogo Bay is located to the north, and 200 m-wide mangrove zones exist along the coastline. Shallow water with the depth up to 27m stretches out across the tidal mudflat. The Yasawa Island Group to the north, along with a plethora of smaller islands and reef systems, largely protect this area from open ocean swells.	
Land tenure and its use	There is no land tenure information for the mangrove area on the northwest, and the remaining areas are owned by State land.	The site and surrounding area is iTaukei land and mangroves (state land). The southern area is used by the Lovu community for sugar cane production.	The site and surrounding area is iTaukei land and mangroves (state land). A part of the site is an island surrounded by mangroves and community people use the area for plantation.
Scenario evaluation	1	2	2
Note	The site is adjacent to large mangrove forests, and there are many residents and businesses around the site. Land acquisition around the site thus is likely to be limited.	New construction is associated with mangrove forest reclamation. The adjacent community has their culturally important area, and the mangroves may be used for their livelihood. Close consultation with these communities is thus necessary for the development of these areas.	

1：Possible to consider as a development scenario
2：Possible to consider as a development scenario but its environmental and social impacts are likely to be big
3：Environmental and social impacts are likely to be significant
Source: JET

(2) Nadi

Thanks to Nadi International Airport, Denarau Port and various tourist spots and services, Nadi is the tourist capital of Fiji, and its economy is supported by tourism, transportation/logistics, and real estates. Although small in contribution, small tourism businesses, agricultural products, and some informal sectors (such as hand crafts) are also popular.
The main town center, Martintar, and Namaka areas consist of multiple tourisms hotspots, restaurants, and hotels. Denarau island is perhaps the most famous tourist attraction. Sugarcane production became smaller in scale as the town’s economy grew; now, much of the once-agricultural land is being developed for commercial and industrial purposes. The coastal area is also under ongoing tourism development with many new resorts.
Navakai WWTP is located near residential areas with many vacant land and industrial sites. Navakai Road was opened a few years ago with the redevelopment of the area. In total, there are 1,436 households with 7,087 residents residing within the 1 km radius of Navakai WWTP.

The analysis results and scenario evaluation are shown in **Table 6-6.2**.

Table 6-6.2 Analysis Results and Scenario Evaluation in Nadi

<table>
<tr><th rowspan="2">Items</th><th rowspan="2">Scenario a (existing: Navakai WWTP)</th><th colspan="4">Scenario b (new WWTP)</th></tr>
<tr><th>Site #1</th><th>Site #2</th><th>Site #3</th><th>Site #4</th></tr>
<tr><td>Site and adjacent area</td><td>North: FRA depot adjacent to the site. Agricultural fields, residential areas, and buildings scattered around the site

East: Vacant land, and a university 150m east

South: Agricultural fields and residential areas across the road</td><td colspan="2">Site: Agricultural fields. An irrigation canal between Site #1 and Site #2

North: Mangroves and Sabeto River

East: Agricultural fields

South: Agricultural fields and residential houses scattered around the area.A community (Naisoso) 1.2 km south

West:
New resort area (Naisoso Resort) downstream of Sabeto River to the west across 1km-wide mangroves</td><td>Site: Mangroves

North: A creek to Denarau Port, mangroves, new development area of Denarau 650 m northwest

East: Agricultural fields and residential houses scattering around the area, and a community(Sikituru) 1.3 km southeast

South: Nadi River, and a Community (Ralete) across agricultural fields and forests

West: Mangroves</td><td>Site: Mangroves and agricultural fields

North: A community(Ralete) 400m northwest across mangroves

East: Agricultural fields and residential houses scattering around the area

South: Mangroves and agricultural fields

West: Mangroves</td></tr>
<tr><td>Lifestyle and livelihood of neighbors</td><td colspan="5">Nadi is a culturally diverse area with some cultural heritages. However, there is no such sites around the area.</td></tr>
<tr><td>Floods</td><td colspan="5">The area is very vulnerable to meteorological disaster such as floods, cyclones, high tides, and saltwater intrusion.</td></tr>
<tr><td>Biodiversity and geological features of nearby coastal area</td><td colspan="5">The existing plant and candidate sites are not located in the coastal area, so no direct coastal damages affect the areas. On the other hand, there are mangrove stands stretching out 1.8 km towards the coastline, and coastal delta 2.5 km toward sea (where Denarau is located in the middle of this coastal delta).
The intertidal mudflat has depths up to 29 m. These coastal characteristics protect this area from open ocean swells.</td></tr>
<tr><td>Land tenure and its use</td><td>The site is located on State land, the south boundary adjacent to iTaukei land.
State land is used for residential area and light industrial business zone.</td><td>The site is located on State land and Freehold land, occupied by residential areas, sugarcane fields and vacant lots.</td><td>The site is located on iTaukei land and State land, occupied by sugarcane fields and vegetable farms.</td><td>The site is located on State land with mangroves. iTaukei land is adjacent to the southeast.
The site is occupied mainly with mangroves, and the surrounding area is used for plantation, residential area, and sugarcane fields.</td><td>The site is located on State land with Sugarcane fields, and some part of the site is iTaukei land.</td></tr>
<tr><td>Scenario evaluation</td><td>1</td><td>3</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td>Note</td><td>Site expansion to the north and east of the site may be considered.</td><td colspan="2">A resort area is located downstream, at the mouth of Sabeto River.</td><td>New construction is associated with mangrove area reclamation.</td><td>Most of the site sugarcane fields. Only few houses are nearby.</td></tr>
</table>

1：Possible to consider as a development scenario
2：Possible to consider as a development scenario but its environmental and social impacts are likely to be big
3：Environmental and social impacts are likely to be significant
Source: JET

(3) Tavua

Tavua is a small town, which was officially incorporated as a town in 1992. The economy is supported by agriculture, especially by the sugarcane industry like Ba and Rakiraki. The Emperor Gold Mining which was in operation from 1930 to 2006 greatly influenced Tavua's economy, at one period formulating the worker's town of Vatukoula (9 km south from Tavua). The mining industry reopened business in 2008 at a smaller scale.

The analysis results and scenario evaluation are shown in **Table 6-6.3**.

Table 6-6.3 Analysis Results and Scenario Evaluation in Tavua

Items	Scenario b (new WWTP)			
	Site #1	Site #2	Site #3	Site #4
Site and adjacent area	Site: Agricultural fields with a creek (Natolele creek) flowing through in the middle North: Agricultural fields East: Agricultural fields and forests South: Agricultural fields West: Mudflat and mangroves	Site: Mudflat with a creek flowing through in the middle North: Mudflat and mangroves across a rail track East: Mudflat and mangroves, Tavua University located 200 m east South: King's Road across mudflat, and a community 80 m south West: Mudflat and mangroves, Site #3 located 400 m west	Site: Mudflat, agricultural fields and mangroves mixed together North: Mangroves across a rail track East: Mangroves across a rail track South: Agricultural fields, residential houses scattered from 50 m south. King's Road located 250 m south West: Mangroves	Site: Agricultural fields and mangroves mixed together North: Mangroves across a creek East: Mangroves South: Vacant land and agricultural fields. King's Road located 450 m south West: Agricultural land and vacant land across a creek
Lifestyle and livelihood of neighbors	Due to location near Tavua, there may be graves, community's agricultural fields, and culturally/traditionally important areas around the site.	There are no such sites around the sites.		
Floods	Tavua has a hilly terrain, and sometimes floods/flash floods occur after cyclones and heavy rain.			
Biodiversity and geological features of nearby coastal area	The area is located in the intertidal delta, with mangrove stands stretching out 3km seaward. The tidal mudflat has depths up to 16m. Coral reefs located at the northbound offshore protects this area from open ocean swells, and sediments brought by rivers help to nourish the mangroves.			
Land tenure and its use	Most of the area is located on iTaukei land, occupied by grassland and agricultural fields with some woods.	Most of the area is located on State land, and some on iTaukei land. Mangroves and mudflats occupy the site.	The site is located on iTaukei land and State land,. A community (Yasiyasi) is located nearby.	Most of the area is located on iTaukei land, and some on State land (mangroves).
Scenario evaluation	2	1	2	1
Note	The nearby communities may use the site on a daily basis, so close consultation with these communities is necessary for the development of this area.	Large mudflat reclamation is necessary.	The nearby communities may use the site on a daily basis, so close consultation with these communities is necessary for the development of this area.	Construction of an access road is necessary.

1：Possible to consider as a development scenario
2：Possible to consider as a development scenario but its environmental and social impacts are likely to be big
3：Environmental and social impacts are likely to be significant
Source: JET

(4) Rakiraki

Rakiraki was officially incorporated as a town in 2010; its current major industry is agriculture and tourism. Sugarcane fields are seen everywhere from flat area to hilly terrains. Cassava is also a popular agricultural product, and animal husbandry is mostly seen in the highland areas. The sugar industry was running at a mid-scale level until 2016, when the sugar mill of the area was shut down. After the sugar mill closed, the economy of Rakiraki slowed down. Recently the tourism industry is becoming increasingly active, especially in Volivoli. In addition, Fiji Water owns a factory in this area, providing employment opportunities to local people.

The analysis results and scenario evaluation are shown in **Table 6-6.4**.

Table 6-6.4 Analysis Results and Scenario Evaluation in Rakiraki

Items	**Scenario b (new)**			
	Site A	**Site B**	**Site C**	**Site D**
Site and adjacent area	Site: Municipal waste dumping site. Occasionally fire and smoke is from the waste heaps North: Mangroves East: Vacant land and mudflat South: Site B across King's Road, agricultural fields (sugarcane fields), and some residential houses West: Residential houses, a primary school 150m west	Site: agricultural fields (sugarcane fields), and some residential houses North: Site A across King's Road East: Agricultural fields and houses West: Agricultural fields and houses, a primary school 150m west South: Agricultural fields and houses	Site: Vacant land surrounded by hilly northern and western sides with a rail track on the western boundary North: Hilly agricultural fields and a residential house East: Site D across a creek West: Agricultural fields (sugarcane fields) and some residential houses South: Agricultural fields and vacant land	Site: Agricultural fields (sugarcane fields) and vacant land with an irrigation canal flowing through the middle of the site west to east of the site North: Mangroves and Penang river across an unpaved road East: Mangroves across an unpaved road and an irrigation canal Candidate C across the stream West: Site C across a creek South: Vacant land
Lifestyle and livelihood of neighbors	2 communities (Navuavua and Navutulevu) located 1.2km southeast might have graves, community's agricultural fields, and culturally and traditionally important area around the site.		Rakiraki has historically important heritages. However, there is no such sites around the area.	
Floods	Although Rakiraki has plenty of hilly areas, the lowland, especially near Penang River that is flowing the western side of the central Rakiraki sometimes floods. Flash flooding after cyclones and heavy rain happen too.			
Biodiversity and geological features of nearby coastal area	There are mangroves with the maximum width of 700m toward sea, and a small island (Ndevoilau Island). The tidal mudflat gradually becomes deep seaward up to 22m. Coral reefs located at the northern offshore protect this area from open ocean swells, and sediments brought by Penang River and other creeks help to nourish the mangroves.			
Land tenure and its use	Mangroves occupy the coastlines but the site itself is used as a waste dumping site with no zoning.	The site is located at State land and used as sugarcane fields by a community (Naira).	Vacant land, located in State land. The hilly Northern side and western side of the site is Freehold land.	The site is flat and located in State Land, used as agricultural fields and vacant land.
Scenario evaluation	3	2	2	1
Note	The site is used as a waste dumping site, and the town council will need to find an alternative waste dumping site if the site is used for the facility development.	Close consultation with the communities is necessary for the development of these areas due to the proximity to residential area.	Close consultation with the communities is necessary for the development of these areas due to the proximity to residential area.	The site is for sugarcane production.

1 : Possible to consider as a development scenario
2 : Possible to consider as a development scenario but its environmental and social impacts are likely to be big
3 : Environmental and social impacts are likely to be significant
Source: JET

(5) Ba

Ba is currently experiencing growth, consists of 5 wards (Varoka, Varadoli, Rarawai, Yalalevu, and Namosau) with communities, villages, and settlements scattered across its region. Votua WWTP is located in a mangrove area. Its 1 km radius is mostly covered by mangroves and sugarcane fields, but 3 communities (125 households and 531 residents) are also located within this zone

The analysis results and scenario evaluation are shown in **Table 6-6.5**.

Table 6-6.5 Analysis Results and Scenario Evaluation in Ba

Items	Scenario b (existing: Votua WWTP)
Site and adjacent area	North: Mangroves spreading 5km seaward East: Mangrove stands and a creek flowing into Tave Creek South: Small mudflat (approx. 100m) and agricultural fields (sugarcane) across mudflat and mangroves. Residential houses scattered 500m and further southwest West: Small mangrove lot (approx. 300m) and agricultural fields (sugarcane) Residential houses scattered 700 m and further west
Lifestyle and livelihood of neighbors	There are no such areas around the site.
Floods	Ba River (located 1 km from the site) occasionally overflows, causing floods.
Biodiversity and geological features of nearby coastal area	Mangrove lot located 5 km north of Votua WWTP, with maximum width of 13.5 km. The tidal mudflat gradually becomes deeper (max. 22 m). Coral reefs located offshore to the north protect this area from open ocean swells. Sediments brought by Ba River and other creeks help nourish the mangroves.
Land tenure and its use	Mangrove area has not been surveyed, not categorized in any zones. Some of the site is iTaukei land; agricultural fields to the west and south is State land.
Scenario evaluation	2
Note	Although Votua is an existing facility, land acquisition is expected to be difficult due to the surrounding mangroves.

1：Possible to consider as a development scenario
2：Possible to consider as a development scenario but its environmental and social impacts are likely to be big
3：Environmental and social impacts are likely to be significant

(6) Sigatoka

Sigatoka river runs between Olosara WWTP and Sigatoka's central area. The neighboring residents use Sigatoka River for transportation and livelihood, such as fishing and shellfish collecting. Sigatoka Valley agriculturally thrives with fruits and vegetable for local consumption and oversea exports. Sugarcane is also an important crop but its production is gradually lessening, mainly due to farmers switching to other cash crops, as well as land lease contracts ending its term.

Some industrial zones also exist in Sigatoka's surroundings. Along with tourist hotels and restaurants, they provide employment opportunities to local people.

The analysis results and scenario evaluation are shown in **Table 6-6.6**.

Table 6-6.6 Analysis Results and Scenario Evaluation in Sigatoka

Items	Scenario b (existing: Olosara)
Site and adjacent area	North: Riverbank, agricultural fields East: Agricultural fields and some residential houses (the closest located 150 m northeast) South: Riverbank, agricultural fields West: Riverbank, Sigatoka River
Lifestyle and livelihood of neighbors	Sigatoka Sand Dune, designated as a protected area in 1989, is located on the opposite side of Sigatoka River. The Dune is known as a popular tourist destination, but also is a culturally/traditionally important area for local people. Sigatoka River is also a sacred site for local people. Some of the river area is restricted, while the eastern bank is used as a recreational spot for swimming and picnics, enjoyed by local people.
Floods	Sigatoka often experiences floods, and the most serious event was in 2009. Olosara WWTP is located very close to Sigatoka River, so the area may flood in the event of heavy rain and/or high tides.
Biodiversity and geological features of nearby coastal area	The WWTP is located at the river mouth, with a sand bar at the western side of the mouth and coral reefs offshore 320 m to the east. From there, the shallow water suddenly plummets as deep as 200 m. The sand bar and coral reefs protect this area from open ocean swells.
Land tenure and its use	A part of Olosara WWTP is located in iTaukei land, but the rest lies on unsurveyed land. The neighboring area, is State land used as agricultural fields, further surrounded by iTaukei land. There are some mangroves on the coastline and riverside. According to Sigatoka Town Council, the land around the WWTP has already been owned by a local private company; private developers are allowed to develop land surrounding the WWTP and its access road
Scenario evaluation	2
Note	Residential houses are in close proximity to the WWTP, and ownership of the surrounding land has been claimed by private developers. Close consultation with these communities and the local government is necessary for the expansion of the WWTP.

1：Possible to consider as a development scenario
2：Possible to consider as a development scenario but its environmental and social impacts are likely to be big
3：Environmental and social impacts are likely to be significant

6-7 Stakeholder Meetings

6-7-1 Stakeholder Identification

Stakeholder involvement and communication at the M/P development stage is essential for proper information sharing and smooth consultation at the subsequent project planning and implementation stage. Taking into account that this M/P will provide a general direction for sewerage services of the entire Western Division, the following key stakeholders (including relevant ministries and agencies, local governments in the western division, service providers) were identified. As further project details are materialized with the formulation of following M/P and Pre-F/S, local stakeholders such as communities will be involved in information sharing and consultation.

Table 6-7.1 Key Stakeholders at the M/P Stage

Category	Stakeholder
Ministries & government agencies	Department of Water and Sewerage (DWS), Ministry of Infrastructure and Meteorology (MIMS*1)
	Ministry of Economy (MOE*2)
	Department of Environment (DOE), Ministry of Waterways and Environment
	Department of Waterways (DOW), Ministry of Waterways and Environment
	Department of Lands (DOL), Ministry of Lands and Mineral Resources
	Department of Town and Country Planning (DTCP), Ministry of Local Government
	Central Board of Health (CBH), Ministry of Health and Medical Service
	Ministry of Forestry (MOF)
	Ministry of Housing and Community
	Ministry of Fisheries
	Ministry of Tourism
	Ministry of Agriculture (MOA)
	iTaukei Land Trust Board (TLTB)
	Investment Fiji
Organizations in the Western division	Commissioner Western Office
	Provincial Councils
	Sigatoka Town Council
	Nadi Town Council
	Lautoka City Council
	Ba Town Council
	Tavua/Rakiraki Town Council
Service providers	Fiji Roads Authority (FRA)
	Energy Fiji Limited (EFL)
	Telecom Fiji Limited
	Fiji Sugar Corporation
	National Fire Authority
	Housing Authority of Fiji
Donors and NGOs	Asian Development Bank (ADB)
	Models Towns Charitable Trust（MTCT）

*1: MIMS: before organizational restructuring; current MPW
*2: MOE: before organizational restructuring; current MOF
Source: JET

6-7-2 Stakeholder Meetings

To obtain opinions for this M/P, stakeholder meetings (workshops) were held at the scoping stage and the draft M/P stage. Comments from the participants were discussed among WAF and JET, and incorporated into corresponding stages of the M/Ps and individual development projects.

[Scoping stage]

Since the workshops were scheduled shortly after COVID-19 related restrictions were lifted in Fiji, two sessions were planned to minimize the number of participants; each session invited participants from three municipalities of the Western Division. Comments from the participants include appreciations of the M/P development because there was no opportunity before to exchange opinions on wastewater treatment/sewerage services among stakeholders. In addition, information on local and frequently-occuring problems/issues were shared.

The 1st stakeholder meeting (for Nadi, Lautoka, Sigatoka)	
Date: April 12, 2022 Venue: Conference Room, Tokatoka Resort, Nadi Participants: 45	
Major comments and questions from the participants	• Request to extend the existing network and capacity as most of the treatment plants around Fiji are primarily located in town boundaries and cities, and a need to expand the treatment system network to the outskirts as well as the surrounding communities living near the treatment plant including the hospital. A pump station situated near Suria building has been generating a lot of problems for the local community creating blockage and backflow without any control, so the sewerage is discharged directly into the creek, resulting in numerous complaints from residents, ratepayers and business owner. Inundation of soakage pit due to its location resulting in waste leakage into drains then into the river. (Sigatoka Town Council) • Inquiry on the extension of the wastewater treatment master plan network – TLTB enquired on how far inland WAF plans to extend the network to so that they can investigate the land tenure situation. The project team requested TLTB to identify and learn about the various trends and growing areas in the iTaukei land. (TLTB) • DTCP has been waiting for a long time to find out what WAF plans do with the sewerage reticulation. The Town Planning Act has general provisions which restricts developments without sewer or with sewer, and at the moment WAF sewerage system is treated as 100% development ratio, if the lot is sewered, they can develop to 100%. There are 2 reasons for the need to do sewerage reticulation and that is to protect the environment and to maximize the potential for development. Stakeholders should look into those 2 areas, protecting the environment and maximizing the potential for development. We all want the town to grow but the sewerage system restrict development in town area and if it’s not up to full capacity then maximum development potential cannot be reached. (DTCP) • The wastewater treatment plant is located near an agricultural subdivision and the plant is directly adjacent to the riverbed and the dredging spoil disposal site. Silts and gravel run down to the river during a severe weather event. Communities have raised their concerns to the DOL about the treatment plant's location, and DOL is requesting stakeholders to investigate whether the treatment plant site is safe for people's lives and the surrounding environment. (DOL) • DOW requests WAF to build their pipelines away from their drainage and creek reserves when building the new treatment plant as well as connecting communities to the new sewer network in future. They’ve had WAF pipelines running extremely close to their drains and creeks which makes their job difficult. (DOW) • LCC would like to understand as to how this masterplan will re-examine approaches to address these issues since Fiji ratified in the Oceans Conference that we will keep our

	waterways clean; it does not paint a positive picture and is not helpful for future generations if our sewerage is pouring into the creeks and ending up in the sea. Now that there is over-development, stakeholders must determine whether those sizes pipes can accommodate the over-development as it highly requires replacement. Squatter or informal communities exist on the outskirts of Sigatoka, Lautoka, and Nadi, and the concern is how WAF would cater all of these places. Factories have been found discharging their waste into the main WAF line. With the masterplan in place, WAF should collaborate closely with the Department of Environment to ensure that they are responsible for their own waste. There are some picnic spots located near the wastewater treatment plant; the concern is the impact it has to the public who utilize the area. This is why monitoring is very critical so that information can be made available to the public upon request or to any complainants. (Lautoka City Council) • The majority of the difficulties faced by Investment Fiji and Investors is with infrastructure on the ground. Investment Fiji request WAF to look into upgrading the existing pipeline and channels on where major resort and hotel developments are in the western division. Majority of the investors have already purchased their land and had prepared a plan to build but the only thing standing in their way is a sewer connection. Investment Fiji is also requesting that the M/P report to propose whether upgrading current infrastructure will take 5 to 10 years or 10 to 15 years, so that Investment Fiji can advise the investors accordingly. (Investment Fiji) • Most of Fiji's infrastructure is naturally aging and they would like to see some form of monitoring and maintenance which will allow them to look into how much WAF will require as short term to long term financing in their current masterplan. With regards to informal settlements, one of the main issues is that most of the stakeholders are working in isolation. There is a formal assessment of informal settlements with Ministry of Housing. (MOE*) • Ministry of Forestry are working together with WAF with regards to planting of seedlings around their water catchment for the purpose of maintaining quality of water. (MoF)

*: MOE: before organizational restructuring; current MOF

<table>
<tr><th colspan="2">The 2nd stakeholder meeting (for Ba, Tavua, and Rakiraki)</th></tr>
<tr><td colspan="2">Date: April 13, 2022 Venue: Conference Room, Tavua Hotel, Tavua Participants: 30</td></tr>
<tr><td>Major comments and questions from the participants</td><td>

Ba has enlarged its municipal boundary and population is expanding too. Government has now recognized that people are building informal settlements on the outskirts of town, which is where the sewerage issue arises. Tavua is so little in comparison to Ba, so DTCP does not anticipate any big problems with reticulating the town. The government is aware that Tavua town has been denied the opportunity to develop to its full potential. In order to continue with the development of the septic tank's operation, they must mitigate the sewer issue by bailing out the septic tank every month. Rakiraki has the same problems as Tavua. (DTCP)
Constructing a septic tank is the main challenge for most commercial premises as it is built inside the walls of the building rather than outside in the lawn area. The primary problem that the town council is facing is finding enough space outside the structure to construct a septic tank. The councils have been receiving numerous complaints from Tavua Levu village located in the town area as they receive majority of the wastewater discharged from the town. During heavy rain or flood, discharged waste from business houses overflows into the village as there is an open drain from town leading to Tavua Levu village. For housing authority subdivision in Tavua, they should have a shared septic tank. (Tavua/Rakiraki Town Council)
If the plants require considerably more capacity, EFL will upgrade the system to accommodate the plant's power requirements. (EFL)
TLTB requested the preliminary engineering assessment as one of the most important stages in ensuring that the development is accomplished effectively. Once the site is determined together on where the network will be laid, they will engage with the landowners through Ba Provincial Council for consent. (TLTB)
The Nadarivatu forest reserve is the only major reserve in the Western Division. (MoF)
The difficulties encountered include wastewater discharge into their major drains, which eventually go to rivers and creeks. MOW do accept discharge into their drain at some point since WAF have no other choice. They're requesting that once the wastewater reticulation system is in place, discharge into the main drain be stopped. (MOW)
Stakeholders requested that they should be on the same page regarding the proposed WAF masterplan because most of the stakeholders have no idea what WAF is going to do and how they are going to do the sewer connections. DOL's concerns are with big foreshore developments or existing companies in the region, particularly in Volivoli, which was formerly agricultural but is rapidly becoming a tourism hotspot, implying an increase in population. DOL have their Vanua GIS website, which is a centralized data center in Fiji that allows multiple levels of government to access information such as transportation networks, and utilities. Those who are interested should contact the Lands GIS department for access to this data. There is no sewer line in residential or commercial properties. If they need to get to it, they'll have to knock down fences and WAF will be responsible for the costs, and if there's a sewer, digging is required, the lot owner is responsible for the cost of the easement over the sewer reserve. (DOL)
There are no existing contractors in Tavua and Rakiraki who bail out septic tanks and although they travel all the way from Lautoka. The town council answered had no knowledge of where they dispose the bailed waste too. The state lands are dealing with a large number of informal settlements along the coastal area with improper waste disposal, such as in Tavarau and Vatia. (Tavua/Rakiraki Town Councils)
They’re concerned about the Ba treatment plant. There is a need for the current pond system to be upgraded, whether to increase the number of ponds, etc. so that it won’t affect the sugar cane farmers. In case it overflows, it might be that it overflows into the next pond and goes through the various pond systems before it goes to the outfall. MOA rarely hands out agricultural land for infrastructural or industrial development unless there is a pressing necessity, particularly if the farm area is close to the municipal boundary. WAF has an MOU with agriculture for testing the quality of WAF sludge. Before they can promote the availability of the sludge as fertilizer, they'll have to go back to the Department of Environment for final permission. WAF will also investigate the stigma associated with the usage of sludge for agricultural purposes. In terms of the master plan, WAF must consider

</td></tr>
</table>

	not only the supply in terms of quantity, but also the quality that they can accept for use as fertilizer. (MOA) • (In response to DTCP's question on recycling of treated wastewater,) Recycling is an option by WAF they would need to look into costing in order to treat sewerage to a high quality for recycling and sludge usage in agriculture. WAF will take notice of the suggestion, and the Ministry of Economy should be able to help with the operational costs, particularly the purchase of chemicals required for the recycling option, which is extremely pricey. (WAF)

[Draft M/P stage]

The workshop was held for Fijian stakeholders, donors, and related organizations who are interested in wastewater treatment, to explain the progress of JICA project, and to publicize the draft M/P. Some participants joined the meeting virtually online.

WAF and JET gave a presentation on the framework of the M/P and its future projections, selection of priority city/towns for the Municipal Sewerage M/P to be formulated in the following project phase, as well as development-related environmental/social considerations.

The participants did not show any counterviews to the M/P, but expressed various comments on future facility construction and expansion. An additional 10-day comment period was set after the workshop; DTCP provided information on their ongoing development plan preparation, and the Housing Authority of Fiji provided housing development plans.

Stakeholder meeting (workshop)	
Date: July 7, 2022	Venue: Conference Room, Tanoak Waterfront Lautoka Participants: 61
Major comments from the participants	• A representative of HA asked if the M/P is working towards potential developments such as in 20 years' time or if it is forecasted according to the M/Ps within the DTCP (JET responded, stating that the WAF drafted the wastewater M/P for the Western Division, taking into account other development plans including DTCP). Housing Authority's future plans are based on DTCP, so all M/Ps should be in line with their DTCP's. (Housing Authority of Fiji) • DTCP is currently preparing a 50-year master plan (2032-2072) for two major growth areas in Fiji, namely 1) the Suva-Nausori Corridor and the Nadi-Lautoka Corridor. This DTCP's M/P is expected to look at multiple perspectives of urban growth such as roads, infrastructure, urban expansion and everything related to urbanization. This will be finalized by the end of the year. People may be surprised to see what is in the DTCP's M/P as there will be drastic changes that will affect what is being planned here now by WAF. DTCP confirmed that they will connect JET to share information and progress to-date and recommends that WAF takes this information on board with regards to the wastewater M/P for the Western Division. (DTCP) • It is understood that there is a lack of scientific and engineering approaches. Currently, residents from Kinoya in Suva are faced with the smells and odors everyday which can become unbearable. A similar situation is happening in Natabua, Lautoka. It would be wise to adopt successful models from other countries (JET responded that one option is to implement mechanical treatment, but this is subject to higher costs, so resource allocation, technical operational/maintenance issues, natural wind direction patterns etc. are taken into account along with the sewerage plant design). He added that sustainable treatment plants are taken into account along with nearby residential areas and economic priority aspects. (CBH) • It was relieving to finally see some plans for the northern side of Lautoka City. Koroipita Project that MTCT implements already have the first model comprising of 263 social housing units with another 105 more units being developed over the next 4-year period. One of the challenges MTCT faced in the early stages of the project was that there was no sewerage system, so MTCT had to put in their own wastewater treatment system. The Naikabula area has gone through rapid industrial and residential development, and MTCT has seen a number of paper subdivisions, who do not follow environmental regulations. MTCT questions JET on the implications of these paper subdivisions. In addition, MTCT queried on the

	regional WWTP plans as to what type of system is being looked at. (JET replied that for informal settlements, DTCP and DOL together with TLTB have some controls in place but for the landowners, it is about making them understand the benefits of strategic planning so that the surrounding areas are not impacted, and in terms of recycling and use of grey and black water, JET will take to the engineering team in terms of looking at recycling options and how that impacts the adjacent physical and human environment. (MTCT) • One of the main complaints that they received daily were complains of black and grey water disposal from the public, and Health Office looked forward to the time this M/P would be implemented. Especially they look after the peri-urban areas. These issues do derive from septic tanks but also in terms of the existing sewer reticulation network where leakages, overflows and discharges of wastewater into nearby drains and streams is a concern. There are many houses in close proximity to one another and during rainy weather, overflows do occur with septic tanks. This leads to complaint made at their office which they have to attend to immediately in order to avoid outbreak of diseases. (Nadroga Health Office) • ADB noted that during the SEA report in the presentation, several of the proposed sites were listed as being flood prone, and she queried on the frequency of floods that occur on the sites. Furthermore, she asked whether the two Nadi sites were considering the proposed Nadi flood alleviation project impacts (JET replied that each site differs in terms of flooding, and there has not been any specific flood study for each site thus far, but JET and WAF would definitely look the proposed Nadi flooding alleviation reports). (ADB) • Sigatoka Town Council was unsure whether the current treatment plant will be able to cater for these services. The surrounding and close by land have all been taken up by big industries in Sigatoka. For example, along the road leading up to the Olosara plant, lands have already been bought by investors for commercial developments. If WAF wants to expand the existing site, where will they put it if developments are already earmarked for those sites? With regards to foul odor, he asked how these issues would be mitigated. In addition, there are many development approval requests being submitted to the Sigatoka Town Council for the areas along the coral coast. From Maui Bay to Sigatoka Town, with major tourism developments taking place. It is important for them to know the location of the selected facilities (JET replied we need to consider development of land surrounding the existing WWTP, as there has not been the identified of an additional or new sites required for the treatment plant in Sigatoka, and the sensitive environment around the existing plant needs to be taken on board as well being close to the river's edge and at the mouth of the river where sensitive coastal and marina environments are located including mangrove areas). In addition, the Sigatoka Town Council added that the existing capacity of WAF should be assessed, in terms of resources such as staffing, plant and machinery equipment as well as the financial aspects. He mentioned that he understands WAF has had issues regarding getting a hold of compressors and other equipment. He also mentioned that WAF take into account diseases such as leptospirosis and implement de-ratting programs to combat. (Sigatoka Town Council) • If one was to take a look at their complaints register the illegal disposal of wastewater would be on the top of the list. Most of the complaints they receive are from formal communities, and prioritization needs to be focused on the informal settlements as residents in the towns and cities are already connected to sewerage services. It is hoped that all the communities within the entire corridor from Sigatoka to Rakiraki would be included in this M/P (JET replied that currently JET&WAF are aiming to achieve a 70% population coverage and service rate, with other communities being added in the future). The project must be ready to answer questions from the communities regarding costs. i.e., when carrying out social surveys as most of them already pay rates (JET replied that the exact costs however will need to be worked out, taking into account how much would be subsidized and what portion would be paid by the user, but the issues

	raised would be taken on board by the project team). (Lautoka Health Office) • Ministry of Housing and Community Development is formalizing informal settlements. She notes that the proposed sites are within close proximity to a number of informal settlements and whether any consideration would be taken into account (JET replied that the informal settlements would definitely be included in the project, but the way they would be connected will need to be looked into). Most of the proposed sites are located along or within boundaries of waterways. And most of the communities in the Western Division rely on waterways for recreational purposes, drinking as well as food sources. MoH asked if these aspects are considered when identifying the potential sites (JET replied that it comes with other issues or criteria such as the type of wastewater treatment that would take place and what quality would go into the receiving environment, and this is something that the engineers would take into account very carefully whilst weighing out the best options). MH also asked if there are any monitoring systems in place for the sites that would be selected and who would be doing such monitoring (JET answered that WAF conducts regular monitoring of their existing WWTP facilities, and DoE is now preparing a Mangrove Management Regulation which would actually have an impact on most of WAFs existing treatment plants sites. In addition, WAF added that WAF has been working closely with the Ministry of Housing and Community Development on the proposed sites, and WAF had welcomed connections to the system if the site is close enough to the reticulation while for other communities and settlements which are quite a distance to the grid systems, WAF has recommended localized treatment options to the Ministry, such as shared or communal septic tanks etc.). (CBH) • DOE will oversee the environmental impact assessment process of the project whenever that is applied for. Social impact assessments are a vital part of the EIA which will allow communities to be consulted and their views to be heard with regards to the project. In terms of the discharged treated wastewater, DoE has a national standard for all the liquid waste that is discharged, and these standards are listed under the Environmental Management Regulations. (DOE) • The extensions of the treatment plants are within the mangrove areas. DOL mentioned that most of the participants by now are aware of the mangrove management regulations developed by the DOE. They could look at possible offsets under carbon impacts from removing mangroves which would happen in cases of extensions or developing new sites. (Foreshore Unit, DOL) • FRA queried on the cost analysis as most of the reticulation would be on the road reserves. The cost analysis needs to include the re-instatement of the roads and to ensure that they do not fall under the carriageway. Whenever a sewer line leaks or breaks it causes more issues such as traffic disruptions and damages to roads? He asked if all these aspects could be taken into consideration. (FRA) • MoF was not sure how the wastewater would be discharged into the ocean after being treated, but from the Ministry of Fisheries their concern was that it should be fully treated before being released so it does not impact the marine eco-system (JET replied that in terms of the potential sites that were selected, these locations were picked by the engineering team based on the 4 criteria mentioned earlier in the presentation. However, the criteria are not set in concrete, and it will likely be expanded upon). (MoF) • Housing Authority of Fiji queried about the concept of recycling water and whether it is too expensive to consider (JET mentioned that there is a need for the expansion of treatment from now 20% coverage to 70% coverage, which means that they would need to invest into huge expansions, and result in extremely high cost especially for recycling methods as well. WAF added that at this stage, it is a very expensive undertaking, and it would be finalized into their next phase when they move into the compilation for the Municipal Sewerge M/P (Housing Authority of Fiji).

CHAPTER 7 Economic and Financial Analysis

7-1 Purpose of Economic and Financial Analysis

The purpose of financial analysis is to evaluate the feasibility of implementing a project from the perspective of financial viability for the project proponent. On the other hand, the purpose of economic analysis is to verify the validity of project implementation from the viewpoint of national economy.

In the analysis, With or Without Project Cases regarding the Master Plan are set as follows.

- With Project Case
  Implement the Master Plan. Wastewater treatment capacity in Western Fiji will be increased. Carry out the development and expansion of the wastewater treatment system in line with National Development Plan (2017-2036).

- Without Project Case
  Do not implement the Master Plan. The Western Division's wastewater treatment capacity remains at current levels. Installation and expansion of wastewater treatment system of National Development Plan will not be implemented.

By comparing the above With and Without cases, the relevance of project implementation from the economic and financial perspective of the Master Plan is examined.

7-2 Financial Analysis

7-2-1 Indicator for Financial Analysis

The financial evaluation of the Master Plan is conducted by calculating the incremental income and expenditure and analyzing the following indicator.

Financial Internal Rate of Return (FIRR)

The financial internal rate of return is the discount rate that becomes zero when the cumulative difference between income and expenditure in the analysis period is converted to the present value.

7-2-2 Preconditions for Financial Analysis

(1) Period of Analysis

From year 2028 to year 2053, for 25years

(2) Average Amount of Wastewater Treated, Construction Period of Treatment plant, Pumping Stations and Preparation Period for Connection

Table 7-2.1 shows the average treated wastewater volume and construction period of each wastewater treatment plant. The amount of processing during the connection preparation period shall be proportional to the connection rate.

Table 7-2.1 Construction Period of Sewerage Facilities and Preparation Period for Connection

Municipality	WWTP	Average Treated Water (m^3/day)	Construction Period (year)	Connection Preparation Period (year)
Nadi	Navakai	32,000	2033-2037	2038-2040
Lautoka	Natabua	31,000	2028-2032	2033-2035
Ba	Votua	9,000	2038-2042	2043-2045
Tavua	—	4,000	2043-2046	2047-2049
Rakiraki	—	3,000	2043-2046	2047-2049
Sigatoka	Olosara	6,000	2047-2050	2050-2052

Source：JET

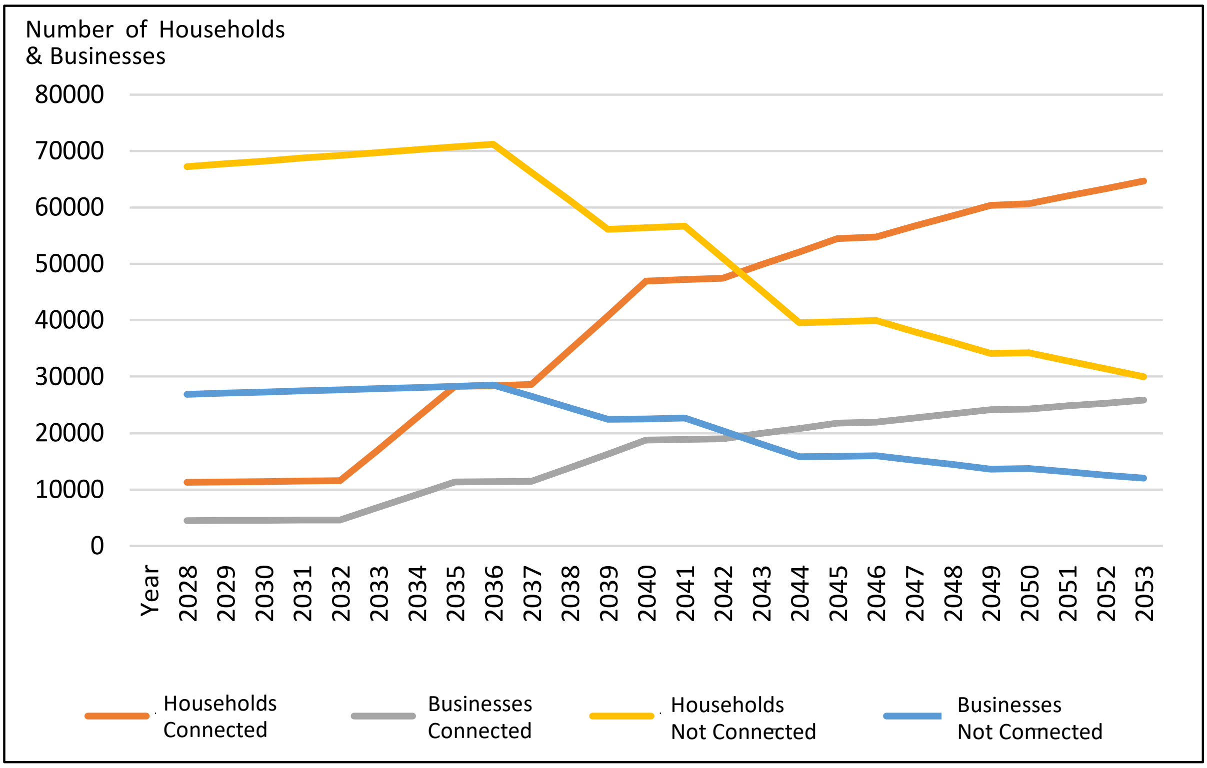
(3) Connections of Households and Business, and Non-Connections

Table 7-2.2 below shows the number of connected and non-connected domestic household and business customers during the analysis period, and **Figure 7-2.1** shows the transition of connections.

Table 7-2.2 Connections of Households and Business, and Non-Connections

Year	Households Connected	Businesses Connected	Households Not Connected	Business Not Connected
2028	11,267	4,507	67,240	26,896
2029	11,356	4,542	67,733	27,093
2030	11,422	4,569	68,222	27,289
2031	11,511	4,604	68,733	27,493
2032	11,600	4,640	69,222	27,689
2033	17,111	6,844	69,711	27,884
2034	22,689	9,076	70,222	28,089
2035	28,333	11,333	70,711	28,284
2036	28,467	11,387	71,200	28,480
2037	28,622	11,449	66,267	26,507
2038	34,689	13,876	61,267	24,507
2039	40,800	16,320	56,111	22,444
2040	47,000	18,800	56,400	22,560
2041	47,222	18,889	56,667	22,667
2042	47,444	18,978	51,022	20,409
2043	49,800	19,920	45,333	18,133
2044	52,156	20,862	39,556	15,822
2045	54,533	21,813	39,756	15,902
2046	54,800	21,920	39,956	15,982
2047	56,644	22,658	38,022	15,209
2048	58,489	23,396	36,089	14,436
2049	60,378	24,151	34,133	13,653
2050	60,711	24,284	34,289	13,716
2051	62,022	24,809	32,867	13,147
2052	63,333	25,333	31,444	12,578
2053	64,667	25,867	29,978	11,991

Source：JET



Source : JET

Figure 7-2.1 Connections of Households, Business Entity, and Non-Connections

(4) Capital Expenditure (CAPEX)

Table 7-2.3 shows CAPEX of wastewater treatment plant (WWTP), and **Table 7-2.4** shows CAPEX of pipes and pump stations ("Sewer Network") as incremental expenditures to be measured in the financial analysis. CAPEX in the master plan does not include price fluctuations, interest during construction, consulting fees and taxes.

Table 7-2.3 CAPEX: WWTP

Municipality	WWTP	Expenditure (1000 FJD)
Nadi	Navakai	303,020
Lautoka	Natabua	293,943
Ba	Votua	104,284
Tavua	—	46,855
Rakiraki	—	34,988
Sigatoka	Olosara	70,147
Total		853,237

Source：JET

Table 7-2.4 CAPEX: Sewer Network

Municipality	Expenditure (1000 FJD)
Nadi	1,471,505
Lautoka	885,624
Ba	499,253
Tavua	123,117
Rakiraki	94,698
Sigatoka	200,041
Total	3,274,239

Source：JET

A portion of each WWTP in the total CAPEX-WWTPs are as follows.

- Construction period 5-year WWTPs (Nadi, Lautoka, Ba): 1st year 4%, 2nd year 15%, 3rd year 34%, 4th year 36%, 5th year 11%
- Construction period 4-year WWTPs (Tavua, Rakiraki, Sigatoka): 1st year 5%, 2nd year 26%, 3rd year 49%, 4th year 20%

A portion of each Pipes in the total CAPEX-Sewer Network are as follows.

- Construction period 5-year Pipes, Pumping Stations (Nadi, Lautoka, Ba): 1st year 20%, 2nd year 20%, 3rd year 20%, 4th year 20%, 5th year 20%
- Construction period 4-year Pipes, Pumping Stations (Tabua, Rakiraki, Sigatoka): 1st year 25%, 2nd year 25%, 3rd year 25%, 4th year 25%

(5) Preparation period for connection

The connection rate at the end of each year is as follows, with a preparation period of three years after the completion of the construction of the WWTPs and sewer networks.

- Connection rate：1st year 33%、2nd year 66%、3rd year 100%

(6) O&M Expenses

O&M expenses[16] at each WWTP is shown in the **Table 7-2.5**, at WWTP Pipe is shown in the **Table 7-2.6**. O&M during the connection preparation period is proportional to the connection rate. Incremental expense of O&M shall be calculated by deducting 1000 FJD/year [17] from total O&M as the existing expense without project in the financial analysis.

Table 7-2.5 WWTP O&M Expenditure

Municipality	WWTP	O&M（1000 FJD/year)
Nadi	Navakai	3,539
Lautoka	Natabua	3,462
Ba	Votua	1,744
Tavua	—	1,089
Rakiraki	—	922
Sigatoka	Olosara	1,378

Source：JET

Table 7-2.6 Sewer Network O&M Expenditure

Municipality	O&M（1000 FJD/year)
Nadi	5,874
Lautoka	3,535
Ba	1,508
Tavua	435
Rakiraki	335
Sigatoka	604

Source：JET

(7) Salvage Value

The salvage value of capital goods that can be used continuously in the final year and beyond, or that can be diverted to other uses, is recorded as a negative expense in the final year. The value is calculated by the following formula by applying the straight-line method (assuming scrap value = 10% of the initial

[16]Refer to the cost function in Japan and the prefectural wastewater concept formulation manual.
[17] Refer to WAF inhouse financial data report in 2019.

investment).

- Salvage Value＝ CAPEX of asset facility/equipment x (1.0-0.9 x years of use ÷ Depreciation period (years) based on statutory useful life)

In this formula；

Useful life : 50 years for civil engineering facilities and pipes, 15 years for mechanical and electrical equipment

Applying the CAPEX and service life of WWTP facility, pipes, and equipment in **Table 7-2.7**, the calculated residual value is recorded as a negative expense in 2053, the final year of analysis.

Table 7-2.7 Salvage Value

Municipality	Items	Invested Amount (FJD 1000)	Period in Use (Year)	Salvage Value (1000 FJD)
Lautoka	C/A (WWTP, pipe & pump)	1,013,775	20	648,816
	M/E	165,792	15	16,579
	Total	1,179,567		**665,395**
Nadi	C/A (WWTP, pipe & pump)	1,604,593	15	1,171,353
	M/E	169,932	15	16,993
	Total	1,774,525		**1,188,346**
Ba	C/A (WWTP, pipe & pump)	542,973	10	445,238
	M/E	60,564	10	24,226
	Total	603,537		**469,463**
Rakiraki	C/A (WWTP, pipe & pump)	109,720	6	97,870
	M/E	19,967	6	12,779
	Total	129,687		**110,649**
Tavua	C/A (WWTP, pipe & pump)	143,254	6	127,783
	M/E	26,717	6	17,099
	Total	169,971		**144,882**
Sigatoka	C/A (WWTP, pipe & pump)	229,816	2	221,543
	M/E	40,372	2	35,527
	Total	270,188		**257,070**

Source：JET　* C/A＝Civil/Architecture、M/E=Mechanical/Electrical equipment

(8) Wastewater Income

Incremental wastewater treatment volume is calculated as income. The annual increment is calculated using the following formula. The amount of processing during the connection preparation period is proportional to the connection rate.

- Annual income from wastewater treatment = (Average treated volume of wastewater per day x 365 – treated volume without project x 365) x Tariff (FJD/m^3)

In this formula；

Average volume of treated water：Total treated volume of wastewater by each WWTP

Treated volume without project：20,000 m^3/day

Tariff：The current tariff 0.20 FJD/m^3

(9) Income from New Connection Charge

Income from new connection is calculated by the following formula.

- Income from New Connection Charge = Increment of new connection x Application fee

In this formula;
Application Fee：Household 22 FJD、Business customer 101 FJD

(10) Income related to Sludge Acceptance

Income related to sludge accepted from unconnected households and businesses is calculated using the following formula.

- Income related to sludge accepted = Number of sludge acceptance per year x Fee for Sludge acceptance

In this formula;
Fee for Sludge acceptance[18]：Household 12 FJD (every 5 years), Business Customer 12 FJD (every year)

7-2-3 Result of Financial Analysis

The results of the financial analysis based on the expenditure and income calculated under the above assumptions are described below. The cash flow table used for this calculation is shown in **APPENDIX 7-1**.

(1) FIRR

FIRR = - 2.1%
FIRR shows a negative return of 2.1%. Sensitivity analysis for change of expenditure/income is not performed because FIRR in the base scenario is a minus figure.

(2) Financial Viability

The FIRR result is well below the 6% yield on Fiji government bonds in recent years. The implementation of the M/P is not viable from a financial perspective based on market interest rates. Consideration should be given to borrowing low-interest, preferential loans from international aid agencies to implement the project.

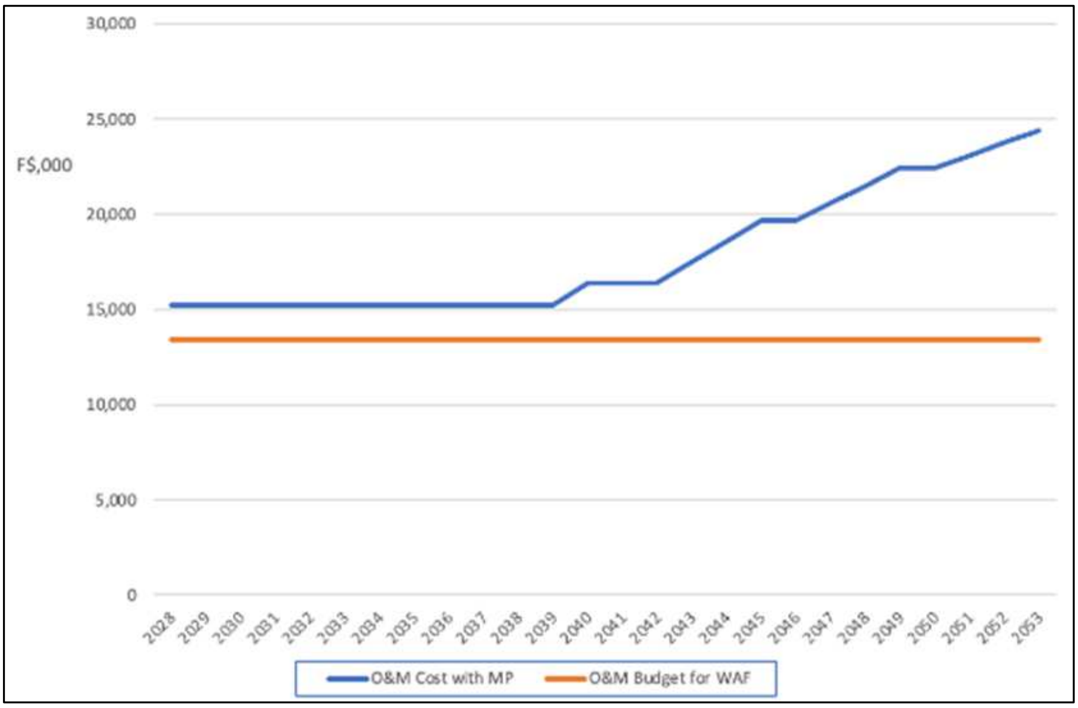
(3) Tariff rate required to finance O&M expense of Master Plan

Even if the project proponent regarding the entire CAPEX as a grant, the wastewater income equal to or more than the O&M expense[19] is required for the continuation of the wastewater operations. The sewerage

[18] For the acceptance fee per household, refer to the septic tank sludge collection fee described in Chapter 4-4-4.
[19] This O&M expense maintenance cost is cash outflow and does not include depreciation cost for accounting term.

tariff required to finance O&M expense is calculated at 0.71 FJD/m^3 or more.

With the income from the current tariff which is 0.20 FJD/m^3, the more the water volume treated due to the increase in connections, the more government budget for O&M will be required as subsidy to cover operating loss. **Figure 7-2.2** shows the comparison between the O&M expense required for the implementation of the Master Plan and the current O&M budget[20] provided by the government.



Source : JET

Figure 7-2.2 Comparison of Master Plan O&M Expenses and Current O&M Budget

7-3 Economic Analysis

7-3-1 Indicator for Economic Analysis

The economic evaluation of the Master Plan is conducted by calculating the incremental costs and benefits of implementation and analyzing the following indicator.

Economic Internal Rate of Return : EIRR

The economic internal rate of return is the discount rate that becomes zero when the cumulative difference between costs and benefits in the analysis period is converted to the present value.

[20] 15% of the O&M budget of 89,577,000 FJD in 2018 was assumed to be the budget of wastewater O&M.

7-3-2 Preconditions for Economic Analysis

(1) Analysis Period

Same as financial analysis.

(2) Average Amount of Wastewater Treated, Construction Period of Treatment Plant, Pumping Stations and Preparation Period for Connection

Same as financial analysis.

(3) Connections of Households and Business, and Non-Connections

Same as financial analysis.

(4) Capital Expenditure (CAPEX)

Same amount of CAPEX in financial analysis is considered as cost.

(5) Preparation Period for Connection

Same as financial analysis.

(6) Operation and Maintenance Cost

O&M expense in the financial analysis are regarded as non-tradable goods and multiplied by the standard conversion factor (hereinafter referred to as "SCF") [21] to obtain economic costs. Here the SCF is 0.96.

- Economic cost of O&M= O&M expenditure 0.96(SCF)

The formula for calculating SCF is stated below.

$$\begin{aligned} \mathrm{SCF} = {} & (\text{Total Import Amout} + \text{Total Export Amount}) \\ & \div [(\text{Total Import Amout} + \text{Total Import Tax Revenue}) \\ & + (\text{Total Export Amout} - \text{Total Export Tax Revenue})] \end{aligned}$$

Table 7-3.1 Trade Figure for Standard Conversion Factor Calculation

Standard Conversion Factor (SCF) *		
Import (CIF)	3,210,000	1000 US$
Import tax	261,560	1000 US$
Export (FOB)	2,650,000	1000 US$
Export tax	8,252	1000 US$
SCF=	**0.96**	

＊Trade figures refer to 2019 World Bank data and Fiji Budget Statement.
Source：JET

[21] Standard conversion factor (SCF) is used as a factor when converting non-tradable goods to international prices.

(7) Salvage Value

The same amount of residual value as the financial analysis is recorded as a negative economic cost in the final year of the analysis.

(8) Benefit of Wastewater Usage

Incremental wastewater consumption is calculated as user benefit. Volume of the incremental treated wastewater is the same the financial analysis, on the other hand, the affordable amount to pay (hereinafter referred to as "ATP") [22] is used as a proxy for the willingness to pay to calculate the benefits.

- Annual user benefit = (Average daily wastewater volume x 365 – Daily treated water volume before project implementation x 365) x ATP (m^3)

In this formula;

Daily treated water volume before project implementation: 20,000 m^3/day

ATP: 1.05 FJD/m^3

(9) Benefits by Eliminating the Need of Septic Tanks

The septic tank installation cost and water pumping cost that are unnecessary due to the sewer pipe connection are calculated as user benefits using the following formula.

- Benefit = increase in the number of connections x (septic tank installation cost + bailing cost)

In this formula ;

Installment cost for septic tank :

Household 8,000 FJD/house ÷ 20 years of use = 200 FJD/year

Business customer 8,000 FJD/business x 2 ÷ 20 years of use = 400 FJD/year

Bailing cost of septic tank :

Household 300 FJD/every 5 years = 60 FJD/year

Business customer 600 FJD/every year = 600 FJD/year

(10) Benefit due to Elimination of Sceptic Tank Installation Space

The cost of the septic tank installation space[23], which becomes unnecessary due to the wastewater connection, is calculated as the user benefit using the following formula.

- Benefit = Incremental number of connections x Cost of space for septic tank installation

In this formula ;

Cost of septic tank space: Household 1,200 FJD/year, Business customer 2,400 FJD/year

[22] ATP is calculated in Chapter 4-7-6.

[23] The space for installing a septic tank is considered to be the same as the parking space for one passenger car, and the benefit is equivalent to the annual parking cost of one car for general households and the cost of two cars for business customer.

(11) Benefits from New Connection Charge

Income from new connection charge in financial analysis is calculated as the operator's benefit.

(12) Benefits related to Sludge Acceptance

Income related to sludge acceptance in financial analysis is calculated as the operator's benefit.

7-3-3 Result of Economic Analysis

The results of the economic analysis based on the costs and benefits calculated under the above preconditions are described below. The cash flow table used for calculation is shown in **APPENDIX 7-1**.

(1) EIRR

EIRR = 2.4%

The result is a positive return of 2.4%. The target EIRR[24] for the implementation of development projects is 9%, or 6.0% for projects such as prevention of environmental pollution, poverty reduction in rural areas, and mitigation of natural disasters. The EIRR of Master Plan is below both targets.

(2) Sensitivity Analysis of EIRR

A sensitivity analysis for cost changes is shown in **Table 7-3.2** below. The benefit is assumed to be constant because it is calculated by using ATP. The result shows that EIRRs are positive in all the range of cost change from plus 20% to minus 20%, however, even in the case of cost minus 20%, EIRR is 3.5%, which does not reach the project implementation guideline.

Table 7-3.2 Sensitivity Analysis of EIRR

Cost	Down 20%	Down 10%	Unchanged	Up 10%	Up 20%
EIRR	3.3%	2.9%	2.4%	2.0%	1.7%

Source：JET

7-4 Recommendations from Economic and Financial Analysis Results

(1) The implementation of the Master Plan is not viable from the viewpoint of economic and financial analysis using FIRR and EIRR as evaluation indicators. However, the National Development Plan differs for each country, and therefore, the significance of project implementation is also different based on national interests. FIRR and EIRR are just one of evaluation methods. It should not be simplified for policy makers to judge the validity of project implementation based on the results of these indicators only.

[24] Based on Asian Development Bank's Cost-Benefit Manual (2017).

(2) Although the purpose of the Master Plan is not to focus on the ripple effect on other industries, such positive effect can be fully assumed as a result of sanitation effect. For example, tourism is an important industry in Fiji, accounting for around 40% of GDP, but the benefits of the projects in this industry are not included. Needless to say, the development and expansion of the sewerage system, which is the cornerstone of public health in the Western Division, is indispensable for the development of the tourism industry and will bring about positive economic effects. In fact, the Fiji Tourism Department has shown great interest in implementing the Master Plan through participation in stakeholder meetings. These qualitative economic effects should also be considered as project implementation factors.

(3) Profitability is not everything for business operators in projects with high public interest. However, stable business operation requires at least an income that can cover daily operation and maintenance costs. The current fixed sewerage tariff of 0.20 FJD/m^3 is not sufficient to cover O&M expense, as stated in the financial analysis. It is essential to secure income from tariff of at least 0.71 FJD/m^3 or higher for operation and maintenance. Wastewater business has high public utility significance that is indispensable for improving living standards of Fijian through sanitation. It is necessary to ask the Fijian people to understand the necessity of higher tariffs in order to take benefit of the stable operation of the sewerage system/wastewater treatment.

CHAPTER 8 Recommendations to Achieve NDP

8-1 Technical Issues and Recommendations to Achieve NDP

8-1-1 Sewerage Collection System (Sewer Network)

The sewerage collection system (sewer network) by pipeline is based on gravity flow. However, pipelines must be laid deep underground to ensure the minimum pipeline slope requirement for gravity flow, as well as factors such as topographical constraints, river crossings, and avoidance of existing underground structures. Therefore, economically advantageous pipe-laying methods (open-cut excavation and pipe jacking) will be examined. In order to achieve the NDP, the sewerage service area is planned to expand out to the existing water supply service area. In cases where the new expanded area connects to existing sewer networks, or when the pipe depth requirement for gravity flow is very deep, pumping facilities will be examined as an option.

8-1-2 Wastewater Treatment Process and Recommended Technology

As for the wastewater treatment process, in the case of effluent SEZ standard applications, the OD process is recommended since its planning/design standards have been made publicly available. On the other hand, the IDEA process has a history of implementation at Kinoya WWTP (Suva) and Navakai WWTP (Nadi), and the application of a single mechanical treatment process across Fiji can simplify O&M. When setting the influent nitrogen concentration to 70 mg/L as done in this report's calculations, the required footprint of the OD and IDEA process does not have a large difference; therefore, the recommended treatment process will be chosen based on comparison of construction/O&M cost estimations in the Municipal Sewerage M/P and Pre-F/S to follow. In addition, MIMS commented on the consideration of the MBBR process which can possibly provide lower O&M costs; upon the Municipal Sewerage M/P, the MBBR process will also be a possible option in the examination process.

8-1-3 Septage/Sludge Management

For the dewatering of excess sludge and dredged sludge from WWTPs, the Volute-type dewatering machine, which has been adopted in countries such as the Philippines and Papua New Guinea, can be suggested as a candidate for Fiji. Septage from households will be bailed/collected to the closest WWTP to be dewatered, and its leachate will be co-treated with pipeline sewerage.

In the required site area and construction cost estimation performed earlier in this report, the sludge from WWTPs were planned to be stored (landfilled) within the site boundaries. In the future, the Fijian efforts/activities towards the utilization of sludge (composting, etc.) and possible final disposal sites outside the WWTP will be confirmed/clarified with the Fijian side for further examinations.

8-2 Proposals for the Organizational and Capacity Improvement of WAF Sewerage Department

Proposals for the organizational and capacity improvement of WAF Sewerage Department at this stage are as follows：

8-2-1 Sustainable Strengthening of Capacity

Currently, not many technical trainings are conducted at WAF. However, to strengthen WAF’s capacity for the future, it is essential to implement technical training related to duties of each staff so that they can fully demonstrate their abilities and engage in the necessary work.

In this project, technical training for implementing sewerage works will be carried out, so it is important for WAF to continuously carry out staff training after the project is completed by referring to the implementation method and training materials used.

It is appropriate that the training conducted in this project is taken over by the human resources unit which is in charge of staff training in WAF and incorporated into the staff training within WAF. It is also necessary to establish a system within WAF to continuously improve training materials.

8-2-2 Staffing Based on the Facility Scale

In the M/P, expansion of the service area, increase of the treatment capacity of WWTPs, and upgrade of the wastewater treatment process to comply with the effluent quality standards will be proposed. **Table 8-2.1** shows the personnel required for such expansion, increase, and upgrades.

Table 8-2.1 Personnel Required According to the Scale of Sewerage Facilities

No.	Group	Personnel required
1	O&M of WWTP	✧ With the expansion of the treatment capacity of WWTPs and the change of wastewater/sludge treatment processes, the number of facilities to be operated and maintained will increase, so it will be necessary to secure an appropriate number of O&M staff. ✧ Depending on the content of the M/P to be formulated it is necessary to consider the personnel assignment plan with reference to the O&M status at the Kinoya WWTP in Suva, which introduced the IDEA process earlier.
2	O&M of sewer network (sewer pipes)	✧ With the expansion of the service area, the length of the sewer pipes to be maintained will increase, so it is necessary to consider the gradual increase in the number of staff for sewer network maintenance according to the expanded area. ✧ It is also necessary to consider whether the high-pressure cleaning work of sewer pipes and the pipe survey works using TV cameras will continue to be outsourced to private companies or will be directly managed by WAF.
3	Maintenance of M/E equipment	✧ When the number of M/E equipment in WWTPs increases, it is necessary to consider increasing the number of staff for maintenance of M/E equipment.
4	LTW	✧ With the expansion of service area, the number of businesses that discharge wastewater into the sewer network will increase, so it is necessary to secure the appropriate number of staff.
5	Laboratory	✧ WAF has a plan to set up small laboratories at each WWTP in the future for analyzing MLDO and activated sludge concentration on a daily basis. (However, this is just a plan, and the implementation time has not been decided.) The WWTPs that use IDEA or SBR process such as Kinoya and Navakai WWTP require these laboratories. The monthly water quality analysis that is currently implemented is sufficient for the WWTPs using the stabilization pond process because there is no operational factor. ✧ When setting up a laboratory, it is necessary to train staff to perform simple water quality analysis.

Source: JET

8-2-3 Securing the Budget

It is necessary to secure labor funds to hire and fill vacancies and increase the total number of staff in line with the scale of the facility. In addition, in order to secure the equipment and materials necessary to carry out the increased work, it is indispensable to secure a budget for O&M of the sewerage facilities. **Table 8-2.2** shows the budget required for O&M of sewerage facilities.

Table 8-2.2 Budget Required for O&M of Sewerage Facilities

No.	Task	Budget
1	O&M of WWTP	✧ Personnel costs related to increasing the number of O&M staff by expanding WWTP capacity and introducing new wastewater/sludge treatment processes. ✧ Energy and chemical costs related to the operation of M/E equipment in the new advanced wastewater/sludge treatment processes.
2	O&M of sewer network (sewer pipes)	✧ Personnel costs related to increasing the number of maintenance staff due to the expansion of sewer service area, budget for equipment required for maintenance.
3	Maintenance of M/E equipment	✧ Personnel costs related to the increase of staff due to expansion of sewer service area, increase in M/E equipment in WWTP, and implementation of preventive maintenance of M/E equipment. ✧ Budget required for preventive maintenance of M/E equipment. ✧ Budget to secure the necessary workspace due to the increase in staff and the start of preventive maintenance of equipment.
4	LTW	✧ Personnel costs related to the increase in the number of staff due to the increase of offices by the expansion of the sewer service area.
5	Water Laboratory	✧ Installation costs to set up small-scale laboratory at each WWTP, including equipment, chemical and personnel costs. ✧ (However, the realization of the plan is completely unknown.)

Source: JET

8-3 Financial Improvement Plan for WAF Operation

Sales of both water and wastewater cannot cover operating expenses. Since the collection rate of sales is at a sufficiently high level of 95% (2017), the low tariff setting is the cause of the financial loss every year because the income from water/wastewater sales cannot cover the expenses. The production cost together with supply of water is about 1.00 FJD/m^3 according to WAF, but the current water and sewerage tariffs are well below this cost, so the more sales volume, the greater the operating loss. In particular, the sewerage tariff is fixed at a low level of 0.20 FJD/m^3 regardless of the customer category and amount of use. Tariff increases are necessary not only for wastewater but also for drinking water supply, in order to secure profits that are essential for the continuation of WAF business operations.

Subsidies for WAF from the government budget are the key to capital investment and operating funds since the original water supply and wastewater business is losing money. Therefore, it is necessary for the MOE to continue its commitment to support the WAF.

The delay in the disclosure of audited financial statements[25] since FY 2018 is due to delays in the work of auditing bodies. However, such delaying is a serious matter of presenting transparency and gaining stakeholders' approval. For prompt disclosure, it is necessary to take supporting measures from supervisory bodies including MIMS and MOE.

[25] Delaying status as of the end of July 2022.

8-3-1 Sewerage Tariff Plan

A calculation was made of the sewerage tariff that allows the necessary profit to be recorded for the O&M expense that arises in the operation of the Regional Wastewater M/P. As a result of the calculation, a minimum of 0.71 FJD/m^3 is necessary to cover the O&M expense.

The total investment for WWTPs, pipes and pumps will exceed the annual expenditure budget of Fiji, since the CAPEX plan is to install household connections to areas with low population density. As a result, a tariff exceeding 3.00 FJD/m^3 is required just to recover the depreciation of the capital investment. It is not realistic to gain the understanding of the Fijian people for a price increase to that level. Therefore, as the first step, the tariff should be set at around 0.71 FJD/m^3 with the aim of securing an income that exceeds O&M expense, and thereafter, the tariff should be continued to be raised gradually based on the Affordable to Pay (ATP) level of household, which is around 1.00 FJD/m^3.

8-3-2 Possibility of Private Investment

Outsourcing of water supply and wastewater business to the private business operators is possible in the medium term of utility policy. For example, in case of the power sector, a joint venture between the Fiji government and a Japanese power company was setup (51% owned by the Fiji government, 5% by the people, 44% owned by Japanese electric power company). As in the case of the electricity, it is also possible to conduct a wastewater business using a similar JV scheme, especially an industrial water treatment business targeting major companies.

On the other hand, securing business profits is an essential condition for private business operators to invest. It is difficult to make a profit with the current sewerage tariff from the standpoint of business owners' investment profitability, so private investment cannot be viable. An increase in the tariff charges is essential for private operators, however, other promoting options should be included as investment subsidies for private operators such as tax exemptions, and free leasing of government land.

8-3-3 Promotion to Household Connections

There are currently no WAFs or government subsidies to promote connections to ordinary households. In addition to the application fee for new connection, the user is responsible for the connecting cost [26]from home to the sewer network.

There may be a situation where the connection of households will not be succeed smoothly, due to the burden of costs associated with such expense become an obstacle. As measures to promote connection, the government should plan providing subsidies for connection costs for the first three years after sewer network development, publicize the promotion of connection to households, and establish a policy that obligates connection within a certain period of time.

[26] According to local contractors, the cost is equivalent to 270 FJD per meter length of connecting pipe.

8-4 Improvement of Decentralized Treatment Systems

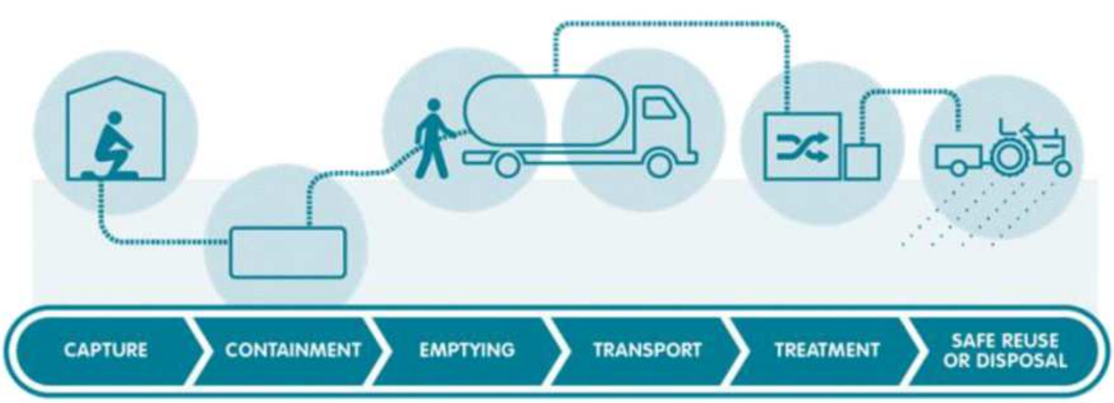
8-4-1 Issues Related to Decentralized Treatment Systems

Table 8-4.1 summarizes issues related to decentralized treatment systems in Fiji, focusing on items pointed out previously in this project. The table summarizes issues at each stage of the service chain, shown in **Figure 8-4.1**. At the same time, institutional organizational issues related to the service chain as a whole has been categorized as “Other issues” in the table.

Table 8-4.1 Issues in Decentralized Treatment Systems

Category	Issues
Capture Containment	・ Basic sanitation services are not yet established ・ Inadequate greywater treatment ・ Systems that do not meet standards (drum systems, etc.) ・ Inadequate septic tank management ・ Insufficient inspection system
Emptying Transportation	・ Septic tanks are rarely bailed (desludged) ・ Bailing companies are concentrated in certain areas, resulting in large disparities in bailing tariffs between regions ・ Insufficient number of trucks to implement regular desludging ・ Installation of septic tanks in locations difficult to access, such as inside buildings
Treatment	・ Unclear distinction between industrial wastewaters and domestic septage ・ Inadequate treatment (discharge into unlined pit at Natabua WWTP, etc.)
Safe reuse or disposal	・ Insufficient biomass utilization ・ Inadequate treatment (discharge into unlined pit at Natabua WWTP)
Other issues	・ Lack of SDGs goals and indicators for decentralized treatment systems ・ Undeveloped laws and regulations related to decentralized treatment systems (the positioning of decentralized treatment systems in domestic wastewater treatment, departments in charge of septage management, WAF's position and responsibilities in decentralized treatment system management, etc.) ・ Lack of guidelines for maintenance of septic tanks ・ Lack of database of onsite facilities ・ Insufficient coordination between public and private sectors ・ Low awareness and knowledge regarding septic tanks in the general public

Source：JET



Source: WASH Discussion Paper - What do safely managed sanitation services mean for UNICEF programmes?

Figure 8-4.1 Sanitation Service Chain

8-4-2 Improvement of Decentralized Treatment Systems

(1) Improvement of Decentralized Treatment Systems and Roles of Various Stakeholders

Regarding the issues described out in the previous sections, **Table 8-4.2** summarizes measures that will be necessary from each stakeholder in the future. In addition, improvement measures related to the implementation of regular desludging will be discussed in a separate section of this report.

Table 8-4.2 Improvement of Decentralized Treatment Systems and Roles of Various Stakeholder

Stakeholder	Proposed Improvement Measures
Central Government	・ Setting goals and indicators for SDGs related to distributed systems ・ Establishment of laws and regulations for decentralized treatment systems and septage management ・ Creation of maintenance guidelines for septic tanks ・ Development of inspection and guidance system for the maintenance and management of decentralized treatment systems ・ Reduction of disparities in bailing fees ・ Development of measures to promote the use of biomass, etc. ・ Development of regular desludging and public awareness
Local Government (Cities/Towns)	・ Development of inspection and guidance system for the maintenance and management of decentralized treatment systems ・ Securing sludge dumping sites ・ Cooperate with the implementation of regular desludging and raise public awareness
WAF	・ Prohibit mixing of industrial waste and domestic septage ・ Improve septage treatment effectiveness ・ Develop organizational structure and facilities for regular desludging
Residents	・ Using septic tanks that meet building code standards ・ Cooperate with regular desludging
Private Sector	・ Stop mixing industrial waste and domestic septage ・ Cooperate in reducing disparities in bailing fees ・ Cooperate with regular desludging

Source: JET

(2) Setting Goals and Indicators Related to SDGs for Decentralized Treatment Systems

When formulating policies, it is important to deepen the understanding of stakeholders of the issues, and the SDGs are used in many countries and regions as a tool for recognizing the current conditions and setting goals based required improvements. In cases where SDGs related to sanitation services are used, in addition to provision of basic sanitation as indicated in the MDGs, the ratio of the population receiving “Safely managed sanitation” defined in Goal 6.2.1a of the SDGs becomes an evaluation indicator. In general, “safely managed sanitation” often requires that septage is removed periodically. However, in Fiji there is no statistical data on the maintenance and management of septic tanks, numerical targets related to SDG 6.2 related to sanitation services have not been published, and data for indicator 6.2.1a have not been published.

The target year of SDGs is 2030, but it is also useful as a tool for understanding the actual situation of decentralized treatment systems and formulating future policies. For this reason, it is important to set SDG goals and indicators related to decentralized treatment systems and establish the necessary monitoring systems. Continuous monitoring is desirable. For example, including related surveys in future housing and population census surveys should be considered.

(3) Establishment of Regulations and Guidelines for Management of Decentralized Treatment Systems and Septic Tanks

In Fiji, the Public Health Act 1936 (2020 Amended) and Public Health (National Building Code) Regulation 2004 are laws related to decentralized treatment systems. These laws and regulations stipulate the agencies and roles related to public health and standards for construction of sanitation facilities. However, in order to properly operate decentralized treatment systems, it is necessary to develop systematic laws and guidelines such as the Johkasou Law and the Waste Management Law in Japan which establish performance regulations, statutory inspections, user obligations, maintenance inspections, and contractor qualifications, as well as requirement of local governments to formulate basic management plans related to wastewater.

(4) Establishment of Inspection and Guidance System for the Operation and Maintenance of Decentralized Treatment Systems

The installation of sanitation facilities such as septic tanks is a basic requirement for buildings according to the National Building Code, and is subject to examination when applying for a building permit. However, regarding the maintenance and management of such facilities, although Building Inspectors and Health Inspectors conduct regular inspections (once every three months to a year) with many survey items, the record of sludge removal and deterioration condition of the tanks are not fully understood. In Japan, the Johkasou Law defines responsibilities for the management of Johkasou tanks, requiring regular inspections by qualified management, etc. Development of similar systems is necessary to ensure effective implementation of decentralized treatment systems in Fiji.

(5) Reducing Disparities in Bailing (Desludging) Fees

Currently, the disparity in bailing (desludging) fees is high and not considered acceptable for users of the services. The disparity is caused by the fact that bailing charges are left to the discretion of private companies (market principles). Some form of public involvement is required to reduce this disparity. Specifically, it may be possible to provide financial support to areas where the burden is high, and to reduce costs by setting up service bases in those areas. This requires securing of financial resources and understanding and cooperation of the private bailing contractors. In addition, in areas where the private sector cannot be financially incentivized to provide services, the government should consider implementing bailing services as a public service.

(6) Prohibition of Combined Transport of Industrial Waste and Septage

Currently, industrial waste sludge (LTW) and domestic septage are collected and treated without distinction in Fiji. The volume of domestic septage is expected to increase and combined treatment of LTW will become problematic. Industrial waste manifesto and laws based on it need to be developed to treat two wastewaters separately.

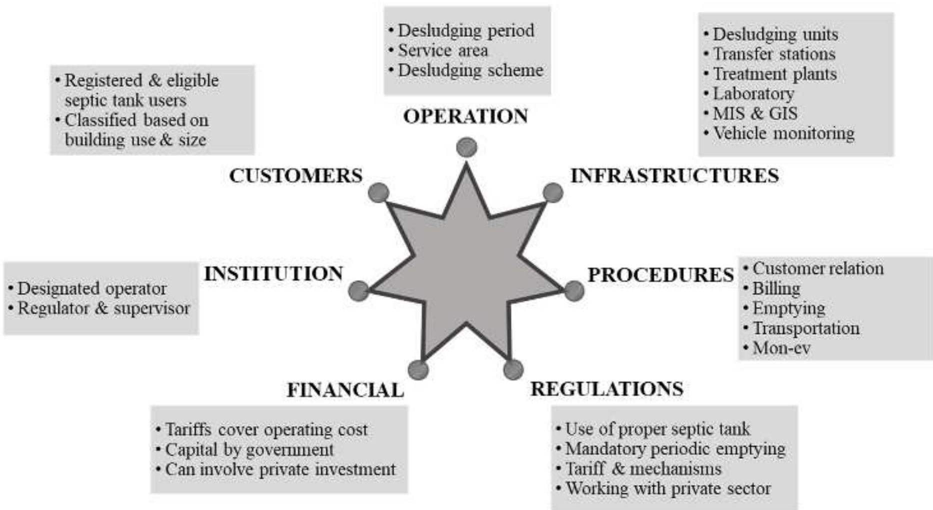
(7) Public Awareness

In order to improve decentralized treatment systems (namely, implement regular desludging, convert to standard septic tanks, and promote conversion from single-purpose treatment tanks to combined treatment), laws, systems, organizations, etc. need to be developed. At the same time, the understanding and cooperation of residents, who are the users, are essential. In the case of Fiji, residents are not very dissatisfied with the current system and generally have little interest in these issues. For this reason, it is difficult to obtain enthusiastic support and cooperation from residents. It is necessary for related ministries, municipalities, and communities to work on awareness and environmental education campaigns in collaboration with "WASH[27]" and other activities that are being promoted in schools and communities.

8-4-3 Implementation of Regular Desludging

(1) Implementation Structure for Regular Desludging

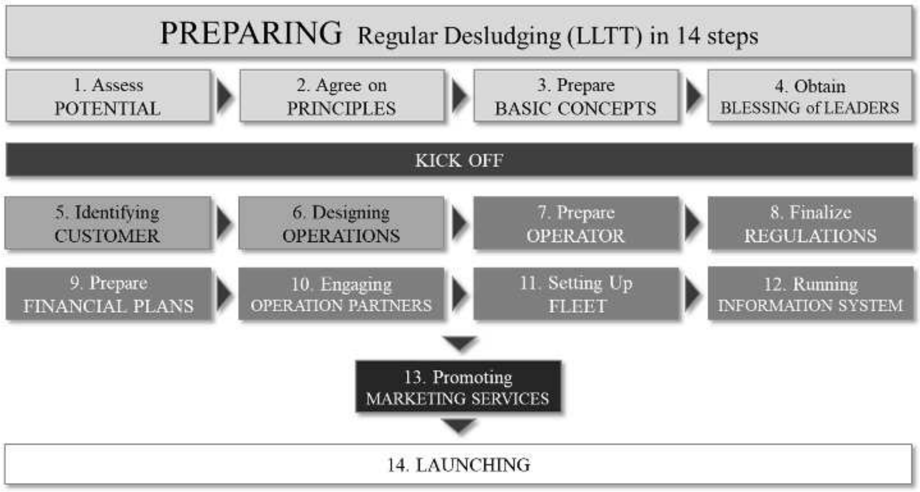
Institutional and organizational improvements and preparations are necessary in order to carry out regular desludging. **Figure 8-4.2** shows the seven aspects of LLTT (Layananl Tinja Terjadwal, regular desludging service) developed in Indonesia with the assistance of USAID. **Figure 8-4.3** shows the 14 steps for implementing regular desludging, from the same USAID guidelines.



Source: "Saatnya Sekarang! Layanan Lumpur Tinja Terjadwal (It's Time Now! Perform the Scheduled Desludging Service) " (2016, USAID IUWASH)

Figure 8-4.2 Seven Aspects of Regular Desludging

[27] WASH stands for Water, Sanitation and Hygiene. It is a rural water and sanitation improvement program that aims to ensure access to and sustainable management of water and sanitation for all people.



Source: Created by JET based on "Saatnya Sekarang! Layanan Lumpur Tinja Terjadwal

Figure 8-4.3 14 Steps for Regular Desludging (LLTT)

Table 8-4.3 describes each step in detail. Specific explanations and proposals that will be important for the kick-off in Fiji are presented.

Table 8-4.3 14 Steps for Implementing Regular Desludging (Descriptions)

Step	Description
1. Assess potential	Investigate the feasibility of implementing regular desludging in the target city (region), septic tank usage rate, truck availability, treatment facility capacity, rules and regulations, and identify bottlenecks.
2. Agreement on principles	Before starting service preparations, the purpose, nature, timing of commencement, related plans, financial principles, etc. of the service must be understood and agreed to by other parties.
3. Prepare basic concepts	Prepare concepts that can be understood by decision-makers and stakeholders including the estimated number of beneficiaries, sludge volume, bailing frequency, truckloads, treatment processes, basic charges and financial aspects.
4. Obtain approval of decisions	Obtain approval from decision-making parties using concepts prepared above.
Kick Off	
5. Identify customers	Investigate the number and distribution of potential customers, building types and septic tank conditions. A complete survey of buildings is desirable, but if that is difficult, alternative surveys (population census, etc.) can be used.
6. Design operations	The operational plan will indicate the division of service zones, customer classifications and distribution, and bailing transportation patterns. Based on this, the load on the treatment facilities and required treatment capacities can be calculated.
7. Prepare operator	Decide which agency will implement (be responsible for) the regular desludging activities, modify the organizational structure for the implementation of the new service, and secure the necessary personnel.
8. Finalize regulations	In order to ensure that regular desludging is carried out, rules and regulations must be developed to make bailing obligatory and to support collection of appropriate fees. At the same time, consideration need to be given for converting single-purpose (blackwater only) septic tanks to dual-purpose (greywater and blackwater treatment) treatment tanks.
9. Prepare financial plans	Based on profit and loss and balance sheet forecasts, ensure soundness and sustainability of regular desludging operations while also considering measures for the poor. Consider application of appropriate service charges through cross subsidization between customer segments in order to alleviate regional fee disparities.
10. Prepare transportation systems/fleet	A vehicle (fleet) management system should be developed based on the bailing and transport patterns described in the operation plan. The system should use digital communication technology to monitor truck conditions in real time. For that purpose, participation of private bailing companies is required. In addition, it is necessary to deal with on-call and unscheduled desludging in areas where regular desludging has not been implemented.
11. Engage operational partners	Build a framework in which private groups such as NGOs and community groups are involved as outsourcers for regular desludging activities.
12. Prepare information systems	Develop a management information system (MIS) in the implementing agency. The system should be linked with other systems such as customer management, fleet management, and bill collection.
13. Promote marketing services	Prior to the start of the service, awareness campaigns to promote information on regular desludging system (system overview, customer rights, obligations and benefits, usage method, etc.) should be implemented.
14. Launch	

Source: Created by JET based on "Saatnya Sekarang! Layanan Lumpur Tinja Terjadwal (It's Time Now! Perform the Scheduled Desludging Service) " (2016, USAID IUWASH)

(2) Concept and Consensus Building

This M/P aims to achieve a population access ratio of 70% for a combination of centralized and decentralized treatment systems by 2036. Decentralized treatment systems account for more than half of this, and requires immediate launch/expansion. However, the level of interest in regular desludging in the people and government of Fiji is low. Raising awareness of the issues in important stakeholders is an urgent task. In order to raise awareness of those involved, it is essential to communicate the current situation and clarify the goals, and to build a consensus on methods for achieving the goals. Time for concept creation and consensus building is limited. Therefore, it is rational to use existing frameworks, such as the SDGs, as a tool for planning.

(Goal Setting Using SDGs)

Although the SDGs are initiatives prescribed for the 2016-2030 period, it is possible to link certain indicators with Fiji's NDP to utilize even after 2030. In this M/P the achievement of 70% access to "safely managed sanitation" by 2036 through a combination of centralized and decentralized treatment systems.

(Indicators and Measurement)

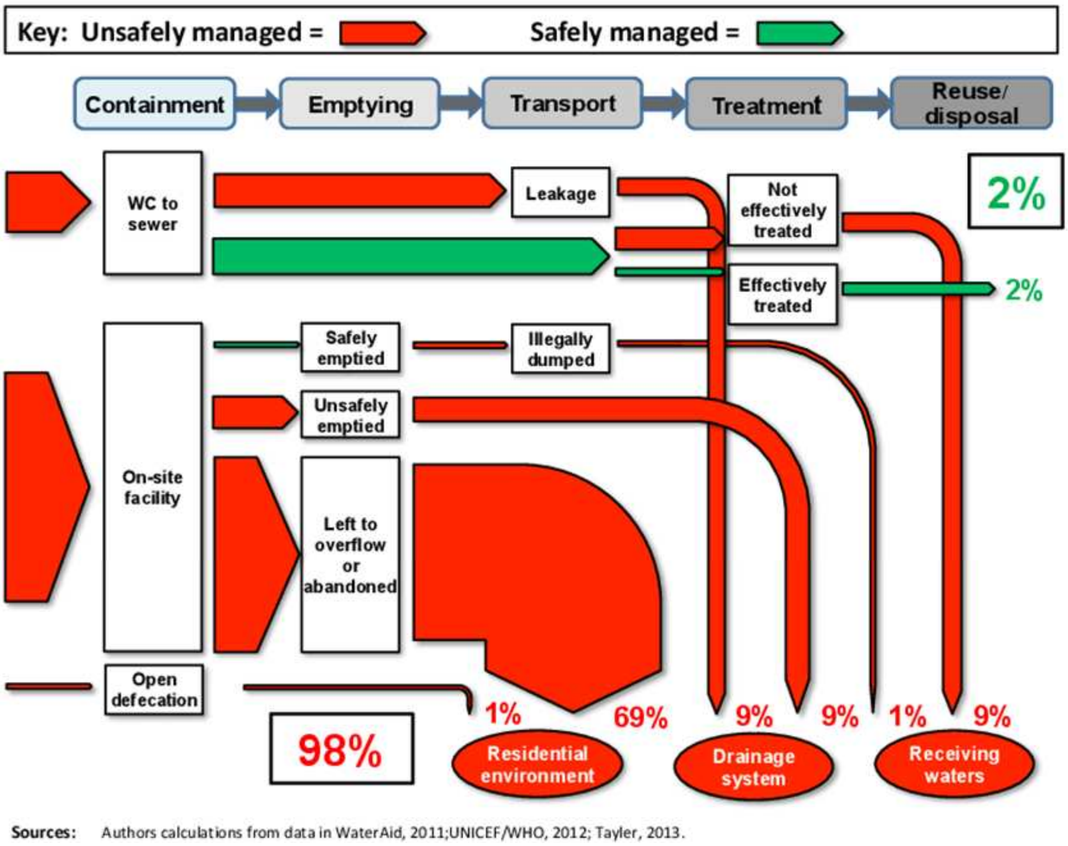
In order to use the SDG frameworks, indicators and their measurement methods must be clearly defined. For this project, the indicator is defined as the proportion of the population receiving "Safely managed sanitation services." "Safely managed sanitation service" is defined as those that use "Improved sanitation facilities." Sludge must be extracted from these facilities at appropriate intervals (every five years in this M/P) and properly treated at an offsite facility. Although the Fiji Population and Housing Census surveyed the types of sanitation facilities (toilets), the timing and intervals of desludging have not been investigated. Therefore, it is necessary to add this as a new survey item in forthcoming censuses. However, for the time being, as a practical way to collect data, it is proposed that interviews should be conducted during regular surveys by building inspectors and health inspectors in leu of a complete nation-wide survey.

（Utilization of Fecal Waste Flow Diagram (SFD)）

It is important to summarize collected data in a form that is easy for stakeholders (residents, decision makers, etc.) to understand. The "fecal waste flow diagram (SFD)" shown in **Figure 8-4.4** is commonly used to visually communicate various service chains and their conditions that constitute the entire "fecal sludge management" environment.

(Analysis of Current Conditions and Issues)

In Indonesia, each prefecture and city are required to prepare SSKs (City/Regency Sanitation Strategies) every five years. In this process, a gap analysis is conducted to examine the discrepancy between the targets and the current situations, including the budget, organizational conditions, personnel, etc. required to achieve the target, and bottlenecks are identified. SWOT analyses which identify elements of the internal environment and the external environment that become obstacles are also performed and the results are reflected in the plan.



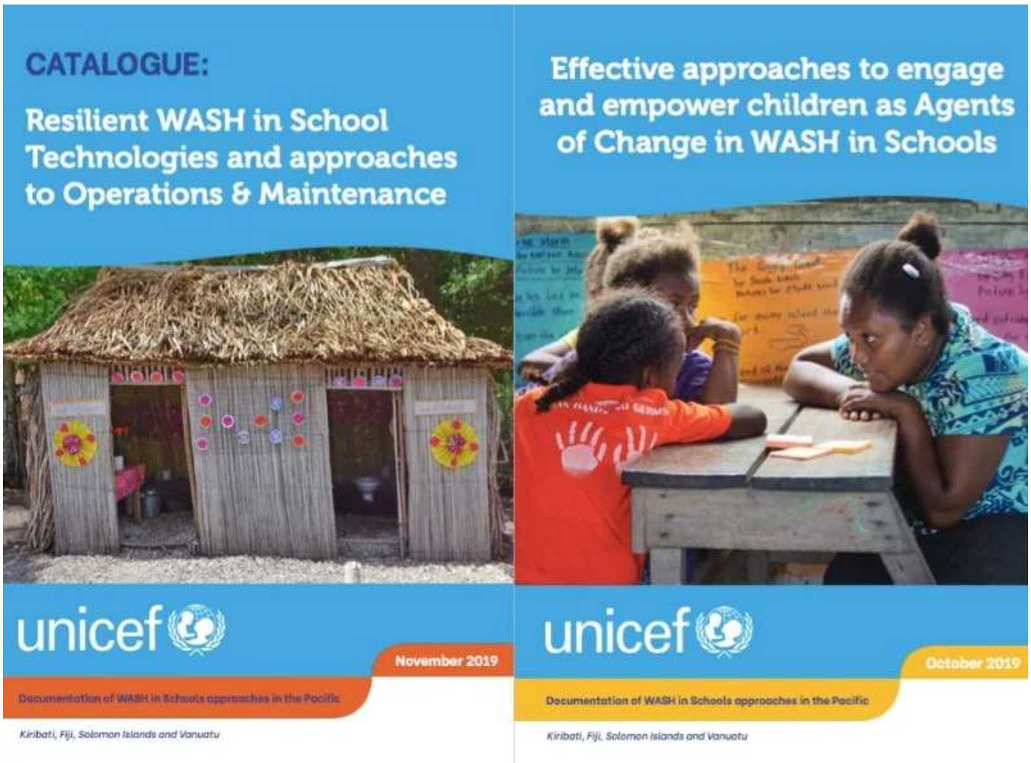
Source: Fecal Sludge Management: a comparative analysis of 12 cities, Andy Peal. et al., Sep. 2014, Journal of Water, Sanitation and Hygiene for Development

Figure 8-4.4 Example of Fecal Waste Flow Diagram

(Public Awareness)

In addition to the development of various information and tools on the government side, it is important to inform residents and raise their awareness of the environment and hygienic impacts of these activities. Various methods are being adopted in Japan and other countries, such as the use of television, newspapers, and internet sites, and the distribution of pamphlets.

In Fiji and other Pacific countries, the WASH (Water, Sanitation and Hygiene) Program has been implemented with the support of UNICEF and other supporting agencies. The program has been implemented in Fiji from 2015 to 2020. In this initiative, children are appointed as "Children as Agents of Change in WASH" and expand WASH activities learned in school throughout the home and community. Using this as an example, programs that encourage children to "notice, think, understand, and act" their own responsibilities and actions regarding domestic wastewater through environmental education activities in school education should be considered.



Source: https://livelearn.org/resources/assessment-of-wash-in-schools-programs-in-fiji-kiribati-solomon-islands-and-vanuatu/

Figure 8-4.5 Example of Publications of WASH (Water, Sanitation and Hygiene) Program

(3) Implementation Plan

The implementation plan will define the service zones, classifications and distribution of customers, and bailing and transportation patterns. From these, frameworks for regular desludging and bailing services can be developed.

(Service Zones and Customers)

Zoning in Fiji is complex, including urban (including peri-urban), rural, city/town council jurisdictions (public service areas), as well as formal and informal settlements, iTaukei villages and communities. All of these can be further classified to near, remote, and mid-distance areas depending on their distances from the service base (truck base, treatment plants, etc.).

In order to achieve the target for 2036, it is necessary to rapidly expand the scope of regular desludging services. To this end, it is recommended to prioritize the introduction of services in areas under the jurisdiction (public service area) of the City/Town Councils, where the administrative service system is more well established. This has the added benefit of possibly utilizing the housing information held by the City/Town Councils, Building Inspectors, and Health Inspectors. This should be followed by areas that will become sewerage service areas in the future. In principle, this area is assumed to be a WAF water supply service area or an area where service expansion is expected, and it is assumed that flush toilets and septic tanks are widespread. Outside of these zones, sludge collection efficiency is low in areas with scattered small settlements. For this reason, it is efficient to carry out, for example, a sanitation improvement campaign for villages, and to include villages that express their willingness to participate in the target of the service.

(Desludging and Transportation Patterns)

As stated earlier in **5-5**, with the expansion of centralized treatment system service areas, the target areas of decentralized treatment systems become more remote, decreasing the efficiency of septic tank desludging, collection, and transportation. For this reason, it is necessary to improve bailing efficiencies by methods such as the consolidation of septic tanks, and/or setup of transfer stations for bailing trucks.

(4) Implementing Agency

Implementing agencies at the policy level and implementation level need to be identified.

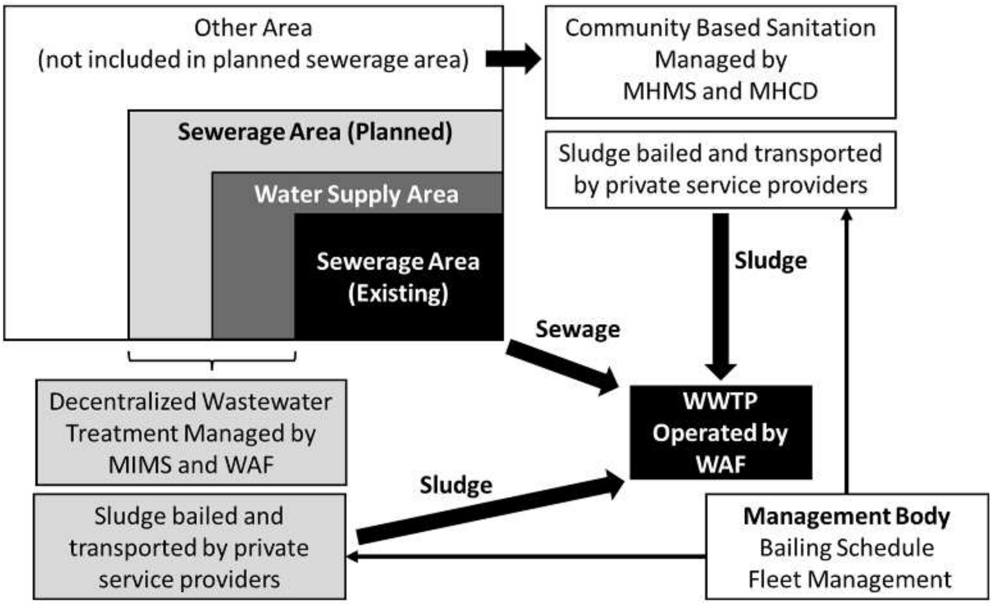
(Policy Level）

Based on the Public Health Act 1936 (2020 Amended) and the Public Health (National Building Code) Regulation 2004, MHMS, CBH, Sanitary Inspector, Health Inspector, and Building Inspector of the City/Town Council, and CBH's local agencies are involved in the management of septic tanks. Water supply and sewerage operations are managed by MIMS and WAF. MHCD is involved with the installation of “community septic tanks” as part of the initiatives to formalize informal settlements

For effective future implementation, the responsibilities and authorities of each of these agencies must be clearly defined and roles for each agency for achieving the goals also need to be established according to these responsibilities and authorities. For existing sewerage service areas and areas that will become sewerage service areas in the future, it is appropriate to create a management system based on the framework of MIMS and WAF, as it is necessary to coordinate sewerage development and regular desludging of septic tanks. For other areas, since the function of WAF is limited to “the Water and the sewerage system” as stipulated Water Authority of Fiji Act, implementation as a sanitation improvement project by MHMS, and an informal settlement-related project by MHCD is considered appropriate

（Implementation Level）

Bailing of sludge is currently carried out by private contractors. Obtaining the consent of both the public and private sectors to create a new system led by the government is expected to be difficult, and the continuation of the current framework is considered to be appropriate. However, in order to implement regular desludging, the works must be scheduled, and trucks and other resources must be available to meet those needs. This requires coordinated operation management of trucks of different companies. In addition, in order to alleviate the disparity in bailing fees between regions, it is necessary to adjust and regulate service fees, both of which require strong involvement of the public sector. Considering the public nature of bailing services and need to ensure fairness to the population, in addition to giving new functions to WAF, establishing a public-private organization is conceivable. There are examples in other countries where fees, including services of private companies, are stipulated by ordinance. **Figure 8-4.6** shows an image of the implementation structure.



Source: JET

Figure 8-4.6 Image of Implementation Structure

(5) Rules and Regulations

Laws, regulations and guidelines outlined in **Table 8-4.4** are required to fulfill legal framework for the implementation of the project.

Table 8-4.4 Rules and Regulations Required for the Implementation of Regular Desludging

Categories	Contents
Clarification of authorities and responsibilities of stakeholders	・ Clarification of responsibilities and authorities of MIMS* and WAF regarding decentralized treatment systems ・ Clarification of MHMS responsibilities and authority regarding community-based systems
Revision of the Building Code	・ Addition of regulations regarding bailing of septic tanks ・ Addition of regulations regarding the timing of inspections of septic tanks by qualified inspectors (at installation, regular intervals, and at decommissioning) and inspection items ・ Standardization of dual-purpose tanks for the expansion of gray water treatment (prohibition of single purpose tanks)
Effective utilization of SDGs	・ Institutionalization of development goal setting based on SDGs ・ Establishment of SDGs indicators and institutionalization of measurement methods
Regular desludging	・ Institutionalization of truck operation management ・ Establishment of standard operating procedures (SOP) for bailing work
Private service providers	・ Registration system for regular desludging companies ・ System to promote the organization of trade unions, etc. ・ System for establishment of the public-private sector ・ Establishment of contractor qualification system to improve service quality and safety and health management (compulsory technical training, awarding of qualifications to those who have completed training, etc.)
Differentiation from LTW	・ Introduction of a manifest (waste management recording) system throughout the waste management system (bailing, transporting, and treating) ・ Development of laws and regulations regarding the handling of LTW
Tariff setting	・ Institutionalization of tariff-setting principles (cost recovery, fairness, efficiency, etc.) ・ Development of third-party guidelines and monitoring methods

*MIMS: before organizational restructuring; current MPW
Source: JET

(6) Financial Plan

For successful implementation of regular desludging, a robust financial plan centered on the tariff system is extremely important to ensure the soundness and sustainability of the project. The following items are important in the financial plan.

- Operational plan that takes into consideration cost recovery
- Tariff setting that takes into consideration sustainability of private service providers
- Business plan that takes into consideration profit-loss and balance sheet forecasts
- Introduction of cross-subsidization between customer segments to support the poor and mitigate regional tariff disparities

However, it is often difficult to achieve these objectives. In many developing countries, it is not even possible to set appropriate tariffs that take into account cost recovery and the sustainability of private service providers and operations are often supplemented by injection of government funds. However, even if the desired outcomes cannot be fully realized, it is necessary and beneficial to maintain an accounting system that is independent from other departments in order to accurately grasp the financial conditions of the operations. This is a necessary condition for ensuring transparency of management and to improve operations. Funds required for non-operational objectives such as poverty reduction and alleviating regional disparities are covered by internal or external government subsidies. In order to avoid undisciplined use of funds, rules such as purpose (target) and spending limits need to be clearly defined.

(7) Desludging Schedule

Activities and timelines to implement regular desludging in 2028 are shown in **Table 8-4-5** (Draft).

Here, it is assumed that sludge treatment capacity of Natabua WWTP will be increased and included in the schedule.

Table 8-4-5 Schedule for the Implementaiton of Regular Desludging (Draft)

Steps	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Assess feasibility, agree on concepts and principles										
Kick-Off										
Identify beneficiaries										
Formulate operation plan Designate implementing agency										
Establish rules and regulations										
Formulate financial plan										
Prepare transport system										
Engage operational partners										
Prepare information systems										
Promotion and awareness										
Prepare systems such as differentiation from LTW and treatment manifests										
Prepare Natabua WWTP										
Start operation of new facilities										
Preliminary acceptance of septage										
Launch services										

Preliminary acceptance of septage: Sludge that does not include LTW will be accepted in the current facilities
Source: JET

8-5 Proposal for Legal Systems and Standards

8-5-1 Clarification of Regulatory Agency for Industrial/Commercial Waste Treatment

In this project, the sewerage to be treated in WWTPs is specified as "pipeline sewerage" and "domestic septage collected by bailing trucks."

The bailing trucks currently collect liquid waste from breweries, sludge from wastewater pretreatment facilities of food processing factories, as well as grease trap waste and residues of hotels/resorts. The mixture is dumped into an unlined pit at the Natabua WWTP site. In Japan, commercial/industrial sludge is regarded as industrial waste, and a sector separate from sewerage works has the responsibility for its management. However, the regulatory agency for industrial waste in Fiji is currently unclear.

If WAF will continue to accept and treat commercial/industrial sludge, it is necessary to establish the required legal framework and standards. Hence, it is necessary to confirm with WAF and other C/P organizations which agency is responsible for the regulation of industrial waste.

8-5-2 Confirmation of Final Disposal Sites for Sewerage Sludge

As mentioned in **4-3**, there is currently no waste disposal site that accepts sewerage sludge. WAF is coordinating with the DOE to secure its own sludge disposal site, but no progress has been made.

As a result of WWTP footprint requirements in **5-3-1**, it was found that an extensive area of land is required for the onsite storage of sludge, leading to increased project costs and possible difficulties in securing land. Therefore, in future studies the securement of sludge final disposal sites, as well as the establishment of legal framework/standards regarding disposal standards, will be necessary.

APPENDIX

APPENDIX 1-1 Minutes of Meeting on JCC

(1) 1st JCC on December 20th, 2021

Minutes of Meetings
on
The First Joint Coordinating Committee
For
Project for Formulation of Wastewater Treatment Master Plan in Western Division (1st Phase)
Agreed upon between
Ministry of Infrastructure & Meteorological Services
and
Water Authority of Fiji
and
Japan International Cooperation Agency

The first joint Coordinating Committee (hereinafter referred to as "JCC") for the Project for Formulation of Wastewater Treatment Master Plan in Western Division (1st Phase) (hereinafter referred to as "the Project") was convened on 20th December 2021 by the chairperson of the JCC and others.
As a result of the discussions, both sides understood and agreed upon on the matters referred to in the document attached hereto.

Suva, December 20th, 2021

Mr. Taitusi VAKADRAVUYACA
Permanent Secretary
Ministry of Infrastructure &
Meteorological Services

Mr. Josaia KOROILAVESAU
Acting Manager
Wastewater Department
Water Authority of Fiji

中嶋 宜信

Ms. Mayumi AMAIKE
Resident Representative
JICA Fiji Office

Mr. Yoshinobu NAKAJIMA
Team Leader
JICA Expert Team

1

ATTACHED DOCUMENTS

1. **Activities and Schedule of the Project**
   The JICA Expert Team (hereinafter referred to as "JET") explained the activities and schedule of the Project as per attached ANNEX 1. JCC agreed to it.

2. **Members of the JCC**
   JET proposed to add the below organizations to the JCC as agreed on Annex II in Record of Discussions (hereinafter refereed to as "the R/D") for the Project, dated on March 16, 2021. JCC agreed to it.
   - Ministry of Housing and Community Development
   - Ministry of Health and Medical Services (Central Board of Health: CBH)

3. **Target Municipalities in the Regional Wastewater Master Plan**
   It was confirmed and agreed to set the below 1 city and 5 towns as the target municipalities for prioritization in the Regional Wastewater Master Plan
   - Lautoka
   - Nadi
   - Rakiraki
   - Tavua
   - Ba
   - Sigatoka

ANNEX 1: Project for Formulation of Wastewater Treatment Master Plan in Western Division (1st Phase), December 20th, 2021, JICA Expert Team

ANNEX 2: Members of JCC

ANNEX 1

PROJECT FOR FORMULATION OF WASTEWATER TREATMENT MASTER PLAN IN WESTERN DIVISION
(1st Phase)

Joint Coordination Committee (1st)
20th December 2021

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Nihon Suido Consultants Co., Ltd.
Yachiyo Engineering Co., Ltd.

1

Table of Contents

Main Purpose of 1st JCC
To confirm and approve above item 5,6,7,8

2

1. Welcome and Introduction

Opening remark from

Mr. Taitusi Vakadravuyaca — Mr. Permanent Secretary, Ministry of Infrastructure and Meteorological Services

3

2. Background

Background and Introduction

- The Master Plans needs to be developed as a guiding document to lead the upgrade of the western wastewater sector in the study area which are in line with forecast developments in order to meet Fiji's National Development Plan.
- This Master Plan will outline the essential projects and will be structured to identify constraints and gaps to ensure the improvement of WAF's wastewater services.

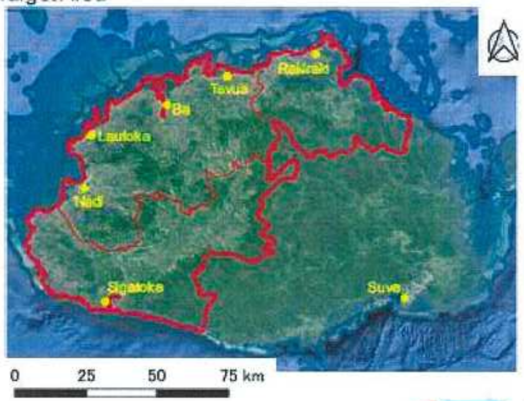
4

3

ANNEX 1

2. Background

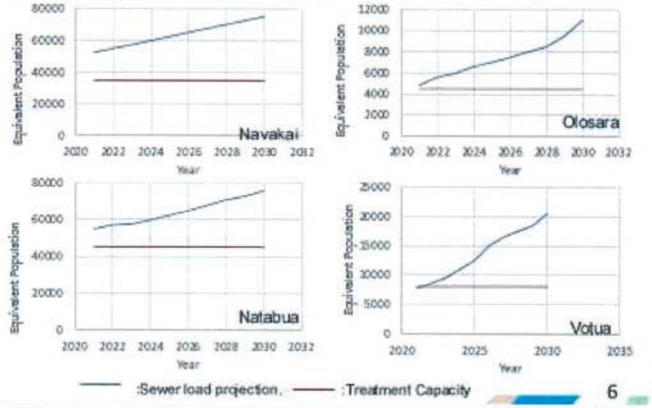
Target Area



5

2. Background

Summary of Existing WWTP Services



6

2. Background

Latest Activities for WWTPs Undertaken by WAF

WWTPs				
Nadi	Sigatoka	Ba	Lautoka	Rakiraki
Navakai	Olosara	Votua	Natabua	
1. Option Assessment for Upgrade Works-2017 2. Detailed Design for Upgrade Works-2018/2019	1. Option Assessment for Upgrade Works-On-going	1. Option Assessment for Upgrade Works-On-going	1. Option Assessment for Upgrade Works- 2019	1.Municipal M/P for W/S W/W in June 2021

7

2. Background

Latest Activities for Sewer Network Undertaken by WAF

Town	Project Name	Estimated Population	Length of Pipe (m)	Number of Pump Station
Sigatoka	Proposed Sigatoka Pump Station and Gravity Main	9648	289.82	1
Nadi	Western Division Sewer Reticulation – Nasoso	9648	20221	8
	Blackrock Sewer Extension*	950	3331	1
Lautoka	Lautoka Urban Catchment	446	2941	0
Ba	Vatulaulau	1746	6720	1
	Ba Prison Compound	570	1001	1
	Tauvegaga	1175	2792	1
	Ba Industrial	1052	9180	4

* Construction in progress

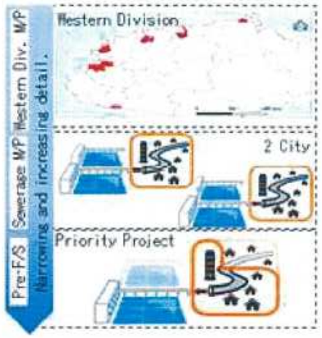
8

4

ANNEX 1

3. Outline of the Project

✓ Strategic improvement of the sewerage infrastructure of the Western Division of Fiji is requested



- Regional Wastewater M/P
- Municipal Sewerage M/P for Priority Cities in the Western Division
- Pre-F/S for the Priority Projects

9

3. Outline of the Project

Output 1	A Regional Wastewater M/P that includes centralized and decentralized wastewater treatment systems for the Western Division of Viti Levu Island of Fiji (Wastewater treatment Master Plan in Western Division) will be formulated.	**Output 4** Capacity on sewerage management of WAF and relevant agencies will be strengthened.
Output 2	Municipal Sewerage M/P in priority cities and/or towns identified in the Regional Wastewater M/P will be formulated. (2 cities)	
Output 3	A Pre-F/S including sludge management for priority sewerage project(s) selected in the Municipal Sewerage M/P will be conducted.	

Overall objective
- Encourage treatment capacity improvement and facility expansion.
- Contribute to improvement of sanitation and water environment

10

3. Outline of the Project

Project Phasing

		2021	2022			2023				2024			
Main Contents		1st Year				2nd Year				3rd Year			
		1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q
Output 1	Regional Wastewater M/P												
Output 2	Municipal Sewerage M/P												
Output 3	Pre-F/S												
Output 4	Capacity Development on sewerage management												
Report		▲ IC/R			▲ PG/R				▲ IT/R			▲ DF/R	▲ F/R

Phase 1　Phase 2

11

3. Outline of the Project

Difference between Regional Wastewater M/P and Municipal Sewerage M/P

M/P	Contents
Regional Wastewater M/P <Conceptual and Strategic>	Target area: Entire Western division Target service: Centralized system and Decentralized system • Prioritization of towns in western division by quantified criterion • Selection of centralized treatment area • Quantitative evaluation of water quality by developing wastewater treatment • Implementation schedule to achieve 70% of centralized treatment access by 2036 • Strategic plan of centralized and decentralized system • Regional-wide strategic environmental assessment
Municipal Sewerage M/P <Practical and Specific>	Target area: 2 prioritized towns Target service: (centralized) sewerage system • Setting service area • Estimation of wastewater flow • Outline design of facility(Collection network, pumping station and WWTP) • Town-level environmental and social consideration • Implementation plan • Cost estimation for entire service area

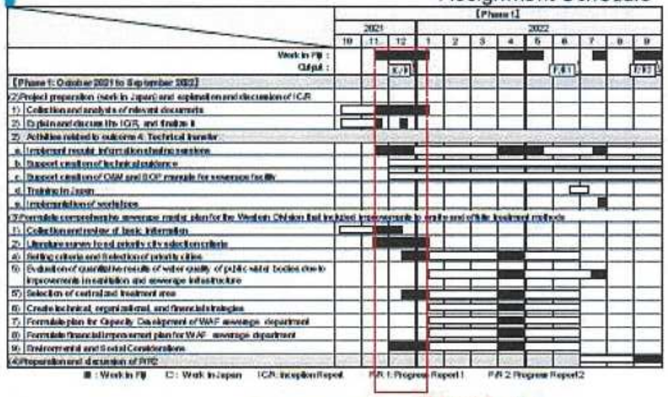
12

5

ANNEX 1

3. Outline of the Project

Assignment Schedule



We are now here!

1st Field Survey

13

4. Findings in First Field Survey (as of middle of Dec.)

(1) Data Collection

- ✓ Requesting to each authorities

(2) Municipality Council

- ✓ Majority of the town is not connected to WAF pipeline, supported by septic tanks
- ✓ National Building Code limits development of subdivisions without WAF service connections (ex. 20% land space), hindering the Town's development
- ✓ Town Councils are requesting WAF service area expansion

14

4. Findings in First Field Survey (as of middle of Dec.)

(3) Existing Sewerage Facilities

- ✓ 3 out of the 4 existing WWTPs are overloaded, and WAF is considering tentative plans to upgrade all plants to IDEA treatment
- ✓ Many pumping stations lack stand-by pumps; pumps are not replaced according to product life, but repaired and re-stationed until breakdown
- ✓ Pipelines are experiencing deterioration and frequent clogging

Figures from Natabua WWTP site visit
Left: overloaded anaerobic pond
Right: pumps waiting for repair at ME workshop

15

4. Findings in First Field Survey (as of middle of Dec.)

(4) Capacity Development

- ✓ WAF needs increase in :
  - ・Staff number
  - ・Staff's technical skills and sewage-related knowledge
  - ・Financial capacity
  - ・Maintenance equipment
  - ・Safety equipment
  - ・Personal protection equip.
  - ....etc.
- ✓ Wide-range target level (technical officers to technical assistants) is requested by WAF to take technical/safety training
- ✓ Knowledge/skills for proper maintenance is requested to prevent quick breakdown of procured equipment
- ✓ The Dashboard System has been implemented from April 2021 to collect/accumulate/organize records of maintenance and failures

16

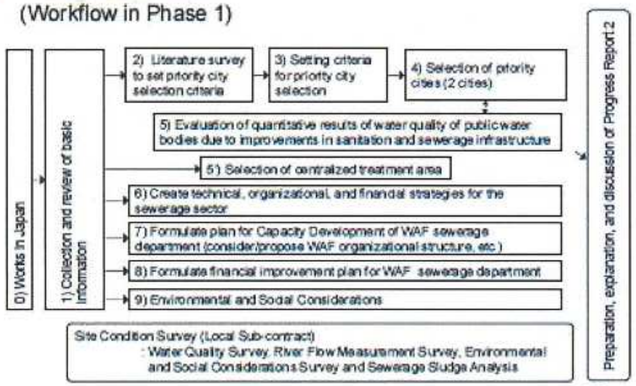
6

ANNEX 1

Output 1

5. Work Plan of the formulation of Regional Wastewater M/P

(Workflow in Phase 1)



17

Output 1

5. Work Plan of the formulation of Regional Wastewater M/P

Draft Criteria and data availability (as of middle of Dec.)

Criteria	Sub-criteria	Data source
Population	Population	Bureau of Statistics
	Population density	Bureau of Statistics
Sanitation	Ratio of waterborne disease	MoHealth and Medical Services
Urban development	Number of tourist	Fiji Hotel & Tourism Association
	No. of hotels/ beds	Fiji Hotel & Tourism Association
	Amount of water usage (Non-domestic)	WAF
Sustainability of sewerage service	Water tariff collection rate	WAF (To be confirmed)
	Average household income	To be confirmed
Water environment	Current water quality	Site survey by JET
	Estimated water quality	Estimated by JET

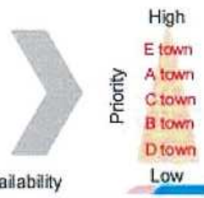
18

Output 1

5. Work Plan of the formulation of Regional Wastewater M/P

Prioritization

Tentative criterion to consider priority
- ✓ Population
- ✓ Sanitation
- ✓ Urban development
- ✓ Sustainability of sewerage service
- ✓ Water environment



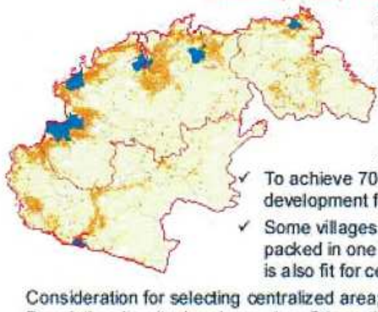
Criterion will be discussed based on data availability

19

Output 1

5. Work Plan of the formulation of Regional Wastewater M/P

Target Municipalities: 1city and 5 towns.
Lautoka, Nadi, Rakiraki, Tavua, Ba ,Sigatoka



Urban, City, Town, Peri-urban	are generally subject to be the target for centralized treatment area
Rural	Areas where decentralized treatment system are generally preferable.

- ✓ To achieve 70% access of centralized treatment, development for rural area is necessary
- ✓ Some villages have many houses densely packed in one area. And surrounding urban area is also fit for centralized area.

Consideration for selecting centralized area;
Population density, Land use plan, Other utility development plan in future

20

7

ANNEX 1

5. Work Plan of the formulation of Regional Wastewater M/P

Output 4

(Capacity Development)

Capacity Evaluation	Implement in collaboration with JET and C/Ps
Setting Goal	Based on the capacity evaluation setting goal
Formulation of Training Plan	Formulate training plan to achieve the goal through collaboration between JET and C/Ps
Preparation of Training Materials	Prepare suitable materials to achieve the goal
Implementation of Training	Implement interactive trainings between JET and C/Ps
Consideration for Improvement	Check the result of the training and consider for improvement

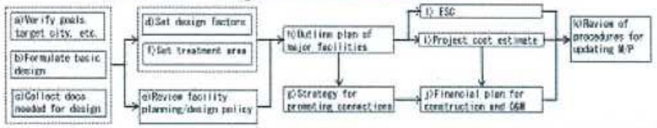
Consultation was made in 1st field survey

21

5. Work Plan of Output 2 and 3

Output 2

1. Formulate Municipal Sewerage M/P for the priority cities identified in the Regional Wastewater M/P



Output 3

2. Formulate Pre-F/S for the priority cities identified in the Sewerage M/P
3. Preparation of Draft Final Report (DF/R) and discussion with Fijian side.
4. Preparation and submission of Final Report (F/R)

22

6. Tentative Programs for Capacity Development

- ✓ Discussion between WAF(Central and Western) and JET, during 1st field survey.
- ✓ Modified Training Category and program are confirmed
- ✓ Based on further discussion with JICA HQ and Fukuoka city, Program will be fixed

	Training Category	Program	Training method	Target
1	Sewerage Works Management	Management of Sewerage Works	L&D	Management level of DWS and WAF
		Public Awareness		
2	Planning/ Design	Planning	L&D OJT	Planning and design staff of WAF (and DWS)
		Sewer Networks Design		
		WWTP Design		
3	Project Management	Budget Management	L&D	Staff of WAF relating to water and sewerage project
		Schedule Management		
		Stakeholder Management		

Items in red was added

23

6. Tentative Programs for Capacity Development

	Training Category	Program		Training method	Target
4	O&M of sewerage facilities	Sewage and Sludge Treatment Technology	Sewage treatment	L&D	Staff of WAF Western relating to O&M of sewerage works
			Sludge treatment		
			Effluent quality management		
		Maintenance of M/E Equipment	Maintenance plan and procedures	L&D	
			Instruction of plan and Procedures	OJT	
		Maintenance of Sewer Pipes	Maintenance plan and procedures	L&D	
			Instruction of plan and Procedures	OJT	
		O&M of WWTP	O&M plan of WWTP	L&D	
			Daily inspection of WWTP	L&D, OJT	
			Water quality analysis	L&D, OJT	
		Health and Safety	Health and safety plan	L&D, OJT	
			Risk management	L&D, OJT	
			Emergency response	L&D, OJT	

24

8

ANNEX 1

6. Tentative Programs for Capacity Development

	Training Category	Program		Training method	Target
5	Liquid Trade Waste	Laws, Regulations		L&D	Staff of Customer Service Department of WAF
		Regulation procedures		L&D	
6	On-site sanitation	On-site sanitation system (Johkasou)	Laws, Regulation and Standards	L&D	Management level of DWS (and WAF)
			O&M	L&D	
		Farm village drainage works in Japan	Planning and design	L&D	
			O&M	L&D	

Items in red was added

25

6. Tentative Programs for Capacity Development

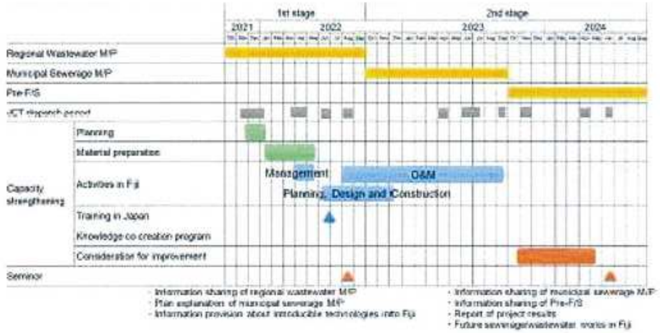
✓ Training in Japan

Date	Schedule (Tentative)
1	Fiji ⇨ Japan (Tokyo)
2	JICA and MoLITT, Fukuoka City (Orientation)
3	E/D of sewerage works of Fukuoka City
4	Site visit to WWTPs
5	Site visit to water quality laboratory
6	E/D of sewer networks in Fukuoka City, Visit to sewer pipe maintenance site
7-8	(Visit Japan)
9	E/D and visit of farm village drainage works E/D and visit of Johkasou system
10	Site visit to feacal sludge (Johkasou sludge) treatment plant
11	Wrap up meeting
12	Visit to Johkasou factory
13	Site visit to a sludge dewatering machine factory and a small diameter pipe jacking machine factory
14	Japan ⇨
15	⇨ Fiji

26

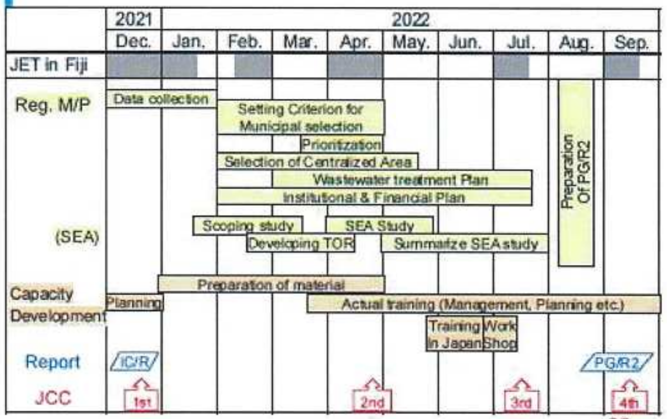
6. Tentative Programs for Capacity Development

✓ Tentative Schedule



27

7. Detailed Schedule in Phase 1



28

9

ANNEX 1

8. Confirmation of JCC Member

Proposed structure of JCC in R/D

Project Team
- Project Director, Permanent Secretary, MIMS
- Project Manager, Chief Executive Officer, WAF
- Personnel from Department of Water and Sewerage, MIMS
- Personnel from Chief Operating Officer, WAF

Technical Committee

Department of Water and Sewerage, MIMS
- Senior Technical Officer Sewerage
- Technical Officer High Grade Sewerage
- Personnel from the Counterpart

WAF
- Chief Operating Officer
- Acting National Manager of Wastewater
- Manager Infrastructure and Service Delivery Western
- Personnel from the Counterpart

Support

JICA Expert Team: JICA Experts, Other Members

Fijian Sides
- Ministry of Waterways and Environment
- Ministry of Economy
- Ministry of Lands and Mineral Resources
- Fiji Bureau of Statistics
- iTaukei Land Trust Board
- Ministry of Local Government
- Municipal Councils
- Provincial Office
- Utility Providers

Japanese Sides
- JICA Fiji Office
- JICA Headquarters

Others
- The Embassy of Japan
- Fukuoka City
- Donors
- Other relevant Organizations

29

8. Confirmation of JCC Member

Modified structure of JCC

Project Team
- Project Director, Permanent Secretary, MIMS
- Project Manager, Chief Executive Officer, WAF
- Personnel from Department of Water and Sewerage, MIMS
- Personnel from Chief Operating Officer, WAF

Technical Committee

Department of Water and Sewerage, MIMS
- Senior Technical Officer Sewerage
- Technical Officer High Grade Sewerage
- Personnel from the Counterpart

WAF
- Chief Operating Officer
- Acting National Manager of Wastewater
- Manager Infrastructure and Service Delivery Western
- Personnel from the Counterpart

Support

JICA Expert Team: JICA Experts, Other Members

Fijian Sides
- Ministry of Waterways and Environment
- Ministry of Economy
- Ministry of Lands and Mineral Resources
- Ministry of Housing and Community Development
- Ministry of Health and Medical Services (Central Board of Health: CBH)
- Fiji Bureau of Statistics
- iTaukei Land Trust Board
- Ministry of Local Government
- Municipal Councils
- Provincial Office
- Utility Providers

Japanese Sides
- JICA Fiji Office
- JICA Headquarters

Others
- The Embassy of Japan
- Fukuoka City
- Donors
- Other relevant Organizations

30

9. Closing Remarks

Closing Remark from

Mr. Mohammed Nistar Khan	Director Water and Sewerage Department of Water and Sewerage Ministry of Infrastructure and Meteorological Services
Ms. Amaike Mayumi	Resident representative, JICA Fiji Office

31

10

Annex 2

List of Modified Members of Joint Coordination Committee

(1) Project Team
1) Project Director, Permanent Secretary, MIMS
2) Project Manager, Chief Executive Officer, WAF
3) Members

The Fijian side

- MIMS
  - Director Water and Sewerage, Department of Water and Sewerage
  - Senior Technical Officer Sewerage, Department of Water and Sewerage
  - Technical Officer High Grade Sewerage, Department of Water and Sewerage
- WAF
  - Chief Operating Officer
  - Acting National Manager of Wastewater
  - Manager Infrastructure and Service Delivery Western

The Japan side

- Members of JICA Mission
- JICA Experts
- Others whom are to be agreed by the Counterpart and JICA

(2) Other members from Fijian side
1) Representatives of other relevant organizations

- Ministry of Waterways and Environment
  - Department of Environment
- Ministry of Economy
  - Budget & Planning Division
- Ministry of Lands and Mineral Resources
- Fiji Bureau of Statistics
- iTaukei Land Trust Board
- Ministry of Local Government
  - Department of Town Planning
  - Department of Local Government
- Municipal Councils
  - Lautoka City
  - Nadi Town
  - Ba Town
  - Sigatoka Town

11

Annex 2

- Tavua Town
- Rakiraki Town

· Provincial Office
- Ba Provincial Council
- Ra Provincial Council
- Nadroga-Navosa Provincial Council

· Utility Providers
- Fiji Roads Authority
- Energy Fiji Limited
- Telecom Fiji Limited

NEW MEMBER
· Ministry of Housing and Community Development
· Ministry of Health and Medical Services (Central Board of Health: CBH)

(3) Other members from Japanese side
· Chief Representative, representative and staff of JICA Fiji Office
· Staff from JICA Headquarters and other offices
· Staff from the Fukuoka city
· Staff from Embassy of Japan

(2) 2nd JCC on July 22nd, 2022

Minutes of Meetings
on
The Second Joint Coordinating Committee
For
Project for Formulation of Wastewater Treatment Master Plan in Western Division (1st Phase)
Agreed upon between
Ministry of Infrastructure & Meteorological Services
and
Water Authority of Fiji
and
Japan International Cooperation Agency

The Second Joint Coordinating Committee (hereinafter referred to as "JCC") for the Project for Formulation of Wastewater Treatment Master Plan in Western Division (1st Phase) (hereinafter referred to as "the Project") was convened on 22nd July 2022 by the chairperson of the JCC and others.
As a result of the discussions, both sides understood and agreed upon on the matters referred to in the document attached hereto.

Suva, July 22nd, 2022

Mr. Taitusi VAKADRAVUYACA
Permanent Secretary
Ministry of Infrastructure &
Meteorological Services

Mr Seru Soderberg
Chief Operating Officer
Water Authority of Fiji

Ms. Mayumi AMAIKE
Resident Representative
JICA Fiji Office

中嶋 宜信
Mr. Yoshinobu NAKAJIMA
Team Leader
JICA Expert Team

1

ATTACHED DOCUMENTS

1. Target Year and Future Population

The JICA Expert Team (hereinafter referred to as "JET") explained the target year and future population based on the attached ANNEX 1. JCC had no objection to it.

- Target year: 2036
- Future Population in 2036 (entire of Fiji): 1.0 million persons
- Future population in 2036 (Western division): 380 thousand persons
- Future population in 2036 (Served population in western division): 266 thousand persons

2. Wastewater Flow

JET explained the estimation of the amount of wastewater flow generated in proposed sewerage service area based on the attached ANNEX1. Amount of wastewater in the target year 2036 is estimated as shown in the table below. JCC had no objection to it.

Municipals	Wastewater Flow: Average Dry Weather Flow	
	(m^3/day)	(Equivalent Population)
Nadi	31,500	156,500
Lautoka	31,000	154,900
Ba	9,000	44,600
Tavua	3,500	17,300
Rakiraki	2,500	10,200
Sigatoka	6,000	28,000

Note: Values in m3/day column is rounded up

3. Treatment Process Assessment

JET assessed applying three treatment methods (Lagoon, Aerated Lagoon, and Mechanical treatment method of IDEA& OD). Regarding the treatment of the septage, leachate from mechanical dewatering will be treated together at the WWTP in JET's proposal. Also storage facility for 20 years of generated sludge will be proposed from JET considering current situation that any landfill site does not receive treated sewage sludge. JET explained that it is necessary to secure a disposal/landfill site for treated sewage sludge because the storage facility for generated sludge occupies a large area.

JCC had no objection to it except for treatment process assessment.

DWS-MIMS requested to add the treatment process of Moving Bed Biofilm Reactor (here in after MBBR) into the process assessment by JET. JET explained that MBBR process will be included in process assessment in municipal sewerage master plan in 2nd phase.

2

4. **Estimation of Construction and O/M Cost**
JET explained the construction and O/M costs of the facilities required in each municipal. JET has been requested in advance to include associated costs such as land acquisition costs by the Ministry of Economy (MOE), and JET will modify it based on MOE's request.

5. **Prioritization of Target Municipalities in Western division**
JET explained the method and results of prioritization for sewerage development in Western division based on the attached ANNEX 1. JCC had no objection to it.
   - 1st: Lautoka, 2nd: Nadi, 3rd: Ba, 4th: Rakiraki, 5th : Sigatoka, 6th: Tavua

6. **Implementation Schedule**
JET explained the implementation schedule for the sewerage development in Western division. And Case 0 of implementation schedule aiming to achieve the target mentioned National Development Plan's (herein after NDP) until 2036 is considered as unfeasible due to overlapping of many construction works period in Western division. Instead of case 0, JET proposed Case 1 avoiding the overlapping of construction works period as a feasible schedule. Based on the schedule of Case 1, the achievement of NDP's target is estimated to be 2053, and the access ratio to centralized system in 2036 is estimated to be 34%. JCC had no objection to it.

7. **Alternative Target for 70% access**
JET proposed to achieve 70% by improvement of the access rate to centralized system and the improvement of the implementation rate of regular desludging of septage from septic tank, which is a typical decentralized treatment facility in current situation. Centralized access population rate will contribute 34 % and the improvement of decentralized system by implementation of regular desludging will contribute 36%.
JCC had no objection to it.

8. **Decentralized System**
JET presented current septage collection system and future suggestions for commencement of regular desludging with assumption of bailed amount of septage to 2 WWTPs. Many steps are required to carry out regular desludging, and it will take about five years to launch actual regular desludging by JET's assumption. The team also provided suggestions for future improvement based on the decentralized treatment of graywater. JCC had no objection to it.

3

ANNEX 1: Project for Formulation of Wastewater Treatment Master Plan in Western Division (1st Phase), July 22nd, 2022, JICA Expert Team

ANNEX 1

PROJECT FOR FORMULATION OF WASTEWATER TREATMENT MASTER PLAN IN WESTERN DIVISION
(1st Phase)

Joint Coordination Committee (2nd)

22th July 2022

JAPAN INTERNATIONAL COOPORATION AGENCY (JICA)

Nihon Suido Consultants Co., Ltd.
Yachiyo Engineering Co., Ltd.

1

Agenda of 2nd JCC and Main Purpose

1. Opening Remark (Mr. Ifraaz ALI, Engineer, Planning and Design, Wastewater Department, WAF)
2. Explanation of Progress of Regional Wastewater Master Plan
   1) Purpose of Regional Wastewater M/P in Western Division
   2) Target Year , 3)Future Population
   4) Centralized System , 5) Prioritization for Sewerage System Development
   6) Proposed Implementation Schedule , 7) Alternative Target
   8) Decentralized System, 9) Summary
3. Remaining Schedule of 1st Phase
4. Discussion/ Q&A
5. Closing Remark (Mr. Josaia KOROILAVESAU, Acting Manager, Wastewater Department, WAF)

Main Purpose

- ✓ Sharing the progress and contents with JCC member
- ✓ Confirm basic agreement of the contents

2

1. Background

Background and Introduction

- The Master Plans needs to be developed as a guiding document to lead the upgrade of the western wastewater sector in the study area which are in line with forecast developments in order to meet Fiji's National Development Plan.
- This Master Plan will outline the essential projects and will be structured to identify constraints and gaps to ensure the improvement of WAF's wastewater services.

3

1. Background

✓ Strategic improvement of the sewerage infrastructure of the Western Division of Fiji is requested

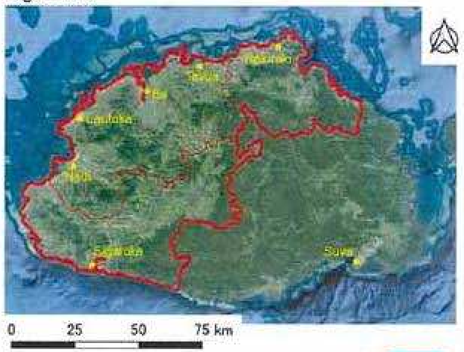
- Regional Wastewater M/P
- Municipal Sewerage M/P for Priority Cities in the Western Division
- Pre-F/S for the Priority Projects

4

ANNEX 1

2. Outline of the Project

Target Area



5

2. Outline of the Project

Output 1	A Regional Wastewater M/P that includes centralized and decentralized wastewater treatment systems for the Western Division of Viti Levu Island of Fiji (Wastewater treatment Master Plan in Western Division) will be formulated.
Output 2	Municipal Sewerage M/P in priority cities and/or towns identified in the Regional Wastewater M/P will be formulated. (2 cities)
Output 3	A Pre-F/S including sludge management for priority sewerage project(s) selected in the Municipal Sewerage M/P will be conducted.
Output 4	Capacity on sewerage management of WAF and relevant agencies will be strengthened.

Overall objective
- Encourage treatment capacity improvement and facility expansion
- Contribute to improvement of sanitation and water environment

6

2. Outline of the Project

Project Phasing

		2021	2022			2023				2024			
Main Contents		1st Year				2nd Year				3rd Year			
		1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
Output 1	Regional Wastewater M/P												
Output 2	Municipal Sewerage M/P												
Output 3	Pre-F/S												
Output 4	Capacity Development on sewerage management												
Report		▲ IC/R			▲ PG/R				▲ IT/R			▲ DF/R	▲ F/R

Phase 1 Phase 2

7

2. Outline of the Project

Difference between Regional Wastewater M/P and Municipal Sewerage M/P

M/P	Contents
Regional Wastewater M/P <Conceptual and Strategic> 2021 Oct. - 2022 Sep.	Target area: Entire Western division Target service: Centralized system and Decentralized system • Selection of centralized treatment area • Quantitative evaluation of water quality by developing wastewater treatment • Prioritization of towns in western division by quantified criterion • Implementation schedule to achieve 70% of centralized treatment access by 2036 • Strategic plan of centralized and decentralized system • Regional-wide strategic environmental assessment
Municipal Sewerage M/P <Practical and Specific> 2022 Oct. - 2023 Sep.	Target area: 2 prioritized towns Target service: (centralized) sewerage system • Setting service area • Estimation of wastewater flow • Outline design of facility(Collection network, pumping station and WWTP) • Town-level environmental and social consideration • Implementation plan • Cost estimation for entire service area

8

ii

ANNEX 1

3. Outline of draft Regional Wastewater M/P

9

3-1. Purpose of Regional Wastewater M/P in Western Division

✓ To clarify the required facilities to achieve 70% population of centralized treatment access mentioned in National Development Plan (2017-2036).
✓ To contribute to improvement of sanitation and water environment through the development/improvement of centralized system and decentralized system.

3-2. Target Year

✓ National Development Plan (2017-2036): 2036
✓ Target Year for this Regional Wastewater M/P is set 2036.

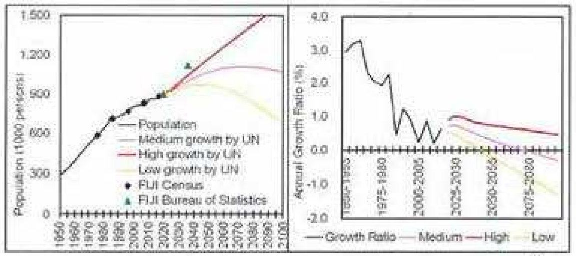
-> Capacity of facility (WWTPs) is estimated considering future population in 2036.

10

3-3. Future Population

(1) National level

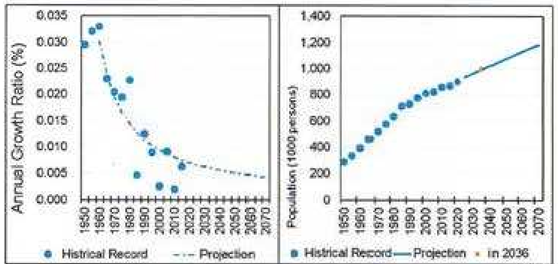
✓ Fiji Bureau of Statistics estimation 1.12 million in 2036.
✓ Population increase from 1990 to 2020 become slowly



11

3-3. Future Population

(1) National level
✓ Population projection for this project is feasible considering past historical trend.
✓ Projected population in 2036: 998 thousand -> **1.0 million**



12

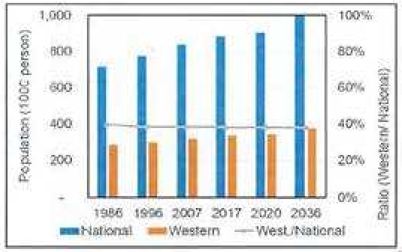
iii

ANNEX 1

3-3. Future Population

(2) Divisional level

- ✓ Historical trend of Western division: Increase moderately
- ✓ Ratio (Western/ National): keeping around 38%
- ✓ Projected population in Western Division: **380 thousand** in 2036



Target Sewerage population

70% of 380,000

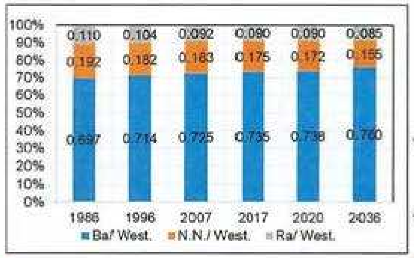
266,000 persons

13

3-3. Future Population

(3) Provincial level

- ✓ Historical trend: Ratio of Ra and Nadroga Navosa decreasing moderately, Ba increasing moderately
- ✓ Ratio: Ba 76.0%, Nadroga Navosa: 15.5% and Ra 8.5% in 2036



(8.5%) 32,300

(15.5%) 58,900

(76.0%) 288,800

(100%) 380,000

14

3-3. Future Population

(3) Provincial level

- ✓ Ratio of Urban, Peri-Urban and Rural in 2036: applying the ratio by Fiji Bureau of Statistic

2017

Province / type	Ba	Nadroga Navosa	Ra	sub-total	Ratio
Urban	61,662	1,533	1,672	84,867	25.2%
Peri-Urban	85,145	8,976	4,292	98,413	29.2%
Rural	80,878	48,431	24,452	153,761	45.6%
sub total	247,685	58,940	30,416	337,041	100.0%
Ratio	73.5%	17.5%	9.0%	100%	

2036

Province / type	Ba	Nadroga Navosa	Ra	sub-total	Ratio
Urban	113,800	1,900	2,100	117,800	31.0%
Peri-Urban	143,400	13,400	6,600	163,400	43.0%
Rural	31,600	43,600	23,600	98,800	26.0%
sub total	288,800	58,900	32,300	380,000	100.0%
Ratio	76.0%	15.5%	8.5%	100%	

Bureau of Statistic

set in previous slide

15

3-3. Future Population

(4) District (Tikina) level

Province	Tikina	Population 2017	Population 2036	Urban	Peri-Urban	Rural
Ba	Ba	39,572	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	4,896	[illegible]	-	-	[illegible]
	Nadi	59,717	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	-	-	870
	[illegible]	16,321	[illegible]	-	[illegible]	[illegible]
	Tavua	23,266	[illegible]	[illegible]	[illegible]	[illegible]
	Vuda	99,264	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	-	-	[illegible]
	sub-total	247,685	[illegible]	[illegible]	[illegible]	[illegible]
Ra	[illegible]	[illegible]	[illegible]	-	-	[illegible]
	[illegible]	[illegible]	[illegible]	-	-	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	-	[illegible]	[illegible]
	sub-total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nadroga Navosa	[illegible]	[illegible]	[illegible]	-	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	-	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	-	-	[illegible]
	[illegible]	[illegible]	[illegible]	-	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	-	-	[illegible]
	[illegible]	[illegible]	[illegible]	-	-	[illegible]
	[illegible]	[illegible]	[illegible]	-	-	[illegible]
	sub-total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Grand total (western region)		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

<Target>
70% of
380,000
->266,000

16

iv

ANNEX 1

3-4. Centralized System

(1) Sewerage Service Area

1) Basic Concept to considering Sewerage Service Area

✓ Following area should be covered

50% Coverage
- All of "Urban" area
- Part of "Peri-Urban" area (Currently high density of buildings)

20% Coverage
- Remaining part of "Peri-Urban"
- Part of "Rural" area laying side by side with "Urban" and "Peri-Urban" (Currently high density of buildings)

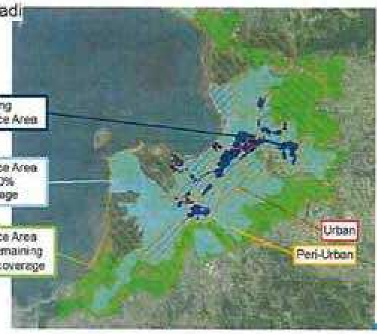
✓ Sewerage service area is within water supply service area

17

3-4. Centralized System

(1) Sewerage Service Area

2) Nadi



18

3-4. Centralized System

(1) Sewerage Service Area

3) Lautoka

19

3-4. Centralized System

(1) Sewerage Service Area

4) Ba

20

ANNEX 1

3-4. Centralized System
(1) Sewerage Service Area

5) Sigatoka

21

3-4. Centralized System
(1) Sewerage Service Area

6) Tavua

22

3-4. Centralized System
(1) Sewerage Service Area

7) Rakiraki

23

3-4. Centralized System
(2) Wastewater Flow Estimation for 6 municipals

1) Summary of Unit Wastewater Flow

- ✓ Domestic wastewater flow is uniform for each municipals
- ✓ Non-domestic ratio varies depend on actual water consumption

Item	Unit	Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka
Domestic water usage	L/day/capita	220	220	220	220	220	220
Return Ratio	%	90	90	90	90	90	90
Domestic wastewater unit flow	L/day/capita	200	200	200	200	200	200
Non-domestic ratio	%	40	45	30	20	30	80
Infiltration ratio	%	10	10	10	10	10	10

24

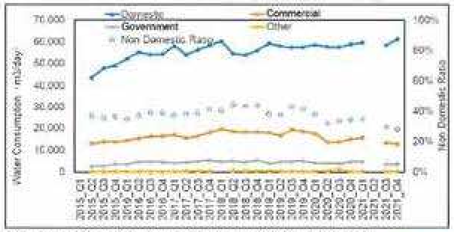
vi

ANNEX 1

(2) Wastewater Flow for 6 municipals

2) Historical water use

- ✓ Domestic water use rise moderately even though 2020
- ✓ Non-domestic water use decrease from Q3 in 2019
- ✓ Latest condition of domestic use -> 2021
  non-domestic use -> 2019



Non-domestic Ratio = (Commercial + Government + Other) / Domestic

25

(2) Wastewater Flow for 6 municipals

3) Confirmation of actual domestic water use in Q1/2021

- ✓ Domestic water consumption: 190 to 252 L/day/capita
- ✓ 6 municipals average: 236 L/day/capita
- ✓ WAF apply 220 L/day/capita for water consumption
  (And 90 % will be counted as unit wastewater flow)
- ✓ 220 L/day/capita is feasible value → Applying for master plan

Municipal	Revenue water		No. of connection	Person in 1 connection	Unit water consumption
	(m^3/ 3 months)	(m^3/ day)	(Connection)	(Capita/Connection)	(L/day/capita)
Nadi	1,993,236	22,147	19,713	4.5	0.250
Lautoka	1,778,871	19,765	17,436	4.5	0.252
Ba	677,151	7,524	8,321	4.5	0.201
Tavua	237,936	2,644	2,841	4.5	0.207
Rakiraki	154,442	1,716	2,006	4.5	0.190
Sigatoka	399,114	4,435	4,564	4.5	0.216
Total	5,240,750	58,231	54,881	4.5	0.236

26

(2) Wastewater Flow for 6 municipals

4) Confirmation of actual non-domestic water use in 2019

- ✓ Non-Domestic ratio: 20 to 60 %

No	Category		Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka	Remark
1	Domestic	m^3	22,110	19,648	7,042	2,596	1,869	4,797	
2	Commercial	m^3	8,007	5,895	1,363	202	371	2,274	
3	Government	m^3	801	2,535	471	218	174	529	
4	Other	m^3	352	37	123	0	6	1	
5	Total	m^3	31,271	28,114	8,999	3,016	2,420	7,601	1+2+3+4
6	Actual Non-domestic ratio	%	41.4	43.1	27.8	16.2	29.5	58.5	(2+3+4)/1
7	Non-domestic ratio	%	40	45	30	20	30	60	(Round)

Non-domestic Ratio = (Commercial + Government + Other) / Domestic

27

(2) Wastewater Flow for 6 municipals

5) Wastewater Flow in 2036

No	Item	Unit	Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka
1	Population		101,600	97,100	31,200	13,100	7,100	15,900
2	Water Consumption	m^3/capita/day	0.220	0.220	0.220	0.220	0.220	0.220
3	Return Ratio	%	90	90	90	90	90	90
4	Unit wastewater Flow	m^3/capita/day	0.200	0.200	0.200	0.200	0.200	0.200
5	Domestic Flow	m^3/day	20,320	19,420	6,240	2,620	1,420	3,180
6	Non-Domestic Ratio	%	40	45	30	20	30	60
7	Non-Domestic Flow	m^3/day	8,128	8,739	1,872	524	426	1,908
8	Generated Wastewater	m^3/day	28,448	28,159	8,112	3,144	1,846	5,088
9	Infiltration ratio	%	10	10	10	10	10	10
10	Infiltration water	m^3/day	2,845	2,816	811	314	185	509
11	Total Inflow ADWF	m^3/day	31,293	30,975	8,923	3,458	2,031	5,597
		EP	156,500	154,900	44,600	17,300	10,200	28,000
12	Total Inflow PDWF	m^3/day	62,586	61,950	17,846	6,917	4,061	11,194
13	Total Inflow PWWF	m^3/day	156,464	154,875	44,616	17,292	10,153	27,984

28

vii

ANNEX 1

5. Treatment Process Assessment

Target Water Quality Standards
- ✓ General Standards
- ✓ Specific Ecological Zone Standards

Parameter	Units	General Standards	Significant Ecological Zone
BOD5	mg/L	40	20
SS		60	30
TDS		1000	1000
Grease		5	2
T-N		25	10
T-P		5	2
E.coli	c/100mL	400	200

29

3-4. Centralized System

Target Water Quality Standards

- ✓ Application of SEZ in current/future WWTP outfall → Waiting for DOE
- ✓ Set assumption of TWQ based on outfall water body
  - ✓ Large Water Bodies: Bays, Ocean ➡ General Standards
  - ✓ Small Water Bodies: Rivers ➡ SEZ Standards
- ✓ WWTPs yet to be built (sites undecided) ➡ SEZ Standards

WWTP (Municipality)	Outfall	Target Water Quality Standard
Navakai (Nadi)	Naci River	SEZ
Natabua (Lautoka)	Ocean (1.2km out to sea)	General
Votua (Ba)	Waterway in mangrove thicket	SEZ
Tavua	Undecided	SEZ
Rakiraki	Undecided	SEZ
Olosara (Sigatoka)	Mouth of Sigatoka River	General

30

3-4. Centralized System

Basic Treatment Process Categories
1. Lagoon
2. Aerated Lagoon
3. Mechanical Treatment
   - ・IDEA method, Oxidation Ditch(OD) method

Fields	Lagoon	Aerated Lagoon	Mechanical Treatment
Treated Water Quality (General)	✓	✓	✓
Treated Water Quality (SEZ)	×	×	✓
Simplicity of O&M	✓	○	×
Economic Efficiency (Electricity, O&M)	✓	○	×
Footprint	×	○	✓

✓:Good ○:Moderate ×:Poor

31

3-4. Centralized System

Sewerage Treatment with Septage
- ✓ Three Options:

A. Treat septage at a completely different site
・Lagoon → Mechanical Dewatering → Sun-drying)

B. Treat septage at WWTP(separate treatment)
・Mechanical Dewatering
→ Leachate: Co-treat with sewerage
→ Dewatered Sludge: Sun-drying

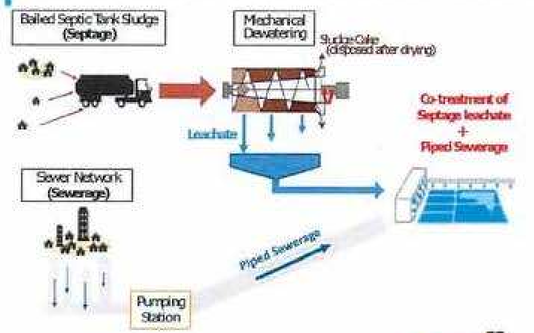
C. Treat septage at WWTP (co-treatment)

32

viii

ANNEX 1

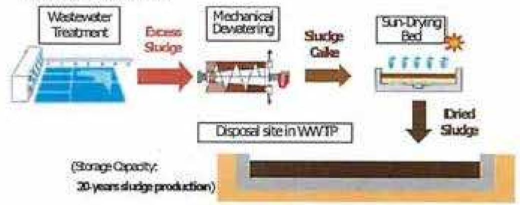
3-4. Centralized System: Sewerage+Septage Treatment



33

3-4. Centralized System: Sewerage+Septage Treatment

- Currently, there are no disposal sites that accept treated sludge generated from WWTPs
- Following WWTP footprints/construction costs include sludge disposal sites made within the WWTP, in case the above situation continue



3-4. Centralized System: Footprint Estimations

WWTP (municipal)	Target Water Quality	Treatment Method	Water Quality Standard	WWTP Footprint (ha)	Sludge Disposal Site (ha)
Navakai (Nadi)	SEZ	OD/IDEA	General/SEZ	20.5	11.5
Natabua (Lautoka)	General	Stabilization Pond	General	72.5	4.2
		Aerated Lagoon	General	49.2	4.2
		OD/IDEA	General/SEZ	22.7	11.8
Vuda (Ba)	SEZ	OD/IDEA	General/SEZ	8.2	3.4
Tavua	SEZ	OD/IDEA	General/SEZ	4.0	1.8
Rakiraki	SEZ	OD/IDEA	General/SEZ	4.1	1.6
Olosara (Sigatoka)	General	Stabilization Pond	General	13.9	1.2
		Aerated Lagoon	General	11.5	1.2
		OD/IDEA	General/SEZ	8.7	2.8

3-4. Footprint Example: Lautoka (Stabilization Pond)

ix

ANNEX 1

3-4. Footprint Example: Lautoka (Aerated Lagoon)

3-4. Footprint Example: Lautoka (OD/IDEA)

38

3-4. Footprint Example: Rakiraki (OD/IDEA)

39

Cost Estimation for sewerage facilities

(1) Assumptions for costing

- ✓ Basically, the outline construction cost for civil portion is estimated by multiplying the outline quantity by the unit price.
- ✓ For the main items of civil work, unit price is set with reference in Fijian cost, and for the unit price that is difficult to obtain, adopt the unit price referring to the case of Japan and other countries.
- ✓ Mechanical Electricity(M/E) costs are estimated based on the ratio of civil costs to M/E costs in Japan.
- ✓ Land acquisition costs for wastewater treatment plants are not included.
- ✓ Unit prices are before Covid-19 pandemic and 2022 Russian invasion of Ukraine.
- ✓ Consultant fees are not included.
- ✓ Price escalation, physical contingency, are not included.

To be modified
<Associated cost will be included based on MOE's comment>

40

ANNEX 1

3-4. Centralized System

(2) Construction cost for WWTPs

- ✓ Cost estimation: 4 process (Stabilization pond, Aerated lagoon, OD and IDEA)
- ✓ IDEA becomes Highest cost, Stabilization pond is lowest

WWTP (Municipal	Treatment Process	Design Flow (m3/day)	Construction Cost (million FJD)	Reference (k JPY/m3)
Navakai (Nadi)	IDEA	35,200	303	516
Natabua (Lautoka)	Stabilization Pond	34,100	177	310
	IDEA		293	517
Votua (Ba)	Stabilization Pond	9,900	63	381
	IDEA		104	632
Tavua	Stabilization Pond	4,400	24	331
	IDEA		47	639
Rakiraki	Stabilization Pond	3,300	19	337
	IDEA		35	636
Olosara (Sigatoka)	Stabilization Pond	6,600	33	300
	IDEA		70	638

- ✓ Japanese price level: around 500 to 600 kJPY/m3 (cost/ design flow)
- ✓ Cost estimation of WWTP in Rakiraki M/P is around 700 kJPY/m3
- ✓ Detailed comparison of cost will be conducted in Municipal Sewerage M/P

To be modified. Cost for Stabilization Pond will be added based on the comment from MOE

41

3-4. Centralized System

(3) O/M cost for WWTPs

- ✓ OD/IDEA: Applying Japanese O/M cost function estimated from design flow
- ✓ Stabilization pond: Estimation of electricity power consumption

WWTP (Municipal	Treatment Process	Design Flow (m3/day)	O/M Cost (k FJD/y)
Navakai (Nadi)	IDEA	35,200	3,540
Natabua (Lautoka)	Stabilization Pond	34,100	1,529
	IDEA		3,460
Votua (Ba)	Stabilization Pond	9,900	582
	IDEA		1,740
Tavua	Stabilization Pond	4,400	281
	IDEA		1,090
Rakiraki	Stabilization Pond	3,300	229
	IDEA		920
Olosara (Sigatoka)	Stabilization Pond	6,600	379
	IDEA		1,380

42

3-4. Centralized System

(4) Construction cost for collection system

- ✓ Huge length of collection network is requested to collect 70% population
- ✓ Length of sewer includes trunk line, branch line and lateral sewer.
- ✓ House connection is not included

	Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka
Total Length (km)	1,730	1,042	587	170	130	236
Total Amount (kFJD)	1,423,051	856,462	482,814	118,371	91,048	193,454
Average Unit Price (FJD/m)	820	820	820	700	700	820

- ✓ Cost estimation of sewer network in Rakiraki M/P is around 670 FJD/m
- ✓ Part of the network in Nadi, Lautoka and Ba have large diameter, resulting higher average unit price.

43

3-4. Centralized System

(5) O/M cost for collection system

- ✓ Actual O/M cost for collection system is not available
- ✓ Unit cost for collection system in Japan is applied for reference.
- ✓ O/M expenditure includes inspection, cleaning of sewer and small repairment work.

	Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka
Total Length of gravity sewer (km)	1,380	833	470	136	104	188
Unit cost (FJD/m)	1	1	1	1	1	1
Average Unit Price (kFJD/yr)	1360	833	470	136	104	188

44

xi

3-4. Centralized System
(6) Construction cost for pumping stations

- ✓ Outline design for collection network, such as hydraulic calculation and longitudinal design, is not conducted in the regional wastewater M/P.
- ✓ Assumption based on the actual number of pumping station and length of sewer network.

Division	System	Length of sewer (m)	No. of pumps	Length / pumps
Central	Kinoya	425,277.28	89	4,778
	ACS	756.07	1	756
	Wailada	1,711.97	1	1,712
	Deuba	39,680.32	13	3,052
	Nandali	4,778.13	5	956
	Naboro	609.54	1	610
Western	Olosara	16,449.96	5	3,290
	Navakai	128,001.09	37	3,459
	Natabua	158,033.35	12	13,169
	Votua	29,999.46	8	3,750
North	Namara	38,250.20	16	2,391
Total		843,547.37	188	4,487

- ✓ Fijian average (total): 1pump for 4.5km
- ✓ In this M/P, 1pump for 13km is applied based on Lautoka record

45

3-4. Centralized System
(6) Construction cost for pumping stations

	Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka
Total Length (km)	1,730	1,042	587	170	130	235
Number of pumps	133	80	45	13	10	18
Total Amount (kFJD)	48,454	29,162	16,440	4,746	3,651	6,587
Average Unit Price (FJD)	364	364	364	364	364	364

(7) O/M cost for pumping stations

- ✓ O/M cost for each municipal is estimated that unit average electric power of 22kW for Nadi and Latutoka, 15 kW for other 4 municipals.

	Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka
Number of pumps	133	80	45	13	10	18
Total Amount (kFJD/yr)	4,489	2,702	1,039	300	231	416

46

3-4. Centralized System
(8) Summary of CAPEX & OPEX

Construction Cost

Item		Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka
WWTPs (million FJD)	IDEA	303	293	104	47	35	70
	S/P	-	177	63	24	19	33
Collection Network (million FJD)		1,423	856	482	118	91	193
Pumping Station (million FJD)		48	29	16	5	4	7
Total (million FJD)	IDEA	1,774	1,178	603	170	130	270
	S/P	-	1,062	562	147	114	233

O/M Cost

Item		Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka
WWTPs (1000 FJD/yr)	IDEA	3,540	3,460	1,740	1,090	920	1,380
	S/P		1,529	582	281	229	379
Collection Network (1000 FJD/yr)		1,380	833	470	136	104	188
Pumping Station (1000 FJD/yr)		4,489	2,702	1,039	300	231	416
Total (1000 FJD/yr)	IDEA	9,409	6,995	3,249	1,526	1,255	1,984
	S/P	-	5,064	2,091	717	564	983

47

3-5. Prioritization for Sewerage System Development

Prioritization

4 Main criterion (7 sub-criterion):
Based on data availability for 6 municipals

- ✓ Population
- ✓ Sanitation
- ✓ Urban development
- ✓ Water environment

: Centralized
: Decentralized

Priority
High
E town
A town
C town
B town
D town
Low

48

ANNEX 1

xii

3-5. Prioritization for Sewerage System Development

Result of Prioritization

	Nadi		Lautoka		Ba		Tavua		Rakiraki		Sigatoka	
	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
Population	55,186	9.1	42,593	9.1	12,658	2.7	8,810	2.7	5,964	2.7	10,028	2.7
Population density	5.1	11.6	11.3	17.8	5.1	11.6	3.0	5.3	1.7	5.3	5.7	11.6
Sanitation	2.34	20.1	0.81	13.1	0.47	6.0	0.65	6.0	0.52	6.0	1.48	13.1
No. of hotels	76	12.7	19	3.8	0	3.8	1	3.8	2	3.8	18	3.8
Non-domestic water usage	9.2	15.8	8.5	15.8	2.0	4.7	0.42	4.7	0.6	4.7	2.8	4.7
Current river water quality	2.6	2.9	8.6	9.8	3.2	6.4	4.49	6.4	3.2	6.4	2.5	2.9
Water Quality Improved ratio	0.13	4.4	0.40	14.7	0.14	9.6	0.18	9.6	0.41	14.7	0.01	4.4
Total		76.6		84.1		44.8		38.5		43.6		43.2

1st Lautoka
2nd Nadi
3rd Ba
4th Rakiraki
5th Sigatoka
6th Tavua

49

3-5. Prioritization for Sewerage System Development

Analytical Hierarchy Method (AHP)

- Method for complex, multi-factor decision making
- Process tangible and intangible data
- Combine judgements of many experts
- INPUT: Simple *pair-wise* comparison survey by questionnaire
- OUTPUT: Importance (*weight*) of each factor

- Total number of questionnaire: 16
- Engineering level: 10, Management level : 6

Criteria	Rating		Sub-Criteria	Rating	Point
Population	0.27	1	Non sewered population	0.34	9.1
		2	Population density	0.66	17.8
Sanitation	0.20	3	Cases of waterborne disease	1.00	20.1
Urban development	0.28	4	No. of hotels	0.45	12.7
		5	Non-domestic water usage	0.55	15.8
Water Environment	0.25	7	Current water quality	0.40	9.8
		8	Estimated water quality	0.60	14.7
	1				100.0

50

3-6. Proposed Implementation Schedule

(1) Assumption for scheduling

- ✓ Each sewerage development projects starts from 2025, just after this M/P project
- ✓ Project will be loan project and
- ✓ International Competitive Bidding (ICB) procedure is considered as below

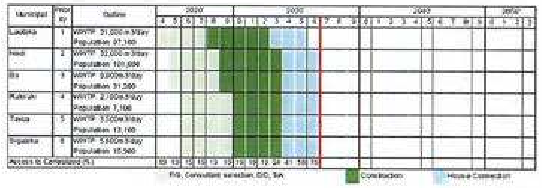
Item	Duration (year)
Feasibility Study	1
Consultant Selection	1
Detailed Design	1
Contractor Selection (Tender Assistant)	1
Construction (Nadi, Lautoka, Ba)	5
Construction (Tavua, Rakiraki, Sigatoka)	4
House connection	3

51

3-6. Proposed Implementation Schedule

(2) Case 0

- ✓ To achieve NDP's target (70% of population access to centralized system until 2036)
- ✓ Many project need to be implemented in parallel



52

ANNEX 1

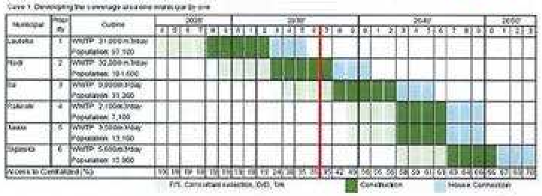
xiii

ANNEX 1

3-6. Proposed Implementation Schedule

(3) Case 1

- ✓ More realistic schedule, construction work does not wrap in each municipal
- ✓ Target will be achieved around 2053
- ✓ Access ratio to centralized system in 2036 is around **34%**



53

3-7. Tentative Achievement of 70%

NDP's target
(70% of population access to centralized system until 2036)

In Case 1
Centralized: 34%
+
Regular desludging
(Decentralized): 36%

- ✓ Currently, regular desludging from septic tank is not implemented in Fiji
- ✓ Necessary for "proper maintenance" and "Reduce the risk of leakage of septage"
- ✓ "Perform regular desludging at intervals of 5 years or less" is set as a definition of "safely managed sanitation service" in this regional wastewater M/P.

54

3-7. Tentative Achievement of 70%

SDG 6.2: Safely managed sanitation service:

- ✓ People should use improved sanitation facilities which are not shared with other households,
- ✓ The excreta produced should either be:
  - Treated and disposed on-site.
  - Stored temporarily and then **emptied and transported to treatment off-site,**
  - Transported through a sewer with wastewater and then treated off-site, and
- ✓ Human waste needs to be safely managed across the entire sanitation service chain.

55

3-7. Tentative Achievement of 70%

56

xiv

3-8. Decentralized System

(3) Septage Collection and Treatment

1) Current situation

✓ Most of septage are bailed to Natabua (Lautoka) WWTP

✓ Septage collection distance varies from province to province

✓ It is an unfair service for residents because the septage desludging fee varies based on the distance

57

3-8. Decentralized System

(3) Septage Collection and Treatment

2) Future (Propose)

✓ 2WWTPs (Natabua and Olosara) receive septage.

✓ New WWTP will be constructed in Lautoka with septage treatment

✓ Regarding to desludging fee, it is necessary to consider measures such as financial support by government

58

3-8. Decentralized System

(3) Septage Collection and Treatment

3) Estimation of amount of bailed septage

Assumption

- Currently, "regular desludging" has not been implemented.
- "Safely managed sanitation service population" will be set to 70% in 2036.
- Commencement of "regular desludging" shall be from 2028 in consideration of the preparation period (5 years from 2023).
- Implementation rate of "regular desludging" (regular desludging population / decentralized population) will increase linearly

Settings for estimation of amount of septage

- Decentralized population = total population - sewered population
- Household size: 4.5 person/ household
- Size of septic tank: 2.0 m3
- Amount of desludging at one time: 2.0m3
- Frequation of desludging (Regular desludging): once every 5 years
- Frequation of desludging (On-call desludging): once every 20 years

59

3-8. Decentralized System

(3) Septage Collection and Treatment

3) Estimation of amount of bailed septage for each WWTPs

✓ Each amount of bailed septage is estimated to be less than 1% of inflow of sewage.

✓ Amount of bailed septage will not affect wastewater treatment extensively.

60

ANNEX 1

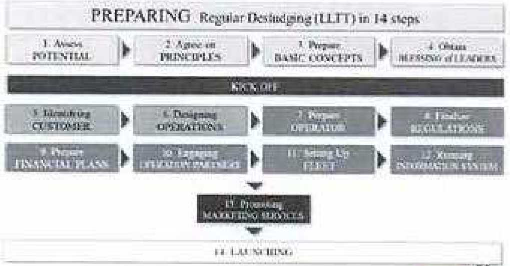
xv

ANNEX 1

3-8. Decentralized System

(4) Preparation for Regular Desludging

- ✓ Various steps are required to start the regular desludging, referring to the cases of other countries, the following 14 steps are required

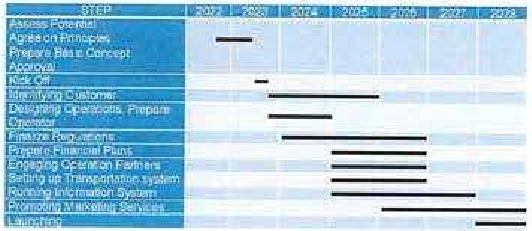


61

3-8. Decentralized System

(4) Preparation for Regular Desludging

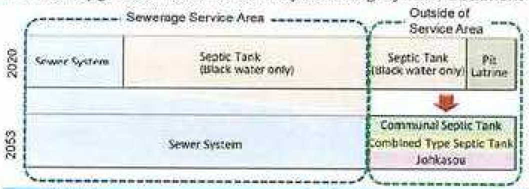
- ✓ To commence regular desludging, it is assumed to be taken 5 years for preparation
- ✓ Several agency need to collaborate for smooth implementation



62

3-8. Decentralized System

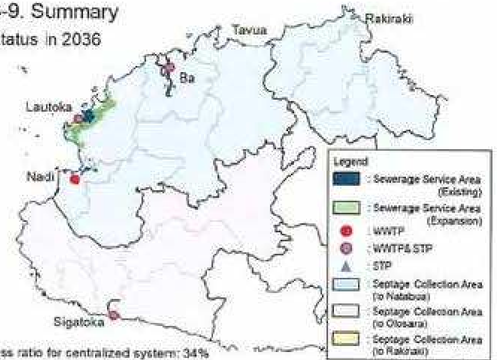
Further Upgrade of Decentralized System for graywater treatment



Process	Adoption
Communal septic tank	➢ Small villages ➢ Low-income communities
Combined (black and graywater) septic tank	➢ Houses to install septic tank newly ➢ Houses to renovate existing black water septic tank ➢ Houses near rivers, ponds and lakes
Aerobic septic tank (Johkasou)	➢ Public facilities such as hospitals and schools ➢ Business offices such as restaurants, shopping malls and factories ➢ Houses facing to environmentally sensitive area ➢ Houses with poor soil drainage/ high ground water level

3-9. Summary

Status in 2036



Access ratio for centralized system: 34%
Safely managed sanitation services: 70%

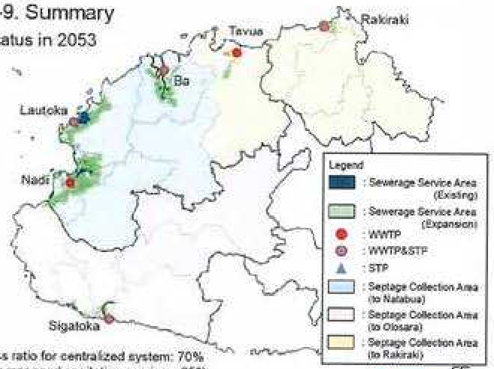
64

xvi

ANNEX 1

3-9. Summary

Status in 2053



Access ratio for centralized system: 70%
Safely managed sanitation services: 85%

65

End of Explanation of Progress of Regional Wastewater Master Plan

Thank you

66

Remaining Schedule of 1st Phase

End of July
- ✓ Workshop to be held on 26th July 2022

August (JET in Japan)
- ✓ Modification of regional wastewater M/P based on the comments
- ✓ On-line meetings with relevant authorities
- ✓ Preparation of Progress Report 2 (draft Regional Wastewater M/P)

September (JET in Fiji: tentative schedule 7th to 20th Sep.)
- ✓ 3rd JCC, Explanation of draft Progress Report 2 (draft Regional Wastewater M/P)
- ✓ Making basic consensus about the contents of draft Regional Wastewater M/P
- ✓ Finalization of Progress Report 2 (Regional Wastewater M/P)

October/November
- ✓ Kick-off of 2nd Phase

67

Reference

68

xvii

(3) 3rd JCC on September 19th, 2022

Minutes of Meetings
on
The Third Joint Coordinating Committee
For
Project for Formulation of Wastewater Treatment Master Plan in Western Division (1st Phase)
Agreed upon between
Ministry of Infrastructure & Meteorological Services
and
Water Authority of Fiji
and
Japan International Cooperation Agency

The Third Joint Coordinating Committee (hereinafter referred to as "JCC") for the Project for Formulation of Wastewater Treatment Master Plan in Western Division (1st Phase) (hereinafter referred to as "the Project") was convened on 19th September 2022 by the chairperson of the JCC and others.
As a result of the discussions, both sides understood and agreed upon on the matters referred to in the document attached hereto.

Suva, September 19th, 2022

Mr. Taitusi VAKADRAVUYACA
Permanent Secretary
Ministry of Infrastructure &
Meteorological Services

Mr Seru Soderberg
Chief Operating Officer
Water Authority of Fiji

Ms. Mayumi AMAIKE
Resident Representative
JICA Fiji Office

中嶋宜信

Mr. Yoshinobu NAKAJIMA
Team Leader
JICA Expert Team

1

ATTACHED DOCUMENTS

The Following topics were explained by JET based on the attached presentation material (ANNEX 1). Following topics were modified based on comments given from several agencies in the 3rd survey, including the Workshop (held in July) and 2nd JCC meeting.
The JCC agreed on the modified contents of the Regional Wastewater M/P, and confirmed the schedule of the project's 2nd phase (formulation of Municipal Sewerage M/P).

1. **Target Year and Future Population**
   Same as the contents in Minutes of Meetings of 2nd JCC.

2. **Wastewater Flow**
   Same as the contents in Minutes of Meetings of 2nd JCC.

3. **Treatment Process Assessment**
   MBBR process will be included in the treatment method assessment of the municipal sewerage master plan in Phase 2, based on DWS-MIMS request.

4. **Estimation of Construction and O/M Cost**
   Construction costs of WWTPs were re-estimated, including the land acquisition costs, based on MOE's request. JCC agreed on it.

5. **Prioritization of Target Municipalities in Western division**
   Same as the contents in Minutes of Meetings of 2nd JCC.

6. **Implementation Schedule**
   Same as the contents in Minutes of Meetings of 2nd JCC.

7. **Alternative Target for 70% access**
   Same as the contents in Minutes of Meetings of 2nd JCC.

8. **Decentralized System**
   Same as the contents in Minutes of Meetings of 2nd JCC.

ANNEX 1: Project for Formulation of Wastewater Treatment Master Plan in Western Division (1st Phase), September 19th, 2022, JICA Expert Team

ANNEX 1

PROJECT FOR FORMULATION OF WASTEWATER TREATMENT MASTER PLAN IN WESTERN DIVISION
(1st Phase)

Joint Coordination Committee (3rd)
19th September 2022

JAPAN INTERNATIONAL COOPORATION AGENCY (JICA)

Nihon Suido Consultants Co., Ltd.
Yachiyo Engineering Co., Ltd.

1

Agenda of 3rd JCC and Main Purpose

1. Opening Remark
2. Explanation of Regional Wastewater Master Plan
   1) Purpose of Regional Wastewater M/P in Western Division
   2) Target Year , 3)Future Population
   4) Centralized System , 5) Prioritization for Sewerage System Development
   6) Proposed Implementation Schedule , 7) Alternative Target
   8) Decentralized System, 9) Summary
3. Schedule of 2nd Phase
4. Discussion/ Q&A
5. Closing Remark

Main Purpose
- ✓ Making basic consensus about the contents of Regional Wastewater M/P

2

1. Activities in 1st Phase

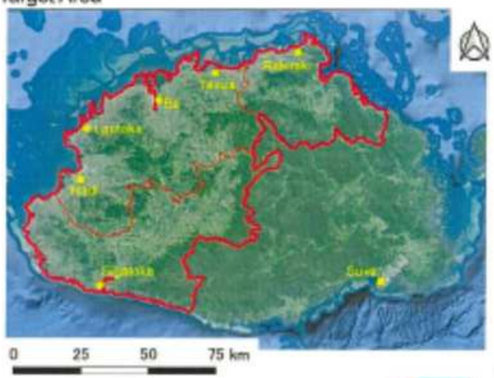
Project Phasing

		2021	2022				2023				2024		
Main Contents		1st Year				2nd Year				3rd Year			
		1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q
Output 1	Regional Wastewater M/P	■	■	■	■								
Output 2	Municipal Sewerage M/P					■	■	■	■				
Output 3	Pre-F/S									■	■	■	■
Output 4	Capacity Development on seweragemanagement	■	■	■	■	■	■	■	■	■	■	■	■
Repot		▲ IC/R			▲ P-F/R				▲ IT/R			▲ DF/R	▲ F/R
		Phase 1				Phase 2							

3

1. Activities in 1st Phase

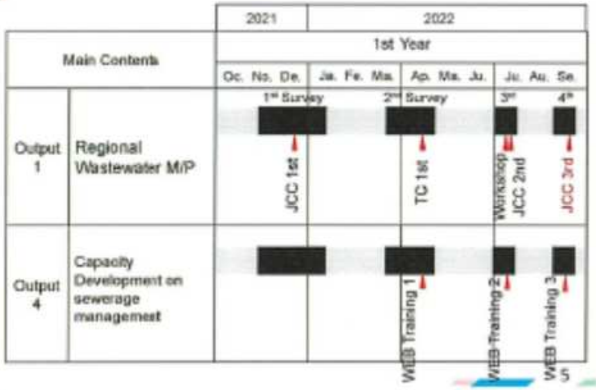
Target Area



4

ANNEX 1

1. Activities in 1st Phase



5

2. Comment on 3rd survey (Meeting & Workshop & JCC)

Agency	Comment
CBH	• Focusing on the Improvement of Basic Sanitation in rural area
MIMS	• MBBR process should be included in selection of treatment process • Regular desludging from septic tanks is difficult considering present condition. Legal system needs to be improved.
MOE	• Land acquisition cost (and associated cost) should be included in construction cost
DOE	• SEZ shall be applied to any discharge to coastal areas, rivers, and streams, which has sensitive environmental characteristics. • In Natabua WWTP, the outfall is located 1.2km to the ocean, which the general standards could apply. • DoE strongly recommends that all projects should first think of avoiding mangroves or any sensitive areas
JCC	• MBBR process should be included in selection of treatment process
Workshop	• Wastewater collection from informal settlements • Consideration and measure for odor from WWTP • Consideration of treated water reuse

Red items is considered in Regional wastewater M/P
Green items will be considered in Municipal Sewerage M/P in 2nd Phase 6

3. Outline of draft Regional Wastewater M/P

3-1. Purpose of Regional Wastewater M/P in Western Division
3-2. Target Year
3-3. Future Population
3-4. Centralized System
3-5. Financial & Economic Analysis
3-6. Prioritization for Sewerage System Development
3-7. Proposed Implementation Schedule
3-8. Alternative Target
3-9. Decentralized System
3-10. Summary

7

3-1. Purpose of Regional Wastewater M/P in Western Division

✓ To clarify the required facilities to achieve 70% population of centralized treatment access mentioned in National Development Plan (2017-2036).
✓ To contribute to improvement of sanitation and water environment through the development/improvement of centralized system and decentralized system.

3-2. Target Year

✓ National Development Plan (2017-2036): 2036
✓ Target Year for this Regional Wastewater M/P is set 2036.

-> Capacity of facility (WWTPs) is estimated considering future population in 2036.

8

ii

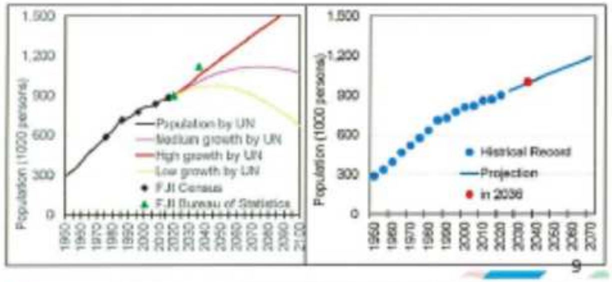
TV SS

ANNEX 1

3-3. Future Population

(1) National level

- ✓ Fiji Bureau of Statistics estimation 1.12 million in 2036.
- ✓ Population projection for this project is feasible considering past historical trend.
- ✓ Projected population in 2036: 998 thousand -> **1.0 million**

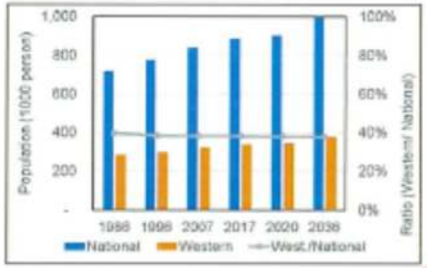


9

3-3. Future Population

(2) Divisional level

- ✓ Historical trend of Western division: Increase moderately
- ✓ Ratio (Western/ National): keeping around 38%
- ✓ Projected population in Western Division: **380 thousand** in 2036



Target Sewerage population

70% of 380,000

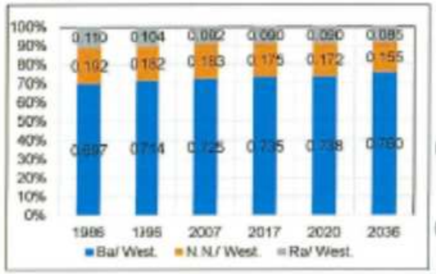
266,000 persons

10

3-3. Future Population

(3) Provincial level

- ✓ Historical trend: Ratio of Ra and Nadroga Navosa decreasing moderately, Ba increasing moderately
- ✓ Ratio: Ba 76.0%, Nadroga Navosa: 15.5% and Ra 8.5% in 2036



(8.5%) 32,300

(15.5%) 58,900

(76.0%) 288,800

(100%) 380,000

11

3-3. Future Population

(3) Provincial level

- ✓ Ratio of Urban, Peri-Urban and Rural in 2036: applying the ratio by Fiji Bureau of Statistic.

	(Ratio)	Ba	Nadroga Navosa	Ra	Total
(Ratio)	-------------	76.0%	15.5%	8.5%	set in the previ slide
Urban	31.0%	113,800	1,900	2,100	117,800
Peri-Urban	43.0%	143,400	13,400	6,600	163,400
Rural	26.0%	31,600	43,600	23,600	98,800
Total	Bureau of Statistic	288,800	58,900	32,300	380,000

12

iii

ANNEX 1

3-4. Centralized System
(1) Sewerage Service Area

1) Basic Concept to considering Sewerage Service Area

✓ Following area should be covered

50% Coverage
- All of "Urban" area
- Part of "Peri-Urban" area
  (Currently high density of buildings)

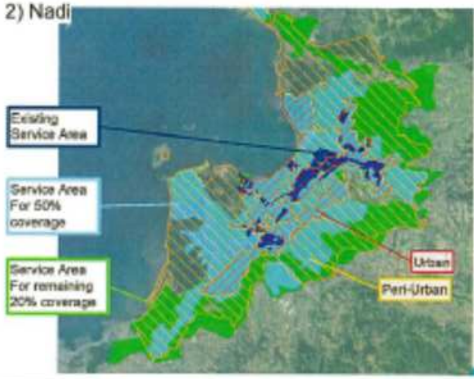
20% Coverage
- Remaining part of "Peri-Urban"
- Part of "Rural" area laying side by side with "Urban" and "Peri-Urban"
  (Currently high density of buildings)

✓ Sewerage service area is within water supply service area

13

3-4. Centralized System
(1) Sewerage Service Area

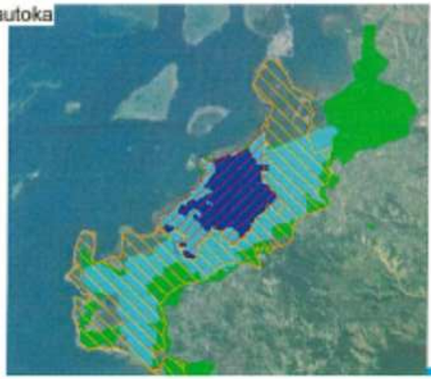
2) Nadi



14

3-4. Centralized System
(1) Sewerage Service Area

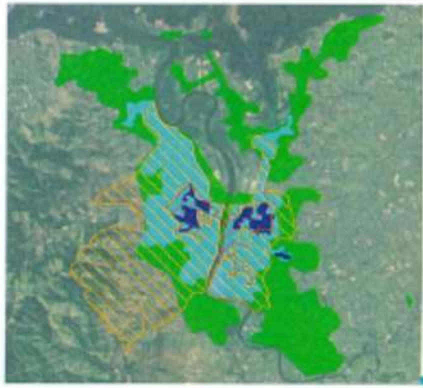
3) Lautoka



15

3-4. Centralized System
(1) Sewerage Service Area

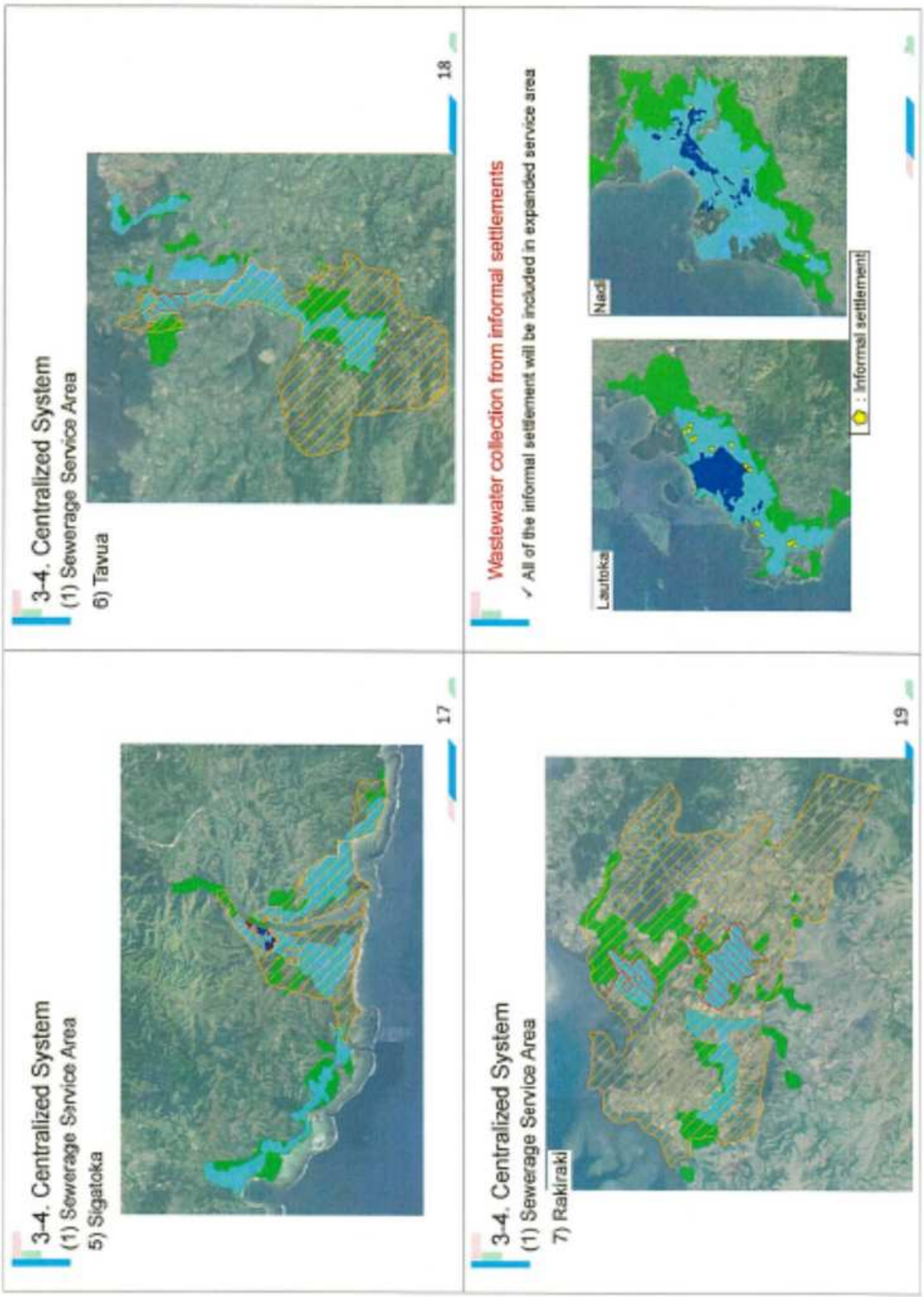
4) Ba



16

iv

ANNEX 1

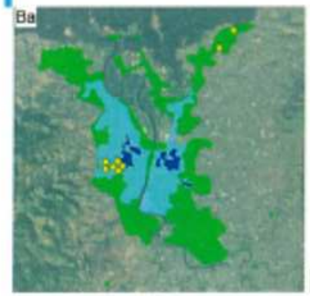

3-4. Centralized System
(1) Sewerage Service Area
5) Sigatoka
17
3-4. Centralized System
(1) Sewerage Service Area
6) Tavua
18
3-4. Centralized System
(1) Sewerage Service Area
7) Rakiraki
19
Wastewater collection from informal settlements
✓ All of the informal settlement will be included in expanded service area
Lautoka
Nadi
: Informal settlement

v

ANNEX 1

Wastewater collection from informal settlements

Ba



Sigatoka

: Informal settlement

- ✓ At the current status, WAF cannot commit to the sewerage services of Informal Settlements
- ✓ WAF can provide sewerage service once
  1) Settlements formalize, and
  2) Sewer systems are laid in close proximity of the settlement

3-4. Centralized System

(2) Wastewater Flow Estimation for 6 municipals

1) Summary of Unit Wastewater Flow

- ✓ Domestic wastewater unit flow is uniform for each municipals based on the water consumption/capita of WAF
- ✓ Non-domestic ratio is depending on actual water consumption

Item	Unit	Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka
Domestic water usage	L/day/capita	220					
Return Ratio	%	90					
Domestic wastewater unit flow	L/day/capita	200					
Non-domestic ratio	%	40	45	30	20	30	60
Infiltration ratio	%	10					

22

(2) Wastewater Flow for 6 municipals

5) Wastewater Flow in 2036

	Item	Unit	Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka
1	Population		101,600	97,100	31,200	13,100	7,100	15,900
2	Domestic Flow	m³/day	20,320	19,420	6,240	2,620	1,420	3,180
3	Non-Domestic Flow	m³/day	8,128	8,739	1,872	524	426	1,908
4	Generated Wastewater	m³/day	28,448	28,159	8,112	3,144	1,846	5,088
5	Infiltration water	m³/day	2,845	2,816	811	314	185	509
6	Total Inflow ADWF	m³/day	31,293	30,975	8,923	3,458	2,031	5,597
7		[illegible]	156,500	154,900	44,600	17,300	10,200	28,000
8	Total Inflow PDWF	m³/day	62,586	61,950	17,846	6,917	4,061	11,194
9	Total Inflow PWWF	m³/day	156,464	154,875	44,616	17,292	10,153	27,984

23

5. Treatment Process Assessment

Target Water Quality Standards

- ✓ General Standards
- ✓ Specific Ecological Zone Standards

Parameter	Units	General Standards	Significant Ecological Zone
BOD5	mg/L	40	20
SS		60	30
TDS		1000	1000
Grease		5	2
T-N		25	10
T-P		5	2
E.coli	c/100mL	400	200

According to DoE

- In general, SEZ shall be applied to any discharge to coastal areas, rivers, and streams, which has sensitive environmental characteristics.
- Navakai WWTP, the outfall is located 1.2km to the ocean, which the general standards could apply.

24

vi

TV SS

ANNEX 1

3-4. Centralized System

Target Water Cuality Standards

【Case 1】 Applies SEZ standards to all WWTP, considering the possibility of tightened environmental regulations (Strictest Case)

【Case 2】 Apply General/SEZ standards based on the scale of outflow water bodies

- ✓ Large Water Bodies: Bays, Ocean : General Standards
- ✓ Small Water Bodies: Rivers : SEZ Standards
- ✓ WWTPs sites undecided : SEZ Standards

WWTP (Municipality)	Outfall	Target Water Quality Standard	
		Case 1	Case 2
Navakai (Nadi)	Nadi River	SEZ	SEZ
Natabua (Lautoka)	Ocean (1.2 km out to sea)	SEZ	General
Votua (Ba)	Waterway in mangrove thicket	SEZ	SEZ
Tavua	Undecided	SEZ	SEZ
Rakiraki	Undecided	SEZ	SEZ
Olosara (Sigatoka)	Mouth of Sigatoka River	SEZ	General

25

3-4. Centralized System

Basic Treatment Process Categories

① Stabilization pond (used in Natabua)
② Aerated Lagoon
③ Mechanical Treatment
・IDEA (Used in Kinoya), Oxidation Ditch(OD), MBBR

Fields	Stabilization pond	Aerated Lagoon	Mechanical Treatment
Treated Water Quality (General)	A	A	A
Treated Water Quality (SEZ)	C	C	A
Simplicity of O&M	A	B	C
Economic Efficiency (Electricity, O&M)	A	B	C
Footprint	C	B	A

A: Good B: Moderate C: Poor

Detailed selection of treatment process, including MBBR, will be conducted in Sewerage M/P phase

26

3-4. Centralized System

Sewerage Treatment with Septage

✓ Three Options:

A. Treat septage at a completely different site
・Lagoon → Mechanical Dewatering → Sun-drying)

B. Treat septage at WWTP(separate treatment)
・Mechanical Dewatering
→ Leachate: Co-treat with sewerage
→ Dewatered Sludge: Sun-drying

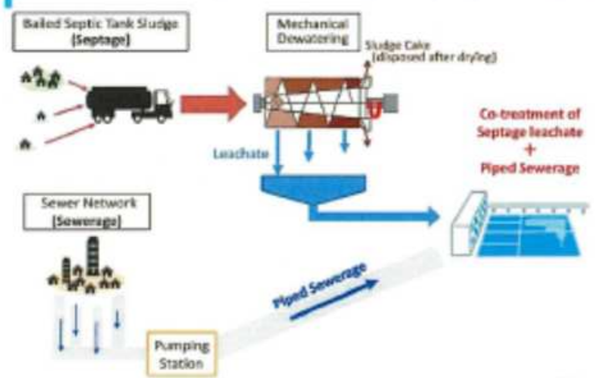
Our proposal

C. Treat septage at WWTP (co-treatment)

Current condition (Natabua, Votua and olosara)

27

3-4. Centralized System: Sewerage+Septage Treatment



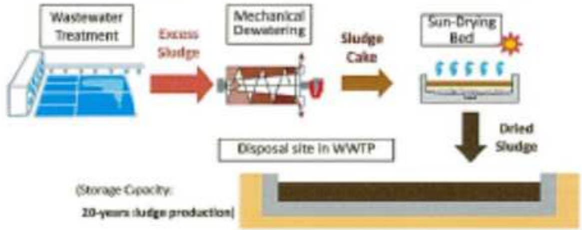
28

vii

ANNEX 1

3-4. Centralized System: Sewerage+Septage Treatment

- Currently, there are no disposal sites that accept treated sludge generated from WWTPs
- Following WWTP footprints/construction costs include sludge disposal sites made within the WWTP, in case the above situation continue



31

3-4. Centralized System: Footprint Estimations

WWTPP (municipal.)	Target Water Quality	Treatment Method	Water Quality Standard	WWTP (ha)	Sludge Disposal Site (ha)
Navakai (Nadi)	SEZ	OD/DEA	General/SEZ	20.5	11.5
Natabua (Lautoka)	General	Stabilization Pond	General	72.5	4.2
		Aerated Lagoon	General	49.2	4.2
		OD/DEA	General/SEZ	22.7	11.8
Votua (Ba)	SEZ	OD/DEA	General/SEZ	8.2	3.4
Tavua	SEZ	OD/DEA	General/SEZ	4.0	1.6
Rakiraki	SEZ	OD/DEA	General/SEZ	4.1	1.5
Olosara (Sigatoka)	General	Stabilization Pond	General	13.9	1.2
		Aerated Lagoon	General	11.5	1.2
		OD/DEA	General/SEZ	6.7	2.8

30

3-4. Footprint Example: Lautoka (Stabilization Pond)

31

3-4. Footprint Example: Lautoka (Aerated Lagoon)

32

viii

ANNEX 1

3-4. Footprint Example: Lautoka (OD/IDEA)

33

Cost Estimation for sewerage facilities

(1) Assumptions for costing

- ✓ Basically, the outline construction cost for civil portion is estimated by multiplying the outline quantity by the unit price.
- ✓ For the main items of civil work, unit price is set with reference in Fijian cost, and for the unit price that is difficult to obtain, adopt the unit price referring to the case of Japan and other countries.
- ✓ Mechanical Electricity(M/E) costs are estimated based on the ratio of civil costs to M/E costs in Japan.
- ✓ Land acquisition costs for wastewater treatment plants are included considering market price of land in Western Division.
- ✓ Unit prices are before Covid-19 pandemic and 2022 Russian invasion of Ukraine.
- ✓ Consultant fees are not included.
- ✓ Price escalation, physical contingency, are not included.

34

3-4. Centralized System

(2) Construction cost for WWTPs

- Land acquisition cost (and associated cost) should be included in construction cost

Collected land unit cost varies from 20 to 110FJD/m² -> (Average) 65FJD/m²

WWTP	Treatment	Construction Cost		Land Acquisition Cost		Total	
(Municipal)	Treatment Process	(mil. JPY)	(mil. FJD)	(mil. JPY)	(mil. FJD)	(mil. JPY)	(mil. FJD)
Navakai (Nadi)	Stab. Pond	10,889	179	2,858.7	48	13,748	227
	OD / IDEA	18,450	303	799.5	13	19,250	316
Natabua (Lautoka)	Stab. Pond	10,778	177	2,827.5	47	13,606	224
	OD / IDEA	17,841	293	885.3	15	18,726	308
Votua (Ba)	Stab. Pond	3,837	63	1,212.9	20	5,050	83
	OD / IDEA	6,333	104	319.8	5	6,653	109
Tavua	Stab. Pond	1,462	24	343.2	6	1,805	30
	OD / IDEA	2,862	47	156.0	3	3,018	50
Rakiraki	Stab. Pond	1,157	19	323.7	5	1,481	24
	OD / IDEA	2,132	35	159.9	3	2,292	38
Olosara (Sigatoka)	Stab. Pond	2,010	33	542.1	9	2,552	42
	OD / IDEA	4,263	70	261.3	4	4,524	74

Cost difference between Stabilization Pond and OD/ IDEA becomes smaller when considering the land cost, but it will not be reversed.

35

3-4. Centralized System

Cost Estimation of Sewerage Facilities

Construction Cost

Item318		Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka
WWTPs (million FJD)	IDEA	316	308	109	50	38	74
	S/P	227	224	83	30	24	42
Collection Network (million FJD)		1,423	856	482	118	91	193
Pumping Station (million FJD)		48	29	16	5	4	7
Total (million FJD)	IDEA	1,787	1,193	582	173	133	274
	S/P	1,698	1,109	608	153	119	242

O/M Cost

Item		Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka
WWTPs (1000 FJD/yr)	IDEA	3,540	3,460	1,740	1,090	920	1,380
	S/P	1,545	1,529	582	281	229	379
Collection Network (1000 FJD/yr)		1,380	833	470	136	104	188
Pumping Station (1000 FJD/yr)		4,489	2,702	1,039	300	231	416
Total (1000 FJD/yr)	IDEA	**9,409**	**6,995**	**3,249**	**1,526**	**1,256**	**1,984**
	S/P	**7,417**	**5,064**	**2,091**	**717**	**664**	**983**

36

ix

ANNEX 1

3-5. Financial & Economic Analysis

ITEM	Million FJD
WWTP(IDEA) CAPEX for 6 municipals	853
Pipe & Pump CAPEX for 6 municipals	3,274
Total	4,127
Fiji Expend Budget 2021	3,675
MP CAPEX/National Budget	1.12

✓ FIRR= -2.1%
  -> When the tariff is 0.20(FJD/m3) same as current tariff

✓ To cover the O/M cost for 6 municipals sewerage system, tariff should be around 0.71(FJD/m3)

✓ EIRR= 2.4%

Detailed analysis will be conducted in Sewerage M/P

37

3-6. Prioritization for Sewerage System Development

Result of Prioritization

By Analytical Hierarchy Method (AHP)

Criteria	Rating		Sub-Criteria	Rating	Point
Population	0.27	1	Non sewered population	0.34	9.1
		2	Population density	0.66	17.8
Sanitation	0.20	3	Cases of waterborne disease	1.00	20.1
Urban development	0.29	4	No. of hotels	0.45	17.7
		5	Non domestic water usage	0.55	15.0
Water Environment	0.25	7	Current water quality	0.40	9.6
		8	Estimated water quality	0.60	14.7
	1				100.0

	Nadi	Lautoka	Ba	Tavua	Rakiraki	Sigatoka
Total Score	76.6	84.1	44.8	38.5	43.6	43.2
Priority	2	1	3	6	4	5

38

3-7. Proposed Implementation Schedule

(1) Assumption for scheduling

✓ Each sewerage development projects starts from 2025, just after this M/P project
✓ Project will be loan project and
✓ International Competitive Bidding (ICB) procedure is considered as below

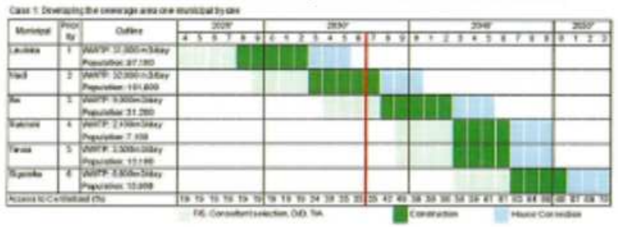
Item	Duration (year)
Feasibility Study	1
Consultant Selection	1
Detailed Design	1
Contractor Selection (Tender Assistant)	1
Construction (Nadi, Lautoka, Ba)	5
Construction (Tavua, Rakiraki, Sigatoka)	4
House connection	3

39

3-7. Proposed Implementation Schedule

(3) Case 1

✓ More realistic schedule, construction work does not wrap in each municipal
✓ Target will be achieved around 2053
✓ Access ratio to centralized system in 2036 is around **34%**



40

ANNEX 1

3-8. Tentative Achievement of 70%

NDP's target
(70% of population access to centralized system until 2036)

In Case 1
Centralized: 34%
+
Decentralized: 36%
by Regular desludging

No regular desludging of septic tank

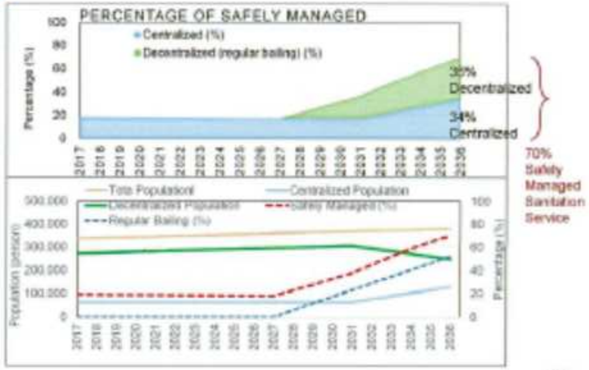
Risk of leakage of septage into environment

Proposal for proper interval desludging
at interval of 5 years or less

"Safely Managed Sanitation Service"
In this regional wastewater M/P

41

3-8. Tentative Achievement of 70%



42

3-9. Decentralized System

(3) Septage Collection and Treatment
2) Future (Propose)
✓ 2WWTPs (Natabua and Olosara) receive septage.

✓ New WWTP will be constructed in Lautoka with septage treatment
✓ Regarding to desludging fee, it is necessary to consider measures such as financial support by government

43

3-9. Decentralized System

(3) Septage Collection and Treatment

3) Estimation of amount of bailed septage for each WWTPs

✓ Each amount of bailed septage is estimated to be less than 1% of inflow of sewage.
✓ Amount of bailed septage will not affect wastewater treatment extensively.

44

xi

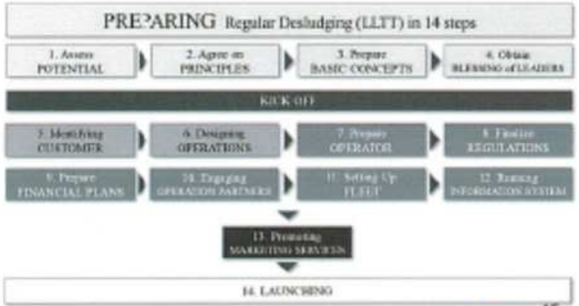
TV SS

ANNEX 1

3-9. Decentralized System

(4) Preparation for Regular Desludging

- ✓ Various steps are required to start the regular desludging, referring to the cases of other countries, the following 14 steps are required

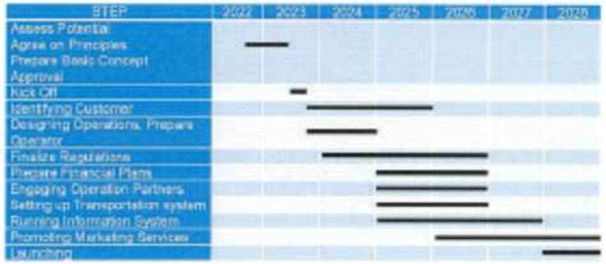


45

3-9. Decentralized System

(4) Preparation for Regular Desludging

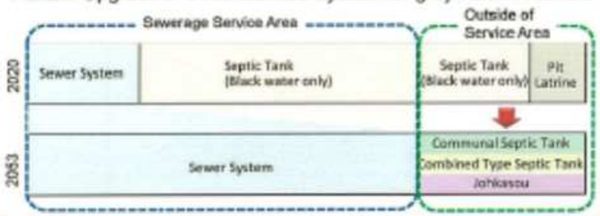
- ✓ To commence regular desludging, it is assumed to be taken 5 years for preparation
- ✓ Several agency need to collaborate for smooth implementation



46

3-9. Decentralized System

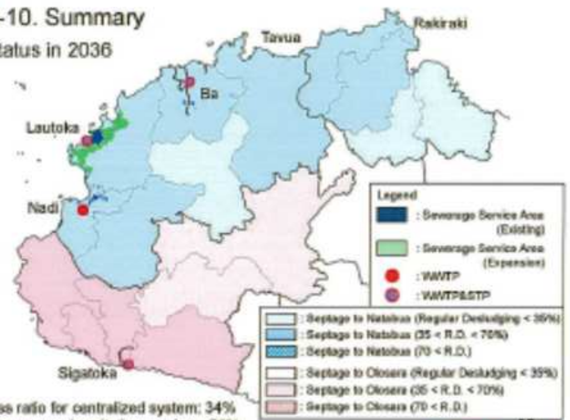
Further Upgrade of Decentralized System for graywater treatment



Process	Adoption
Communal septic tank	➢ Small villages ➢ Low-income communities
Combined (black and graywater) septic tank	➢ Houses to install septic tank newly ➢ Houses to renovate existing black water septic tank ➢ Houses near rivers, ponds and lakes
Aerobic septic tank (Johkasou)	➢ Public facilities such as hospitals and schools ➢ Business offices such as restaurants, shopping malls and factories ➢ Houses facing to environmentally sensitive area ➢ Houses with poor soil drainage/ high ground water level

3-10. Summary

Status in 2036



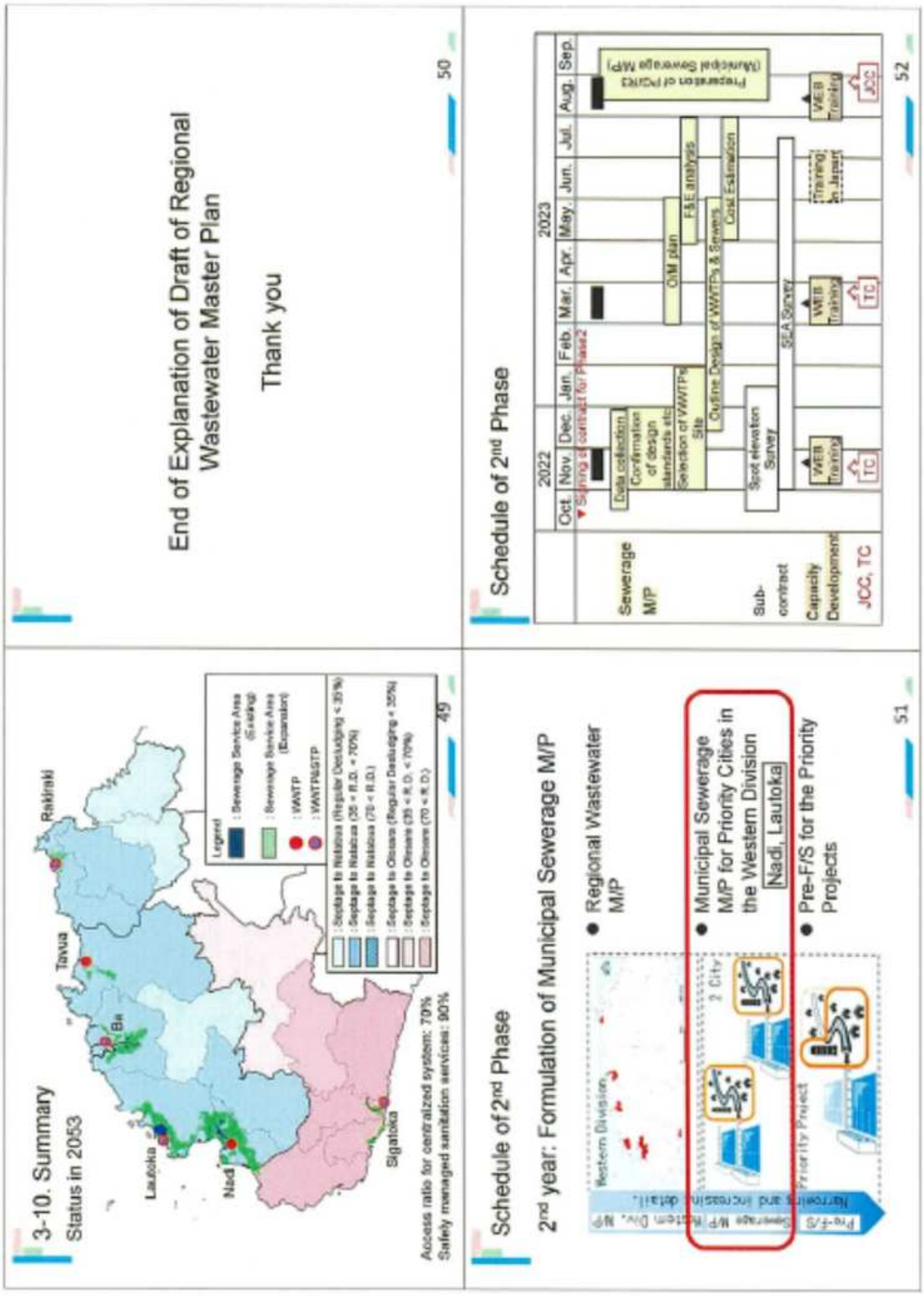
Access ratio for centralized system: 34%
Safely managed sanitation services: 70%

48

xii


TV
SS

ANNEX 1


3-10. Summary
Status in 2053
Rakiraki
Tavua
Ba
Lautoka
Nadi
Sigatoka
Legend
: Sewerage Service Area (Existing)
: Sewerage Service Area (Expansion)
: WWTP
: WWTP&STP
Access ratio for centralized system: 70%
Safely managed sanitation services: 90%
49
End of Explanation of Draft of Regional Wastewater Master Plan
Thank you
50
Schedule of 2nd Phase
2nd year: Formulation of Municipal Sewerage M/P
Western Division
2 City
Priority Project
Regional Wastewater M/P
Municipal Sewerage M/P for Priority Cities in the Western Division
Nadi, Lautoka
Pre-F/S for the Priority Projects
51
Schedule of 2nd Phase
2022
2023
Oct. Nov. Dec. Jan. Feb. Mar. Apr. May. Jun. Jul. Aug. Sep.
Signing of contract for Phase2
Sewerage M/P
Data collection
Confirmation of design standards etc
Selection of WWTPs Site
O/M plan
F&E analysis
Outline Design of WWTPs & Sewers
Cost Estimation
Preparation of PC/R3 (Municipal Sewerage M/P)
Sub-contract
Spot elevation Survey
SEA Survey
Capacity Development
WEB Training
Training in Japan
JCC, TC
TC
JCC
52

xiii

APPENDIX 3-1 Water Quality Analysis

(1) Nadi & Namori 30 Nov 2021

water authority of fiji
Clean Water for a Better Life.

IANZ
ACCREDITED LABORATORY
Tests indicated as not accredited are outside the scope of the laboratory's accreditation

National Water Quality Laboratory Report

Ratu Dovi Road Nasinu, Fiji Islands GPO Box 1272, Suva, Fiji Islands
Telephone (679) 3345677 or 577 (Vodafone & Inkk) users.
Email: contact@waf.com.fj Website:www.waterauthority.com.fj

Certificate of Analysis: Chemical and Biological Analysis
Sample: Environment (NGO)

Lab Reference No : NWQL/180/21-22	Date Generated: 16 Dec 2021
Sample From: Nihon Suido Consultants Co. Ltd.	Address : c/- NRW Macallan (Fiji) Ltd.
Sample Type : Grab	Sample time : 1030 - 1200hrs
Sampled By : Yasuo Iijima	Sample date : 30/11/2021
Sample Received : 30 Nov 2021	Weather Condition : Fine
Date Analysis Started : 01 Dec 2021	Cust Reference No : -

SL. No	DETERMINANDS	Units	APHA Method Code	SAMPLE LOCATION		General Standards
				1	2	
1	*pH	0-14	4500- H+B	8.09	7.69	-
2	*Conductivity [Chem]	µS/cm	2510 B	123.7	237.4	-
3	*Total Suspended Solids	mg/L	2540D	61.8	13.7	-
4	*Total Kjeldahl Nitrogen (TKN)	mg/L	4500-NorgB	0.36	0.64	-
5	*Total Phosphate	mg/L	4500PE	0.72	0.80	-
6	*Chemical Oxygen Demand	mg/l	5220B	36.0	28.0	-
7	*Dissolved Oxygen†	mg/L	4500-O C	8.50	8.44	-
8	*Biochemical Oxygen Demand	mg/L	5210B	1.72	4.92	-

Sampling Points
1 Nadi Bridge - River Water
2 Namoli Creek - River Water

Remarks:
†All results apply to samples as received by Laboratory. Avg means Average < means Less than, > means Greater than, N/A means Not Applicable
* These tests are outside the laboratory's scope of accreditation.

Checked By:Vikash Ram
Position: Technical Officer
Signature :

Authorised By: Mosese Nariva
Position: Actg Manager Laboratory & Water Treatment
Signature :

No : NWQL/ 266/18-19
This test report shall not be reproduced except in full.

Page 1 of 2

BACTERIOLOGICAL ANALYSIS

Lab Reference No : 180/21-22 **Date Generated: 16 Dec 2021**

SL. No	DETERMINANDS	Units	APHA Method Code	SAMPLE LOCATION		General Standards
				1	2	
1	Total Coliform	cfu/100ml	9222B	7,200	360	-

Sampling Points

1. Nadi Bridge - River Water
2. Namoli Creek - River Water

Checked By:Kirti Chandra
Position: Key Technical Person
Signature :

Authorised By: Mosese Nariva
Position: Actg Manager Laboratory & Water Treatment
Signature :

End of Test Report.

No : NWQL/ 266/18-19
This test report shall not be reproduced except in full.

Page 2 of 2

(2) Nadi & Ba 7 Dec 2021

water authority of fiji
Clean Water for a Better Life.

IANZ
ACCREDITED LABORATORY

National Water Quality Laboratory Report

Ratu Dovi Road Nasinu, Fiji Islands GPO Box 1272, Suva, Fiji Islands
Telephone (679) 3345877 or 577 (Vodafone & Inkk) users.
Email: contact@waf.com.fj Website: www.waterauthority.com.fj

Certificate of Analysis: Chemical and Biological Analysis
Sample: Environment (NGO)

Lab Reference No : NWQL/182/21-22	Date Generated: 05 Jan 2022
Sample From: Nihon Suido Consultants Co. Ltd.	Address : c/- NRW Macallan (Fiji) Ltd.
Sample Type : Grab	Sample time : 1130 - 1330hrs
Sampled By : Yasuo Iijima	Sample date : 07/12/2021
Sample Received : 07 Dec 2021	Weather Condition : Fine
Date Analysis Started : 08 Dec 2021	Cust Reference No : -

SL. No	DETERMINANDS	Units	APHA Method Code	SAMPLE LOCATION		General Standards
				1	2	
1	*pH	0-14	4500- H+B	7.48	7.47	-
2	*Conductivity [Chem]	µS/cm	2510 B	493.0	223.5	-
3	*Total Suspended Solids	mg/L	2540D	63.2	62.7	-
4	*Total Kjeldahl Nitrogen (TKN)	mg/L	4500-NorgB	0.38	0.20	-
5	*Total Phosphate	mg/L	4500PE	0.49	0.42	-
6	*Chemical Oxygen Demand	mg/l	5220B	N/D	N/D	-
7	*Dissolved Oxygen†	mg/L	4500-O C	7.93	8.36	-
8	*Biochemical Oxygen Demand	mg/L	5210B	3.15	2.52	-

Sampling Points

1 Ba - River Water
2 Nadi - River Water

Remarks:

†All results apply to samples as received by Laboratory. Avg means Average < means Less than, > means Greater than, N/A means Not Applicable

* These tests are outside the laboratory's scope of accreditation.

Checked By: Vikash Ram
Position: Technical Officer
Signature :

Authorised By: Mosese Nariva
Position: Actg Manager Laboratory & Water Treatment
Signature :

No : NWQL/ 266/18-19
This test report shall not be reproduced except in full.

Page 1 of 2

BACTERIOLOGICAL ANALYSIS

Lab Reference No : 182/21-22 **Date Generated: 05 Jan 2022**

SL. No	DETERMINANDS	Units	APHA Method Code	SAMPLE LOCATION		General Standards
				1	2	
1	Total Coliform	cfu/100ml	9222B	3,400	5,200	-

Sampling Points
1 Ba - River Water
2 Nadi - River Water

Checked By:Kirti Chandra
Position: Key Technical Person
Signature :

Authorised By: Mosese Nariva
Position: Actg Manager Laboratory & Water Treatment
Signature :

End of Test Report.

No : NWQL/ 265/18-19
This test report shall not be reproduced except in full.

Page 2 of 2

(3) Nadi & Namori 13 Dec 2021

water authority of fiji
Clean Water for a Better Life.

IANZ
ACCREDITED LABORATORY
Tests indicated as not accredited are outside the scope of the laboratory's accreditation

National Water Quality Laboratory Report

Ratu Dovi Road Nasinu, Fiji Islands GPO Box 1272, Suva, Fiji Islands
Telephone (679) 3346077 or 577 (Vodafone & inkk) users.
Email: contact@waf.com.fj Website:www.waterauthority.com.fj

Certificate of Analysis: Chemical and Biological Analysis
Sample: Environment (NGO)

Lab Reference No : NWQL/174/21-22	Date Generated: 05 Jan 2022
Sample From: Nihon Suido Consultants Co. Ltd.	Address : c/- NRW Macallan (Fiji) Ltd.
Sample Type : Grab	Sample time : 0700 - 0800hrs
Sampled By : Yasuo Iijima	Sample date : 13/12/2021
Sample Received : 13 Dec 2021	Weather Condition : Fine
Date Analysis Started : 14 Dec 2021	Cust Reference No : -

SL. No	DETERMINANDS	Units	APHA Method Code	SAMPLE LOCATION 1	SAMPLE LOCATION 2	General Standards
1	*pH	0-14	4500- H+B	7.88	7.89	-
2	*Conductivity (Chem)	µS/cm	2510 B	202.5	211.5	-
3	*Total Suspended Solids	mg/L	2540D	103.9	9.8	-
4	*Total Kjeldahl Nitrogen (TKN)	mg/L	4500-NorgB	0.18	0.30	-
5	*Total Phosphate	mg/L	4500PE	0.39	0.32	-
6	*Chemical Oxygen Demand	mg/l	5220B	N/D	N/D	-
7	*Dissolved Oxygen†	mg/L	4500-O C	9.08	9.09	-
8	*Biochemical Oxygen Demand	mg/L	5210B	3.16	3.55	-

Sampling Points
1 Nadi - River Water
2 Namoli - River Water

Remarks:
†All results apply to samples as received by Laboratory. Avg means Average < means Less than, > means Greater than, N/A means Not Applicable
* These tests are outside the laboratory's scope of accreditation.

Checked By:Vikash Ram
Position: Technical Officer
Signature :

Authorised By: Mosese Nariva
Position: Actg Manager Laboratory & Water Treatment
Signature :

No : NWQL/ 265/18-19
This test report shall not be reproduced except in full.

Page 1 of 2

BACTERIOLOGICAL ANALYSIS

Lab Reference No : 174/21-22

Date Generated: 05 Jan 2022

SL. No	DETERMINANDS	Units	APHA Method Code	SAMPLE LOCATION		General Standards
				1	2	
1	Total Coliform	cfu/100ml	9222B	86,000	72,000	-

Sampling Points

1 Nadi - River Water

2 Namoli - River Water

Checked By:Kirti Chandra

Position: Key Technical Person

Signature :

Authorised By: Mosese Nariva

Position: Actg Manager Laboratory & Water Treatment

Signature :

End of Test Report.

No : NWQL/ 265/18-19

This test report shall not be reproduced except in full.

Page 2 of 2

(4) Ba 2 Dec 2021

water authority fiji
Clean Water for a Better Life.

IANZ
ACCREDITED LABORATORY
Tests indicated as not accredited are outside the scope of the laboratory's accreditation

National Water Quality Laboratory Report

Ratu Dovi Road Nasinu, Fiji Islands GPO Box 1272, Suva, Fiji Islands
Telephone (679) 3345677 or 577 (Vodafone & Inkk) users.
Email: contact@waf.com.fj Website:www.waterauthority.com.fj

Certificate of Analysis: Chemical and Biological Analysis
Sample: Environment (NGO)

Lab Reference No : NWQL/150/21-22	Date Generated: 05 Jan 2022
Sample From: Nihon Suido Consultants Co. Ltd.	Address : c/- NRW Macallan (Fiji) Ltd.
Sample Type : Grab	Sample time : 1000hrs
Sampled By : Yasuo Iijima	Sample date : 02/12/2021
Sample Received : 02 Dec 2021	Weather Condition : Fine
Date Analysis Started : 03 Dec 2021	Cust Reference No : -

SL. No	DETERMINANDS	Units	APHA Method Code	SAMPLE LOCATION	General Standards
				1	
1	*pH	0-14	4500- H+B	7.34	-
2	*Conductivity [Chem]	µS/cm	2510 B	137.2	-
3	*Total Suspended Solids	mg/L	2540D	23.0	-
4	*Total Kjeldahl Nitrogen (TKN)	mg/L	4500-NorgB	0.12	-
5	*Total Phosphate	mg/L	4500PE	0.74	-
6	*Chemical Oxygen Demand	mg/l	5220B	N/D	-
7	*Dissolved Oxygen†	mg/L	4500-O C	7.93	-
8	*Biochemical Oxygen Demand	mg/L	5210B	3.15	-

Sampling Points

1 Ba Bridge - River Water

Remarks:

†All results apply to samples as received by Laboratory. Avg means Average < means Less than, > means Greater than, N/A means Not Applicable

* These tests are outside the laboratory's scope of accreditation.

Checked By:Vikash Ram
Position: Technical Officer
Signature :

Authorised By: Mosese Nariva
Position: Actg Manager Laboratory & Water Treatment
Signature :

No : NWQL/ 265/18-19
This test report shall not be reproduced except in full.

Page 1 of 2

BACTERIOLOGICAL ANALYSIS

Lab Reference No : 150/21-22 **Date Generated: 05 Jan 2022**

SL. No	DETERMINANDS	Units	APHA Method Code	SAMPLE LOCATION	General Standards
				1	
1	Total Coliform	cfu/100ml	9222B	9,800	-

Sampling Points

1 Ba Bridge - River Water

Checked By:Kirti Chandra
Position: Key Technical Person
Signature :

Authorised By: Mosese Nariva
Position: Actg Manager Laboratory & Water Treatment
Signature :

End of Test Report

No : NWQL/ 265/18-19
This test report shall not be reproduced except in full.

Page 2 of 2

(5) Tavua & Rakiraki 6 Dec 2021

water authority fiji
Clean Water for a Better Life

IANZ
ACCREDITED LABORATORY
Tests indicated as not accredited are outside the scope of the laboratory's accreditation

National Water Quality Laboratory Report

Ratu Dovi Road Nasinu, Fiji Islands GPO Box 1272, Suva, Fiji Islands
Telephone (679) 3346677 or 577 (Vodafone & Inkk) users.
Email: contact@waf.com.fj Website www.waterauthority.com.fj

Certificate of Analysis: Chemical and Biological Analysis
Sample: Environment (NGO)

Lab Reference No : NWQL/181/21-22	Date Generated: 05 Jan 2022
Sample From: Nihon Suido Consultants Co. Ltd.	Address : c/- NRW Macallan (Fiji) Ltd.
Sample Type : Grab	Sample time : 1100 - 1200hrs
Sampled By : Yasuo Iijima	Sample date : 06/12/2021
Sample Received : 06 Dec 2021	Weather Condition : Fine
Date Analysis Started : 07 Dec 2021	Cust Reference No : -

SL. No	DETERMINANDS	Units	APHA Method Code	SAMPLE LOCATION 1	SAMPLE LOCATION 2	General Standards
1	*pH	0-14	4500- H+B	7.74	7.65	-
2	*Conductivity [Chem]	µS/cm	2510 B	333.8	989.0	-
3	*Total Suspended Solids	mg/L	2540D	3.5	14.5	-
4	*Total Kjeldahl Nitrogen (TKN)	mg/L	4500-NorgB	0.08	0.31	-
5	*Total Phosphate	mg/L	4500PE	0.49	0.63	-
6	*Chemical Oxygen Demand	mg/l	5220B	N/D	N/D	-
7	*Dissolved Oxygen†	mg/L	4500-O C	8.97	8.91	-
8	*Biochemical Oxygen Demand	mg/L	5210B	1.77	4.18	-

Sampling Points

1 Rakiraki - River Water
2 Tavua - River Water

Remarks:

†All results apply to samples as received by Laboratory. Avg means Average < means Less than, > means Greater than, N/A means Not Applicable

* These tests are outside the laboratory's scope of accreditation.

Checked By:Vikash Ram
Position: Technical Officer
Signature :

Authorised By: Mosese Nariva
Position: Actg Manager Laboratory & Water Treatment
Signature :

No : NWQL/ 265/18-19
This test report shall not be reproduced except in full.

Page 1 of 2

BACTERIOLOGICAL ANALYSIS

Lab Reference No : 181/21-22 **Date Generated: 05 Jan 2022**

SL. No	DETERMINANDS	Units	APHA Method Code	SAMPLE LOCATION		General Standards
				1	2	
1	Total Coliform	cfu/100ml	9222B	8,200	2,400	-

Sampling Points
1 Rakiraki - River Water
2 Tavua - River Water

Checked By:Kirti Chandra
Position: Key Technical Person
Signature :

Authorised By: Mosese Nariva
Position: Actg Manager Laboratory & Water Treatment
Signature :

End of Test Report.

No : NWQL/ 265/18-19
This test report shall not be reproduced except in full.

Page 2 of 2

(6) Tavua & Rakiraki 9 Dec 2021

water authority fiji
Clean Water for a Better Life.

IANZ
ACCREDITED LABORATORY
Tests indicated as not accredited are outside the scope of the laboratory's accreditation

National Water Quality Laboratory Report

Ratu Dovi Road Nasinu, Fiji Islands GPO Box 1272, Suva, Fiji Islands
Telephone (679) 3346677 or 577 (Vodafone & inkk) users.
Email: contact@waf.com.fj Website:www.waterauthority.com.fj

Certificate of Analysis: Chemical and Biological Analysis
Sample: Environment (NGO)

Lab Reference No : NWQL/197/21-22	**Date Generated: 05 Jan 2022**
Sample From: Nihon Suido Consultants Co. Ltd.	Address : c/- NRW Macallan (Fiji) Ltd.
Sample Type : Grab	Sample time : 1500 - 1545hrs
Sampled By : Yasuo Iijima	Sample date : 09/12/2021
Sample Received : 09 Dec 2021	Weather Condition : Fine
Date Analysis Started : 10 Dec 2021	Cust Reference No : -

SL. No	DETERMINANDS	Units	APHA Method Code	SAMPLE LOCATION		General Standards
				1	2	
1	*pH	0-14	4500- H+B	7.81	7.48	-
2	*Conductivity [Chem]	µS/cm	2510 B	322.6	847.2	-
3	*Total Suspended Solids	mg/L	2540D	9.4	15.0	-
4	*Total Kjeldahl Nitrogen (TKN)	mg/L	4500-NorgB	0.09	0.27	-
5	*Total Phosphate	mg/L	4500PE	0.49	0.58	-
6	*Chemical Oxygen Demand	mg/l	5220B	N/D	N/D	-
7	*Dissolved Oxygen†	mg/L	4500-O C	8.70	8.24	-
8	*Biochemical Oxygen Demand	mg/L	5210B	3.00	3.83	-

Sampling Points
1 Rakiraki - River Water
2 Tavua - River Water

Remarks:

†All results apply to samples as received by Laboratory. Avg means Average < means Less than, > means Greater than, N/A means Not Applicable

* These tests are outside the laboratory's scope of accreditation.

Checked By:Vikash Ram
Position: Technical Officer
Signature :

Authorised By: Mosese Nariva
Position: Actg Manager Laboratory & Water Treatment
Signature :

No : NWQL/ 266/18-19
This test report shall not be reproduced except in full.

Page 1 of 2

BACTERIOLOGICAL ANALYSIS

Lab Reference No : 197/21-22

Date Generated: 05 Jan 2022

SL. No	DETERMINANDS	Units	APHA Method Code	SAMPLE LOCATION		General Standards
				1	2	
1	Total Coliform	cfu/100ml	9222B	5,600	2,400	-

Sampling Points

1 Rakiraki - River Water
2 Tavua - River Water

Checked By:Kirti Chandra
Position: Key Technical Person
Signature :

Authorised By: Mosese Nariva
Position: Actg Manager Laboratory & Water Treatment
Signature :

End of Test Report.

No : NWQL/ 265/18-19
This test report shall not be reproduced except in full.

Page 2 of 2

(7) Sigatoka Bridge-7km upstream 29 Nov 2021

water authority of fiji
Clean Water for a Better Life.

IANZ
ACCREDITED LABORATORY

National Water Quality Laboratory Report

Ratu Dovi Road Nasinu, Fiji Islands GPO Box 1272, Suva, Fiji Islands
Telephone (679) 3346677 or 577 (Vodafone & Inkk) users.
Email: contact@waf.com.fj Website: www.waterauthority.com.fj

Certificate of Analysis: Chemical and Biological Analysis
Sample: Environment (NGO)

Lab Reference No : NWQL/145/21-22	Date Generated: 14 Dec 2021
Sample From: Nihon Studio Consultant	Address : c/- NRW Macallan (Fiji) Ltd.
Sample Type : Grab	Sample time : 1000hrs
Sampled By : Yasuo Iijima	Sample date : 29/11/2021
Sample Received : 29 Nov 2021	Weather Condition : Fine
Date Analysis Started : 30 Nov 2021	Cust Reference No : -

SL. No	DETERMINANDS	Units	APHA Method Code	SAMPLE LOCATION 1	General Standards
1	*pH	0-14	4500- H+B	7.57	-
2	*Conductivity [Chem]	µS/cm	2510 B	4200.0	-
3	*Total Suspended Solids	mg/L	2540D	25.7	-
4	*Total Kjeldahl Nitrogen (TKN)	mg/L	4500-NorgB	0.12	-
5	*Total Phosphate	mg/L	4500PE	0.74	-
6	*Chemical Oxygen Demand	mg/l	5220B	4.0	-
7	*Dissolved Oxygen†	mg/L	4500-O C	7.11	-
8	*Biochemical Oxygen Demand	mg/L	5210B	1.70	-

Sampling Points
1 Sigatoka River

Remarks:
†All results apply to samples as received by Laboratory. Avg means Average < means Less than, > means Greater than, N/A means Not Applicable
* These tests are outside the laboratory's scope of accreditation.

Checked By:Vikash Ram
Position: Technical Officer
Signature :

Authorised By: Mosese Nariva
Position: Actg Manager Laboratory & Water Treatment
Signature :

No : NWQL/ 266/18-19
This test report shall not be reproduced except in full.

Page 1 of 2

BACTERIOLOGICAL ANALYSIS

Lab Reference No : 145/21-22

Date Generated: 14 Dec 2021

SL. No	DETERMINANDS	Units	APHA Method Code	SAMPLE LOCATION 1	General Standards
1	Total Coliform	cfu/100ml	9222B	68,000	-

Sampling Points
1 Sigatoka River

Checked By:Raijieli Ratuvili
Position: Technical Officer
Signature :

Authorised By: Mosese Nariva
Position: Actg Manager Laboratory & Water Treatment
Signature :

End of Test Report.

No : NWQL/ 266/18-19
This test report shall not be reproduced except in full.

Page 2 of 2

(8) Sigatoka 8 Dec 2021

water authority of fiji

Clean Water for a Better Life.

IANZ ACCREDITED LABORATORY

Tests indicated as not accredited are outside the scope of the laboratory's accreditation

National Water Quality Laboratory Report

Ratu Dovi Road Nasinu, Fiji Islands GPO Box 1272, Suva, Fiji Islands

Telephone (679) 3345677 or 577 (Vodafone & Inkk) users.

Email: contact@waf.com.fj Website:www.waterauthority.com.fj

Certificate of Analysis: Chemical and Biological Analysis
Sample: Environment (NGO)

Lab Reference No : NWQL/166/21-22	**Date Generated: 16 Dec 2021**
Sample From: Nihon Suido Consultants Co. Ltd.	Address : c/- NRW Macallan (Fiji) Ltd.
Sample Type : Grab	Sample time : 1345hrs
Sampled By : Yasuo Iijima	Sample date : 08/12/2021
Sample Received : 08 Dec 2021	Weather Condition : Fine
Date Analysis Started : 09 Dec 2021	Cust Reference No : -

SL No	DETERMINANDS	Units	APHA Method Code	SAMPLE LOCATION 1	General Standards
1	*pH	0-14	4500- H+B	7.63	-
2	*Conductivity [Chem]	µS/cm	2510 B	2515.0	-
3	*Total Suspended Solids	mg/L	2540D	28.5	-
4	*Total Kjeldahl Nitrogen (TKN)	mg/L	4500-NorgB	0.09	-
5	*Total Phosphate	mg/L	4500PE	0.41	-
6	*Chemical Oxygen Demand	mg/l	5220B	44.0	-
7	*Dissolved Oxygen†	mg/L	4500-O C	8.39	-
8	*Biochemical Oxygen Demand	mg/L	5210B	2.46	-

Sampling Points

1 Sigatoka - River Water

Remarks:

†All results apply to samples as received by Laboratory. Avg means Average < means Less than, > means Greater than, N/A means Not Applicable

* These tests are outside the laboratory's scope of accreditation.

Checked By:Vikash Ram
Position: Technical Officer
Signature :

Authorised By: Mosese Nariva
Position: Actg Manager Laboratory & Water Treatment
Signature :

No : NWQL/ 265/18-19
This test report shall not be reproduced except in full.

Page 1 of 2

BACTERIOLOGICAL ANALYSIS

Lab Reference No : 166/21-22

Date Generated: 16 Dec 2021

SL. No	DETERMINANDS	Units	APHA Method Code	SAMPLE LOCATION	General Standards
				1	
1	Total Coliform	cfu/100ml	9222B	4,200	-

Sampling Points

1 Sigatoka - River Water

Checked By:Kirti Chandra
Position: Key Technical Person
for Signature : Kkatrih

Authorised By: Mosese Nariva
Position: Actg Manager Laboratory & Water Treatment
Signature :

End of Test Report.

No : NWQL/ 265/18-19
This test report shall not be reproduced except in full.

Page 2 of 2

(9) Sigatoka 14 Dec 2021

water authority of fiji
Clean Water for a Better Life.

IANZ
ACCREDITED LABORATORY
Tests indicated as not accredited are outside the scope of the laboratory's accreditation

National Water Quality Laboratory Report

Ratu Dovi Road Nasinu, Fiji Islands GPO Box 1272, Suva, Fiji Islands
Telephone (679) 3345677 or 577 (Vodafone & Inkk) users.
Email: contact@waf.com.fj Website:www.waterauthority.com.fj

Certificate of Analysis: Chemical and Biological Analysis
Sample: Environment (NGO)

Lab Reference No : NWQL/179/21-22	**Date Generated: 19 Jan 2022**
Sample From: Nihon Suido Consultants Co. Ltd.	Address : c/- NRW Macallan (Fiji) Ltd.
Sample Type : Grab	Sample time : 0800hrs
Sampled By : Yasuo Iijima	Sample date : 14/12/2021
Sample Received : 14 Dec 2021	Weather Condition : Fine
Date Analysis Started : 15 Dec 2021	Cust Reference No : -

SL. No	DETERMINANDS	Units	APHA Method Code	SAMPLE LOCATION 1	General Standards
1	*pH	0-14	4500- H+B	7.72	-
2	*Conductivity [Chem]	µS/cm	2510 B	213.6	-
3	*Total Suspended Solids	mg/L	2540D	57.3	-
4	*Total Kjeldahl Nitrogen (TKN)	mg/L	4500-NorgB	0.17	-
5	*Total Phosphate	mg/L	4500PE	0.66	-
6	*Chemical Oxygen Demand	mg/l	5220B	4.0	-
7	*Dissolved Oxygen†	mg/L	4500-O C	7.78	-
8	*Biochemical Oxygen Demand	mg/L	5210B	2.35	-

Sampling Points

1 Sigatoka River

Remarks:

†All results apply to samples as received by Laboratory. Avg means Average < means Less than, > means Greater than, N/A means Not Applicable

* These tests are outside the laboratory's scope of accreditation.

Checked By:Raijieli Ratuvili
Position: Technical Officer
Signature :

Authorised By: Mosese Nariva
Position: Actg Manager Laboratory & Water Treatment
Signature :

BACTERIOLOGICAL ANALYSIS

Lab Reference No : 179/21-22

Date Generated: 19 Jan 2022

SL. No	DETERMINANDS	Units	APHA Method Code	SAMPLE LOCATION	General Standards
				1	
1	Total Coliform	cfu/100ml	9222B	10,400	-

Sampling Points

1 Sigatoka River

Checked By:Kirti Chandra
Position: Key Technical Person
Signature :

Authorised By: Mosese Nariva
Position: Actg Manager Laboratory & Water Treatment
Signature :

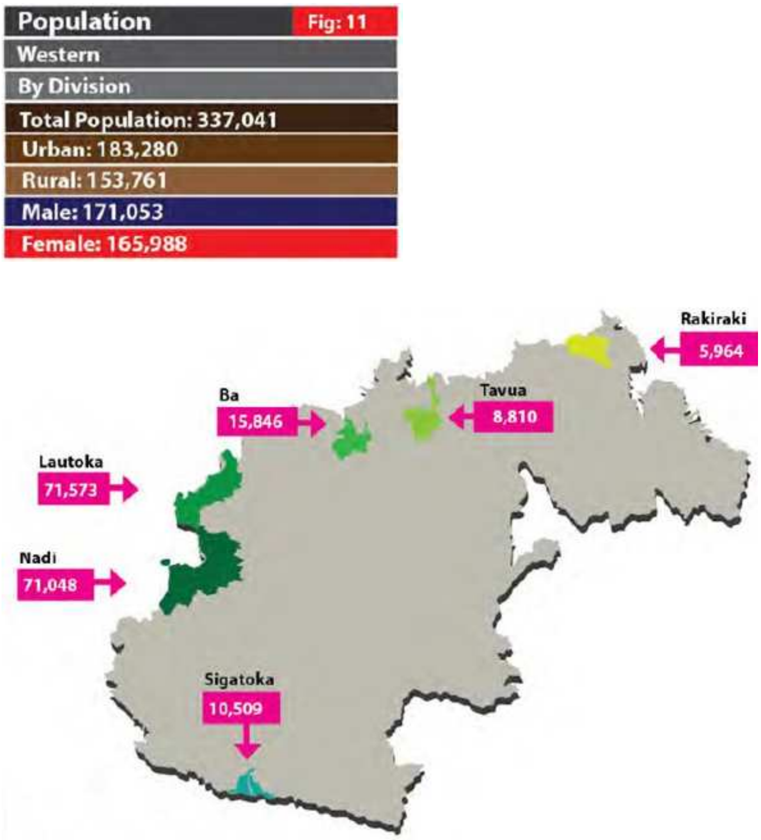
End of Test Report.

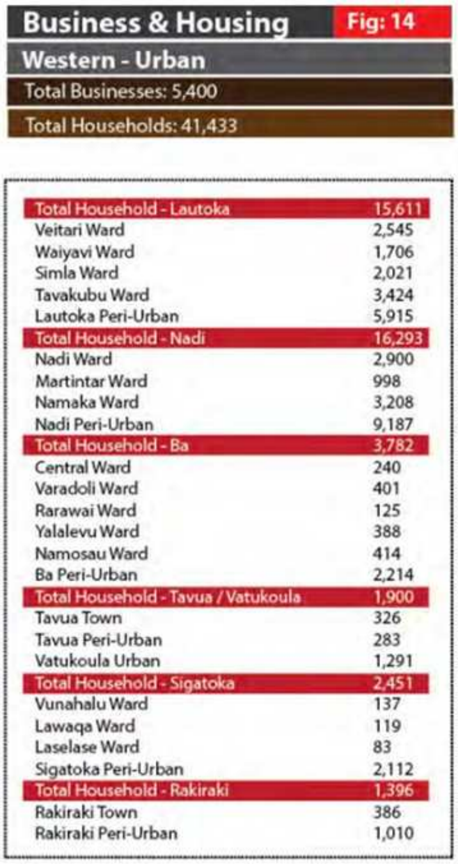
APPENDIX 4-1 Population per Household

Summary of Population Per Household

Municipals	Population	No of Households	Population per Household (population/ household)
Lautoka	71,573	15,611	4.58
Nadi	71,048	16,293	4.36
Ba	15,846	3,782	4.19
Tavua/Vatukoula	8,810	1,900	4.64
Sigatoka	10,509	2,451	4.29
Rakiraki	5,964	1,396	4.27
Total	183,750	41,433	4.43

Source: FBoS, 2017 Population and Housing Census, Infographics Release





Source: FBoS, 2017 Population and Housing Census, Infographics Release

APPENDIX 4-2 Record of training implementation related to Output 4

(1) Training on Sewerage works management (on-line training on 20th April 2022)

<table>
<tr><td>Subject</td><td>Project for Formulation of Wastewater Treatment M/P in Western Division The 1st On-line Training “Sewerage Works Management”</td><td rowspan="2">Venue</td><td rowspan="2">WAF Central Conference Room/
ZOOM meeting</td></tr>
<tr><td>Date</td><td>20, April 2022 10:00-12:00（JST）、 13:00-15:00 (FJT)</td></tr>
<tr><td>Participants</td><td colspan="3">JICA Global Environment Department
Mr. Matsuoka Hideaki Director Environment Management Group Global Environment Department
Mr. Hosaka Yukiya Officer Environment Management Group Global Environment Department
JICA Fiji office
Mr. Oba Takashi Assistant Resident Representative
Mr. Namba Shigeki Project Formulation Advisor
Road and Sewerage Department Fukuoka City
Mr. Yashima Hironori Director Policy Coordination Section
Mr. Morikawa Shingo Chief Policy Coordination Section
Mr. Hashizume Shojiro Assistant Chief Policy Coordination Section
WAF Central
Mr. Josaia K Acting Manager Wastewater Treatment
Mr. Ifraaz Ali Engineer Planning and Design
Mr. Hillary Fisher Engineer Technical Assistance and Development
Mr. Matapule Finiasi Team Leader Wastewater
Mr. Iliesa Masi Supervisor Wastewater
Mr. Shomal Narayan Graduate Engineer PD
Mr. Monish Kumar Engineer Asset Management
Mr. Isireli V Engineer Asset Management
WAF West
Mr. Sanil Nand Engineer Planning and Design
Mr. Pita Lagicere Project Leader
Mr. Engtesh Permal Team Leader Wastewater West
Mr. Vilimoni Rovouvou Supervisor Wastewater
Mr. Edwin Nambiar Supervisor Wastewater
WAF North
Mr. Mesake V Technical Officer Namara WWTP
In house Participants from the WAF Central
Mr. Isireli Teuu
Mr. Materoti Naborisi
Ms. Litea Matakibau
Mr. Vinay Prasad
Ms. Rahinuva Nisha
Ms. Rebecca G
Ms. Anaseini Nasetava
In house Participants from the WAF West
Mr. Livinai Tavisa
Mr. Mesake Navugona
Mr. Roneel Prakash
Mr. Nasoni Saukuru
Participants from the Ministry of Infrastructure and Meteorological Services
Department of Water and Sewerage
Mr. Noa Tamani
Mr. Vishwa Jeet
JICA Expert Team
Mr. Nakajima Masanobu Team Leader/ Sewerage Works Management</td></tr>
</table>

<table>
<tr><td></td><td>Mr. Hayashi Kiyohiko Deputy Team Leader/ Organization & Institutions
Ms. Kotegawa Yoko WWTP planning and Design</td></tr>
<tr><td>Materials</td><td>(1) Training Implementation Method
(2) Current conditions and issues of sewerage works in Japan
(3) Current conditions and issues of sewerage works in Fiji</td></tr>
<tr><td>Agenda</td><td>1. Opening remarks
Mr. Hideaki Matsuoka JICA Director Environmental Management Group Global Environment Department
Mr. Seru Soderberg WAF Chief Operating Officer
Mr. Yashima Hironori Director Policy Coordination Section, Road and Sewerage Department, Fukuoka City
2. Explanation of training implementation method (JET)
3. Sewerage works management in Japan (Fukuoka City)
4. Sewerage works management in Fiji (WAF)
5. Discussion
6. Closing remarks
Mr. Josaia Koroilavesau Acting Manager Wastewater Treatment</td></tr>
<tr><td>Outline

Presentation Explanation</td><td>This training program was conducted in collaboration with the Water Authority of Fiji (WAF)/the Road and Sewerage Department of Fukuoka City. The JICA Global Environment Department and JICA Fiji office participated as observers.
The topic of the first training was “Sewerage works management.”
First, JET explained the training implementation method. Then, Fukuoka City and WAF presented the current situation and issues of Fukuoka City and WAF to each other. Finally, both sides participated in an in-depth discussion session.
The outline of the training are as follows.

1. Sewerage works management in Japan (Fukuoka City)
● Introduction of the history and relevant laws of sewerage works in Japan
➢ Deterioration of urban environment due to increase of population and urbanization in 1960~ 1980.
➢ Enactment of water pollution control law in the diet in 1970.
➢ Rapid construction of sewerage system, and 80.1% of sewer service ratio in 2020
● Introduction of the effective methods for reduction of expenditure and increase of revenue to solve the issues of sewerage works due to the decrease in staff, aging facilities, decrease in profits by population decline, etc.
➢ Review of prefectural strategy, including cross-regional cooperation plans
➢ Introduction of effective use of sewerage resources and energy recovery from sewerage
2. Sewerage works management in Fiji (WAF)
● Introduction of the history of WAF, and the outline of sewerage facilities pipes managed by WAF
● Introduction of the current situation/issues and the measures planned by WAF
➢ WWTP/Pumping stations
▪ Current condition: Aging of facilities
▪ Issues: Lack of proper asset management and O&M plans
➢ Sewer networks
▪ Current condition: Aging of pipes, overflow from manholes due to inflow/infiltration
▪ Issues: Inflow of sewerage exceeding the flow capacity of pipes due to lack of renewal/upgrade plan of the sewer pipe
➢ Others
▪ Lack of asset management in human resources/materials/budget
▪ No sewerage M/P reflecting current situation
▪ Necessity of considering sewerage tariff
➢ Comments from Fukuoka City
▪ Regarding inflow/infiltration of storm water explained as an issue, Fukuoka City will share the knowledge of surveys, plans and measures with Fijian side through training.
▪ Fukuoka City will work toward the realization of better training while discussing, coordinating and adding training programs based on the request of Fijian side.</td></tr>
</table>

3. Discussion

- [WAF] Introduction of inflow/infiltration measure plan
  - Purpose: Mitigation of damage caused by manhole overflow
  - Outline: Identifying areas where the impact of inflow/infiltration is particularly large with data of WAF, Evaluating the degree of improvement through the pilot project, and formulating future measure policies.
  - Detail
    - 5 years project (started from June 2021)
    - Data Collection and analysis (age of pipe networks, pipe material, power consumption in pumping stations, dye survey, CCTV survey results, rainfall and flood damage), and identification of areas where the impact of inflow/infiltration is particularly high
    - Currently considering three areas in WAF Central as candidates for improvement pilot project
  - Issue
    - Flow meter and SCADA system is not installed in the pipeline, and it is not possible to get real-time inflow in wet weather.

✧ Comments from Fukuoka City

- Is the purpose of the project to improve public health by preventing flood damage?
  → (Answer of WAF)
  ・WAF expects cost reduction by reduction of power consumption in pumping stations in wet weather as well as prevention of flood damage.

- Fukuoka City will share information on inflow/infiltration measures in Japan and Fukuoka City in future training.

- [Fukuoka City] Confirmation of WAF's request for training on H&S and emergency response
  - Which target does WAF consider to be the most important in terms of H&S: WWTP plant operators, construction staff, pipe maintenance staff, and the citizens in road collapses?
    → (Answer of WAF)
    ・In recent years, there have been many accidents of aged pipe collapse, and WAF wants to obtain knowledge on H&S and emergency response to these accidents.

  - In the case of a pipe collapse accidents, which does WAF want to take H&S measures, WAF staff or citizens?
    → (Answer of WAF)
    ・Both

  - In recent years, there have been cases of sewer pipe collapse due to disasters such as large-scale storms and earthquakes in Japan. Is it okay to introduce examples of disaster response, and focus on the response to collapse accidents due to aging?
    → (Answer of WAF)
    ・That is okay.

- [Fukuoka City] Questions to presentation of WAF
  - Does WAF have a concrete plan for when and from which WWTP to install the flow meter?
    → (Answer of WAF)
    ・All existing WWTPs are targeted for installation, but the specific installation schedule is not fixed yet.

  - Is there any sludge treatment plan such as construction of treatment facility?
    → (Answer of WAF)
    ・At present, there is no standards for final disposal and utilization of sludge in Fiji.
    ・It is necessary to formulate a strategic plan for sludge treatment and utilization, and also the demand in Fiji.
    ・The treatment facility will be constructed after the above investigation and planning have been

	completed. ● [WAF] Questions to presentation of Fukuoka City ➢ The future population forecast shown in No.2, what is the ratio of the Wastewater loading to Water consumption? (Example, in Fiji the demand for water per capita per day is 220L and 90% is wastewater) → *(Answer of Fukuoka City)* *・200L/capita/day is used for the planned domestic wastewater volume in Fukuoka City. The ratio is 100%.* ➢ What is the most common method used for sludge treatment in Japan? → *(Answer of Fukuoka City)* *・The most common method of sludge treatment in Japan is incineration. In Fukuoka City, in order to make effective use of sewerage sludge, part of it is used as a raw material for cement and the rest is incinerated. The incinerated ash is recycled as a soil stabilizer and construction material to make 100% effective use of sludge.* ➢ The biogas power generated from the facilities are used within the treatment plant only or sold to the power supply utility? → *(Answer of Fukuoka City)* *・The power generated by biogas in Washiro WWTP is used in the plant.* *・The biogas generated in Chubu WWTP is sold to external power suppliers and they generate sell power.* ➢ The reclaimed water supplied to public facilities and office buildings is used for which purposes mainly? → *(Answer of Fukuoka City)* *・Reclaimed water is used for flush toilets and for watering trees in parks and streets.* ● [WAF] Initiatives for Climate Resilience in Fukuoka City ➢ Climate change resilience has begun to be considered in the design of sewerage facilities, etc. throughout Fiji, including WAF. How is Fukuoka City considering on it? → *(Answer of Fukuoka City)* *・Fukuoka City is planning to start formulating specific measures and plans on it.* *・In Japan, based on (1)increase in rainfall due to climate change, (2) concerns about frequent short-term heavy rainfall, and (3) inland water damage caused by rainfall exceeding the sewerage facility capacity, the urban inundation measure plan by sewerage has been revised to a plan that takes into account the effects of climate change, and the national guidelines have been revised to promote planned advance disaster prevention.* END

(2) Training on Sewerage planning and Sewer pipe design (On-line training on 19th July 2022, Retraining on 27th July 2022)

Topic	The Project for Formulation of Wastewater Treatment Master Plan in Western Division Second Training Session: Day 1	**Venue**	WAF Central Office/Zoom Meeting
Date/ Time	July 19th, 2022 13:30-15:30 (FJT)		
Participants	<u>WAF Central</u> Ifraaz Ali — Engineer Paula.K — Engineer Peter Qalilawa — Engineer Water Jone Vunidawa — Manager Planning & Design Rahul Nand — Engineer Shavil Sharma — Graduate Engineer Ashnil Kumar — Engineer Pita Lagicere — Project Leader Kemueli Serevi — Engineer Planning & Design Hillary Fisher\ — Engineer Monish Kumar — Engineer Asneet Sagar — Graduate Engineer <u>Fukuoka City</u> Shingo MORIKAWA — Chief Policy Coordination Section Shojiro HASHIZUME — Assistant Chief Policy Coordination Section Kouichi TSUKIMORI — Assistant Chief Sewerage Planning Section Hiroki HIEDA — Chief Construction Coordination Section Kazuhisa SHIKI — Assistant Chief Construction Coordination Section Yoko YAMANE — Interpreter <u>JICA Expert Team (JET)</u> NAKAJIMA Yoshinobu — Team Leader/ Sewerage Works management (NSC) HAYASHI Kiyohiko — Deputy Team Leader/ Organization & Institutions (NSC) WADA Tetsuo — Sewerage planning KAWASHIMA Yukinori — On-site wastewater treatment planning KUDO Yuriko — Environmental & Social considerations/ Public Awareness KOTEGAWA Yoko — WWTP planning and design / Coordinator (NSC)		
Material	(1) Sewerage Planning (2) Sewer Pipe Design (3) WAF Wastewater Project Updates		
Agenda	1. Sewerage Planning 2. Sewer Pipe Design 3. WAF Wastewater Project Updates 4. Discussion Session 5. Re-scheduling of Training Session		
Explanation of outline Comment	This training session was jointly held between the Water Authority of Fiji (WAF), Fukuoka City Bureau of Roads and Sewerage, and the JICA Expert Team. The Second Training Session was planned to be held on two days, Discussion sessions were held after Fukuoka City's lectures (Sewerage Planning. Sewer Pipe Design) and WAF's presentation (WAF Wastewater Project Updates). The discussions' outline is as follows. In addition, due to a sewer pipe collapse incident on 7/18, most of the WAF wastewater staff could not attend the training session. Since the staff were expected to be full at hands also on 7/20, Day 2 of the training session was decided to be postponed and rescheduled		

4. Sewerage Planning (Fukuoka City)

(1) Presentation

- Introduction of Basics on Sewerage Systems in Japan
  - ✧ Legislations related to Sewerage System
  - ✧ Costs/funds for wastewater and stormwater systems
  - ✧ Basic flow of Sewerage systems and Sewerage conveyance processes
- Outline of Sewerage Planning
  - ✧ Relationship between the Overall Vision, Master Plan, and Operational Plan
  - ✧ Four Key Tips for sewerage planning
    - ➢ ①Baseline Survey
    - ➢ ②Coordination with local authorities
    - ➢ ③Financial Evaluation
    - ➢ ④Securing Land
- Master Plan Formulation
  - ✧ Items defined in the Master Plan (wastewater treatment/stormwater management)
  - ✧ Design parameters of sewerage system and points to be considered

(2) Question and Answer/Discussion Session

【WAF Question】

- ✧ We understand that the design sewerage flow is the basis of sewerage pipe and WWTP design.
- ✧ How is the flow's future projection calculated? For example, is there a specific calculation method?

→（Fukuoka City）

- ▪ In the case of Fukuoka City, the design sewerage is flow is calculated based on the actual inflow amount of existing WWTPs. The calculation also takes into consideration of future population projections and rainfall. Drinking water consumption data is also referred to

→（JET Team Comment）

- ▪ The future projection of sewerage flow in this project's M/P is also calculated from the drinking water consumption data provided from WAF

【WAF Question】

- ✧ Where is this actual flow data of sewerage measured/recorded at?

→（Fukuoka City）

- ▪ Each existing WWTP has specific points where the influent amount is measured/recorded.

【WAF Question】

- ✧ Does Japan also have restrictions/standards on effluent water quality? If so, is this also a factor that WWTP design is based on?

→（Fukuoka City）

- ▪ Yes. Factors other than effluent water quality is also considered in design.

5. Sewer Pipe Design (Fukuoka City)

(1) Presentation

- Design Parameters in Sewer Pipe Design
  - ✧ Design Flow Volume
  - ✧ Excess Capacity allowance
  - ✧ Flow velocity/gradient
  - ✧ Minimum pipe diameter

- Conditions to be considered in Sewer Pipe design
  - ✧ Burial location and depth (coordination with administrators of public roads, waterways, railways)
  - ✧ Pipe materials and cross-sectional profiles
  - ✧ Pipe bedding
  - ✧ Structural Calculations
- Manhole Design
  - ✧ Structure and Installation Locations

- ✧ Types of manholes (Pre-cast and Site-constructed)
- ✧ Auxiliary pipe/risers and their purposes
- ● Selection of Construction Methods
- ✧ Open-cut Method, Pipe-jacking method, Shield method
- ✧ Outline of each method and their pros/cons

(2) Question and Answer/Discussion Session

【Fukuoka City Question】

- ✧ How much excess capacity does Fiji's sewerage pipeline allow in its design?

→（WAF）

- ▪ For gravitational flow pipelines, the excess capacity is set at 75%. However, in Fiji there are more pressurized flow pipes compared to gravitational flow pipes。

6. Updates on WAF Sewerage Projects（WAF）

(1) Presentation

- ● Introducing WAF's Customer Charters and Subdivision Standards
- ● Flagship Projects (CAPEX)
- ✧ Water Projects
- ✧ Kinoya WWTP Consolidation Works (Central)
- ✧ Sewer Rising Main Project (West)
- ● CAPEX Delivery Report
- ✧ Large gap between approved budget and Commitment/Actual
- ✧ Caused by lack of staff with specific skills and field experience, unstable/unmatured Fijian markets, difficulty in obtaining outsourcing consultants etc., and external factors postponing projects
- ● Sewerage System Related Projects
- ✧ Sewer Pipes：Maintenance-related projects and pipe damage/collapse issues
- ✧ WWTP：Equipment maintenance, Upgrade consultancy, Master Plan of some municipalities
- ● Implementation Methods for Construction Supervision Works
- ✧ Small-scale projects：mainly managed in-house, including project management and supervision
- ✧ Medium~Large projects：Outsourcing (including management and supervision)
- ✧ Construction supervisions done within WAF is carried out through the Project Delivery Framework（PDF）
- ● Issues in Planning &Design Works/Construction Supervision Works
- ✧ Internal：Lack of staff with specific field experiences and expertise
- ✧ External：Postponement of projects due to issues in land acquisition/consents, and environment screening applications

(2) Question and Answer/Discussion Session

【Fukuoka City Question】

- ✧ The current issues of WAF were listed, but does WAF have any practices/programs that are made to solve these issues, other than the training session of this project?

→（WAF）

- ▪ WAF also has some in-house field training programs. This year, three training programs are planned to be done.
- ▪ Other projects funded by the European Investment Bank, Asia Development Bank etc. are formulating capacity-building training programs for WAF staff
- ▪ WAF's engineers and technical staff are divided into three groups of their expertise (Mechanical, Electrical, Civil). When staff has gained enough years/cases of experience, they can move to other disciplines to gain knowledge of other but related fields.

【Fukuoka City Comment】

- ✧ JICA is planning to hold the Knowledge Co-Creation Program (KCCP) "Maintenance and Management of Sewerage Systems" in Fukuoka City around November 2022.
- ✧ Fiji is set as one of the target countries, so we would like WAF to consider participating in the program.
- ✧ It is expected that the JICA Fiji office will be notifying you about the event, but if needed, Fukuoka City can update WAF on any information related to the program.

→（WAF）
- Thank you for the information. WAF will consider its participation of the program.

→（JET Comment）
- Since this is JICA program, the JICA Fiji office could be referred to for more information

【Fukuoka City Question】
- WWTP Desludging projects and a pipeline replacement project was listed in the current projects list. How are these projects related to the Regional Wastewater M/P that is being formulated right now?

→（WAF＋JET）
- Both projects are maintenance projects, so they are not directly related to the Project M/P
- The stabilization pond WWTPs of the West did not have their periodic desludging done since their commissioning, resulting to the deterioration of its treatment capacity. Desludging was done to solve this problem.
- The pipeline replacement was done in response to the collapse of the system's trunk line.

【Fukuoka City Question】
- According to Slide 26 the wastewater treatment M/P of Korovou and Rakiraki are listed as completed projects. How are these projects related to the Regional Wastewater M/P that is being formulated right now? If WAF is formulating other M/Ps parallel with JET's M/P, there is the possibility of overlaps and discoordination. To prevent this from happening, we think that the M/P preconditions should be organized/clarified

→（WAF＋JET）
- These M/Ps are that of municipality levels. WAF generally formulated master plans ahead of time, and when necessary, budgets are obtained, move onto its conduction
- Rakiraki is included in the Western Division. Its M/P was formulated few years before this project, and JET is aware of its existence
- In addition, the WWTPs of Nadi and Lautoka will need consolidation works to be done in the close future, and their design/detailed design is also being done.
- The M/P of this project will consider and make coordination with these existing/ongoing plans and projects to prevent overlaps and discoordination.

【Fukuoka City Question】
- According to Slide 21, two existing WWTPs in the West (Lautoka and Ba) are already experiencing over capacity issues. The PGR1 turned in by JET did not include this factor (over-capacity WWTPs should be prioritized over WWTPs running at/under the designed capacity) in its priority city evaluation, but why is this?

→（JET）
- Out of the six municipalities considered in the priority evaluation. Tavua and Rakiraki does not have existing WWTPs in the first place. Therefore, the "overcapacity of existing WWTPs" cannot be measured for these two cities, thus this factor was removed from the priority evaluation.

【Fukuoka City Question】
- As for the CAPEX delivery report, if the sewerage system construction overrides WAF's financial capacity (budget from the Fijian government), are there any other financial sources WAF is considering?

→（WAF）
- WAF is considering obtaining external funding from ADB, World Bank, JICA, and various Australian donors. The WAF water department has had experience in conducting multiple external source-funded projects, but the Sewerage department is yet to have this type of experience
- We are hoping to make proposals for such external source funding based on the JET team's M/P

7. Rescheduling of Training Session Day 2 Program

	● Since it is unknown to both JET and the WAF staff when the pipeline collapse incident will be resolved, WAF informed that there was a high possibility that the remaining WAF wastewater staff cannot attend the Day 2 program of the training session ● Fukuoka city strongly believes that the WAF wastewater staff in need of this training should participate to make value of this training program, and have asked the cooperation of several departments related to sewerage systems, If the WAF sSwerage department staff cannot participate, we strongly ask to be notified beforehand so we can adjust our schedules. The “implementation of training sessions” is not our goal, but to “have WAF staff ● From the above situation, it was decided between WAF, Fukuoka City, and JET to postpone the 7/20 Training sessions ● Rescheduling of the training session will be done as follows. ✧ It is better for the training session to be held while the JET team is staying in Fiji. If this is difficult to achieve, the JET team local engineer team will make arrangements with WAF, and the session will be held online around early August. ✧ The training material from Day 1 will be presented to the absent WAF staff by the JET team. Questions will be collected from WAF staff and sent to Fukuoka City, or a separate online discussion session will be held. END

(3) Training on WWTP design (Mechanical, Electrical and Civil) (On-line training on 28th July2022)

<table>
<tr><td>Topic</td><td>The Project for Formulation of Wastewater Treatment Master Plan in Western Division Second Training Session: Day 2</td><td rowspan="2">Venue</td><td rowspan="2">WAF Central Office/Zoom Meeting</td></tr>
<tr><td>Date/ Time</td><td>28, July 2022 10:00-13:00（JST）、 13:00-16:00 (FJT)</td></tr>
<tr><td>Participants</td><td colspan="3">WAF Central
Ifraaz Ali — Engineer
Paula.K — Engineer
Peter Qalilawa — Engineer Water
Jone Vunidawa — Manager Planning & Design
Rahul Nand — Engineer
Shavil Sharma — Graduate Engineer
Ashnil Kumar — Engineer
Pita Lagicere — Project Leader
Kemueli Serevi — Engineer Planning & Design
Hillary Fisher\ — Engineer
Monish Kumar — Engineer
Asneet Sagar — Graduate Engineer

Fukuoka City
Shingo MORIKAWA — Chief Policy Coordination Section
Shojiro HASHIZUME — Assistant Chief Policy Coordination Section
Masao ISHIZAKI — Chief （mechanical engineer） Treatment Facility Section
Shigeyuki YANO — Chief （electrical engineer） Treatment Facility Section
Katsutomo TANAKA — Chief（civil engineer） Treatment Facility Section
Yoko YAMANE — Interpreter

JICA Expert Team (JET)
NAKAJIMA Yoshinobu — Team Leader/ Sewerage Works management (NSC)
HAYASHI Kiyohiko — Deputy Team Leader/ Organization & Institutions (NSC)
WADA Tetsuo — Sewerage planning
KOTEGAWA Yoko — WWTP planning and design / Coordinator (NSC)</td></tr>
<tr><td>Material</td><td colspan="3">(1) Design and Supervision of Sewerage Systems-Ⅱ (Mechanical)
(2) Design and Supervision of Sewerage Systems-Ⅱ (Electrical)
(3) Design and Supervision of Sewerage Systems-Ⅱ (Civil)</td></tr>
<tr><td>Agenda</td><td colspan="3">7. (1) Design and Supervision of Sewerage Systems-Ⅱ (Mechanical) (Fukuoka City)
8. (2) Design and Supervision of Sewerage Systems-Ⅱ (Electrical) (Fukuoka City)
9. (3) Design and Supervision of Sewerage Systems-Ⅱ (Civil) (Fukuoka City)
10. Discussion</td></tr>
<tr><td>Explanation of outline

Comment</td><td colspan="3">This training session was jointly held between the Water Authority of Fiji (WAF), Fukuoka City Bureau of Roads and Sewerage, and the JICA Expert Team.
The Second Training Session was planned to be held on two days,
Discussion sessions were held after Fukuoka City’s lectures (Sewerage Planning. Sewer Pipe Design) and WAF’s presentation (WAF Wastewater Project Updates).
The discussions’ outline is as follows.

8. Design and Supervision of Sewerage Systems-Ⅱ (Mechanical)
(1) Presentation
● Schematic flow of wastewater treatment
● Mechanical Assets of WWTPs
✧ Settling/Grit Removal Basin（Gate, screens, grit removal, main pump equipment）
✧ Primary Sedimentation Tank (Sludge scraper, sludge removal, scum removal equipment)
✧ Biological Reactor (Introduction of various treatment processes, mixer, aerator, blower equipment)</td></tr>
</table>

- ✧ Final Sedimentation Tank (Sludge scraper, sludge removal, scum removal equipment)
- ✧ Disinfection equipment
- ✧ Sludge Thickening (Gravity thickeners, mechanical thickeners)
- ✧ Sludge Digestion (Digestion tank, desulfurizer, gas tanks)
- ✧ Sludge Dewatering (centrifugal/press-fit screw press dewatering)
- ✧ Other (Treated water recycling equipment, deodorization equipment)

(2) Question and Answer Session

【WAF QUESTION 】

- ✧ Is septage and human waste collected by bailing trucks accepted/treated at wastewater treatment plants? Or is there a different facility that treats them separately?

→（Answer by Fukuoka City）

- ▪ For households not connected to centralized treatment systems, bailing trucks collect human waste, which are brought to human waste treatment plants, which are separate from WWTPs.

【WAF QUESTION】

- ✧ Is the treated water filtered in any way before disinfection? For example, by the dissolved air floatation method?

→（Answer from Fukuoka City）

- ▪ No, the water is not filtered. Normally there are no extra treatment steps between the final sedimentation tank and disinfection

【WAF QUESTION】

- ✧ What types of sludge dewatering machines are used in Japan?

→（Answer from Fukuoka City）

- ▪ The centrifugal and press-fit screw press dewatering machines introduced in the slides are usually used.
- ▪ Sludge treatment in WWTPs are usually done in the order of sludge thickening→ anaerobic digestion→dewatering.

【WAF QUESTION】

- ✧ How are odor problems dealt with? Is deodorization done by using chemicals?

→（Answer from Fukuoka City）

- ▪ Deodorization has roughly two types of methods, chemical deodorization (using chemicals) and biological deodorization.

【WAF QUESTION】

- ✧ Around what temperature is sludge incinerated at?

→（Answer from Fukuoka City）

- ▪ Sludge is incinerated at about 850℃.

【WAF QUESTION】

- ✧ Is the biogas collected from anaerobic digestion also used in sludge incineration?

→（Answer from Fukuoka City）

- ▪ The above is correct.

【WAF QUESTION】

- ✧ Are harmful gasses other than H2S also scrubbed from the biogas before being used for sludge incineration?

→（Answer from Fukuoka City）

- ▪ The above is correct. Other harmful gasses/substances are removed from the biogas before being used.

【WAF QUESTION】

- ✧ How often is the maintenance of mechanical equipment in WWTPs done?
- ✧ We are especially interested about the maintenance of equipment that comes in direct contact with raw sewerage and are easily corroded, for example the equipment in grit removal basins.

→（Answer from Fukuoka City）
- ▪ There are roughly three types of maintenance:
- ▪ Daily maintenance：Operational data is recorded every day, and checked to see if there are any abnormalities
- ▪ Visual Checkups：Equipment is visually inspected once a month for any abnormalities.
- ▪ Overhaul: Depending on the equipment, assets go through complete overhauls every 3~5 years.

9. Design and Supervision of Sewerage Systems-Ⅱ (Electrical) (Fukuoka City)

(1) Presentation

- ● Outline and Composition of Electrical Equipment
  - ✧ Tips in planning/design
  - ✧ Relationship and flow of each equipment
- ● Substation（composition, safety measures, status monitoring）
- ● Emergency Power Generation Equipment（Generators, tips in planning/design）
- ● Load Equipment（tips in planning/design, control center, speed control devices）
- ● Supervisory and Control Equipment（Operator Console, tips in planning/design, control center）
- ● Control and Instrumentation Power Supply Equipment（Mechanism of the machinery, and design tips of the battery capacity）
- ● Instrumentation Equipment（Study of instrumentation equipment and selection of instruments）
- ● Introduction of the FORViS System
  - ✧ F：Fukuoka O：Observation R：Remote Vi：Viewing S：System
  - ✧ ICT-based monitoring system that centralizes the operational information of WWTPS and pumping stations
  - ✧ System can swiftly collect/share information between stations at times of natural disasters, as well as show real-time visual footages of damages, water levels, etc.
  - ✧ System is to be expected to be utilized for wastewater treatment BCPs

(2) Question and Answer Session

【WAF QUESTION】
- ✧ Is the FORViS system similar to that of Fiji's SCADA system?

→（Comment from Fukuoka City）
- ▪ We do not know what the SCADA system is. Can we have some explanations of the system?

→（Supplementary comment from JET）
- ▪ SCADA is the centralized pump station monitoring system in Fiji. It monitors the operational status of pumps not only in the West, but also those in the Central Region.

→（Answer from Fukuoka City）
- ▪ In that case, it can be considered that FORViS is similar to the SCADA system. However, it should be taken note that FORViS can also monitor visual data

【WAF QUESTION】
- ✧ What is the voltage of electricity brought to the WWTPs, before and after going through transformers?
- ✧ Also, is the voltage transformed in a single step?

→（Answer from Fukuoka City）
- ▪ Large WWTPs use a large amount of electricity, so they receive 6,600~66,000V, which is converted to 200V by transformers。
- ▪ Conversion is done in two steps. For example, when the receiving voltage is 66,000V, it is first converted to 3,300V, then once again converted to 200V.

【WAF QUESTION】

- ✧ How does the Star Delta Unit (Slide 13) control large-capacity motors? Do you use DOL or VSD?
  →（Answer from Fukuoka City）
  - ▪ When starting up large motors, the electric current sharply rises. The Star Delta Unit is used to suppress that sharp rise
  - ▪ It is difficult to understand the intent of the question, so please send us your question in writing later on.

  →（Detailed Answer provided by Fukuoka City in Writing）
  - ▪ The star-delta starter (a type of reduced-voltage starting method) is a method different from DOL (Direct Online motor starter), and it is adopted to reduce the starting current surge. This unit can reduce the starting current surge down to 1/3 to that of the DOL.
  - ▪ When the motor is starting, the motor windings are connected in a star configuration, which reduces the voltage across each winding. A few seconds later, the motor windings are then connected as a delta configuration, and the motor starts running normally.

【WAF QUESTION】
- ✧ What is the capacity of emergency power generators shown in Slide 7?
  →（Answer from Fukuoka City）
  - ▪ Large WWTPs usually have two units, 2,500KVA each. Small pumping stations usually have one unit, that is around 150KVA

【Question from JET to WAF】
- ✧ What is the capacity of emergency power generators equipped at Kinoya WWTP?
  →（Answer from WAF）
  - ▪ There is one 1,500KVA unit.

10. Design and Supervision of Sewerage Systems-Ⅱ (Civil) (Fukuoka City)

(1) Presentation
- ● Role and Components of Sewerage Systems
- ● Types of Pumping Stations（Stormwater Removal, Sewerage Relay, WWTP Pump-ups）
- ● Setting Design Flowrates（Separate vs Combined Sewer systems）
- ● Components of Pumping Stations
  - ✧ Grit Chamber（shape, number of basins, structure, design standards ）
  - ✧ Pump wells（structure, design standards）
  - ✧ Number of pumps（Types of pumps, design standards for separate/combined sewers）
- ● WWTPs
  - ✧ Setting Design Flowrates
  - ✧ Primary Settling Tank（design standards, shape）
  - ✧ Bioreactor（Function, design standards, SRT, characteristics of various treatment processes）
  - ✧ Final Sedimentation Tank（Difference between Primary settling tanks, design standards）
  - ✧ Disinfection（Design standards and tips on planning）

(2) Question and Answer Session

【WAF QUESTION】
- ✧ Is infiltration of rainwater and groundwater also included in the design flow of pumping stations?
  →（Answer from Fukuoka City）
  - ▪ Infiltrated water is not included in the design flowrates of rainwater pumping stations. However, in some cases the amount of these waters is considered in the design of sewerage pipes
  - ▪ In the case of design flowrates of sewerage pumping stations, infiltrated water is included.

【WAF QUESTION】
- ✧ WAF has some plans for setting up one more primary sedimentation tank at Suva's WWTP. Is there any way to improve the settling efficiency while having the same footprint?
  →（Answer from Fukuoka City）

- In Fukuoka City, there are no past records of utilizing methods to improve settling efficiencies of primary settling tanks
- However, when it comes to final sedimentation tanks, there is a method called the two-story settling tanks
- We will check of the methods applicability to primary settling tanks and answer back later on. Please send your question in writing.

→（Detailed Answer provided by Fukuoka City in Writing）

- A two-story system is possible, but since the structure of the sedimentation tank becomes deep, it is considered to have disadvantages in terms of maintenance and management, such as inspection of the sludge scraper.
- In Fukuoka City, the two-story structure has been adopted for some final sedimentation tanks.

【WAF COMMENTS】

✧ Kinoya WWTP currently has a temporary disinfection basin (the actual basin will be constructed later on), where disinfectants are being added to the treated water.

✧ The amount of disinfectants is decided by the water quality lab at Kinoya, so this is the first time we learned about the contact time of disinfectants and treated water

✧ Sine the disinfectants are added at the head of the basin, we think that 15 minutes will pass before the water is released into the environment, but we are not sure.

✧ We will ask the lab if the factor of contact time is included in their calculation, and if needed change the amount of disinfectants

→（Comment form Fukuoka City）

- For disinfection, the most important point is if the coliform count after disinfection is below the effluent standards.
- If the current disinfection dosage fulfills Fiji's effluent standards, then there is really no need of securing the 15-minute contact time.

【FUKUOKA CITY QUESTION】

✧ Is the coliform count included in Fiji's effluent standards?

→（Answer from WAF）

- Yes, it is.

→（Supplementary comment from JET）

- In Fiji's General Effluent Standards, the Fecal Coliform Count is 400CFU/100mL; for Significant Ecological Zone Standards, the fecal coliform count is set at 200CFU/100mL

【WAF QUESTION】

✧ How is the flowrate of disinfectants added to the disinfection basin decided?

→（Answer from Fukuoka City）

- Today, the chief of treated water quality is not here. Please send us your question along with its background (for example, if you want to know this information to compare it with Kinoya's current disinfection process, etc.) in writing, and we will send back an answer later on.

→（Detailed Answer provided by Fukuoka City in Writing）

- The dosage is adjusted based on regular sampling/water quality testing of the effluent, so that the coliform count falls below the standard value. (Since increasing the chemicals' dosage will increases the operational costs, we are adjusting the dosage to its optimal amount)

11. Other Questions

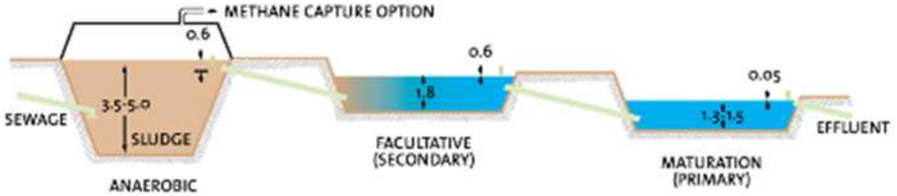
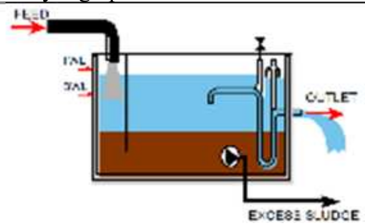
【FUKUOKA CITY QUESTION】

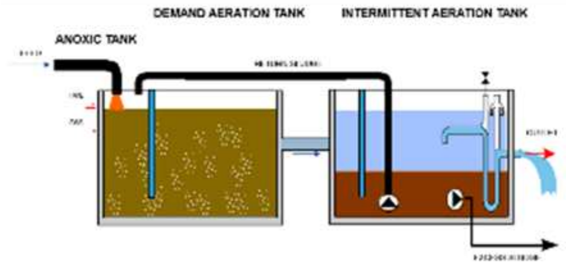
✧ The training sessions up to this day mainly introduced the standard planning, design, and facilities of sewerage systems in Fukuoka City/Japan.

✧ While Fukuoka City's system ensures high levels of treatment, we assume that there are many gaps between Fiji's system and treatment plants (for example: scale of WWTPs)

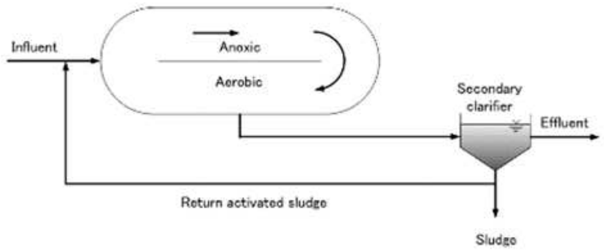
	✧ Please tell us if the contents of the past two training sessions have been applicable to the situations in Fiji. For example, if we are introducing methods that cannot be used in Fiji, or if we should adjust the contents of our presentation to the scales of Fijian WWTPs, please tell us. →（Answer from WAF） ▪ In both training sessions, the training material is very well organized and easy for us to understand. We feel that the level/scale of the contents are also fit for the Fijian side. ▪ Thus, we don't think there is the need to significantly change the contents of the training session. ▪ Through the training and discussion, the Fijian side is starting to see some points we would like to recheck/review on our current operation methods. We hope that in the future, these discussions and trainings will lead to the improvement of our facility O&M 【FUKUOKA CITY QUESTION】 ✧ As for the collected questions for the Training Session 2 Day 1 material, who will be translating the answers from Fukuoka City to English? →（Answer from JET） ▪ The JET team will translate the answers and send them to WAF 【FUKUOKA CITY QUESTION】 ✧ One of the questions from Training Session 2 Day 1 asks "How much rainwater infiltration is included in the design of separate sewer system pipes." ✧ Is the intent of this question "How much infiltration is included in the design sewerage flow rate of separate sewer system pipes?" →（Answer from WAF） ▪ That is correct. END

APPENDIX 5-1 Wastewater Treatment Process Description

Process	Process Description	
Lagoon1)	 This is the most popular treatment in Fiji. This process consists of three ponds. First pond is an anaerobic pond (normally at least 3m deep) where sewerage is digested anaerobically. Second pons is a facultative pond (normally 1.5m to 2m deep) where both anaerobic and aerobic digestion of sewerage. Last pond is a maturation pond (normally 0.9m to 1.5m deep) primarily responsible for pathogen removal by various ways mechanisms, including UV disinfection and daily high pH levels.	Advantages Operation is very easy. Operation and construction costs are very low. Limitations: Large area is required. Treatment capability depends on the weather condition. Intentional removal of nitrogen and phosphorus is difficult.
Intermittently Decanted Extended Aeration (IDEA)3)	 Single System	Advantages: 15 to 20 mg/L TN is achievable in Original IDEA process (single system). Less than 10 mg/L TN is achievable when the modified IDEA process (dual system) is adopted by installing return sludge pipe and pumps. Less area because of no equalization tank and final clarifiers. Simple layout because of tank shape is square or rectangular. Limitations: The balance tank is required to attenuate flows from the IDEA reactors. To achieve high nitrogen removal, operation of IDEA process is more complicated than original IDEA because the process flow is almost same as that of Ludzak-Ettinger process.

<table>
<tr><td>Intermittently Decanted Extended Aeration (IDEA)3)</td><td>

Dual System

The Intermittently Decanted Extended Aeration (IDEA) Activated Sludge System is a hybrid between conventional sequencing batch reactor (SBR) and extended aeration (EA) systems. The treatment process is the same type of Sequencing Batch reactor (SBR) except for continuous feeding. The influent is fed into one side of the reactor, so the flow does not disturb the mixed liquor during the settling and decant period. Wastewater flows through inlet pipe and into the reactor where BOD and nitrification occur. After aeration and settling, separated liquid is removed by an automated, time-controlled decant mechanism. Sludge wasting is also accomplished during phase.</td><td></td></tr>
<tr><td>Oxidation Ditch4)</td><td>

The Oxidation ditch (OD)consists of a ring- or racetrack-shaped channel equipped with mechanical aeration and mixed devices. Screened and degritted wastewater enters the channel and is combined with the return activated sludge. In Japan Advanced OD process which can remove nitrogen by denitrification is developed. As the wastewater leaves the aerobic zone, the DO concentration decreases, and denitrification occurs downstream from the anaerobic zone in the reactor.</td><td>Advantages:
Less than 5 mg/L effluent TN is possible.
Large reactor volume is resistant to load variations without affecting effluent quality significantly.

Limitations:
Large area is required.
DO monitoring is required.</td></tr>
</table>

Source:
Power and Water Corporation, Waste Stabilization Pond Design Manual
http://www.envitech.com.my/index.php/technology/idea-sewerage-treatment-system/
Metcalf & Eddy, Wastewater Engineering Fifth Edition.

APPENDIX 5-2 Wastewater Treatment Plant Calculation Input Parameters

(1) Influent Flow

The target wastewater to be treated at the WWTPs was set to be "inflow of sewerage from pipelines" (hereinafter referred as "pipeline sewerage"), and "domestic septage collected by bailing trucks"(hereinafter referred as "septage" or "domestic septage"). Refer to Section 5-3-1(3)1) for details.
The inflow of piped sewerage was set to the projected flowrate in year 2036, when the connection to centralized treatment systems reaches its maximum during the M/P's target period (**Table A5-2. 1**) .

Table A5-2. 1 Influent flow from pipeline sewerage (Expected flowrate of 2036)

Parameter	Units	Navakai (Nadi)	Natabua (Lautoka)	Votua (Ba)	Tavua	Rakiraki	Olosara (Sigatoka)
Average Dry Weather Flowrate (ADWF)	m^3/day	31292.8	30974.9	8923.2	3458.4	2030.6	5596.8

Source : JET

Domestic septage is expected to be accepted at three locations: Natabua, Rakiraki, and Olosara WWTP. Since the flowrate of domestic septage will change with the increase of households connected to centralized treatment systems, the largest daily average flowrate during the M/P's target period (2017-2036) was adopted (**Table A5-2. 2**).

Table A5-2. 2 Domestic Septage Flowrate Projection of 2017-2036

WWTP	Bailed Septage Volume		Projected Year																				MAX
			2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	
Natabua (Lautoka)	Annual Avg.	m3/yr	5047	4865	4675	4491	4308	4122	3936	3748	3565	3832	4060	4232	4356	4424	4451	4420	4346	4214	4030	3799	**5047**
	Daily Avg.	m3/d	21	20	19	19	18	17	16	16	15	16	17	18	18	18	19	18	18	18	17	16	**21**
Rakiraki	Annual Avg.	m3/yr	1467	1471	1479	1486	1497	1504	1512	1520	1529	1743	1966	2183	2411	2530	2643	2735	2814	2877	2928	2960	**2960**
	Daily Avg.	m3/d	6	6	6	7	7	7	7	7	7	8	8	9	10	11	11	12	12	12	12	12	**12**
Natabua (Lautoka)	Annual Avg.	m3/yr	1536	1507	1480	1451	1425	1398	1369	1342	1313	1460	1599	1730	1856	1972	2083	2184	2281	2367	2446	2520	**2520**
	Daily Avg.	m3/d	7	7	6	6	6	6	6	6	6	6	7	8	8	8	9	9	10	10	10	11	**11**

(Daily Avg.=Annual Avg ÷ (247 workdays/yr))

Source : JET

The daily inflow of the above three WWTPs was set as the sum of pipeline sewerage and domestic septage (to be more exact, the leachate produced from the dewatering of domestic septage), which was rounded up to 1000 m^3/d (**Table A5-2. 3**). The calculated influent flowrates of all WWTPs are listed in **Table A5-2. 4**.

Table A5-2. 3 Daily Flowrate of Influents at Natabua, Rakiraki, and Olosara WWTP

Parameter	Units	Natabua (Lautoka)	Rakiraki	Olosara (Sigatoka)
Piped Sewerage (ADWF)	m^3/day	30,974.9	2,030.6	5,596.8
Domestic Septage (Daily Avg.)	m^3/day	21.0	12.0	11.0
Piped Sewerage + Domestic Septage	m^3/day	30,995.9	2,042.6	5,607.8
Total Influent (ADWF)	m^3/day	31,000	3,000	6,000

Source: JET

Table A5-2. 4 Influent Flowrate of WWTPs

Parameter	Units	Navakai (Nadi)	Natabua (Lautoka)	Votua (Ba)	Tavua	Rakiraki	Olosara (Sigatoka)
Average Dry Weather Flowrate (ADWF)	m^3/day	32,000	31,000	9,000	4,000	3,000	6,000

Source: JET

(2) Influent Water Quality

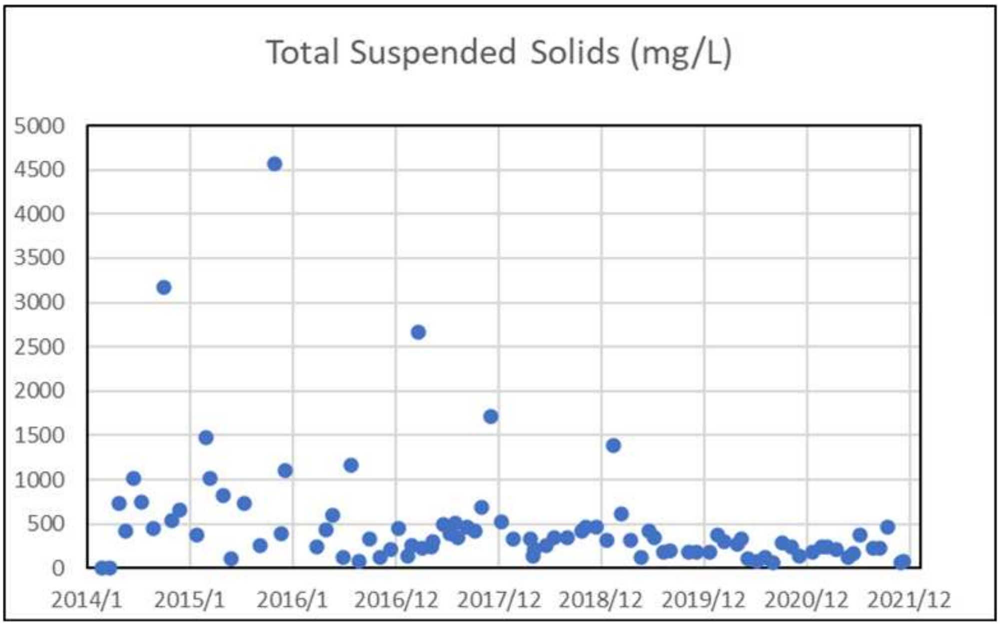
1) Piped Sewerage

Existing WWTPs have recorded influent water quality data from 2014-2021, as well as parameter values that were adopted in past Donor projects. In this project, the highest value from these records/reports were adopted for safekeeping.

i) Recorded Influent Data (Raw data)

During the field survey, 8 years' worth (2014-2021) of influent data was provided by WAF; however, due to the COVID-19 pandemic that started in 2019, the tourist population visiting Fiji sharply dropped from 2020, significantly affecting the economy and industrial activities. It is believed that the influent flowrate and water quality of sewerage also was affected by this decrease, producing irregular data. Therefore, in this report the raw data from 2014-2018 was adopted.

In addition, the recorded data showed some unusually high/low results, which were perhaps caused by sample contamination, mismeasurements etc. As an example, Navakai WWTP's TSS data is shown in **Figure A5-2. 1**.



Source： Created by JET based on WAF laboratory data

Figure A5-2. 1 TSS data of Navakai WWTP Influent

Since these abnormally high/low data values can lead to the over/under-estimation of influent water quality, the outlier data (top 5% and bottom 5%) was removed from each data group before calculations. **Table A5-2. 5** organizes the annual average of raw influent data for each existing WWTP, as well as their maximum value

Table A5-2. 5 2014-2018 Annual Average of Raw Influent Data, and its Maximum Value

WWTP	2014-2018 Raw Influent Data (Annual Average)					
	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	T-N (mg/L)	T-P (mg/L)	FOG (mg/L)
Navakai (Nadi)	484.1	325.7	712.3	31.2	3.5	75.7
Natabua (Lautoka)	413.0	285.6	559.5	25.9	3.7	83.0
Votua (Ba)	406.2	242.8	558.0	20.3	3.3	52.4
Olosara (Sigatoka)	328.3	251.7	512.4	23.2	3.5	59.0
Maximum Value	484.1	325.7	712.3	31.2	3.7	83.0

Source: Created by JET based on WAF data

ii) Adopted Values in Past Projects

Navakai, Natabua, and Votua WWTP has had past projects designing to increase its' treatment capacities. The adopted influent water quality parameters of each project are organized in **Table A5-2. 6** below.

Table A5-2. 6 Adopted Influent Water Quality Parameters of Past Donor Projects, and Their Maximum Value

Target WWTP	Report Title	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	T-N (mg/L)	T-P (mg/L)
Navakai (Nadi)	Navakai WWTP Upgrade Detailed Design Report (2021)	310	300	659	58	6.0
	Navakai WWTP Upgrade Concept Report (2018)	372	360	792	70	7.0
Natabua (Lautoka)	Consultancy for the Upgrading of Wastewater Treatment Plant at Natabua Options Assessment	300	300	600	60	9.0
	Upgrading of Wastewater Treatment Plant at Natabua (2019)	300	300	624	60	9.0
Votua (Ba)	VotuaWWTP_Options_Memo_Client Issue_221121 (2021)	300	250	550	45	7.0
Maximum Value		372	360	792	70	9.0

Source: Created by JET based on "Navakai WWTP Upgrade Detailed Design Report," "Navakai WWTP Upgrade Concept Report," "VotuaWWTP_Options_Memo_Client Issue_221121"(Hunter H2O)," Consultancy for the Upgrading of Wastewater Treatment Plant at Natabua Options Assessment," "Upgrading of Wastewater Treatment Plant at Natabua" (GHD)

iii) Adopted Influent Water Quality Input Data

Table A5-2. 7 organizes the input data of each influent water quality parameter that was adopted based on recorded raw data and past donor projects.

Table A5-2. 7 Adopted Input Data for Influent Water Quality

Data Group	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	T-N (mg/L)	T-P (mg/L)	FOG (mg/L)
2014-2018 Data	484.1	325.7	712.3	31.2	3.7	83.0
Past Projects	372.0	360.0	792.0	70.0	9.0	—
Input Data	484.1 →485.0	360.0	792.0	70.0	9.0	83.0

Source： JET

2) Domestic Septage

Since Fiji does not have past records of septage water quality data, the recorded data from "Adoption/Demonstration Experiment Project of Johkasou Sludge Dewatering Machines in Cebu City (Philippines)" (2016) was adopted as a substitute. This project publicly provides actual data of the leachate and sludge cakes of mechanically dewatered Johkasou sludge.

Table A5-2. 8 Adopted Water Quality Input Data of Domestic Septage

Leachate			Dewatered Sludge	
TSS	BOD	COD	Water Content	TSS
620 mg/L	250 mg/L	200 mg/L	75%	20,000 mg/L

Source: "Adoption/Demonstration Experiment Project of Johkasou Sludge Dewatering Machines in Cebu City (Philippines)" (AMCON INC.) (2016)

3) Influent Water Quality Parameters of WWTPs Accepting Domestic Septage

As mentioned earlier, Natabua, Rakiraki, and Olosara WWTPs accept domestic septage, and are planned to treat its dewatering leachate along with piped sewerage. The water quality of the mixture was calculated, and its results are organized in **Table A5-2. 9**.

Since the amount of leachate was much smaller compared to the inflow of pipeline sewerage, the addition of domestic septage leachate only minimally affected the water quality. Therefore, the same input values for water quality parameters will be adopted at all WWTPs of the Western Division.

Table A5-2. 9 Water Quality Input Data of Domestic Septage-accepting WWTPs

WWTP	Pipeline Sewerage			Domestic Septage Leachate			Total Influent	
	TSS (mg/L)	BOD (mg/L)	Flowrate (m^3/day)	TSS (mg/L)	BOD (mg/L)	Flowrate (m^3/day)	TSS (mg/L)	BOD (mg/L)
Natabua (Lautoka)	484.1	360	30,974.9	620	250	21.0	484.1 →450	359.9 →360
Rakiraki	484.1	360	2,030.6	620	250	12.0	484.8 →450	359.4 →360
Olosara (Sigatoka)	484.1	360	5,596.8	620	250	11.0	484.3 →450	359.8 →360

Source: JET

(3) Influent Water Temperature

The influent water temperature was set based on actual data recorded at Suva’s Kinoya WWTP.

In the capacity calculation of WWTPs, safer-side results are produced by adopting lower water temperatures. The lowest water temperature recorded at Kinoya WWTP during 2007-2021 was 17.6℃. However, during this 15-year period this was the only instance when the influent temperature fell below 18℃, suggesting that this was an abnormal value.

On the other hand, influent temperatures between 19.4～19.8℃ was recorded multiple times. From the above data analysis results, the water temperature in this project’s calculations was set at 20℃.

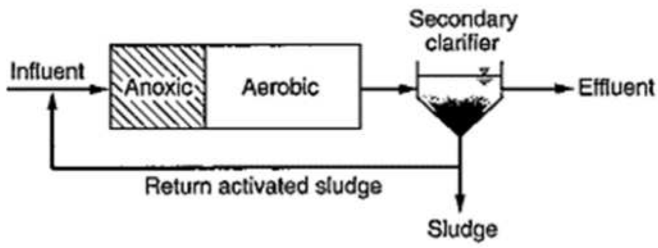
APPENDIX 5-3 IDEA Treatment Capacity

1) Objective

IDEA process is used in Australia and other countries. However, in-depth performance evaluation of a full-scale IDEA plant is rare, making it challenging for water utilities to meet the increasingly stringent discharge requirements with these assets. Based on these backgrounds, this section evaluated the ability of IDEA processes on nitrogen by literature reviews.

2) Literature review

Several literatures mention the abilities on IDEA process which are summarized as follows. Simple IDEA process and the same process mechanism as IEDA can remove BOD and oxidize ammonia which is called as nitrification. As for nitrogen removal, simple IDEA process can achieve around 15 to 20 mg/L as N of treated water quality. However, to achieve less than 10 mg/L of TN, the installation of RAS system to IDEA process was proposed. This modified IDEA process seems to be similar to the Ludzak-Ettinger process categorized in the pre-anoxic process without the secondary clarifier. Since the process flow are similar, the nitrogen removal ability of modified IDEA process could be almost same as that of the Ludzak-Ettinger process.



Source: Metcalf & Eddy, Wastewater Engineering Fifth Ed.

Figure A5-3. 1 IDEA Process Diagram of Ludzak-Ettinger process

Table A5-3. 1 IDEA Process Literature

Name of Literature	Descriptions on Treated Water Quality
Insights drawn from a full-scale Intermittently Decanted Extended Aeration (IDEA) plant for optimizing nitrogen and phosphorus removal from municipal wastewater1)	Results of actual full scale IDEA process showed that the plant enabled good nitrification in the IDEA effluent. However, the denitrification efficiency was low (ca. 50%) and could be improved by decreasing oxygen supply to suppress nitrite oxidation and preserve influent carbon.
Metcalf & Eddy, Wastewater Engineering Fifth Ed., PP786-7952)	ICEAS process which is the same process as IDEA is mentioned as a process for BOD removal and nitrification. This process is not mentioned as intentionally nitrogen removal process.
Envitech Web site 3)	Total-N concentrations of 15 mg/l on a 90-percentile basis are typically achieved in the IDEA single tank treatment process. In the dual tank IDEA treatment process, total -N concentrations of 6 mg/l on a 90-percentile basis are achieved. Dual tank IDEA process has addressed the limitations of single tank processes by providing a demand aeration tank prior to the intermittent tank, and incorporating a recycle activated sludge (RAS) stream.
Warrnambool STP Upgrade Project Report 2 4)	The existing Warrnambool IDEA tanks provide biological Nitrogen removal, and are capable of producing treated effluent with an annual median total Nitrogen concentration of approximately 20mg/L. Under suitable influent conditions, the Warrnambool STP theoretically has the capability to produce treated effluent with a total Nitrogen limit of 15–20mg/L. To secure the 15 mg/L of total nitrogen, the addition of two additional treatment tanks, which are IDEA reactors and will treat approximately one third of the influent, was proposed. The reactors have dedicated anoxic zones that further enhance Nitrogen removal, with a capability of achieving a median effluent Nitrogen concentration of 15mg/L under suitable conditions.
Introduction of IDEA 5)	The IDEA can achieve high nitrogen removal, with proper carbon to nitrogen ratio, less than 10 mg/L of total nitrogen in the decant can be expected by modifying the basic IDEA system with an anoxic zone which can help the nitrogen removal. In the modification, a concrete structure is built at the inlet end of the IDEA tank, there are mixers in the anoxic zone, and a pump will transfer the mixed liquor from the main aerated zone back to the anoxic zone, the mixed liquor has been exposed to aeration, and ammonia has been converted to nitrate.

Source:
Science of The Total Environment, Volume 744, 20 November 2020, 140576
Metcalf & Eddy, Wastewater Engineering Fifth Ed.
http://www.envitech.com.my/index.php/technology/idea-sewerage-treatment-system/wannon water .co. au
https://engage.vic.gov.au/

3) Conclusions

Basic IEDA can remove BOD and oxidize ammonia. Around 15 to 20 mg/L of total nitrogen can be achieved in basic IDEA process. To achieve less than 10 mg/L of total nitrogen, the modification with adding recycling activated sludge stream to basic IDEA is necessary.

APPENDIX 5-4 Stabilization Pond/Aerated Lagoon Calculation

Natabua WWTP in Lautoka
Waste Stabilization Pond

Design Flow

ADWF (with Septage)	m3/day	31,000
Max Daily Flow Rate	m3/day	34,100
Max Hourly Flow Rate	m3/day	62,000
PWWF (with Septage)	m3/day	155,000

Design Qualitiy
Inflow

BOD	360	mg/L
TSS	464	mg/L
TKN	70	mg/l
TP	9	mg/l
COD	792	mg/l

Pond Dimention

AN 1	Anaerobic Pond 1	Surface Area Volume Average depth	6,350 m^2 11,500 m^3 2 m
AN 2	Anaerobic Pond 2	Surface Area Volume Average depth	6,150 m^2 11,000 m^3 2 m
FA 1	Facultative Pond 1	Surface Area Volume Average depth	16,800 m^2 22,900 m^3 1.5 m
FA2	Facultative Pond 2	Surface Area Volume Width Average depth	14,200 m^2 20,590 m^3 92 m 1.5 m
MA 1	Maturation Pond 1	Surface Area Volume Average depth	12,200 m^2 13,150 m^3 1.1 m
MA 2	Maturation Pond 2	Surface Area Volume Average depth	12,200 m^2 13,150 m^3 1.1 m
SDS 1	Septage Dumping Site	n.d.	Septage is dumped in a septage dumping site.

Other	Lift Pump station	3 pumps	Pump 1 (100 L/s@ 10m H) Pump 2&3 (160 L/s@ 10m H x 2 pumps) Estimated Inflow based on pumps 29,000 m^3/d (=(100+160 x 2) x 60 x 60 x 24/1000 x 0.8)

Source:GHD, Updrading of Wastewater Treatment Plant at Natabua Data and Information Data and Information Review, September 2019

1) Anaerobic Pond
Q = AaDa λv/Li
Q is average flow, m3/d
Aa Da is anaerobic pond working Volume, m3
Aa Da = 11,500 + = 11,500 m3
λv is volumetric loading, g/m3/d
T= 20 Celsius
λv = 10 x 20 + 100 = 300 g/m3/d

Facultative Pond	Loading g BOD/m^3 day	BOD removal %
< 10	100	40
10-20	20T-100	2T + 20
20-25	10T+100	2T +20
>25	350	70

Source: Duncan Mara, Domestic Wastewater Treatment in Developing Countries (2003), p109

Li is raw sewage strength, mg BOD/L
(Influence BOD = 360 mg/L)
Q= 11,500 x 300 / 360 = 9,583 m3/d

2)Facultative Pond
Q = λsAf / 10Li
Q is average flow, m3/d
λs is surface loading, kg /ha/d
T= 20 Celsius
λv = 350 x(1.107 - 0.002 x 20)^ (20 - 25)
= 253.07 /ha/d

Facultative Pond	Surface Loading kg BOD/ ha day	Facultative Pond Effluent BOD, mg/l

Primary Pond	350 x $(1.107\text{-}0.002\ T)^{(T-25)}$	$Li/(1+k_1\theta_f)$, $k_1=k_{(20)}(1.05)^{T-20}$, $k_{(20)}=0.3$
Secondary Pond	350 x $(1.107\text{-}0.002\ T)^{(T-25)}$	$Li/(1+k_1\theta_f)$, $k_1=k_{(20)}(1.05)^{T-20}$, $k_{(20)}=0.1$

Source: Duncan Mara, Domestic Wastewater Treatment
in Developing Countries (2003), pp118-121

A^f is facultative pond mid depth area, m2 (FA1,FA2,AN2,MA1)
A^f = 16,800 + 14,200 + 6,150 + 12,200 = 49,350 m2
Li is raw sewage strength, mg BOD/L = 360 mg/L
BOD removal % of anaerobic pond
BOD removal % = 2T + 20 = 2 x 20 + 20 = 60 %
Assuming Reduced Removal rate of anaerobic pond is 50 % .
Effluent BOD from anaerobic pond = Li - Li x BOD Rem. x 50 %
= 360 - 360 x 60 % x 50 %
= 252 mg/L

Q= 253.07 x 49,350 / 10 / 252 = 4,956 m3/d
→ 4,000 m3/d

k1(T)= k1(20) x 1.05 ^(T - 20)
For primary facultative pond, k1(20) = 0.3 /day
For secondary facultative pond, k1(20) = 0.1 /day
k1(T)= 0.3 x 1.05 ^(20 - 20) = 0.3
θ = V^f / Q =(22,900 + 20,590 + 11,000 + 13,150)/ 4,000
= 16.91

$$\text{Effluent BOD from facultative pond} = \frac{Li}{1 + k1 \times \theta}$$

= 252 /(1 + 0.3 x 16.9)
= 41.5 mg/L

3)Maturation Pond
Q = V/3 = (13,150 +) / 3 = 4,383 m3/d
Q is average flow, m3/d

$$\text{Effluent BOD from maturation pond} = \frac{Li}{1 + k1 \times \theta}$$

k1 = 0.05
θ = 13,150 / 4,000 = 3.288

= 41.5 /(1 + 0.05 x 3.288)
= 35.6 mg/L < 40 mg/L : General in Concentration Standards

of National Liquid Waste Standards

(PowerWater)
Effluent BOD from maturation pond = Effluent BOD from facultative pond x 0.75
= 41.5 x 0.75 = 31.1 mg/l < 40 mg/l

For Q= 4,000 m3/d
Sludge Volume =(11,500 + 11,000 + 22,900 + 20,590 + 13,150)
= 79,140 m3
Desludging Duration : 10 years
Desludging Volume = 79,140 / 10 = 7,914 m3/year
Lagoon TSS = 20,000 mg/L 75 %
Desludge Volume(Dewater) = 7,914 x 20,000 / 1,000,000
x 1,000 / 0.25 / 1,000
= 633 m3
h= 0.3 m
Dry Sludge Area = 633 / 0.3 = 2,110 m3
→ 100 m x 25 m = 2,500 m2
For Q= 31,000 m3/d
Sludge Volume = 79,140 / 4,000 x 31,000
= 613,335 m3
Desludging Duration : 10 years
Desludging Volume = 613,335 / 10 = 61,334 m3/year
Lagoon TSS = 20,000 mg/L 75 %
Desludge Volume(Dewater) = 61,334 x 20,000 / 1,000,000
x 1,000 / 0.25 / 1,000
= 4,907 m3
h= 0.3 m
Dry Time: 5 months
Dry Sludge Area = 4,907 / 0.3 x 5 = 81,778 m2
→ **100 m x 820 m** = 82,000 m2

Dry Desludge Storage for 20 years
= 633 x 31,000 / 4,000 x 20 = 98,134 m3
→ **3 m x 200 m x 170 m** = 102,000 m3

Sepage Acceptance pond
Septage Volume = 42 m3/d → 42 x 30 days = 1,260 m3/month
3months Volume = 1,260 x 3 = 3,780 m3
Sepage Acceptance pond
→ **2 m x 100 m x 20 m** = 4,000 m3

Septage TSS	=	20,000	mg/l		75	% of water cont.					
Deseptage Volume	=	3,780	m3/3 month	x	20,000	/	1,000,000				
(Dewatered)	x	1,000	/		0.25 /		1,000				
	=	302	m3								
Dry Area : 5 months											
Septage Dry Area	=	302	/	0.3	/	3 x	5 =	1,680	m2		
	→	**100**	**m x**	**20**	**m** =	2,000	m2				
Dry Septage Strage for 20 years=		302	m3/3 month	X	4 X	20	years				
= 24,192 m3	→	**3 m x**	**200**	**m x**	**40**	**m** =	24,000	m3			

Votua WWTP in Ba
Waste Stabilization Pond

Design Flow

ADWF (with Septage)	m3/day	9,000
Max Daily Flow Rate	m3/day	9,900
Max Hourly Flow Rate	m3/day	18,000
PWWF(with Septage)	m3/day	45,000

Design Qualitiy
Inflow

BOD	360	mg/l
TSS	484	mg/L
TKN	70	mg/L
TP	9	mg/l
COD	792	mg/L

Pond Dimention

AN 1	Anaerobic Pond 1	Surface Area	1,600 m^2
		Volume	4,320 m^3
		Average depth	2.7 m
AN 2	Anaerobic Pond 2	Surface Area	1,600 m^2
		Volume	4,320 m^3
		Average depth	2.7 m
FA 1	Facultative Pond 1	Surface Area	3,200 m^2
		Volume	4,480 m^3
		Average depth	1.4 m
FA2	Facultative Pond 2	Surface Area	3,200 m^2
		Volume	4,480 m^3
		Average depth	1.4 m
MA 1	Maturation Pond 1	Surface Area	9,450 m^2
		Volume	11,340 m^3
		Average depth	1.2 m

Source:hunterh2O, Votua Wastewater Treatment Plant Site Condition Assessment, February 2020

1) Anaerobic Pond
Q = AaDa λv/Li
Q is average flow, m3/d
Aa Da is anaerobic pond working Volume, m3
Aa Da = 4,320 + = 4,320 m3

λv is volumetric loading, g/m3/d
T= 20 Celsius
λv = 10 x 20 + 100 = 300 g/m3/d

Facultative Pond	Loading g BOD/m^3 day	BOD removal %
< 10	100	40
10-20	20T-100	2T + 20
20-25	10T+100	2T +20
> 25	350	70

Source: Duncan Mara, Domestic Wastewater Treatment in Developing Countries (2003), p109

Li is raw sewage strength, mg BOD/L
(Influence BOD = 360 mg/L)
Q= 4,320 x 300 / 360 = 3,600 m3/d

2)Facultative Pond
Q = λsAf / 10Li
Q is average flow, m3/d
λs is surface loading, kg /ha/d
T= 20 Celsius
λv = 350 x(1.107 - 0.002 x 20)^ (20 - 25)
= 253.07 /ha/d

Facultative Pond	Surface Loading kg BOD/ ha day	Facultative Pond Effluent BOD, mg/L
Primary Pond	$350 \times (1.107\text{-}0.002\ T)^{(T-25)}$	$Li/(1+k_1\theta_f)$, $k_1=k_{(20)}(1.05)^{T-20}$, $k_{(20)}=0.3$
Secondary Pond	$350 \times (1.107\text{-}0.002\ T)^{(T-25)}$	$Li/(1+k_1\theta_f)$, $k_1=k_{(20)}(1.05)^{T-20}$, $k_{(20)}=0.1$

Source: Duncan Mara, Domestic Wastewater Treatment in Developing Countries (2003), pp118-121

Af is facultative pond mid depth area, m2 (FA1,FA2,AN2)
Af = 3,200 + 3,200 + 1,600 + = 8,000 m2
Li is raw sewage strength, mg BOD/L = 360 mg/L
BOD removal % of anaerobic pond
BOD removal % = 2T + 20 = 2 x 20 + 20 = 60 %
Assuming Reduced Removal rate of anaerobic pond is 50 %
Effluent BOD from anaerobic pond = Li - Li x BOD Rem. x 50 %
= 360 - 360 x 60 % x 50 %
= 252 mg/L

Q= 253.07 x 8,000 / 10 / 252 = 803 m3/d
≒ 1,000 m3/d

k1(T)= k1(20) x 1.05 ^(T - 20)
For primary facultative pond, k1(20) = 0.3 /day
For secondary facultative pond, k1(20) = 0.1 /day
k1(T)= 0.3 x 1.05 ^(20 - 20) = 0.3
θ = V* / Q =(4,480 + 4,480 + 4,320 + 11,340)/ 1,000
= 24.62

Li
Effluent BOD from facultative pond = --------------------
1 + k1 x θ
= 252 /(1 + 0.3 x 24.6)
= 30.1 mg/L

3)Maturation Pond
Q = V/3 = (11,340 +) / 3 = 3,780 m3/d
Q is average flow, m3/d

Li
Effluent BOD from maturation pond = --------------------
1 + k1 x θ
k1 = 0.05
θ = 11,340 / 1,000 = 11.3

= 30.1 /(1 + 0.05 x 11.3)
= 19.2 mg/L < 40 mg/L : General in Concentration Standards of National Liquid Waste Standards

(PowerWater)
Effluent BOD from maturation pond = Effluent BOD from facultative pond x 0.75
= 30.1 x 0.75 = 22.5 mg/l < 40 mg/l

For Q= 1,000 m3/d
Sludge Volume =(4,320 + 4,320 + 4,480 + 4,480 + 11,340)
= 28,940 m3
Desludging Duration : 10 years
Desludging Volume = 28,940 / 10 = 2,894 m3/year
Lagoon TSS = 20,000 mg/L 75 %
Desludge Volume(Dewater) = 2,894 x 20,000 / 1,000,000
x 1,000 / 0.25 / 1,000
= 232 m3
h= 0.3 m

Dry Sludge Area = 232 / 0.3 = 772 m3
→ 100 m x 80 m = 8,000 m2

For Q= 9,000 m3/d

Sludge Volume = 28,940 / 1,000 x 9,000
= 260,460 m3

Desludging Duration : 10 years

Desludging Volume = 260,460 / 10 = 26,046 m3/year

Lagoon TSS = 20,000 mg/L 75 %

Desludge Volume(Dewater) = 26,046 x 20,000 / 1,000,000
x 1,000 / 0.25 / 1,000
= 2,084 m3

h= 0.3 m

Dry Time: 5 months

Dry Sludge Area = 2,084 / 0.3 x 5 = 34,728 m2
→ **100 m x 350 m** = 35,000 m2

Dry Desludge Storage for 20 years
= 232 x 9,000 / 1,000 x 20 = 41,674 m3
→ **3 m x 100 m x 150 m** = 45,000 m3

Olosara WWTP in Sigatoka
Waste Stabilization Pond

Design Flow

ADWF (with Septage)	m3/day	6,000
Max Daily Flow Rate	m3/day	6,600
Max Hourly Flow Rate	m3/day	12,000
PWWF(with Septage)	m3/day	29,000

Design Qualitiy
Inflow

BOD	360	mg/l
TSS	484	mg/L
TKN	70	mg/L
TP	9	mg/l
COD	792	mg/L

Pond Dimention

AN 1	Anaerobic Pond 1	Surface Area	1,140 m^2
		Volume	3,420 m^3
		Average depth	3 m
AN 2	Anaerobic Pond 2	Surface Area	1,140 m^2
		Volume	3,420 m^3
		Average depth	3 m
FA 1	Facultative Pond 1	Surface Area	9,779 m^2
		Volume	13,691 m^3
		Average depth	1.4 m
MA 1	Maturation Pond 1	Surface Area	5,476 m^2
		Volume	6,571 m^3
		Average depth	1.2 m
MA 2	Maturation Pond 2	Surface Area	5,476 m^2
		Volume	6,571 m^3
		Average depth	1.2 m

Source:hunterh2O, Olosara Wastewater Treatment Plant Site Condition Assessment, February 2020

1) Anaerobic Pond
$Q = AaDa\ \lambda v / Li$
Q is average flow, m3/d
Aa Da is anaerobic pond working Volume, m3
Aa Da = 3,420 m = 3,420 m3

λv is volumetric loading, g/m3/d
T= 20 Celsius
λv = 10 x 20 + 100 = 300 g/m3/d

Facultative Pond	Loading g BOD/m^3 day	BOD removal %
< 10	100	40
10-20	20T-100	2T + 20
20-25	10T+100	2T +20
>25	350	70

Source: Duncan Mara, Domestic Wastewater Treatment in Developing Countries (2003), p109

Li is raw sewage strength, mg BOD/L
(Influence BOD = 360 mg/L)
Q= 3,420 x 300 / 360 = 2,850 m3/d

2)Facultative Pond
Q = λsAF / 10Li
Q is average flow, m3/d
λs is surface loading, kg /ha/d
T= 20 Celsius
λv = 350 x(1.107 - 0.002 x 20)^ (20 - 25)
= 253.07 /ha/d

Facultative Pond	Surface Loading kg BOD/ ha day	Facultative Pond Effluent BOD, mg/L
Primary Pond	$350 \times (1.107\text{-}0.002\ T)^{(T-25)}$	$Li/(1+k_1\theta_F)$, $k_1 = k_{(20)}(1.05)^{T-20}$, $k_{(20)}=0.3$
Secondary Pond	$350 \times (1.107\text{-}0.002\ T)^{(T-25)}$	$Li/(1+k_1\theta_F)$, $k_1 = k_{(20)}(1.05)^{T-20}$, $k_{(20)}=0.1$

Source: Duncan Mara, Domestic Wastewater Treatment in Developing Countries (2003), pp118-121

AF is facultative pond mid depth area, m2 (FA1, AN2, MA1)
AF = 9,779 + 1,140 + 5,476 + = 16,395 m2
Li is raw sewage strength, mg BOD/L = 360 mg/L
BOD removal % of anaerobic pond
BOD removal % = 2T + 20 = 2 x 20 + 20 = 60 %
Assuming Reduced Removal rate of anaerobic pond is 50 %
Effluent BOD from anaerobic pond = Li - Li x BOD Rem. x 50 %
= 360 - 360 x 60 % x 50 %
= 252 mg/L

Q= 253.07 x 16,395 / 10 / 252 = 1,646 m3/d
≒ 1,500 m3/d

k1(T)= k1(20) x 1.05 ^(T - 20)
For primary facultative pond, k1(20) = 0.3 /day
For secondary facultative pond, k1(20) = 0.1 /day
k1(T)= 0.3 x 1.05 ^(20 - 20) = 0.3
θ = V* / Q =(13,691 + 3,420 + 6,571 +)/ 1,500
= 15.7879

Li
Effluent BOD from facultative pond = -------------------
1 + k1 x θ
= 252 /(1 + 0.3 x 15.8)
= 43.9 mg/L

3)Maturation Pond
Q = V/3 = (6,571 +) / 3 = 2,190 m3/d
Q is average flow, m3/d

Li
Effluent BOD from maturation pond = -------------------
1 + k1 x θ
k1 = 0.05
θ = 6,571 / 1,500 = 4.381

= 43.9 /(1 + 0.05 x 4.381)
= 36 mg/L < 40 mg/L : General in Concentration Standards of National Liquid Waste Standards

(PowerWater)
Effluent BOD from maturation pond = Effluent BOD from facultative pond x 0.75
= 43.9 x 0.75 = 32.9 mg/l < 40 mg/l

For Q= 1,500 m3/d
Sludge Volume =(3,420 + 3,420 + 13,691 + 6,571 +)
= 27,102 m3
Desludging Duration : 10 years
Desludging Volume = 27,102 / 10 = 2,710 m3/year
Lagoon TSS = 20,000 mg/L 75 %
Desludge Volume(Dewater) = 2,710 x 20,000 / 1,000,000
x 1,000 / 0.25 / 1,000
= 217 m3
h= 0.3 m

Dry Sludge Area = 217 / 0.3 = 723 m3
→ 100 m x 10 m = 1,000 m2

For Q= 6,000 m3/d
Sludge Volume = 27,102 / 1,500 x 6,000
= 108,407 m3
Desludging Duration : 10 years
Desludging Volume = 108,407 / 10 = 10,841 m3/year
Lagoon TSS = 20,000 mg/L 75 %
Desludge Volume(Dewater) = 10,841 x 20,000 / 1,000,000
x 1,000 / 0.25 / 1,000
= 867 m3
h= 0.3 m
Dry Time: 5 months
Dry Sludge Area = 867 / 0.3 x 5 = 14,454 m2
→ 60 m x 250 m = 15,000 m2

Dry Desludge Storage for 20 years
= 217 x 6,000 / 1,500 x 20 = 17,345 m3
→ **3 m x 300 m x 20 m** = 18,000 m3

Sepage Acceptance pond
Septage Volume = 22 m3/d ・ 22 x 30 days = 660 m3/month
3months Volume = 660 x 3 = 1,980 m3
Sepage Acceptance pond
→ **2 m x 38 m x 30 m** = 2,280 m3

Septage TSS = 20,000 mg/L 75 % of water cont.
Deseptage Volume = 1,980 m3/3 month x 20,000 / 1,000,000
(Dewatered) x 1,000 / 0.25 / 1,000
= 158 m3
Dry Area : 5 months
Septage Dry Area = 158 / 0.3 / 3 x 5 = 880 m2
→ **60 m x 20 m** = 1,200 m2
Dry Septage Strage for 20 years= 158 m3/3 month X 4 X 20 years
= 12,672 m3 → **3 m x 300 m x 20 m** = 18,000 m3

WWTP in Tavua
Waste Stabilization Pond

Design Flow

ADWF (with Septage)	m3/day	4,000
Max Daily Flow Rate	m3/day	4,400
Max Hourly Flow Rate	m3/day	7,000
PWWF(with Septage)	m3/day	18,000

Design Qualitiy
Inflow

BOD	360	mg/l
TSS	484	mg/L
TKN	70	mg/L
TP	9	mg/l
COD	792	mg/L

1) Anaerobic Pond
AaDa=QxLi/λv
Aa Da is anaerobic pond working Volume, m3
Q is average flow, m3/d
Li is raw sewage strength, mg BOD/L
(Influence BOD = 360 mg/L)
λv is volumetric loading, g/m3/d
T= 20 Celsius
λv = 10 x 20 + 100 = 300 g/m3/d

Facultative Pond	Loading g BOD/m^3 day	BOD removal %
< 10	100	40
10-20	20T-100	2T + 20
20-25	10T+100	2T +20
>25	350	70

Source: Duncan Mara, Domestic Wastewater Treatment in Developing Countries (2003), p109

AaDa = 4,000 x 360 / 300
= 4,800 m3
> **4 m x 40 m x 20 m x 4** = 12,800 m3

2)Facultative Pond
Af=Qx10Li/λs

λ s is surface loading, kg /ha/d
T= 20 Celsius
λ s = 350 x(1.107 - 0.002 x 20)^(20 - 25)
= 253.07 /ha/d

Facultative Pond	Surface Loading kg BOD/ ha day	Facultative Pond Effluent BOD, mg/L
Primary Pond	350 x $(1.107\text{-}0.002\ T)^{(T\text{-}25)}$	Li/(1 +k_1 θ), $k_1=k_{(20)}(1.05)^{T\text{-}20}$, $k_{(20)}=0.3$
Secondary Pond	350 x $(1.107\text{-}0.002\ T)^{(T\text{-}25)}$	Li/(1 +k_1 θ), $k_1=k_{(20)}(1.05)^{T\text{-}20}$, $k_{(20)}=0.1$

Source: Duncan Mara, Domestic Wastewater Treatment in Developing Countries (2003), pp118-121

Li is raw sewage strength, mg BOD/L = 360 mg/L

Af = 4,000 x 10 x 360 / 253.07 = 56,901 m2
> **40 m x 250 m x 4** = 40,000 m2

θf = 2xAfxDf/(2Q-0.001eAf)
θf : Retantion time (days)
Df = 1.8 m : Depth of Facultative Pond
e = 5 mm/d : net evaporation rate
θf = 2 x 40,000 x 1.8 /(2 x 4,000 - 0.001 x 5 x 40,000)
= 18.5 days

BOD removal % of anaerobic pond
BOD removal % = 2T + 20 = 2 x 20 + 20 = 60 %
Assuming Reduced Removal rate of anaerobic pond is 50 % .
Effluent BOD from anaerobic pond = Li - Li x BOD Rem. x 50 %
= 360 - 360 x 60 % x 50 %
= 252 mg/L

k1(T)= k1(20) x 1.05 ^(T - 20)
For primary facultative pond, k1(20) = 0.3 /day
For secondary facultative pond, k1(20) = 0.1 /day
k1(T)= 0.3 x 1.05 ^(20 - 20) = 0.3

$$\text{Effluent BOD from facultative pond} = \frac{Li}{1 + k1 \times \theta}$$

= 252 /(1 + 0.3 x 18.5)

= 36.5 mg/L

3)Maturation Pond
V= 3Q
= 3 x 4,000
= 12,000 m3
→ **1.5 m x 80 m x 50 m x 2** = 12,000 m3

$$\text{Effluent BOD from maturation pond} = \frac{Li}{1 + k1 \times \theta}$$

k1 = 0.05

θ = 12,000 / 4,000 = 3.0 days

= 36.5 /(1 + 0.05 x 3.0)
= 33.5 mg/L < 40 mg/L : General in Concentration Standards of National Liquid Waste Standards

(PowerWater)
Effluent BOD from maturation pond = Effluent BOD from facultative pond x 0.75
= 36.5 x 0.75 = 26.9 mg/L < 40 mg/L

Sludge Volume =(12,800 + 40,000 x 1.8)
= 84,800 m3
Desludging Duration : 10 years
Largest pond is desludeg in one month. Sludge is dried in three months.
Desludging Volume = 40,000 x 1.8 / 4 = 18,000 m3
Lagoon TSS = 20,000 mg/l 75 %
Desludge Volume(Dewater) = 18,000 x 20,000 / 1,000,000
x 1,000 / 0.25 / 1,000
= 1,440 m3/month
h= 0.3 m
Dry Sludge Area = 1,440 / 0.3 x 5 month dry ai= 24,000 m3
→ **100 m x 250 m** = 25,000 m2

Total dewater sludge Volume for 10 years
Lagoon TSS = 20,000 mg/L 75 %
Desludge Volume(Dewater) = 84,800 x 20,000 / 1,000,000
x 1,000 / 0.25 / 1,000
= 6,784 m3/ 10 years

Dry Desludge Storage for 20 years

= 6,784 x 20 / 10 = 13,568 m3

> **3 m x 100 m x 50 m =** 15,000 m3

Pond Dimention

AN	Anaerobic Pond	Surface Area Volume Average depth	3,200 m² 12,800 m³ 4 m	W 40 m L 20 m 4 Ponds
FA	Facultative Pond	Surface Area Volume Average depth	40,000 m² 72,000 m³ 1.8 m	W 40 m L 250 m 4 Ponds
MA	Maturation Pond	Surface Area Volume Average depth	8,000 m² 12,000 m³ 1.5 m	W 80 m L 50 m 2 Ponds
SDB	Sludge Drying Bed	Surface Area Volume Average depth	25,000 m² 7,500 m³ 0.3 m	W 100 m L 250 m 1 Ponds
SS	Sludge Storage	Surface Area Volume Average depth	5,000 m² 15,000 m³ 3 m	W 100 m L 50 m 1 Ponds

WWTP in Rakiraki
Waste Stabilization Pond

Design Flow

ADWF (with Septage)	m3/day	3,000
Max Daily Flow Rate	m3/day	3,300
Max Hourly Flow Rate	m3/day	6,000
PWWF(with Septage)	m3/day	11,000

Design Qualitiy
Inflow

BOD	360	mg/l
TSS	484	mg/L
TKN	70	mg/L
TP	9	mg/l
COD	792	mg/L

1) Anaerobic Pond
AaDa=QxLi/λv
Aa Da is anaerobic pond working Volume, m3
Q is average flow, m3/d
Li is raw sewage strength, mg BOD/L
(Influence BOD = 360 mg/L)
λv is volumetric loading, g/m3/d
T= 20 Celsius
λv = 10 x 20 + 100 = 300 g/m3/d

Facultative Pond	Loading g BOD/m^3 day	BOD removal %
< 10	100	40
10-20	20T-100	2T + 20
20-25	10T+100	2T +20
>25	350	70

Source: Duncan Mara, Domestic Wastewater Treatment in Developing Countries (2003), p109

AaDa = 3,000 x 360 / 300
= 3,600 m3
> 4 m x 40 m x 10 m x 4 = 6,400 m3

2)Facultative Pond
A^f=Qx10Li/λs

λs is surface loading, kg /ha/d
T= 20 Celsius
λs = 350 x(1.107 - 0.002 x 20)^(20 - 25)
= 253.07 /ha/d

Facultative Pond	Surface Loading kg BOD/ ha day	Facultative Pond Effluent BOD, mg/l
Primary Pond	$350 \times (1.107-0.002\,T)^{(T-25)}$	$Li/(1+k_1\theta_f)$, $k_1=k_{(20)}(1.05)^{T-20}$, $k_{(20)}=0.3$
Secondary Pond	$350 \times (1.107-0.002\,T)^{(T-25)}$	$Li/(1+k_1\theta_f)$, $k_1=k_{(20)}(1.05)^{T-20}$, $k_{(20)}=0.1$

Source: Duncan Mara, Domestic Wastewater Treatment in Developing Countries (2003), pp118-121

Li is raw sewage strength, mg BOD/L = 360 mg/L

Af = 3,000 x 10 x 360 / 253.07 = 42,675 m2
→ **40 m x 200 m x 4** = 32,000 m2

θf = $2 \times Af \times Df / (2Q - 0.001eAf)$
θf : Retention time (days)
Df = 1.8 m : Depth of Facultative Pond
e = 5 mm/d : net evaporation rate
θf = 2 x 32,000 x 1.8 /(2 x 3,000 - 0.001 x 5 x 32,000)
= 19.7 days

BOD removal % of anaerobic pond
BOD removal % = 2T + 20 = 2 x 20 + 20 = 60 %
Assuming Reduced Removal rate of anaerobic pond is 50 % .
Effluent BOD from anaerobic pond = Li - Li x BOD Rem. x 50 %
= 360 - 360 x 60 % x 50 %
= 252 mg/L

k1(T)= k1(20) x 1.05 ^(T - 20)
For primary facultative pond, k1(20) = 0.3 /day
For secondary facultative pond, k1(20) = 0.1 /day
k1(T)= 0.3 x 1.05 ^(20 - 20) = 0.3

Effluent BOD from facultative pond $= \dfrac{Li}{1 + k1 \times \theta}$
= 252 /(1 + 0.3 x 19.7)

= 36.4 mg/L

3)Maturation Pond
V= 3Q
= 3 x 3,000
= 9,000 m3
→ **1.5 m x 80 m x 40 m x 2** = 9,600 m3

Effluent BOD from maturation pond = Li / (1 + k1 x θ)
k1 = 0.05
θ = 9,600 / 3,000 = 3.2 days

= 36.4 /(1 + 0.05 x 3.2)
= 31.4 mg/L < 40 mg/L : General in Concentration Standards of National Liquid Waste Standards

(PowerWater)
Effluent BOD from maturation pond = Effluent BOD from facultative pond x 0.75
= 36.4 x 0.75 = 27.3 mg/L < 40 mg/L

Sludge Volume =(6,400 + 32,000 x 1.8)
= 64,000 m3
Desludging Duration : 10 years
Largest pond is desludeg in one month. Sludge is dried in three months.
Desludging Volume = 32,000 x 1.8 / 4 = 14,400 m3
Lagoon TSS = 20,000 mg/l 75 %
Desluge Volume(Dewater) = 14,400 x 20,000 / 1,000,000
x 1,000 / 0.25 / 1,000
= 1,152 m3/month
h= 0.3 m
Dry Sludge Area = 1,152 / 0.3 x 5 dry month ar= 19,200 m3
→ **100 m x 200 m** = 20,000 m2

Total dewater slude Volume for 10 years
Lagoon TSS = 20,000 mg/L 75 %
Desluge Volume(Dewater) = 64,000 x 20,000 / 1,000,000
x 1,000 / 0.25 / 1,000
= 5,120 m3/ 10 years

Dry Desludge Storage for 20 years
= 5,120 x 20 / 10 = 10,240 m3
→ **3 m x 100 m x 40 m** = 12,000 m3

Sepage Acceptance pond
Septage Volume = 24 m3/d → 24 x 30 days = 720 m3/month
3months Volume = 720 x 3 = 2,160 m3
Sepage Acceptance pond
→ **1.8 m x 40 m x 50 m** = 3,600 m3

Septage TSS = 20,000 mg/l 75 % of water cont.
Deseptage Volume = 2,160 m3/3 month x 20,000 / 1,000,000
(Dewatered) x 1,000 / 0.25 / 1,000
= 173 m3
Dry Area : 5 months
Septage Dry Area = 173 / 0.3 x 5 / 3 = 960 m2
→ **100 m x 10 m** = 1,000 m2
Dry Septage Strage for 20 years= 173 m3/3 month X 4 X 20 years
= 13,824 m3 → **3 m x 100 m x 50 m** = 15,000 m3

Pond Dimention

AN	Anaerobic Pond	Surface Area	1,600 m^2	W 40 m
		Volume	6,400 m^3	L 10 m
		Average depth	4 m	4 Ponds
FA	Facultative Pond	Surface Area	32,000 m^2	W 40 m
		Volume	57,600 m^3	L 200 m
		Average depth	1.8 m	4 Ponds
MA	Maturation Pond	Surface Area	6,400 m^2	W 80 m
		Volume	9,600 m^3	L 40 m
		Average depth	1.5 m	2 Ponds
SDB	Sludge Drying Bed	Surface Area	20,000 m^2	W 100 m
		Volume	6,000 m^3	L 200 m
		Average depth	0.3 m	1 Ponds
SS	Sludge Storage	Surface Area	4,000 m^2	W 100 m
		Volume	12,000 m^3	L 40 m
		Average depth	3 m	1 Ponds
Septage Acceptance AN	Anaerobic Pond	Surface Area	2,000 m^2	W 40 m
		Volume	3,600 m^3	L 50 m
		Average depth	1.8 m	1 Ponds
Septage		Surface Area	1,000 m^2	W 100 m

Septage SDB	Sludge Drying Bed	Volume	300 m^3	L 10 m
		Average depth	0.3 m	1 Ponds
Septage SS	Sludge Storage	Surface Area	5,000 m^2	W 100 m
		Volume	15,000 m^3	L 50 m
		Average depth	3 m	1 Ponds

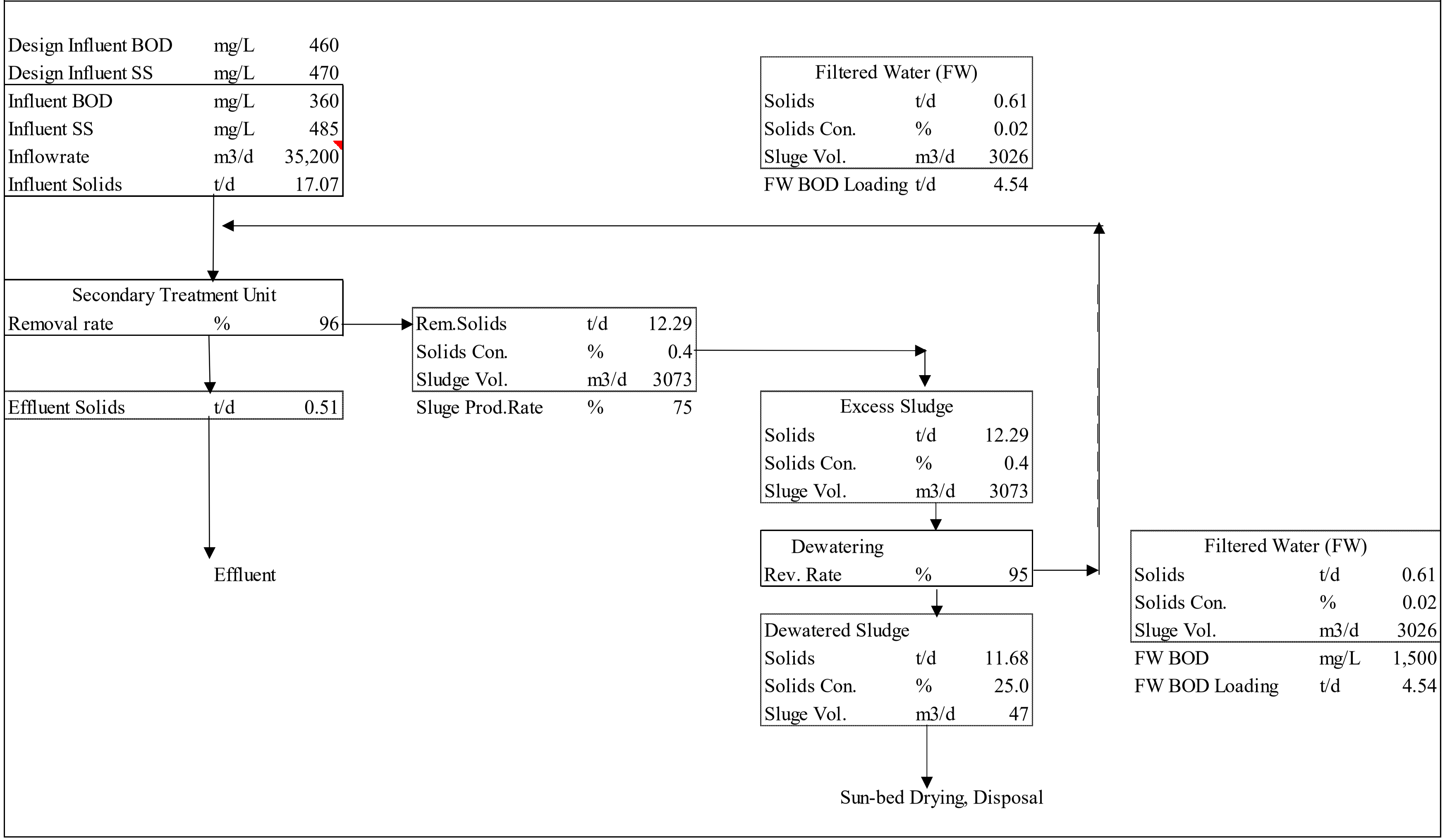
APPENDIX 5-5 Oxidation Ditch Calculation

(1) Navakai WWTP（Nadi）

Item	Calculation
1. Design Parameters	
1-1 Outline of Wastewater Treatment	
(1) Area of Plant	ha
(2) Grand Level of Plant	M
(3) Type of Collection System	Separate Sewer System
(4) Water Treatment Process	Oxidation ditch
1-2 Design Flowrate	
【Pipeline Sewerage】	
(1) Average Daily Flowrate	31293 m^3/d
(2) Peak Dry Weather Flowrate	62586 m^3/d
(3) Peak Wet Weather Flowrate	156464 m^3/d
【Trucked-in Domestic Septage】	
(1) Average Daily Quantity	0 m^3/d
(2) Peak Daily Quantity	0 m^3/d
【Total Influent Flowrate】	
(1) Average Daily Flowrate	32,000 m^3/d
(2) Maximum Daily Flowrate	35,200 m^3/d
(3) Maximum Hourly Flowrate	64,000 m^3/d
(4) Peak Wet Weather Flowrate	157,000 m^3/d
1-3 Influent Wastewater Quality	
【Pipeline Sewerage】	
(1) BOD	360 mg/L
(2) SS	485 mg/L
【Trucked-in Domestic Septage】	
(1) BOD	250 mg/L
(2) SS	620 mg/L
【Total Influent Flowrate】	
(1) BOD	360 mg/L
(2) SS	485 mg/L
1-4 Design Influent Wastewater	
(1) BOD	460 mg/L
(2) SS	470 mg/L
1-5 Removal Efficency (Total System)	
(1) BOD	96 %
(2) SS	96 %
1-6 Effluent Wastewater Quality	
(1) BOD	19 mg/L
(2) SS	19 mg/L

Item	Calculation
Sludge Production (Maximum Daily Flowrate)	
1-7 Waste Activated Sludge	Solids＝ Maximum Daily Flowrate × Influent SS × $0.95\times0.75\times10^{-6}$ Solids＝ 35,200 m3/d × 470 mg/L × 96 %×0.75× 10^-6 ＝ 11.9 ds-t/d Solid Concentration ＝ 0.3 % Sludge ＝ Solids÷Solids Concentration$\times10^{2}$ Sludge ＝ 11.90 t/d ÷ 0.3 % × 10^2 Sludge(OUT) ＝ 3,967 m^3/d
1-8 Dewatering	Solids (IN) ＝ 11.9 ds-t/d Solids(OUT) ＝ WAS × Recovery Rate$\times10^{-2}$ Solids (OUT) ＝ 11.90 t/d × 95 % × 10^-2 Recovery Rate ＝ 95 % ＝ 11.4 ds-t/d Sludge(OUT) ＝ Solids÷Solids Concentration$\times10^{2}$ Sludge(OUT) ＝ 11.40 t/d ÷ 25 % × 10^2 Solid Concentratio ＝ 25 % Sludge(OUT) ＝ 46 m^3/d

2 Solids Mass Balance (Final Stage)



Item	Calculation
3. Oxidation Ditch	
3-1 Reactor Volume	
Design Flowrate	
Maximum Daily Flowrate	= 35,200 m^3/d 5,867
Maximum hourly Flowrate	= 64,000 m^3/d
Hydraulic Retention Time	= 24 hours
Req. Volume	= 35,200.00 m3/d × 24.00 hrs ÷ 24
	= 35,200 m^3
Shape of Reactor	Oval
Water Depth	D = 3.5 m
Width	W = 6.0 m
Length	L = 110 m
Area	A = Width ×Water depth - 0.3 ×0.3×2/2
	= 6.00 m × 3.50 m − 0.3 × 0.3 × 2 ÷ 2
	= 20.9 m^2
Volume per Reactor	v = (L-2W)*2A+πWA
	= (110 - 2* 6.0)*2* 20.90 +π* 6.0 * 20.9
	= 4490.3 m3/reactor
Number of Reactor	n = 8 Reactors
Total Volume	V = n*v = 8 * 4,490
	= 35,922 m^3
Actual Hydraulic Retention Time	HRT = V÷Q*24
	= 35,922 ÷ 35,200 *24
	= 24.5 hrs Range(Japan): 24~36hr OK
	Range(Metcalf&Eddy): 16~30hr OK
3-2 Aerator	
(1) Design Parameters	
Maximum Daily Flowrate	= 35,200 m^3/d
Influent BOD	= 460 mg/L
Influent S-BOD	= 230 mg/L
Influent SS	= 470 mg/L
Influent Kj-N	= 70 mg/L
MLSS	= 4,000 mg/L
Effluent BOD	= 40 mg/L
Aerobic volume ratio	= 0.5
HRT	= 16 hrs

Item	Calculation
(2) ASRT	
ASRT	$= \dfrac{t_a}{24} \times \dfrac{X_A \times V}{X_W \times Q_W}$
	$= \dfrac{t_a}{24} \times \dfrac{X_A \times V}{Q \times X_1 \times \alpha}$
	ASRT ; Aerobic Sludge Retention Time
	ta ; Aeration Time in a day
	＝ 12 hours
	Xw ; SS in WAS, mg/L
	V ; Reactor Volume, m3
	Qw ; Volume of WAS, m3
	Q ; Maximum Daily Flowrate/Reactor
	＝ 35,200 ÷ 8 ＝ 4,400 m3/d
	X_1 ; Influent SS ＝ 470 mg/L
	α ; Sludge production rate per SS
	0.75
ASRT	$= \dfrac{12 \times 4{,}000 \times 4{,}490}{24 \times 4{,}400 \times 470 \times 0.75}$
	＝ 5.8 日
(3) Empirical ASRT	
	ASRT > 29.7 EXP (-0.102 × T)
	T ; Lowest water temperature in monthly average
	＝ 20 Celsius
ASRT	＝ 29.7 exp (-0.102 × 20)
	＝ 3.90 日 < 5.80 日 OK
(4) Prediction of C-BOD based on ASRT	
T	＝ 20 Celsius
C-BOD	＝ 9.75 × ASRT ^ -0.671
	＝ 9.75 × 5.8 ^ -0.671
	＝ 3 mg/L
	Assumming BOD/C-BOD is 3
BOD	＝ 3 × C-BOD
	＝ 3 × 3
	＝ 9.0 mg/L < 40 mg/L OK
	(General standard)
	＝ 9.0 mg/L < 20 mg/L OK
	(Significan Eco Zone standard)

Item	Calculation
(5) Oxigen requirement for BOD oxidation	
OD1	= A × (Removed BOD − Denitrified N × K)
	A ; Reqired O_2/Removed BOD
	= 0.6 kg as O_2/kg as BOD
	K ; Consumed BOD by Denitrification
	= 2.5 kg as BOD/kg as N
	Removed BOD = (0.46 - 0.04) × 35,200
	= 14,784 kg as BOD/d
	Denitrified N ; Assuming all nitrified N is denitrified.
OD1	= 0.6 × (14,784 − 2464 × 2.5)
	= 5,175 kg as O_2/d
(6) Oxigen requirement for Internal aspiration	
OD2	= B × Va × MLVSS
	B ; O_2 Volume for internal aspiration
	= 0.1 kg as O^2/kg as MLVSS/d
	Va ; Aerobic zone volume
	= Volume ÷ 2
	Assuming MLVSS/MLSS is 0.8
OD2	= 0.1 × 35,920 ÷ 2 × 4 × 0.8
	= 5,748 kg as O_2/d
(7) Oxigen requirement for nitrification	
OD3	= C × Nitrified N
	C ; O_2 consumed by nitrification
	= 4.57 kg as O_2/kg as N
	Nitrified N ; Amount of nitrified nitrogen
	; Influent N − Effluent nitrified N
	− nitrogen of WAS
	Influent N ; 0.070 × 35,200
	= 2464 kg as N/d
	Effluent N ; Assuming all N is nitrified
	Nitrogen of WAS = 0.07 (kg as N/kg as MLSS)
	× Qw×Xx

Item	Calculation
	$Q_W \times X_X = Q_{in}(a \times C_{S-BOD,in} + b \times C_{ss,in} - c \times X_A \times \tau_A) \times 10^{-3}$
	a ; Rate of Sludge coversion from S-BOD = 0.5 gMLSS/gS-BOD
	$C_{S\text{-}BOD}$; Influent soluble BOD = 230 mg/L
	b ; Rate of Sludge production from SS = 0.75 gMLSS/gSS
	c ; Decay rate = 0.04 1/d
	τ_A ; Aeration time = 0.5 d
	Qw×Xa = 35,200 ×(0.5 × 230 + 0.75 × 470 − 0.04 × 4,000 × 0.5)× 10^-3
	= 13,640 kg/d
	Nitrogen of WAS = 0.07 × 13,640
	= 954.8 kg as N/d
OD3	= 4.57 ×(2464 − 0 − 954.8)
	= 6,898 kg as O_2/d
(8) Oxygen requirement in Effluent	
	Assuming Sludge return rate of 100 %
OD4	= Oxygen in effluent
	= 1.5 × 35,200 ×(1+ 1.00) × 10^-3
	= 106 kg as O_2/d
(9) Actual Oxigen Requirement	
AOR	= OD_1 + OD_2 + OD_3 + OD_4
	= 5,175 + 5,748 + 6,898 + 106
	= 17,927 kg as O_2/d
(10) Standard Oxygen Requirement	
SOR	= $\dfrac{AOR \times C_{SW}}{1.024^{(t-20)} \times \alpha \times (\beta \times C_S - C_a)} \times \dfrac{760}{P}$
	C_{SW} ; Oxygen saturation concentration in clean water at 20 Celsius
	= 8.84 mg/L
	Ca ; Average DO
	= 1.5 mg/L
	Cs ; Oxygen saturation concentration in clean water at t Celsius
	= 8.84 mg/L
	t = 20.0 Celsius

Item	Calculation
	α ; 0.93
	β ; 0.97
	P ; 760
Number of Reactor	= 8 Reactors
SOR	= 24,086 kg as O_2/d
SOR/reactor	= 3011 kg as O_2/d (per reactor)
	Required Oxygen
	$= \frac{24,086}{0.46 \times 35,200} =$ 1.5 kg as O_2/kg per unit BOD
4. Secondary clarifier	
4-1 Basin Volume	
Design Flowrate	
Maximum Daily Flowrate	= 35,200 m^3/d
Maximum hourly Flowrate	= 64,000 m^3/d
Overflow rate	= 12 $m^3/m^2/d$
Required Area for settling	= 35,200 ÷ 12 = 2,934 m^2
Diameter of Basin	26 m
No. of basin	= 8 basins
Effective Area	= 26 ^ 2 ÷ 4 × π × 8
	= 4,247 m^2
Depth of basin	= 3 m
Overflow rate	= 35,200 m^3/d ÷ 4,247 m^2
	= 8.3 $m^3/m^2/d$ Range: 8～12m3/m2/d OK
Settling Time	= (4,247 × 3 × 24)
	÷ 35,200
	= 8.7 hrs Range: 6～12hr OK
Req. Length of weir	= (26 − 1.6) × π = 76.7 m
	(Outer Weir)
	= (26 − 2.6) × π = 73.5 m
	(Inner Weir)
Weir Loading rate	= 35,200 ÷ (76.7 + 73.5) ÷ 8
	= 29.3 $m^3/m/d$ Range: 25~30m3/m/d
	OK

Item	Calculation
5. Disinfection	
5-1 Basin Volume	
Design Flowrate	
Maximum Daily Flowrate	= 35,200 m^3/d
Maximum hourly Flowrate	= 64,000 m^3/d
Peak Wet Weather Flowrate	= 157,000 m^3/d
Chlorine Contact Time	= 15 minutes
	= 900 seconds
Req. Volume	= 157,000 ÷ 24 ÷ 60 ÷ 60
	× 900
	= 1636 m^3
Depth	= 2 m
Width	= 2 m
Length	= 409 m
Volume	= 2 × 2 × 409
	= 1636 m^3
Actual Contact Time	= 1636 ÷ 157,000 × 24× 60
	= 15.01 min OK
6-1 Sludge Dewatering	
Solids (IN)	= 11.9 t/d
Solid Concentration	= 0.30 %
Sludge(IN)	= 3,967 m3/d
Operation Conditions	7 hrs in one day and 5 days in a week
Solids	= 11.9 × 7 ÷ 5 ÷ 7
(Required Dewatering Cap.)	× 1,000
	= 2380.0 kg/d
Actual Dewatering capacity	= 400 kg/d
Number of Units	= 6 (Standby 1)
Solids (OUT)	= 11.68 t/d
Solid Concentration(OUT)	= 25.00 %
Sludge(OUT)	= 47 m3/d

Item	Calculation
6-2 Sludge Drying Bed	
Sludge Drying Period	= 3 month
Drying Bed Volume	= 5 month's worth sludge
	= 150 d
Sludge Volume	= 47 m3/d × 150 d
	= 7050 m3
Sludge Depth	= 0.3 m
Required Drying Bed Area	= 7050 m3 ÷ 0.3 m
	= 23500 m2
Drying Bed Area	= 80 m × 300 m
	= 24000 m2 OK
6-3 Sludge Storage Space	
Sludge Storage Period	= 20 yrs
Sludge Volume	= 47 m3/d × 20 yrs × 365 d
	= 343100 m3
Sludge Depth	= 3.0 m
Required Storage Area	= 343100 m3 ÷ 3.0 m
	= 114367 m2
Sludge Storage Area	= 330 m × 200 m
	+ 400 m × 110 m
	+ 110 m × 40 m
	= 114400 m2 OK
7. Primary Treatment (Rainwater)	
Design Flowrate	= 4* Maximum Daily Flowrate
	= 4* 35,200 m^3/d
	= 140,800 m^3/d

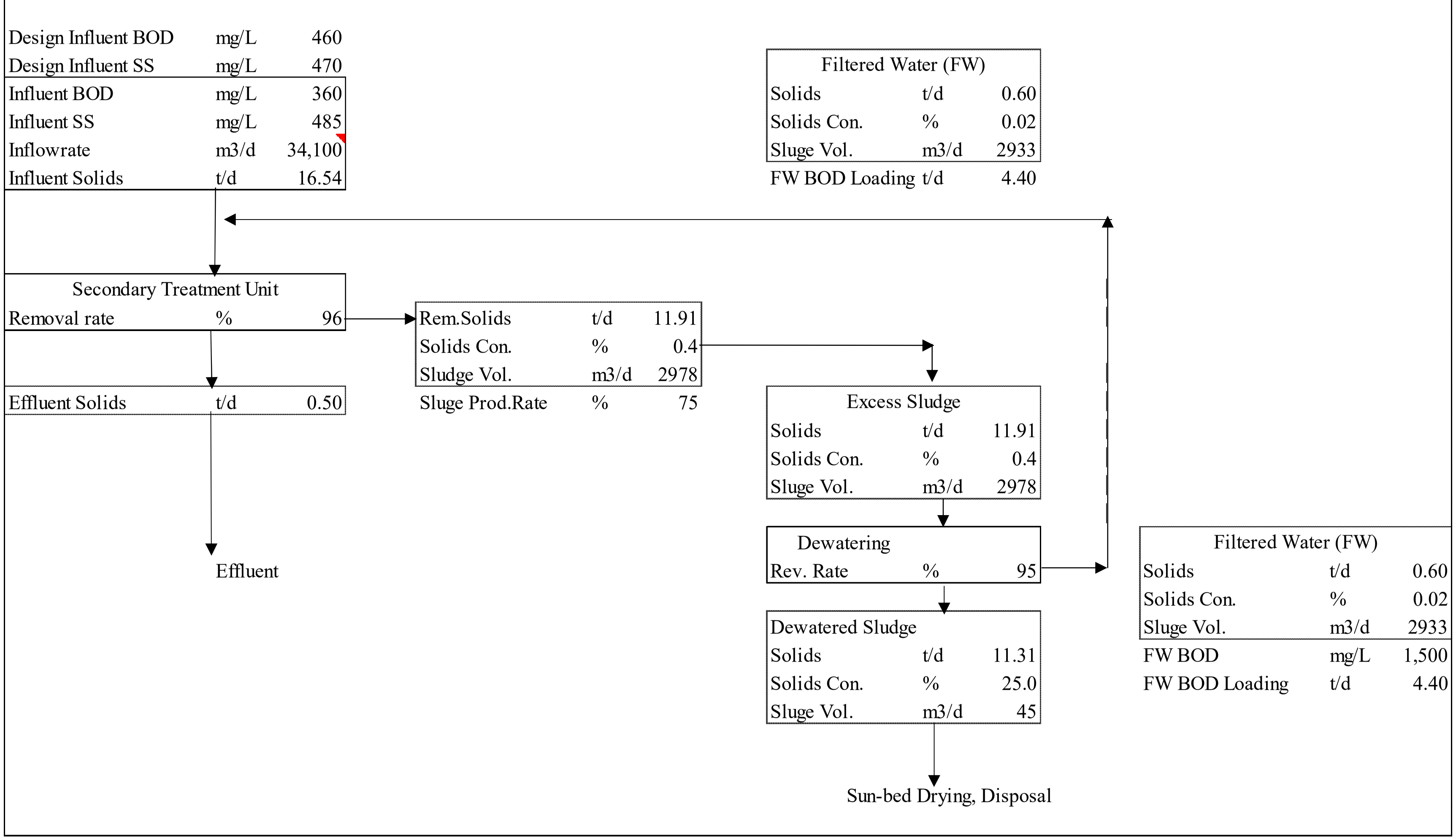
Item	Calculation
Required Retention Time	= 2.50 hrs
Required Volume	= 140,800.00 m3/d × 2.50 hrs ÷ 24 = 14,667 m^3
Design Depth	= 3 m
Required Surface Area	= 4,889 m2
Maturation Pond Volume	= 280 m × 20 m × 3 m = 16800 m3 > 14,667 m^3 OK

(2) Natabua WWTP（Lautoka）

Item	Calculation
1. Design Parameters	
1-1 Outline of Wastewater Treatment	
(1) Area of Plant	ha
(2) Grand Level of Plant	M
(3) Type of Collection System	Separate Sewer System
(4) Water Treatment Process	Oxidation ditch
1-2 Design Flowrate	
【Pipeline Sewerage】	
(1) Average Daily Flowrate	30975 m^3/d
(2) Peak Dry Weather Flowrate	61950 m^3/d
(3) Peak Wet Weather Flowrate	154875 m^3/d
【Trucked-in Domestic Septage】	
(1) Average Daily Quantity	21 m^3/d
(2) Peak Daily Quantity	42 m^3/d
【Total Influent Flowrate】	
(1) Average Daily Flowrate	31,000 m^3/d
(2) Maximum Daily Flowrate	34,100 m^3/d
(3) Maximum Hourly Flowrate	62,000 m^3/d
(4) Peak Wet Weather Flowrate	155,000 m^3/d
1-3 Influent Wastewater Quality	
【Pipeline Sewerage】	
(1) BOD	360 mg/L
(2) SS	484 mg/L
【Trucked-in Domestic Septage】	
(1) BOD	250 mg/L
(2) SS	620 mg/L
【Total Influent Flowrate】	
(1) BOD	360 mg/L
(2) SS	485 mg/L
1-4 Design Influent Wastewater	
(1) BOD	460 mg/L
(2) SS	470 mg/L
1-5 Removal Efficency (Total System)	
(1) BOD	96 %
(2) SS	96 %
1-6 Effluent Wastewater Quality	
(1) BOD	19 mg/L
(2) SS	19 mg/L
Sludge Production (Maximum Daily Flowrate)	
1-7 Waste Activated Sludge	Solids＝ Maximum Daily Flowrate × Influent SS × 0.95×0.75×10^{-6} Solids＝ 34,100 m3/d × 470 mg/L × 96 %×0.75× 10^-6 ＝ 11.5 ds-t/d Solid Concentration ＝ 0.3 % Sludge ＝ Solids÷Solids Concentration×10^2 Sludge ＝ 11.50 t/d ÷ 0.3 % × 10^2 Sludge(OUT) ＝ 3,834 m^3/d

Item	Calculation
1-8 Dewatering	Solids (IN) ＝ 11.5 ds-t/d Solids(OUT) ＝ WAS × Recovery Rate $\times 10^{-2}$ Solids (OUT) ＝ 11.50 t/d × 95 % × 10^-2 Recovery Rate ＝ 95 % ＝ 11 ds-t/d Sludge(OUT) ＝ Solids ÷ Solids Concentration $\times 10^{2}$ Sludge(OUT) ＝ 11.00 t/d ÷ 25 % × 10^2 Solid Concentratio ＝ 25 % Sludge(OUT) ＝ 44 m^3/d

2 Solids Mass Balance (Final Stage)



Item	Calculation
3. Oxidation Ditch	
3-1 Reactor Volume	
Design Flowrate	
Maximum Daily Flowrate	= 34,100 m^3/d
Maximum hourly Flowrate	= 62,000 m^3/d
Hydraulic Retention Time	= 24 hours
Req. Volume	= 34,100.00 m3/d × 24.00 hrs ÷ 24
	= 34,100 m^3
Shape of Reactor	Oval
Water Depth	D = 3.5 m
Width	W = 6.0 m
Length	L = 110 m
Area	A = Width ×Water depth - 0.3 ×0.3×2/2
	= 6.00 m × 3.50 m − 0.3 × 0.3 × 2 ÷ 2
	= 20.9 m^2
Volume per Reactor	v = (L-2W)*2A+πWA
	= (110 - 2* 6.0)*2* 20.90 +π* 6.0 * 20.9
	= 4490.3 m3/reactor
Number of Reactor	n = 8 Reactors
Total Volume	V = n*v = 8 * 4,490
	= 35,922 m^3
Actual Hydraulic Retention Time	HRT = V÷Q*24
	= 35,922 ÷ 34,100 *24
	= 25.3 hrs Range(Japan): 24~36hr OK
	Range(Metcalf&Eddy): 16~30hr OK
3-2 Aerator	
(1) Design Parameters	
Maximum Daily Flowrate	= 34,100 m^3/d
Influent BOD	= 460 mg/L
Influent S-BOD	= 230 mg/L
Influent SS	= 470 mg/L
Influent Kj-N	= 70 mg/L
MLSS	= 4,000 mg/L
Effluent BOD	= 40 mg/L
Aerobic volume ratio	= 0.5
HRT	= 16 hrs

Item	Calculation
(2) ASRT	
ASRT	$= \frac{t_a}{24} \times \frac{X_A \times V}{X_W \times Q_W}$
	$= \frac{t_a}{24} \times \frac{X_A \times V}{Q \times X_1 \times \alpha}$
	ASRT ; Aerobic Sludge Retention Time
	ta ; Aeration Time in a day
	＝ 12 hours
	Xw ; SS in WAS, mg/L
	V ; Reactor Volume, m3
	Qw ; Volume of WAS, m3
	Q ; Maximum Daily Flowrate/Reactor
	＝ 34,100 ÷ 8 ＝ 4,263 m3/d
	X_I ; Influent SS ＝ 470 mg/L
	α ; Sludge production rate per SS
	0.75
ASRT	$= \frac{12 \times 4{,}000 \times 4{,}490}{24 \times 4{,}263 \times 470 \times 0.75}$
	＝ 6.0 日
(3) Empirical ASRT	
	ASRT > 29.7 EXP (-0.102 × T)
	T ; Lowest water temperature in monthly average
	＝ 20 Celsius
ASRT	＝ 29.7 exp (-0.102 × 20)
	＝ 3.90 日 < 6.00 日 OK
(4) Prediction of C-BOD based on ASRT	
T	＝ 20 Celsius
C-BOD	＝ 9.75 × ASRT ^ -0.671
	＝ 9.75 × 6 ^ -0.671
	＝ 2.93 mg/L
	Assumming BOD/C-BOD is 3
BOD	＝ 3 × C-BOD
	＝ 3 × 2.93
	＝ 8.8 mg/L < 40 mg/L OK
	(General standard)
	＝ 8.8 mg/L < 20 mg/L OK
	(Significan Eco Zone standard)

Item	Calculation
(5) Oxygen requirement for BOD oxidation	
OD1	= A × (Removed BOD − Denitrified N × K)
	A ; Reqired O_2/Removed BOD
	= 0.6 kg as O_2/kg as BOD
	K ; Consumed BOD by Denitrification
	= 2.5 kg as BOD/kg as N
	Removed BOD = (0.46 - 0.04) × 34,100
	= 14,322 kg as BOD/d
	Denitrified N ; Assuming all nitrified N is denitrified.
OD1	= 0.6 × (14,322 − 2387 × 2.5)
	= 5,013 kg as O_2/d
(6) Oxygen requirement for Internal aspiration	
OD2	= B × Va × MLVSS
	B ; O_2 Volume for internal aspiration
	= 0.1 kg as O^2/kg as MLVSS/d
	Va ; Aerobic zone volume
	= Volume ÷ 2
	Assuming MLVSS/MLSS is 0.8
OD2	= 0.1 × 35,920 ÷ 2 × 4 × 0.8
	= 5,748 kg as O_2/d
(7) Oxygen requirement for nitrification	
OD3	= C × Nitrified N
	C ; O_2 consumed by nitrification
	= 4.57 kg as O_2/kg as N
	Nitrified N ; Amount of nitrifired nitrogen
	; Influent N − Effluent nitrified N
	− nitrogen of WAS
	Influent N ; 0.070 × 34,100
	= 2387 kg as N/d
	Effluent N ; Assuming all N is nitrified
	Nitrogen of WAS = 0.07 (kg as N/kg as MLSS)
	× Qw×Xx

Item	Calculation
	$Q_W \times X_X = Q_{in}(a \times C_{S-BOD,in} + b \times C_{ss,in} - c \times X_A \times \tau_A) \times 10^{-3}$
	a ; Rate of Sludge coversion from S-BOD = 0.5 gMLSS/gS-BOD
	$C_{S\text{-}BOD}$; Influent soluble BOD = 230 mg/L
	b ; Rate of Sludge production from SS = 0.75 gMLSS/gSS
	c ; Decay rate = 0.04 1/d
	τ_A ; Aeration time = 0.5 d
	Qw×Xa = 34,100 ×(0.5 × 230 + 0.75 × 470 − 0.04 × 4,000 × 0.5)× 10^-3
	= 13,214 kg/d
	Nitrogen of WAS = 0.07 × 13,214
	= 925.0 kg as N/d
OD3	= 4.57 ×(2387 − 0 − 925.0)
	= 6,682 kg as O_2/d
(8) Oxygen requirement in Effluent	
	Assuming Sludge return rate of 100 %
OD4	= Oxygen in effluent
	= 1.5 × 34,100 ×(1+ 1.00) × 10^-3
	= 103 kg as O_2/d
(9) Actual Oxigen Requirement	
AOR	= OD_1 + OD_2 + OD_3 + OD_4
	= 5,013 + 5,748 + 6,682 + 103
	= 17,546 kg as O_2/d
(10) Standard Oxygen Requirement	
SOR	= $\dfrac{AOR \times C_{SW}}{1.024^{(t-20)} \times \alpha \times (\beta \times C_S - C_a)} \times \dfrac{760}{P}$
	C_{SW} ; Oxygen saturation concentration in clean water at 20 Celsius
	= 8.84 mg/L
	Ca ; Average DO
	= 1.5 mg/L
	Cs ; Oxygen saturation concentration in clean water at t Celsius
	= 8.84 mg/L
	t = 20.0 Celsius

Item	Calculation
	α ; 0.93
	β ; 0.97
	P ; 760
Number of Reactor	= 8 Reactors
SOR	= 23,574 kg as O_2/d
SOR/reactor	= 2947 kg as O_2/d (per reactor)
	Required Oxygen
	$= \dfrac{23{,}574}{0.46 \times 34{,}100} =$ 1.6 kg as O_2/kg per unit BOD
4. Secondary clarifier	
4-1 Basin Volume	
Design Flowrate	
Maximum Daily Flowrate	= 34,100 m^3/d
Maximum hourly Flowrate	= 62,000 m^3/d
Overflow rate	= 12 $m^3/m^2/d$
Required Area for settling	= 34,100 ÷ 12 = 2,842 m^2
Diameter of Basin	25 m
No. of basin	= 8 basins
Effective Area	= 25 ^ 2 ÷ 4 × π × 8
	= 3,927 m^2
Depth of basin	= 3 m
Overflow rate	= 34,100 m^3/d ÷ 3,927 m^2
	= 8.7 $m^3/m^2/d$ Range: 8～12m3/m2/d OK
Settling Time	= (3,927 × 3 × 24)
	÷ 34,100
	= 8.3 hrs Range: 6～12hr OK
Req. Length of weir	= (25 − 1.6) × π = 73.5 m
	(Outer Weir)
	= (25 − 2.6) × π = 70.4 m
	(Inner Weir)
Weir Loading rate	= 34,100 ÷ (73.5 + 70.4) ÷ 8
	= 29.6 $m^3/m/d$ Range: 25~30m3/m/d
	OK

Item	Calculation
5. Disinfection	
5-1 Basin Volume	
Design Flowrate	
Maximum Daily Flowrate	= 34,100 m^3/d
Maximum hourly Flowrate	= 62,000 m^3/d
Peak Wet Weather Flowrate	= 155,000 m^3/d
Chlorine Contact Time	= 15 minutes
	= 900 seconds
Req. Volume	= 155,000 ÷ 24 ÷ 60 ÷ 60
	× 900
	= 1615 m^3
Depth	= 2 m
Width	= 2 m
Length	= 403.75 m
Volume	= 2 × 2 × 403.75
	= 1615 m^3
Actual Contact Time	= 1615 ÷ 155,000 × 24× 60
	= 15.00 min OK
6-1 Sludge Dewatering	
Solids (IN)	= 11.5 t/d
Solid Concentration	= 0.30 %
Sludge(IN)	= 3,834 m3/d
Operation Conditions	7 hrs in one day and 5 days in a week
Solids	= 11.5 × 7 ÷ 5 ÷ 7
(Required Dewatering Cap.)	× 1,000
	= 2300.0 kg/d
Actual Dewatering capacity	= 400 kg/d
Number of Units	= 6 (Standby 1)
Solids (OUT)	= 11.31 t/d
Solid Concentration(OUT)	= 25.00 %
Sludge(OUT)	= 45 m3/d

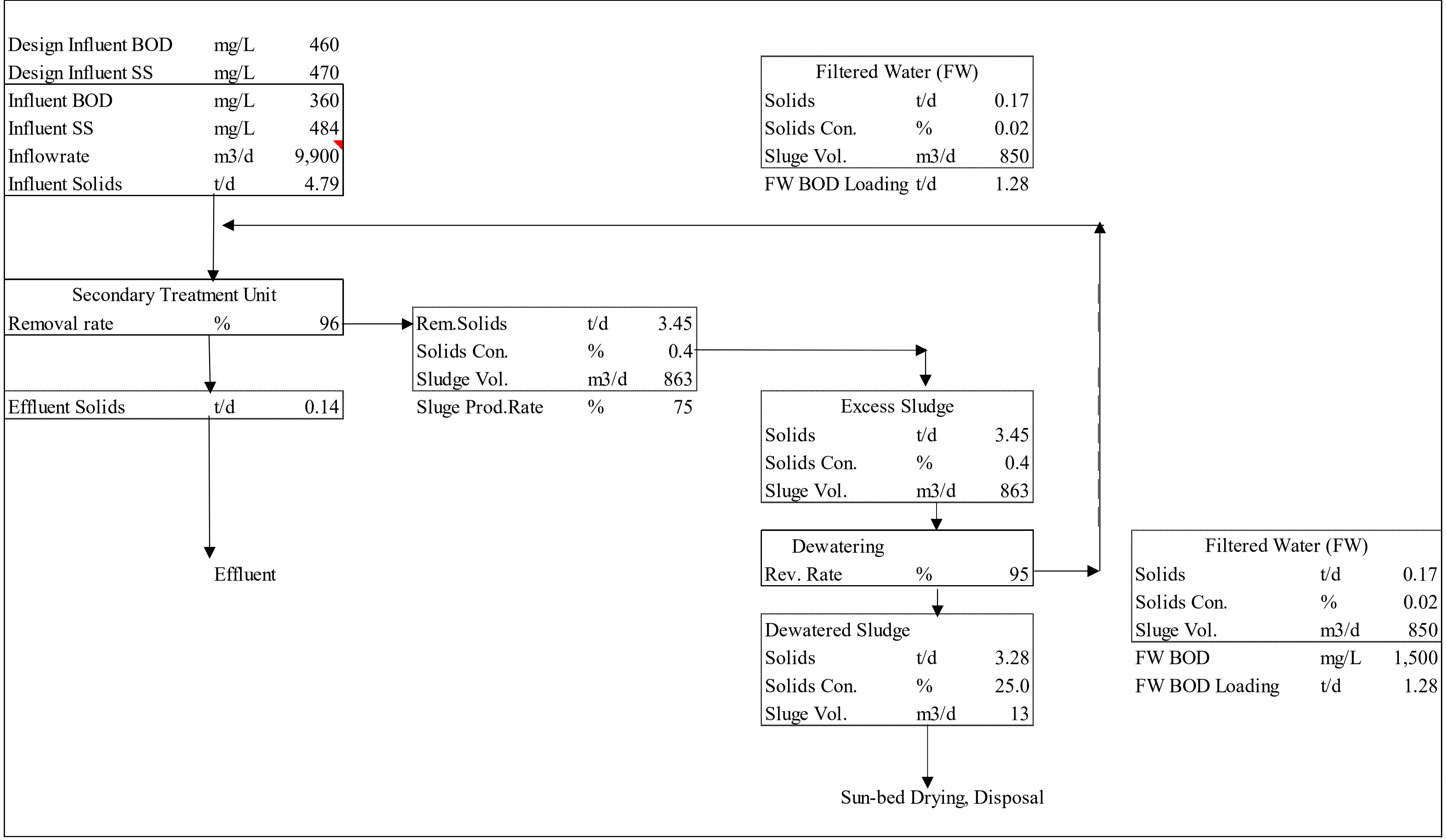
Item	Calculation
6-2 Sludge Drying Bed	
Sludge Drying Period	= 3 month
Drying Bed Volume	= 5 month's worth sludge
	= 150 d
Sludge Volume	= 45 m3/d × 150 d
	= 6750 m3
Sludge Depth	= 0.3 m
Required Drying Bed Area	= 6750 m3 ÷ 0.3 m
	= 22500 m2
Drying Bed Area	= 140 m × 165 m
	= 23100 m2 OK
6-3 Sludge Storage Space	
Sludge Storage Period	= 20 yrs
Sludge Volume	= 45 m3/d × 20 yrs × 365 d
	= 328500 m3
Sludge Depth	= 3.0 m
Required Storage Area	= 328500 m3 ÷ 3.0 m
	= 109500 m2
Sludge Storage Area	= 500 m × 220 m
	= 110000 m2 OK
7. Primary Treatment (Rainwater)	
Design Flowrate	= 4* Maximum Daily Flowrate
	= 4* 34,100 m^3/d
	= 136,400 m^3/d
Required Retention Time	= 2.50 hrs
Required Volume	= 136,400.00 m3/d × 2.50 hrs ÷ 24
	= 14,209 m^3
Maturation Pond Volume (Current Anaerobic Pond)	= 11,500 m^3 > 14,209 m^3 NO
Current Surface Area (Current Anaerobic Pond)	= 6,350 m2
Required Pond Depth	= 2.3 m → 2.5 m
Maturation Pond Volume	= 6,350 m2 × 2.5 m
	= 15875 m3 > 14,209 m^3 OK

(3) Votua WWTP（Ba）

Item	Calculation
1. Design Parameters	
1-1 Outline of Wastewater Treatment	
(1) Area of Plant	ha
(2) Grand Level of Plant	M
(3) Type of Collection System	Separate Sewer System
(4) Water Treatment Process	Oxidation ditch
1-2 Design Flowrate	
【Pipeline Sewerage】	
(1) Average Daily Flowrate	8924 m^3/d
(2) Peak Dry Weather Flowrate	17848 m^3/d
(3) Peak Wet Weather Flowrate	44620 m^3/d
【Trucked-in Domestic Septage】	
(1) Average Daily Quantity	0 m^3/d
(2) Peak Daily Quantity	0 m^3/d
【Total Influent Flowrate】	
(1) Average Daily Flowrate	9,000 m^3/d
(2) Maximum Daily Flowrate	9,900 m^3/d
(3) Maximum Hourly Flowrate	18,000 m^3/d
(4) Peak Wet Weather Flowrate	45,000 m^3/d
1-3 Influent Wastewater Quality	
【Pipeline Sewerage】	
(1) BOD	360 mg/L
(2) SS	484 mg/L
【Trucked-in Domestic Septage】	
(1) BOD	250 mg/L
(2) SS	620 mg/L
【Total Influent Flowrate】	
(1) BOD	360 mg/L
(2) SS	484 mg/L
1-4 Design Influent Wastewater	
(1) BOD	460 mg/L
(2) SS	470 mg/L
1-5 Removal Efficency (Total System)	
(1) BOD	96 %
(2) SS	96 %
1-6 Effluent Wastewater Quality	
(1) BOD	19 mg/L
(2) SS	19 mg/L
Sludge Production (Maximum Daily Flowrate)	
1-7 Waste Activated Sludge	Solids＝ Maximum Daily Flowrate × Influent SS × $0.95\times0.75\times10^{-6}$ Solids＝ 9,900 m3/d × 470 mg/L × 96 %×0.75× 10^-6 ＝ 3.4 ds-t/d Solid Concentration ＝ 0.3 % Sludge ＝ Solids÷Solids Concentration×10^2 Sludge＝ 3.40 t/d ÷ 0.3 % × 10^2 Sludge(OUT) ＝ 1,134 m^3/d

Item	Calculation
1-8 Dewatering	Solids (IN) ＝ 3.4 ds-t/d Solids(OUT) ＝ WAS × Recovery Rate$\times 10^{-2}$ Solids (OUT) ＝ 3.40 t/d × 95 % × 10^-2 Recovery Rate ＝ 95 % ＝ 3.3 ds-t/d Sludge(OUT) ＝ Solids ÷ Solids Concentration$\times 10^{2}$ Sludge(OUT) ＝ 3.30 t/d ÷ 25 % × 10^2 Solid Concentratio ＝ 25 % Sludge(OUT) ＝ 14 m^3/d

2 Solids Mass Balance (Final Stage)



Item	Calculation
3. Oxidation Ditch	
3-1 Reactor Volume	
Design Flowrate	
Maximum Daily Flowrate	= 9,900 m^3/d
Maximum hourly Flowrate	= 18,000 m^3/d
Hydraulic Retention Time	= 24 hours
Req. Volume	= 9,900.00 m3/d × 24.00 hrs ÷ 24
	= 9,900 m^3
Shape of Reactor	Oval
Water Depth	D = 3.5 m
Width	W = 6.0 m
Length	L = 90 m
Area	A = Width ×Water depth - 0.3 ×0.3×2/2
	= 6.00 m × 3.50 m － 0.3 × 0.3 × 2 ÷ 2
	= 20.9 m^2
Volume per Reactor	v = (L-2W)*2A+πWA
	= (90 - 2* 6.0)*2* 20.90 +π* 6.0 * 20.9
	= 3654.3 m3/reactor
Number of Reactor	n = 3 Reactors
Total Volume	V = n*v = 3 * 3,654
	= 10,963 m^3
Actual Hydraulic Retention Time	HRT = V÷Q*24
	= 10,963 ÷ 9,900 *24
	= 26.6 hrs Range(Japan): 24~36hr OK
	Range(Metcalf&Eddy): 16~30hr OK
3-2 Aerator	
(1) Design Parameters	
Maximum Daily Flowrate	= 9,900 m^3/d
Influent BOD	= 460 mg/L
Influent S-BOD	= 230 mg/L
Influent SS	= 470 mg/L
Influent Kj-N	= 70 mg/L
MLSS	= 4,000 mg/L
Effluent BOD	= 40 mg/L
Aerobic volume ratio	= 0.5
HRT	= 16 hrs

Item	Calculation
(2) ASRT	
ASRT	$= \frac{t_a}{24} \times \frac{X_A \times V}{X_W \times Q_W}$
	$= \frac{t_a}{24} \times \frac{X_A \times V}{Q \times X_I \times \alpha}$
	ASRT ; Aerobic Sludge Retention Time
	ta ; Aeration Time in a day
	＝ 12 hours
	Xw ; SS in WAS, mg/L
	V ; Reactor Volume, m3
	Qw ; Volume of WAS, m3
	Q ; Maximum Daily Flowrate/Reactor
	＝ 9,900 ÷ 3 ＝ 3,300 m3/d
	X_I ; Influent SS ＝ 470 mg/L
	α ; Sludge production rate per SS
	0.75
ASRT	$= \frac{12 \times 4{,}000 \times 3{,}654}{24 \times 3{,}300 \times 470 \times 0.75}$
	＝ 6.3 日
(3) Empirical ASRT	
	ASRT > 29.7 EXP (-0.102 × T)
	T ; Lowest water temperature in monthly average
	＝ 20 Celsius
ASRT	＝ 29.7 exp (-0.102 × 20)
	＝ 3.90 日 < 6.30 日 OK
(4) Prediction of C-BOD based on ASRT	
T	＝ 20 Celsius
C-BOD	＝ 9.75 × ASRT ^ -0.671
	＝ 9.75 × 6.3 ^ -0.671
	＝ 2.84 mg/L
	Assumming BOD/C-BOD is 3
BOD	＝ 3 × C-BOD
	＝ 3 × 2.84
	＝ 8.6 mg/L < 40 mg/L OK
	(General standard)
	＝ 8.6 mg/L < 20 mg/L OK
	(Significan Eco Zone standard)

Item	Calculation
(5) Oxigen requirement for BOD oxidation	
OD1	= A × (Removed BOD − Denitrified N × K)
	A ; Reqired O_2/Removed BOD
	= 0.6 kg as O_2/kg as BOD
	K ; Consumed BOD by Denitrification
	= 2.5 kg as BOD/kg as N
	Removed BOD = (0.46 - 0.04) × 9,900
	= 4,158 kg as BOD/d
	Denitrified N ; Assuming all nitrified N is denitrified.
OD1	= 0.6 × (4,158 − 693 × 2.5)
	= 1,456 kg as O_2/d
(6) Oxigen requirement for Internal aspiration	
OD2	= B × Va × MLVSS
	B ; O_2 Volume for internal aspiration
	= 0.1 kg as O^2/kg as MLVSS/d
	Va ; Aerobic zone volume
	= Volume ÷ 2
	Assuming MLVSS/MLSS is 0.8
OD2	= 0.1 × 10,962 ÷ 2 × 4 × 0.8
	= 1,754 kg as O_2/d
(7) Oxigen requirement for nitrification	
OD3	= C × Nitrified N
	C ; O_2 consumed by nitrification
	= 4.57 kg as O_2/kg as N
	Nitrified N ; Amount of nitrifired nitrogen
	; Influent N − Effluent nitrified N − nitrogen of WAS
	Influent N ; 0.070 × 9,900
	= 693 kg as N/d
	Effluent N ; Assuming all N is nitrified
	Nitrogen of WAS = 0.07 (kg as N/kg as MLSS) × Qw×Xx

Item	Calculation
	$Q_W \times X_X = Q_{in}(a \times C_{S-BOD,in} + b \times C_{ss,in} - c \times X_A \times \tau_A) \times 10^{-3}$
	a ; Rate of Sludge coversion from S-BOD = 0.5 gMLSS/gS-BOD
	C_{S-BOD} ; Influent soluble BOD = 230 mg/L
	b ; Rate of Sludge production from SS = 0.75 gMLSS/gSS
	c ; Decay rate = 0.04 1/d
	τ_A ; Aeration time = 0.5 d
	Qw×Xa = 9,900 ×(0.5 × 230 + 0.75 × 470 − 0.04 × 4,000 × 0.5)× 10^-3
	= 3,836 kg/d
	Nitrogen of WAS = 0.07 × 3,836
	= 268.6 kg as N/d
OD3	= 4.57 ×(693 − 0 − 268.6)
	= 1,940 kg as O_2/d
(8) Oxygen requirement in Effluent	
	Assuming Sludge return rate of 100 %
OD4	= Oxygen in effluent
	= 1.5 × 9,900 ×(1+ 1.00) × 10^-3
	= 30 kg as O_2/d
(9) Actual Oxigen Requirement	
AOR	= OD_1 + OD_2 + OD_3 + OD_4
	= 1,456 + 1,754 + 1,940 + 30
	= 5,180 kg as O_2/d
(10) Standard Oxygen Requirement	
SOR	= $\dfrac{AOR \times C_{SW}}{1.024^{(t-20)} \times \alpha \times (\beta \times C_S - C_a)} \times \dfrac{760}{P}$
	C_{SW} ; Oxygen saturation concentration in clean water at 20 Celsius
	= 8.84 mg/L
	Ca ; Average DO
	= 1.5 mg/L
	Cs ; Oxygen saturation concentration in clean water at t Celsius
	= 8.84 mg/L
	t = 20.0 Celsius

Item	Calculation
	α ; 0.93
	β ; 0.97
	P ; 760
Number of Reactor	= 3 Reactors
SOR	= 6,960 kg as O_2/d
SOR/reactor	= 2320 kg as O_2/d (per reactor)
	Required Oxygen
	$= \dfrac{6{,}960}{0.46 \times 9{,}900} =$ 1.6 kg as O_2/kg per unit BOD
4. Secondary clarifier	
4-1 Basin Volume	
Design Flowrate	
Maximum Daily Flowrate	= 9,900 m^3/d
Maximum hourly Flowrate	= 18,000 m^3/d
Overflow rate	= 12 $m^3/m^2/d$
Required Area for settling	= 9,900 ÷ 12 = 825 m^2
Diameter of Basin	20 m
No. of basin	= 3 basins
Effective Area	= 20 ^ 2 ÷ 4 × π × 3
	= 942 m^2
Depth of basin	= 3.5 m
Overflow rate	= 9,900 m^3/d ÷ 942 m^2
	= 10.5 $m^3/m^2/d$ Range: 8～12m3/m2/d OK
Settling Time	= (942 × 3.5 × 24)
	÷ 9,900
	= 8.0 hrs Range: 6～12hr OK
Req. Length of weir	= (20 − 1.6) × π = 57.8 m
	(Outer Weir)
	= (20 − 2.6) × π = 54.7 m
	(Inner Weir)
Weir Loading rate	= 9,900 ÷ (57.8 + 54.7) ÷ 3
	= 29.3 $m^3/m/d$ Range: 25~30m3/m/d
	OK

Item	Calculation
5. Disinfection	
5-1 Basin Volume	
Design Flowrate	
Maximum Daily Flowrate	= 9,900 m^3/d
Maximum hourly Flowrate	= 18,000 m^3/d
Peak Wet Weather Flowrate	= 45,000 m^3/d
Chlorine Contact Time	= 15 minutes
	= 900 seconds
Req. Volume	= 45,000 ÷ 24 ÷ 60 ÷ 60
	× 900
	= 469 m^3
Depth	= 2 m
Width	= 2 m
Length	= 118 m
Volume	= 2 × 2 × 118
	= 472 m^3
Actual Contact Time	= 472 ÷ 45,000 × 24× 60
	= 15.10 min OK
6-1 Sludge Dewatering	
Solids (IN)	= 3.4 t/d
Solid Concentration(IN)	= 0.30 %
Sludge(IN)	= 1,134 m3/d
Operation Conditions	7 hrs in one day and 5 days in a week
Solids	= 3.4 × 7 ÷ 5 ÷ 7
(Required Dewatering Cap.)	× 1,000
	= 680.0 kg/d
Actual Dewatering capacity	= 400 kg/d
Number of Units	= 2 (Standby 1)
Solids (OUT)	= 3.28 t/d
Solid Concentration(OUT)	= 25.00 %
Sludge(OUT)	= 13 m3/d

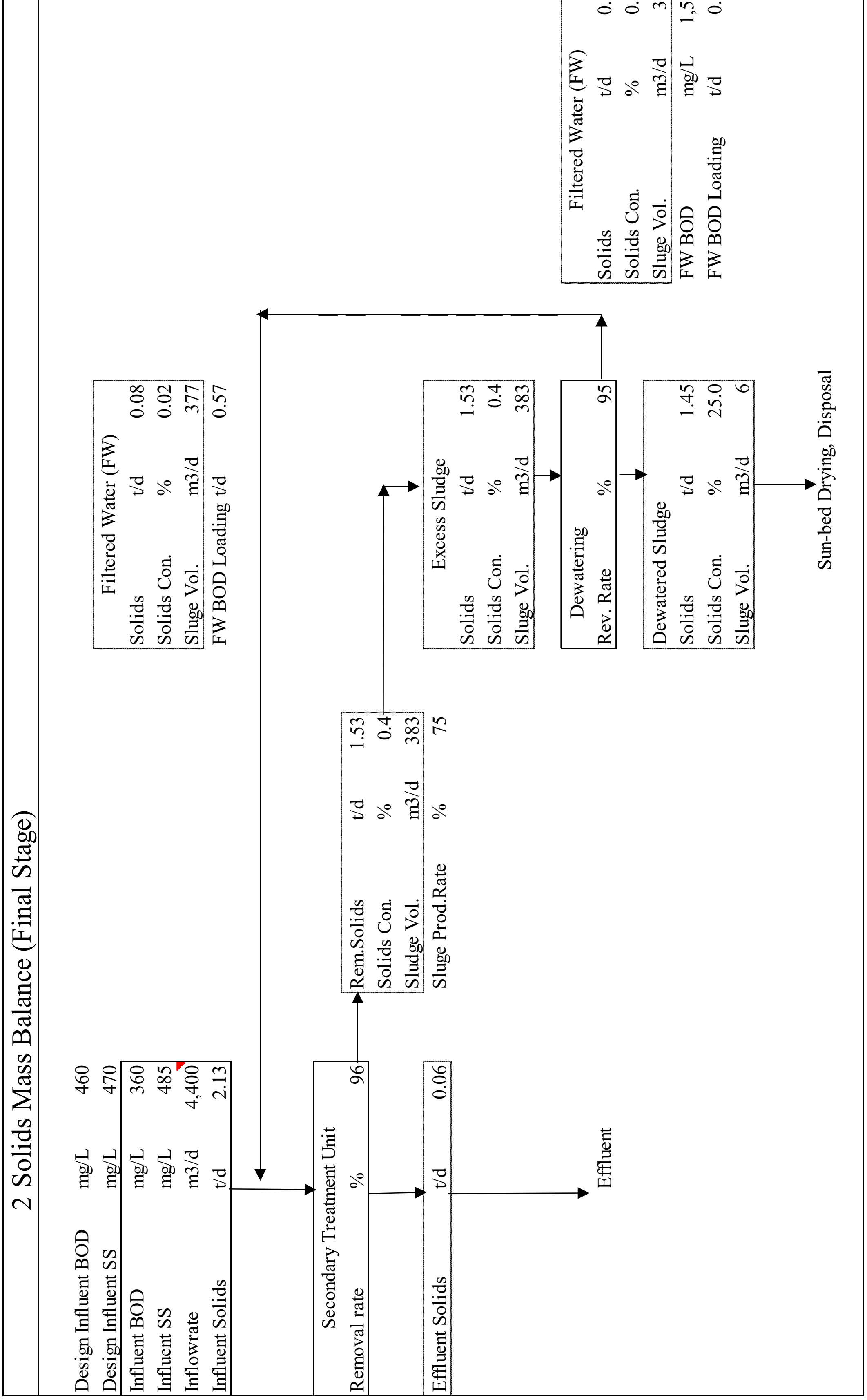
Item	Calculation
6-2 Sludge Drying Bed	
Sludge Drying Period	= 3 month
Drying Bed Volume	= 5 month's worth sludge
	= 150 d
Sludge Volume	= 13 m3/d × 150 d
	= 1950 m3
Sludge Depth	= 0.3 m
Drying Bed Area	= 1950 m3 ÷ 0.3 m
	= 6500 m2
Drying Bed Area	= 35 m × 200 m
	= 7000 m2 OK
6-3 Sludge Storage Space	
Sludge Storage Period	= 20 yrs
Sludge Volume	= 13 m3/d × 20 yrs × 365 d
	= 94900 m3
Sludge Depth	= 3.0 m
Area	= 94900 m3 ÷ 3.0 m
	= 31634 m2
Sludge Storage Area	= 200 m × 30 m
	= 280 m × 100 m
	= 34000 m2 OK
7. Primary Treatment (Rainwater)	
Design Flowrate	= 4* Maximum Daily Flowrate
	= 4* 9,900 m^3/d
	= 39,600 m^3/d
Required Retention Time	= 2.50 hrs
Required Volume	= 39,600.00 m3/d × 2.50 hrs ÷ 24
	= 4,125 m^3
Maturation Pond Volume (Current Anaerobic Pond)	= 4,320 m^3 > 4,125 m^3 OK

(4) Tavua WWTP

Item	Calculation
1. Design Parameters	
1-1 Outline of Wastewater Treatment	
(1) Area of Plant	ha
(2) Grand Level of Plant	M
(3) Type of Collection System	Separate Sewer System
(4) Water Treatment Process	Oxidation ditch
1-2 Design Flowrate	
【Pipeline Sewerage】	
(1) Average Daily Flowrate	3459 m^3/d
(2) Peak Dry Weather Flowrate	6918 m^3/d
(3) Peak Wet Weather Flowrate	17295 m^3/d
【Trucked-in Domestic Septage】	
(1) Average Daily Quantity	0 m^3/d
(2) Peak Daily Quantity	0 m^3/d
【Total Influent Flowrate】	
(1) Average Daily Flowrate	4,000 m^3/d
(2) Maximum Daily Flowrate	4,400 m^3/d
(3) Maximum Hourly Flowrate	8,000 m^3/d
(4) Peak Wet Weather Flowrate	18,000 m^3/d
1-3 Influent Wastewater Quality	
【Pipeline Sewerage】	
(1) BOD	360 mg/L
(2) SS	485 mg/L
【Trucked-in Domestic Septage】	
(1) BOD	250 mg/L
(2) SS	620 mg/L
【Total Influent Flowrate】	
(1) BOD	360 mg/L
(2) SS	485 mg/L
1-4 Design Influent Wastewater	
(1) BOD	460 mg/L
(2) SS	470 mg/L
1-5 Removal Efficency (Total System)	
(1) BOD	96 %
(2) SS	96 %
1-6 Effluent Wastewater Quality	
(1) BOD	19 mg/L
(2) SS	19 mg/L
Sludge Production (Maximum Daily Flowrate)	
1-7 Waste Activated Sludge	Solids＝ Maximum Daily Flowrate × Influent SS × 0.95×0.75×10^{-6} Solids＝ 4,400 m3/d × 470 mg/L × 96 %×0.75× 10^-6 ＝ 1.5 ds-t/d Solid Concentration ＝ 0.3 % Sludge ＝ Solids÷Solids Concentration×10^2 Sludge ＝ 1.50 t/d ÷ 0.3 % × 10^2 Sludge(OUT) ＝ 500 m^3/d

Item	Calculation
1-8 Dewatering	Solids (IN) ＝ 1.5 ds-t/d Solids(OUT) ＝ WAS × Recovery Rate$\times 10^{-2}$ Solids (OUT) ＝ 1.50 t/d × 95 % × 10^-2 Recovery Rate ＝ 95 % ＝ 1.5 ds-t/d Sludge(OUT) ＝ Solids ÷ Solids Concentration$\times 10^{2}$ Sludge(OUT) ＝ 1.50 t/d ÷ 25 % × 10^2 Solid Concentratio ＝ 25 % Sludge(OUT) ＝ 6 m^3/d

2 Solids Mass Balance (Final Stage)



Item	Calculation
3. Oxidation Ditch	
3-1 Reactor Volume	
Design Flowrate	
Maximum Daily Flowrate	= 4,400 m^3/d
Maximum hourly Flowrate	= 8,000 m^3/d
Hydraulic Retention Time	= 24 hours
Req. Volume	= 4,400.00 m3/d × 24.00 hrs ÷ 24
	= 4,400 m^3
Shape of Reactor	Oval
Water Depth	D = 3.5 m
Width	W = 4.0 m
Length	L = 55 m
Area	A = Width ×Water depth - 0.3 ×0.3×2/2
	= 4.00 m × 3.50 m － 0.3 × 0.3 × 2 ÷ 2
	= 13.9 m^2
Volume per Reactor	v = (L-2W)*2A+πWA
	= (55 - 2* 4.0)*2* 13.90 +π* 4.0 * 13.9
	= 1481.2 m3/reactor
Number of Reactor	n = 3 Reactors
Total Volume	V = n*v = 3 * 1,481
	= 4,444 m^3
Actual Hydraulic Retention Time	HRT = V÷Q*24
	= 4,444 ÷ 4,400 *24
	= 24.2 hrs Range(Japan): 24~36hr OK
	Range(Metcalf&Eddy): 16~30hr OK
3-2 Aerator	
(1) Design Parameters	
Maximum Daily Flowrate	= 4,400 m^3/d
Influent BOD	= 460 mg/L
Influent S-BOD	= 230 mg/L
Influent SS	= 470 mg/L
Influent Kj-N	= 70 mg/L
MLSS	= 4,000 mg/L
Effluent BOD	= 40 mg/L
Aerobic volume ratio	= 0.5
HRT	= 16 hrs

Item	Calculation
(2) ASRT	
ASRT	$= \frac{t_a}{24} \times \frac{X_A \times V}{X_W \times Q_W}$
	$= \frac{t_a}{24} \times \frac{X_A \times V}{Q \times X_1 \times \alpha}$
	ASRT ; Aerobic Sludge Retention Time
	ta ; Aeration Time in a day
	＝ 12 hours
	Xw ; SS in WAS, mg/L
	V ; Reactor Volume, m3
	Qw ; Volume of WAS, m3
	Q ; Maximum Daily Flowrate/Reactor
	＝ 4,400 ÷ 3 ＝ 1,467 m3/d
	X_I ; Influent SS ＝ 470 mg/L
	α ; Sludge production rate per SS
	0.75
ASRT	$= \frac{12 \times 4{,}000 \times 1{,}481}{24 \times 1{,}467 \times 470 \times 0.75}$
	＝ 5.7 日
(3) Empirical ASRT	
	ASRT > 29.7 EXP (-0.102 × T)
	T ; Lowest water temperature in monthly average
	＝ 20 Celsius
ASRT	＝ 29.7 exp (-0.102 × 20)
	＝ 3.90 日 < 5.70 日 OK
(4) Prediction of C-BOD based on ASRT	
T	＝ 20 Celsius
C-BOD	＝ 9.75 × ASRT ^ -0.671
	＝ 9.75 × 5.7 ^ -0.671
	＝ 3.04 mg/L
	Assumming BOD/C-BOD is 3
BOD	＝ 3 × C-BOD
	＝ 3 × 3.04
	＝ 9.2 mg/L < 40 mg/L OK
	(General standard)
	＝ 9.2 mg/L < 20 mg/L OK
	(Significan Eco Zone standard)

Item	Calculation
(5) Oxigen requirement for BOD oxidation	
OD1	= A × (Removed BOD − Denitrified N × K)
	A ; Reqired O_2/Removed BOD
	= 0.6 kg as O_2/kg as BOD
	K ; Consumed BOD by Denitrification
	= 2.5 kg as BOD/kg as N
	Removed BOD = (0.46 - 0.04) × 4,400
	= 1,848 kg as BOD/d
	Denitrified N ; Assuming all nitrified N is denitrified.
OD1	= 0.6 × (1,848 − 308 × 2.5)
	= 647 kg as O_2/d
(6) Oxigen requirement for Internal aspiration	
OD2	= B × Va × MLVSS
	B ; O_2 Volume for internal aspiration
	= 0.1 kg as O^2/kg as MLVSS/d
	Va ; Aerobic zone volume
	= Volume ÷ 2
	Assuming MLVSS/MLSS is 0.8
OD2	= 0.1 × 4,443 ÷ 2 × 4 × 0.8
	= 711 kg as O_2/d
(7) Oxigen requirement for nitrification	
OD3	= C × Nitrified N
	C ; O_2 consumed by nitrification
	= 4.57 kg as O_2/kg as N
	Nitrified N ; Amount of nitrifired nitrogen
	; Influent N − Effluent nitrified N
	− nitrogen of WAS
	Influent N ; 0.070 × 4,400
	= 308 kg as N/d
	Effluent N ; Assuming all N is nitrified
	Nitrogen of WAS = 0.07 (kg as N/kg as MLSS)
	× Qw×Xx

Item	Calculation
	$Q_W \times X_X = Q_{in}(a \times C_{S-BOD,in} + b \times C_{ss,in} - c \times X_A \times \tau_A) \times 10^{-3}$
	a ; Rate of Sludge coversion from S-BOD ＝ 0.5 gMLSS/gS-BOD
	C_{S-BOD} ; Influent soluble BOD ＝ 230 mg/L
	b ; Rate of Sludge production from SS ＝ 0.75 gMLSS/gSS
	c ; Decay rate ＝ 0.04 1/d
	τ_A ; Aeration time ＝ 0.5 d
	Qw×Xa ＝ 4,400 ×(0.5 × 230 ＋ 0.75 × 470 － 0.04 × 4,000 × 0.5)× 10^-3
	＝ 1,705 kg/d
	Nitrogen of WAS ＝ 0.07 × 1,705
	＝ 119.4 kg as N/d
OD3	＝ 4.57 ×(308 － 0 － 119.4)
	＝ 862 kg as O_2/d
(8) Oxygen requirement in Effluent	
	Assuming Sludge return rate of 100 %
OD4	＝ Oxygen in effluent
	＝ 1.5 × 4,400 ×(1+ 1.00) × 10^-3
	＝ 14 kg as O_2/d
(9) Actual Oxigen Requirement	
AOR	＝ OD_1 ＋ OD_2 ＋ OD_3 ＋ OD_4
	＝ 647 ＋ 711 ＋ 862 ＋ 14
	＝ 2,234 kg as O_2/d
(10) Standard Oxygen Requirement	
SOR	＝ $\dfrac{AOR \times C_{SW}}{1.024^{(t-20)} \times \alpha \times (\beta \times C_S - C_a)} \times \dfrac{760}{P}$
	C_{SW} ; Oxygen saturation concentration in clean water at 20 Celsius
	＝ 8.84 mg/L
	Ca ; Average DO ＝ 1.5 mg/L
	Cs ; Oxygen saturation concentration in clean water at t Celsius
	＝ 8.84 mg/L
	t ＝ 20.0 Celsius

Item	Calculation
	α ; 0.93
	β ; 0.97
	P ; 760
Number of Reactor	= 3 Reactors
SOR	= 3,001 kg as O_2/d
SOR/reactor	= 1001 kg as O_2/d (per reactor)
	Required Oxygen
	$= \frac{3{,}001}{0.46 \times 4{,}400} =$ 1.5 kg as O_2/kg per unit BOD
4. Secondary clarifier	
4-1 Basin Volume	
Design Flowrate	
Maximum Daily Flowrate	= 4,400 m^3/d
Maximum hourly Flowrate	= 8,000 m^3/d
Overflow rate	= 12 $m^3/m^2/d$
Required Area for settling	= 4,400 ÷ 12 = 367 m^2
Diameter of Basin	13 m
No. of basin	= 3 basins
Effective Area	= 13 ^ 2 ÷ 4 × π × 3
	= 398 m^2
Depth of basin	= 3.5 m
Overflow rate	= 4,400 m^3/d ÷ 398 m^2
	= 11.1 $m^3/m^2/d$ Range: 8～12m3/m2/d OK
Settling Time	= (398 × 3.5 × 24)
	÷ 4,400
	= 7.6 hrs Range: 6～12hr OK
Req. Length of weir	= (13 − 1.6) × π = 35.8 m
	(Outer Weir)
	= (13 − 3.0) × π = 31.4 m
	(Inner Weir)
Weir Loading rate	= 4,400 ÷ (35.8 + 31.4) ÷ 3
	= 21.8 $m^3/m/d$ Range: 25~30m3/m/d

Item	Calculation
5. Disinfection	
5-1 Basin Volume	
Design Flowrate	
Maximum Daily Flowrate	= 4,400 m^3/d
Maximum hourly Flowrate	= 8,000 m^3/d
Peak Wet Weather Flowrate	= 18,000 m^3/d
Chlorine Contact Time	= 15 minutes
	= 900 seconds
Req. Volume	= 18,000 ÷ 24 ÷ 60 ÷ 60
	× 900
	= 188 m^3
Depth	= 2 m
Width	= 2 m
Length	= 47 m
Volume	= 2 × 2 × 47
	= 188 m^3
Actual Contact Time	= 188 ÷ 18,000 × 24× 60
	= 15.04 min OK
6-1 Sludge Dewatering	
Solids (IN)	= 1.5 t/d
Solid Concentration	= 0.30 %
Sludge(IN)	= 500 m3/d
Operation Conditions	7 hrs in one day and 5 days in a week
Solids	= 1.5 × 7 ÷ 5 ÷ 7
(Required Dewatering Cap.)	× 1,000
	= 300.0 kg/d
Actual Dewatering capacity	= 400 kg/d
Number of Units	= 1 (Standby 1)
Solids (OUT)	= 1.45 t/d
Solid Concentration(OUT)	= 25.00 %
Sludge(OUT)	= 6 m3/d

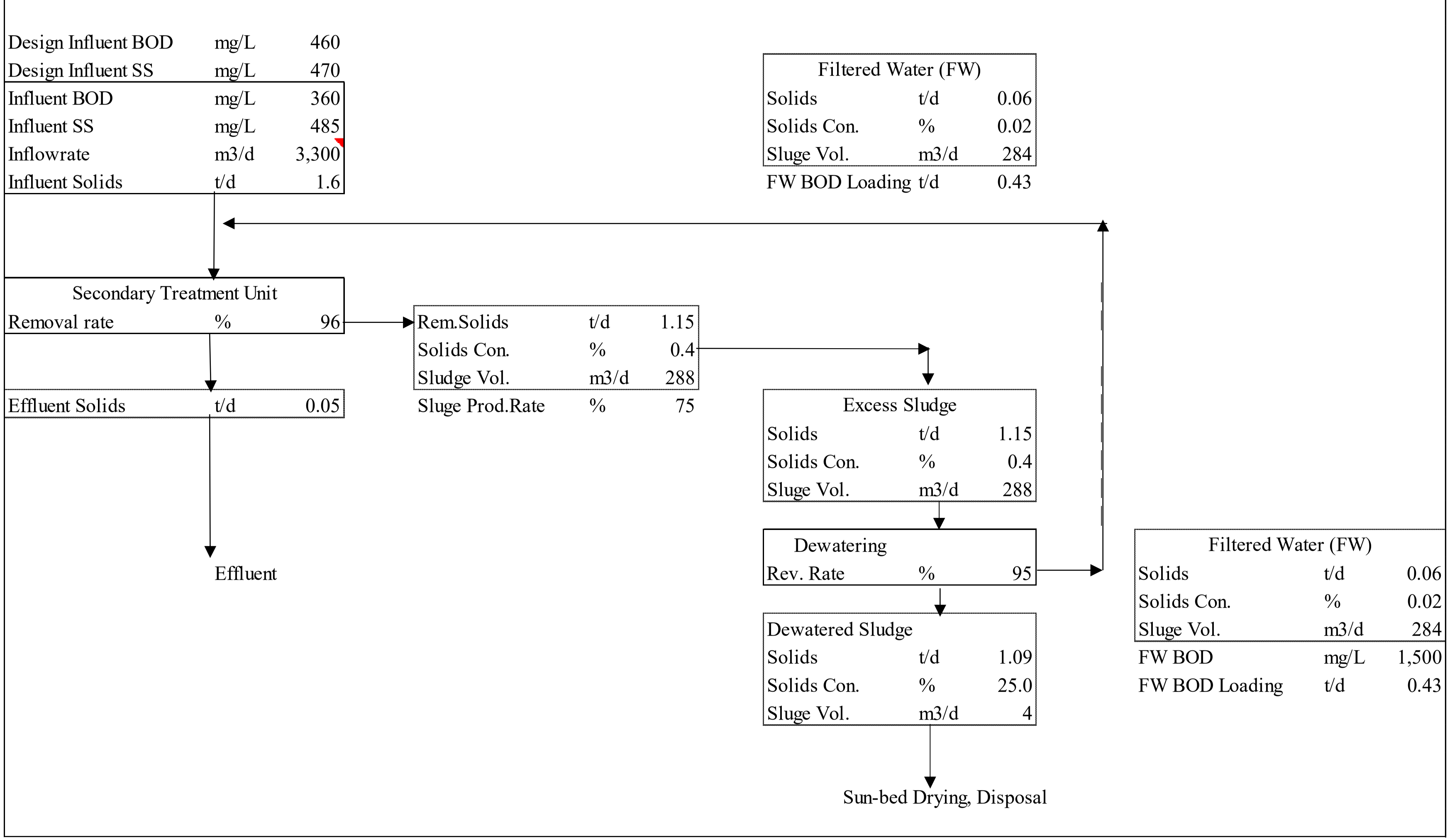
Item	Calculation
6-2 Sludge Drying Bed	
Sludge Drying Period	= 3 month
Drying Bed Volume	= 5 month's worth sludge
	= 150 d
Sludge Volume	= 6 m3/d × 150 d
	= 900 m3
Sludge Depth	= 0.3 m
Drying Bed Area	= 900 m3 ÷ 0.3 m
	= 3000 m2
Drying Bed Area	= 150 m × 20 m
	= 3000 m2 OK
6-3 Sludge Storage Space	
Sludge Storage Period	= 20 yrs
Sludge Volume	= 6 m3/d × 20 yrs × 365 d
	= 43800 m3
Sludge Depth	= 3.0 m
Required Storage Area	= 43800 m3 ÷ 3.0 m
	= 14600 m2
Sludge Storage Area	= 180 m × 85 m
	= 15300 m2 OK
7. Primary Treatment (Rainwater)	
Design Flowrate	= 4* Maximum Daily Flowrate
	= 4* 4,400 m^3/d
	= 17,600 m^3/d
Required Retention Time	= 2.50 hrs
Required Volume	= 17,600.00 m3/d × 2.50 hrs ÷ 24
	= 1,834 m^3
Depth	= 3 m
Required Area	= 612 m2
	= 40 m × 16 m
	= 640 m2 OK

(5) Rakiraki WWTP

Item	Calculation
1. Design Parameters	
1-1 Outline of Wastewater Treatment	
(1) Area of Plant	ha
(2) Grand Level of Plant	M
(3) Type of Collection System	Separate Sewer System
(4) Water Treatment Process	Oxidation ditch
1-2 Design Flowrate	
【Pipeline Sewerage】	
(1) Average Daily Flowrate	2031 m^3/d
(2) Peak Dry Weather Flowrate	4062 m^3/d
(3) Peak Wet Weather Flowrate	10155 m^3/d
【Trucked-in Domestic Septage】	
(1) Average Daily Quantity	12 m^3/d
(2) Peak Daily Quantity	24 m^3/d
【Total Influent Flowrate】	
(1) Average Daily Flowrate	3,000 m^3/d
(2) Maximum Daily Flowrate	3,300 m^3/d
(3) Maximum Hourly Flowrate	6,000 m^3/d
(4) Peak Wet Weather Flowrate	11,000 m^3/d
1-3 Influent Wastewater Quality	
【Pipeline Sewerage】	
(1) BOD	360 mg/L
(2) SS	484 mg/L
【Trucked-in Domestic Septage】	
(1) BOD	250 mg/L
(2) SS	620 mg/L
【Total Influent Flowrate】	
(1) BOD	360 mg/L
(2) SS	485 mg/L
1-4 Design Influent Wastewater	
(1) BOD	460 mg/L
(2) SS	470 mg/L
1-5 Removal Efficency (Total System)	
(1) BOD	96 %
(2) SS	96 %
1-6 Effluent Wastewater Quality	
(1) BOD	19 mg/L
(2) SS	19 mg/L
Sludge Production (Maximum Daily Flowrate)	
1-7 Waste Activated Sludge	Solids＝ Maximum Daily Flowrate × Influent SS × $0.95 \times 0.75 \times 10^{-6}$ Solids＝ 3,300 m3/d × 470 mg/L × 96 %×0.75× 10^-6 ＝ 1.1 ds-t/d Solid Concentration ＝ 0.3 % Sludge ＝ Solids÷Solids Concentration×10^2 Sludge ＝ 1.10 t/d ÷ 0.3 % × 10^2 Sludge(OUT) ＝ 367 m^3/d

Item	Calculation
1-8 Dewatering	Solids (IN) = 1.1 ds-t/d Solids(OUT) = WAS × Recovery Rate×10^{-2} Solids (OUT) = 1.10 t/d × 95 % × 10^-2 Recovery Rate = 95 % = 1.1 ds-t/d Sludge(OUT) = Solids ÷ Solids Concentration×10^{2} Sludge(OUT) = 1.10 t/d ÷ 25 % × 10^2 Solid Concentratio = 25 % Sludge(OUT) = 5 m^3/d

2 Solids Mass Balance (Final Stage)



Item	Calculation
3. Oxidation Ditch	
3-1 Reactor Volume	
Design Flowrate	
Maximum Daily Flowrate	= 3,300 m^3/d
Maximum hourly Flowrate	= 6,000 m^3/d
Hydraulic Retention Time	= 24 hours
Req. Volume	= 3,300.00 m3/d × 24.00 hrs ÷ 24 = 3,300 m^3
Shape of Reactor	Oval
Water Depth	D = 3.5 m
Width	W = 4.0 m
Length	L = 42 m
Area	A = Width ×Water depth - 0.3 ×0.3×2/2 = 4.00 m × 3.50 m − 0.3 × 0.3 × 2 ÷ 2 = 13.9 m^2
Volume per Reactor	v = (L-2W)*2A+πWA = (42 - 2* 4.0)*2* 13.90 +π* 4.0 * 13.9 = 1119.8 m3/reactor
Number of Reactor	n = 3 Reactors
Total Volume	V = n*v = 3 * 1,120 = 3,359 m^3
Actual Hydraulic Retention Time	HRT = V÷Q*24 = 3,359 ÷ 3,300 *24 = 24.4 hrs Range(Japan): 24~36hr OK Range(Metcalf&Eddy): 16~30hr OK
3-2 Aerator	
(1) Design Parameters	
Maximum Daily Flowrate	= 3,300 m^3/d
Influent BOD	= 460 mg/L
Influent S-BOD	= 230 mg/L
Influent SS	= 470 mg/L
Influent Kj-N	= 70 mg/L
MLSS	= 4,000 mg/L
Effluent BOD	= 40 mg/L
Aerobic volume ratio	= 0.5
HRT	= 16 hrs

Item	Calculation
(2) ASRT	
ASRT	$= \frac{t_a}{24} \times \frac{X_A \times V}{X_W \times Q_W}$
	$= \frac{t_a}{24} \times \frac{X_A \times V}{Q \times X_I \times \alpha}$
	ASRT ; Aerobic Sludge Retention Time
	ta ; Aeration Time in a day
	＝ 12 hours
	Xw ; SS in WAS, mg/L
	V ; Reactor Volume, m3
	Qw ; Volume of WAS, m3
	Q ; Maximum Daily Flowrate/Reactor
	＝ 3,300 ÷ 3 ＝ 1,100 m3/d
	X_I ; Influent SS ＝ 470 mg/L
	α ; Sludge production rate per SS
	0.75
ASRT	$= \frac{12 \times 4{,}000 \times 1{,}119}{24 \times 1{,}100 \times 470 \times 0.75}$
	＝ 5.8 日
(3) Empirical ASRT	
	ASRT ＞ 29.7 EXP (-0.102 × T)
	T ; Lowest water temperature in monthly average
	＝ 20 Celsius
ASRT	＝ 29.7 exp (-0.102 × 20)
	＝ 3.90 日 ＜ 5.80 日 OK
(4) Prediction of C-BOD based on ASRT	
T	＝ 20 Celsius
C-BOD	＝ 9.75 × ASRT ^ -0.671
	＝ 9.75 × 5.8 ^ -0.671
	＝ 3 mg/L
	Assumming BOD/C-BOD is 3
BOD	＝ 3 × C-BOD
	＝ 3 × 3
	＝ 9.0 mg/L ＜ 40 mg/L OK
	(General standard)
	＝ 9.0 mg/L ＜ 20 mg/L OK
	(Significan Eco Zone standard)

Item	Calculation
(5) Oxigen requirement for BOD oxidation	
OD1	= A × (Removed BOD − Denitrified N × K)
	A ; Reqired O_2/Removed BOD
	= 0.6 kg as O_2/kg as BOD
	K ; Consumed BOD by Denitrification
	= 2.5 kg as BOD/kg as N
	Removed BOD = (0.46 - 0.04) × 3,300
	= 1,386 kg as BOD/d
	Denitrified N ; Assuming all nitrified N is denitrified.
OD1	= 0.6 × (1,386 − 231 × 2.5)
	= 486 kg as O_2/d
(6) Oxigen requirement for Internal aspiration	
OD2	= B × Va × MLVSS
	B ; O_2 Volume for internal aspiration
	= 0.1 kg as O^2/kg as MLVSS/d
	Va ; Aerobic zone volume
	= Volume ÷ 2
	Assuming MLVSS/MLSS is 0.8
OD2	= 0.1 × 3,357 ÷ 2 × 4 × 0.8
	= 538 kg as O_2/d
(7) Oxigen requirement for nitrification	
OD3	= C × Nitrified N
	C ; O_2 consumed by nitrification
	= 4.57 kg as O_2/kg as N
	Nitrified N ; Amount of nitrifired nitrogen
	; Influent N − Effluent nitrified N
	− nitrogen of WAS
	Influent N ; 0.070 × 3,300
	= 231 kg as N/d
	Effluent N ; Assuming all N is nitrified
	Nitrogen of WAS = 0.07 (kg as N/kg as MLSS)
	× Qw×Xx

Item	Calculation
	$Q_W \times X_X = Q_{in}(a \times C_{S-BOD,in} + b \times C_{ss,in} - c \times X_A \times \tau_A) \times 10^{-3}$
	a ; Rate of Sludge coversion from S-BOD
	＝ 0.5 gMLSS/gS-BOD
	C_{S-BOD} ; Influent soluble BOD
	＝ 230 mg/L
	b ; Rate of Sludge production from SS
	＝ 0.75 gMLSS/gSS
	c ; Decay rate ＝ 0.04 1/d
	τ_A ; Aeration time ＝ 0.5 d
	Qw×Xa ＝ 3,300 ×(0.5 × 230 + 0.75 × 470 － 0.04 × 4,000 × 0.5)× 10^-3
	＝ 1,279 kg/d
	Nitrogen of WAS ＝ 0.07 × 1,279
	＝ 89.6 kg as N/d
OD3	＝ 4.57 ×(231 － 0 － 89.6)
	＝ 647 kg as O_2/d
(8) Oxygen requirement in Effluent	
	Assuming Sludge return rate of 100 %
OD4	＝ Oxygen in effluent
	＝ 1.5 × 3,300 ×(1+ 1.00) × 10^-3
	＝ 10 kg as O_2/d
(9) Actual Oxigen Requirement	
AOR	＝ OD_1 + OD_2 + OD_3 + OD_4
	＝ 486 + 538 + 647 + 10
	＝ 1,681 kg as O_2/d
(10) Standard Oxygen Requirement	
SOR	＝ $\dfrac{AOR \times C_{SW}}{1.024^{(t-20)} \times \alpha \times (\beta \times C_S - C_a)} \times \dfrac{760}{P}$
	Csw ; Oxygen saturation concentration in clean water at 20 Celsius
	＝ 8.84 mg/L
	Ca ; Average DO
	＝ 1.5 mg/L
	Cs ; Oxygen saturation concentration in clean water at t Celsius
	＝ 8.84 mg/L
	t ＝ 20.0 Celsius

Item	Calculation
	α ; 0.93
	β ; 0.97
	P ; 760
Number of Reactor	= 3 Reactors
SOR	= 2,259 kg as O_2/d
SOR/reactor	= 753 kg as O_2/d (per reactor)
	Required Oxygen
	$= \frac{2,259}{0.46 \times 3,300} = 1.5$ kg as O_2/kg per unit BOD
4. Secondary clarifier	
4-1 Basin Volume	
Design Flowrate	
Maximum Daily Flowrate	= 3,300 m^3/d
Maximum hourly Flowrate	= 6,000 m^3/d
Overflow rate	= 12 $m^3/m^2/d$
Required Area for settling	= 3,300 ÷ 12 = 275 m^2
Diameter of Basin	11 m
No. of basin	= 3 basins
Effective Area	= 11 ^ 2 ÷ 4 × π × 3
	= 285 m^2
Depth of basin	= 3.5 m
Overflow rate	= 3,300 m^3/d ÷ 285 m^2
	= 11.6 $m^3/m^2/d$ Range: 8～12m3/m2/d OK
Settling Time	= (285 × 3.5 × 24)
	÷ 3,300
	= 7.3 hrs Range: 6～12hr OK
Req. Length of weir	= (11 − 1.6) × π = 29.5 m
	(Outer Weir)
	= (11 − 2.6) × π = 26.4 m
	(Inner Weir)
Weir Loading rate	= 3,300 ÷ (29.5 + 26.4) ÷ 3
	= 19.7 $m^3/m/d$ Range: 25~30m3/m/d

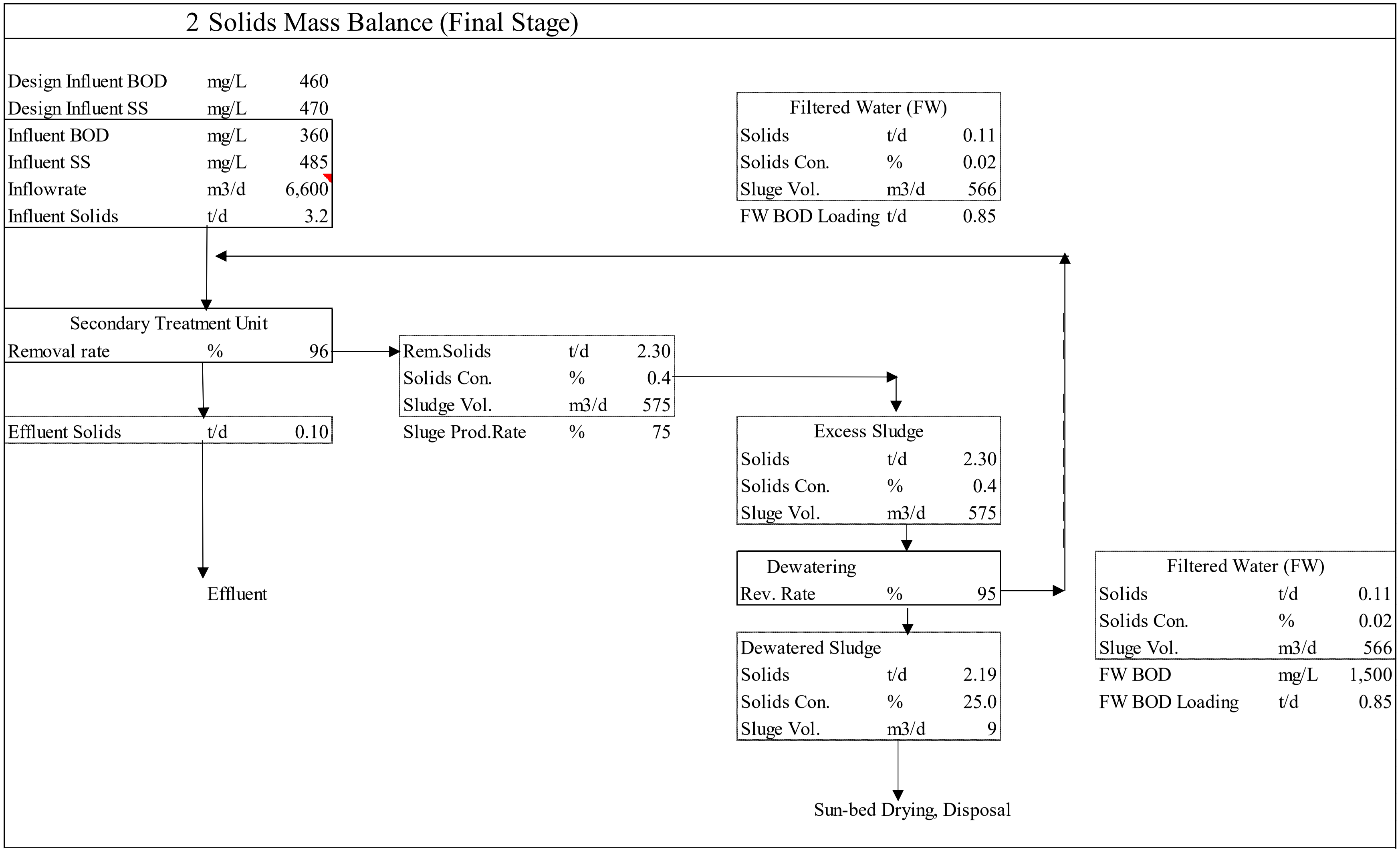
Item	Calculation
5. Disinfection	
5-1 Basin Volume	
Design Flowrate	
Maximum Daily Flowrate	= 3,300 m^3/d
Maximum hourly Flowrate	= 6,000 m^3/d
Peak Wet Weather Flowrate	= 11,000 m^3/d
Chlorine Contact Time	= 15 minutes
	= 900 seconds
Req. Volume	= 11,000 ÷ 24 ÷ 60 ÷ 60
	× 900
	= 115 m^3
Depth	= 2 m
Width	= 2 m
Length	= 28.75 m
Volume	= 2 × 2 × 28.75
	= 115 m^3
Actual Contact Time	= 115 ÷ 11,000 × 24× 60
	= 15.05 min OK
6-1 Sludge Dewatering	
Solids (IN)	= 1.1 t/d
Solid Concentration	= 0.30 %
Sludge(IN)	= 367 m3/d
Operation Conditions	7 hrs in one day and 5 days in a week
Solids	= 1.1 × 7 ÷ 5 ÷ 7
(Required Dewatering Cap.)	× 1,000
	= 220.0 kg/d
Actual Dewatering capacity	= 400 kg/d
Number of Units	= 1 (Standby 1)
Solids (OUT)	= 1.09 t/d
Solid Concentration(OUT)	= 25.00 %
Sludge(OUT)	= 4 m3/d

Item	Calculation
6-2 Sludge Drying Bed	
Sludge Drying Period	= 3 month
Drying Bed Volume	= 5 month's worth sludge
	= 150 d
Sludge Volume	= 4 m3/d × 150 d
	= 600 m3
Sludge Depth	= 0.3 m
Required Drying Bed Area	= 2000 m2
Drying Bed Area	= 40 m × 50 m
	= 2000 m2 OK
6-3 Sludge Storage Space	
Sludge Storage Period	= 20 yrs
Sludge Volume	= 4 m3/d × 20 yrs × 365 d
	= 29200 m3
Sludge Depth	= 3.0 m
Sludge Storage Area	= 29200 m3 ÷ 3.0 m
	= 9734 m2
Sludge Storage Area	= 100 m × 100 m
	= 10000 m2 OK
7. Primary Treatment (Rainwater)	
Design Flowrate	= 4* Maximum Daily Flowrate
	= 4* 3,300 m^3/d
	= 13,200 m^3/d
Required Retention Time	= 2.50 hrs
Required Volume	= 13,200.00 m3/d × 2.50 hrs ÷ 24
	= 1,375 m^3
Depth	= 3 m
Required Lake Area	= 459 m2
	= 20 m × 25 m
	= 500 m2 OK

(6) Olosara WWTP（Sigatoka）

Item	Calculation
1. Design Parameters	
1-1 Outline of Wastewater Treatment	
(1) Area of Plant	ha
(2) Grand Level of Plant	M
(3) Type of Collection System	Separate Sewer System
(4) Water Treatment Process	Oxidation ditch
1-2 Design Flowrate	
【Pipeline Sewerage】	
(1) Average Daily Flowrate	5597 m^3/d
(2) Peak Dry Weather Flowrate	11194 m^3/d
(3) Peak Wet Weather Flowrate	27985 m^3/d
【Trucked-in Domestic Septage】	
(1) Average Daily Quantity	11 m^3/d
(2) Peak Daily Quantity	22 m^3/d
【Total Influent Flowrate】	
(1) Average Daily Flowrate	6,000 m^3/d
(2) Maximum Daily Flowrate	6,600 m^3/d
(3) Maximum Hourly Flowrate	12,000 m^3/d
(4) Peak Wet Weather Flowrate	29,000 m^3/d
1-3 Influent Wastewater Quality	
【Pipeline Sewerage】	
(1) BOD	360 mg/L
(2) SS	484 mg/L
【Trucked-in Domestic Septage】	
(1) BOD	250 mg/L
(2) SS	620 mg/L
【Total Influent Flowrate】	
(1) BOD	360 mg/L
(2) SS	485 mg/L
1-4 Design Influent Wastewater	
(1) BOD	460 mg/L
(2) SS	470 mg/L
1-5 Removal Efficency (Total System)	
(1) BOD	96 %
(2) SS	96 %
1-6 Effluent Wastewater Quality	
(1) BOD	19 mg/L
(2) SS	19 mg/L
Sludge Production (Maximum Daily Flowrate)	
1-7 Waste Activated Sludge	Solids＝ Maximum Daily Flowrate × Influent SS × $0.95\times0.75\times10^{-6}$ Solids＝ 6,600 m3/d × 470 mg/L × 96 %×0.75× 10^-6 ＝ 2.2 ds-t/d Solid Concentration ＝ 0.3 % Sludge ＝ Solids÷Solids Concentration×10^2 Sludge ＝ 2.20 t/d ÷ 0.3 % × 10^2 Sludge(OUT) ＝ 734 m^3/d

Item	Calculation
1-8 Dewatering	Solids (IN) ＝ 2.2 ds-t/d Solids(OUT) ＝ WAS × Recovery Rate$\times 10^{-2}$ Solids (OUT) ＝ 2.20 t/d × 95 % × 10^-2 Recovery Rate ＝ 95 % ＝ 2.1 ds-t/d Sludge(OUT) ＝ Solids ÷ Solids Concentration$\times 10^{2}$ Sludge(OUT) ＝ 2.10 t/d ÷ 25 % × 10^2 Solid Concentratio ＝ 25 %


2 Solids Mass Balance (Final Stage)
Design Influent BOD mg/L 460
Design Influent SS mg/L 470
Influent BOD mg/L 360
Influent SS mg/L 485
Inflowrate m3/d 6,600
Influent Solids t/d 3.2
Secondary Treatment Unit
Removal rate % 96
Effluent Solids t/d 0.10
Effluent
Rem.Solids t/d 2.30
Solids Con. % 0.4
Sludge Vol. m3/d 575
Sluge Prod.Rate % 75
Filtered Water (FW)
Solids t/d 0.11
Solids Con. % 0.02
Sluge Vol. m3/d 566
FW BOD Loading t/d 0.85
Excess Sludge
Solids t/d 2.30
Solids Con. % 0.4
Sluge Vol. m3/d 575
Dewatering
Rev. Rate % 95
Dewatered Sludge
Solids t/d 2.19
Solids Con. % 25.0
Sluge Vol. m3/d 9
Sun-bed Drying, Disposal
Filtered Water (FW)
Solids t/d 0.11
Solids Con. % 0.02
Sluge Vol. m3/d 566
FW BOD mg/L 1,500
FW BOD Loading t/d 0.85

Item	Calculation
3. Oxidation Ditch	
3-1 Reactor Volume	
Design Flowrate	
Maximum Daily Flowrate	= 6,600 m^3/d
Maximum hourly Flowrate	= 12,000 m^3/d
Hydraulic Retention Time	= 24 hours
Req. Volume	= 6,600.00 m3/d × 24.00 hrs ÷ 24 = 6,600 m^3
Shape of Reactor	Oval
Water Depth	D = 3.5 m
Width	W = 5.5 m
Length	L = 60 m
Area	A = Width ×Water depth - 0.3 ×0.3×2/2 = 5.50 m × 3.50 m − 0.3 × 0.3 × 2 ÷ 2 = 19.2 m^2
Volume per Reactor	v = (L-2W)*2A+πWA = (60 - 2* 5.5)*2* 19.20 +π* 5.5 * 19.2 = 2213.3 m3/reactor
Number of Reactor	n = 3 Reactors
Total Volume	V = n*v = 3 * 2,213 = 6,640 m^3
Actual Hydraulic Retention Time	HRT = V÷Q*24 = 6,640 ÷ 6,600 *24 = 24.1 hrs Range(Japan): 24~36hr OK Range(Metcalf&Eddy): 16~30hr OK
3-2 Aerator	
(1) Design Parameters	
Maximum Daily Flowrate	= 6,600 m^3/d
Influent BOD	= 460 mg/L
Influent S-BOD	= 230 mg/L
Influent SS	= 470 mg/L
Influent Kj-N	= 70 mg/L
MLSS	= 4,000 mg/L
Effluent BOD	= 40 mg/L
Aerobic volume ratio	= 0.5
HRT	= 16 hrs

Item	Calculation
(2) ASRT	
ASRT	$= \frac{t_a}{24} \times \frac{X_A \times V}{X_W \times Q_W}$
	$= \frac{t_a}{24} \times \frac{X_A \times V}{Q \times X_I \times \alpha}$
	ASRT ; Aerobic Sludge Retention Time
	ta ; Aeration Time in a day
	＝ 12 hours
	Xw ; SS in WAS, mg/L
	V ; Reactor Volume, m3
	Qw ; Volume of WAS, m3
	Q ; Maximum Daily Flowrate/Reactor
	＝ 6,600 ÷ 3 ＝ 2,200 m3/d
	X_I ; Influent SS ＝ 470 mg/L
	α ; Sludge production rate per SS
	0.75
ASRT	$= \frac{12 \times 4{,}000 \times 2{,}213}{24 \times 2{,}200 \times 470 \times 0.75}$
	＝ 5.7 日
(3) Empirical ASRT	
	ASRT > 29.7 EXP (-0.102 × T)
	T ; Lowest water temperature in monthly average
	＝ 20 Celsius
ASRT	＝ 29.7 exp (-0.102 × 20)
	＝ 3.90 日 < 5.70 日 OK
(4) Prediction of C-BOD based on ASRT	
T	＝ 20 Celsius
C-BOD	＝ 9.75 × ASRT ^ -0.671
	＝ 9.75 × 5.7 ^ -0.671
	＝ 3.04 mg/L
	Assumming BOD/C-BOD is 3
BOD	＝ 3 × C-BOD
	＝ 3 × 3.04
	＝ 9.2 mg/L < 40 mg/L OK
	(General standard)
	＝ 9.2 mg/L < 20 mg/L OK
	(Significan Eco Zone standard)

Item	Calculation
(5) Oxigen requirement for BOD oxidation	
OD1	= A × (Removed BOD − Denitrified N × K)
	A ; Reqired O_2/Removed BOD
	= 0.6 kg as O_2/kg as BOD
	K ; Consumed BOD by Denitrification
	= 2.5 kg as BOD/kg as N
	Removed BOD = (0.46 - 0.04) × 6,600
	= 2,772 kg as BOD/d
	Denitrified N ; Assuming all nitrified N is denitrified.
OD1	= 0.6 × (2,772 − 462 × 2.5)
	= 971 kg as O_2/d
(6) Oxigen requirement for Internal aspiration	
OD2	= B × Va × MLVSS
	B ; O_2 Volume for internal aspiration
	= 0.1 kg as O^2/kg as MLVSS/d
	Va ; Aerobic zone volume
	= Volume ÷ 2
	Assuming MLVSS/MLSS is 0.8
OD2	= 0.1 × 6,639 ÷ 2 × 4 × 0.8
	= 1,063 kg as O_2/d
(7) Oxigen requirement for nitrification	
OD3	= C × Nitrified N
	C ; O_2 consumed by nitrification
	= 4.57 kg as O_2/kg as N
	Nitrified N ; Amount of nitrifired nitrogen
	; Influent N − Effluent nitrified N − nitrogen of WAS
	Influent N ; 0.070 × 6,600
	= 462 kg as N/d
	Effluent N ; Assuming all N is nitrified
	Nitrogen of WAS = 0.07 (kg as N/kg as MLSS) × Qw×Xx

Item	Calculation
	$$Q_W \times X_X = Q_{in}(a \times C_{S-BOD,in} + b \times C_{ss,in} - c \times X_A \times \tau_A) \times 10^{-3}$$
	a ; Rate of Sludge coversion from S-BOD = 0.5 gMLSS/gS-BOD
	$C_{S\text{-}BOD}$; Influent soluble BOD = 230 mg/L
	b ; Rate of Sludge production from SS = 0.75 gMLSS/gSS
	c ; Decay rate = 0.04 1/d
	τ_A ; Aeration time = 0.5 d
	Qw×Xa = 6,600 ×(0.5 × 230 + 0.75 × 470 − 0.04 × 4,000 × 0.5)× 10^-3
	= 2,558 kg/d
	Nitrogen of WAS = 0.07 × 2,558
	= 179.1 kg as N/d
OD3	= 4.57 ×(462 − 0 − 179.1)
	= 1,293 kg as O_2/d
(8) Oxygen requirement in Effluent	
	Assuming Sludge return rate of 100 %
OD4	= Oxygen in effluent
	= 1.5 × 6,600 ×(1+ 1.00) × 10^-3
	= 20 kg as O_2/d
(9) Actual Oxigen Requirement	
AOR	= OD_1 + OD_2 + OD_3 + OD_4
	= 971 + 1,063 + 1,293 + 20
	= 3,347 kg as O_2/d
(10) Standard Oxygen Requirement	
SOR	= $\dfrac{AOR \times C_{SW}}{1.024^{(t-20)} \times \alpha \times (\beta \times C_S - C_a)} \times \dfrac{760}{P}$
	C_{SW} ; Oxygen saturation concentration in clean water at 20 Celsius
	= 8.84 mg/L
	Ca ; Average DO
	= 1.5 mg/L
	Cs ; Oxygen saturation concentration in clean water at t Celsius
	= 8.84 mg/L
	t = 20.0 Celsius

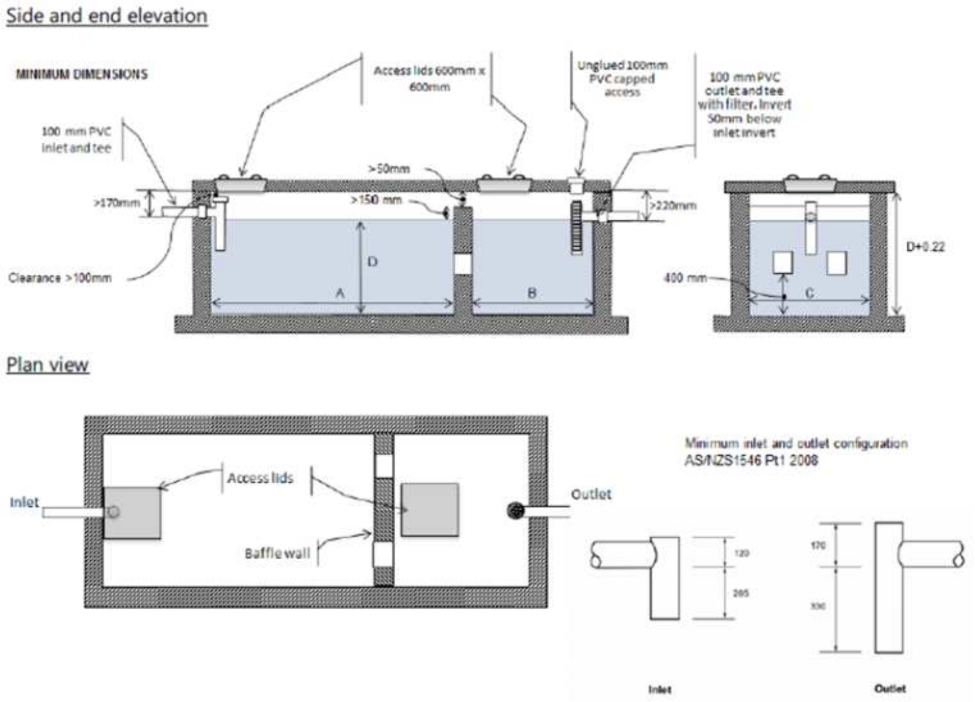
Item	Calculation
	α ; 0.93
	β ; 0.97
	P ; 760
Number of Reactor	= 3 Reactors
SOR	= 4,497 kg as O_2/d
SOR/reactor	= 1499 kg as O_2/d (per reactor)
	Required Oxygen
	$= \dfrac{4{,}497}{0.46 \times 6{,}600} =$ 1.5 kg as O_2/kg per unit BOD
4. Secondary clarifier	
4-1 Basin Volume	
Design Flowrate	
Maximum Daily Flowrate	= 6,600 m^3/d
Maximum hourly Flowrate	= 12,000 m^3/d
Overflow rate	= 12 $m^3/m^2/d$
Required Area for settling	= 6,600 ÷ 12 = 550 m^2
Diameter of Basin	16 m
No. of basin	= 3 basins
Effective Area	= 16 ^ 2 ÷ 4 × π × 3
	= 603 m^2
Depth of basin	= 3.5 m
Overflow rate	= 6,600 m^3/d ÷ 603 m^2
	= 10.9 $m^3/m^2/d$ Range: 8～12m3/m2/d OK
Settling Time	= (603 × 3.5 × 24)
	÷ 6,600
	= 7.7 hrs Range: 6～12hr OK
Req. Length of weir	= (16 − 1.6) × π = 45.2 m
	(Outer Weir)
	= (16 − 2.6) × π = 42.1 m
	(Inner Weir)
Weir Loading rate	= 6,600 ÷ (45.2 + 42.1) ÷ 3
	= 25.2 $m^3/m/d$ Range: 25~30m3/m/d
	OK

Item	Calculation
5. Disinfection	
5-1 Basin Volume	
Design Flowrate	
Maximum Daily Flowrate	= 6,600 m^3/d
Maximum hourly Flowrate	= 12,000 m^3/d
Peak Wet Weather Flowrate	= 29,000 m^3/d
Chlorine Contact Time	= 15 minutes
	= 900 seconds
Req. Volume	= 29,000 ÷ 24 ÷ 60 ÷ 60
	× 900
	= 303 m^3
Depth	= 2 m
Width	= 2 m
Length	= 75.75 m
Volume	= 2 × 2 × 75.75
	= 303 m^3
Actual Contact Time	= 303 ÷ 29,000 × 24× 60
	= 15.05 min OK
6-1 Sludge Dewatering	
Solids (IN)	= 2.2 t/d
Solid Concentration	= 0.30 %
Sludge(IN)	= 734 m3/d
Operation Conditions	7 hrs in one day and 5 days in a week
Solids	= 2.2 × 7 ÷ 5 ÷ 7
(Required Dewatering Cap.)	× 1,000
	= 440.0 kg/d
Actual Dewatering capacity	= 400 kg/d
Number of Units	= 2 (Standby 1)
Solids (OUT)	= 2.19 t/d
Solid Concentration(OUT)	= 25.00 %
Sludge(OUT)	= 9 m3/d

Item	Calculation
6-2 Sludge Drying Bed	
Sludge Drying Period	= 3 month
Drying Bed Volume	= 5 month's worth sludge = 150 d
Sludge Volume	= 9 m3/d × 150 d = 1350 m3
Sludge Depth	= 0.3 m
Required Drying Bed Area	= 1350 m3 ÷ 0.3 m = 4500 m2
Drying Bed Area	= 40 m × 120 m = 4800 m2 OK
6-3 Sludge Storage Space	
Sludge Storage Period	= 20 yrs
Sludge Volume	= 9 m3/d × 20 yrs × 365 d = 65700 m3
Sludge Depth	= 3.0 m
Required Storage Area	= 65700 m3 ÷ 3.0 m = 21900 m2
Sludge Storage Area	= 200 m × 110 m = 22000 m2 OK
7. Primary Treatment (Rainwater)	
Design Flowrate	= 4* Maximum Daily Flowrate = 4* 6,600 m^3/d = 26,400 m^3/d
Required Retention Time	= 2.50 hrs
Required Volume	= 26,400.00 m3/d × 2.50 hrs ÷ 24 = 2,750 m^3
Maturation Pond Volume (Current Anaerobic Pond)	= 3,420 m^3 > 2,750 m^3 OK

APPENDIX 5-6 Calculation of Septic Tank Capacity (1)

Recommended dimensions for two chamber septic tanks are shown below. The tanks are dimensioned to provide working capacities based on international best practice codes and standards, as adopted in New Zealand and Australia (e.g., AS/NZS 1547:2012).



Required septic tank capacities for combined black and grey water. A–D refer to key dimensions.

No. of occupants	A (m)	B (m)	D (m)	C (m)	Working Capacity (Liters)
1 – 5	1.4	0.8	1.2	1.2	3,170
6 – 8	1.6	0.8	1.2	1.4	4,030
9 – 10	1.8	1.0	1.2	1.4	4,700

Required septic tank capacities for black water only. A–D refer to key dimensions.

No. of occupants	A (m)	B (m)	D (m)	C (m)	Working Capacity (Liters)
1 – 5	1.2	0.6	0.9	1.0	1,620
6 – 8	1.6	0.8	1.0	1.0	2,400
9 – 10	1.8	1.0	1.0	1.2	3,360

Source: On-site Household Sanitation Guidelines for Fiji, #3 Septic tank Construction Using Concrete Blocks (Sep. 2017, WASH Koro Project)

APPENDIX 5-7 Calculation of Septic Tank Capacity (2)

The total capacity of the tank (C) is:

C = A + B

where

A = Required volume for 24 hours' liquid retention;

B = Required sludge and scum storage capacity

A = P x q = 8 x 0.9 x 220 = 1,584 liters

where,

P = number of people served by the tank (= 8, for minimum capacity septic tank in the Building Code)

q = sewerage flow per person (litters per person per day).= 0.9 x Q;

Q = Daily water consumption = 220 liters/day/person (WAF's Planning parameter for domestic use)

B = P x N x F x S

where

N = Number of years between dislodging (often 2-5 years; more frequent dislodging may be assumed where there is a cheap and reliable emptying service) (assumed as 5 years)

F = a factor which relates the sludge digestion rate to temperature and the dislodging interval, as shown in the table below. (=1.0, temperature >20℃)

Number of years between desludging	Ambient temperature		
	> 20 throughout year	> 10 throughout year	< 10 during winter
1	1.3	1.5	2.5
2	1.0	1.15	1.5
3	1.0	1.0	1.27
4	1.0	1.0	1.15
5	1.0	1.0	1.06
6 or more	1.0	1.0	1.0

S = Rate of sludge and scum accumulation which may be taken as 25 liters per person per year for tanks receiving WC waste only, and 40 liters per person per year for tanks receiving WC waste and sullage.

B = P x N x F x S = 8 x 5 x 1.0 x 25 = 1,000 liters for tanks receiving WC waste only

B = P x N x F x S = 8 x 5 x 1.0 x 40 = 1,600 liters for tanks receiving WC waste and sullage

Thus, the required tank capacity is calculated as follows.

C = 1,584 + 1,000 = 2,584 liters for tanks receiving WC waste only

C = 1,584 + 1,600 = 3,184 liters for tanks receiving WC waste and sullage

The calculation above was done referring to “A Guide to the Development of on-Site Sanitation” issued by WHO in 1992.

APPENDIX 5-8 Standards for Frequency of Septic Tank Desludging

Standards for frequency of septic tank desludging.

Country	Septic tank desludging frequency	Agency setting the norm
1 India	2–3 years	Central Public Health and Environmental Engineering Organization (CPHEEO), 2013
2 USA	Every 3 years	Environmental Protection Agency (EPA) (2005), A Homeowner's Guide to Septic Systems
3 Australia	Every 5 years	Department of Health, Australian Government, 2010
4 Ireland	5 years or depending on the septic tank capacity and the number of people living in the house	The Water Services (Amendment) Act 2012
5 Malaysia	Every 2 years	MS 1228 on Design of sewerage system [Standards and Industrial Research Institute of Malaysia (SIRIM), 1991; Span, 2009]
6 Philippines	Inspected at least once a year and be cleaned when the bottom of the scum mat is within 7.50 cm (3 inches) of the bottom of the outlet device	Sewerage Collection and Disposal, Excreta Disposal And Drainage Of The Code On Sanitation Of The Philippines (P.D. 856.) (Department of Health, Manila, Philippines, 1995)
7 Canada	Inspect the system every 3–5 years and pump out the solids and scum when required	Ontario Septic Smart-Understanding Your Home's Septic System; Canadian Environmental Protection Act (R.R.O, 1990), Reg. 358: sewerage systems (Last amendment: O. Reg. 244/09.) (R.R.O, 1990; WHO, n.d.)

Source: "Citywide Inclusive Sanitation Through Scheduled Desludging Services: Emerging Experience From India", Meera Mehta, Dinesh Mehta and Upasana Yadav, Frontiers in Environmental Science, Vol. 7, Article 188, November 2019)

APPENDIX 5-9 Study of Septage Treatment in Ra Province

(1) Setting Septage Collection Area

Ra Province has a low population density and is expected to have a low priority for sewerage development. Consequently, sewerage development in this region is expected to take longer than in other regions. In addition, it is far from Lautoka where many bailing companies are located, leading to bailing fees that are higher than in other areas. For these reasons, as a temporary measure for domestic wastewater treatment, development decentralized treatment systems, regular desludging, and construction of a new sludge treatment facility were considered.

Figure A5-9. 1 shows a proposed sludge transportation route if a new septage treatment plant (STP) is constructed in Rakiraki and septage is transported to Rakiraki, Natabua, and Olosara for treatment. In this proposal, sludge from Tavua, one of the Districts (Tikina) in Ba Province, which is adjacent to Ra Province, will be treated at the Rakiraki STP nearby.

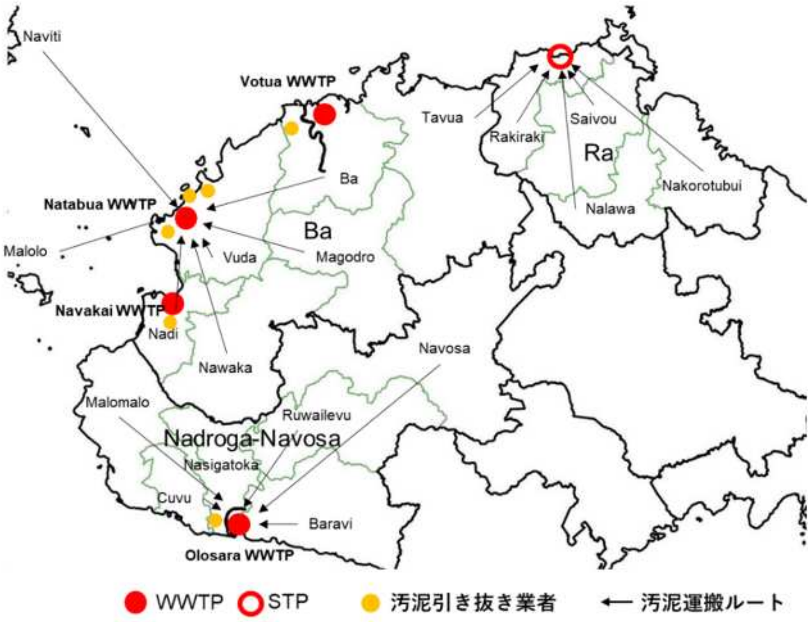
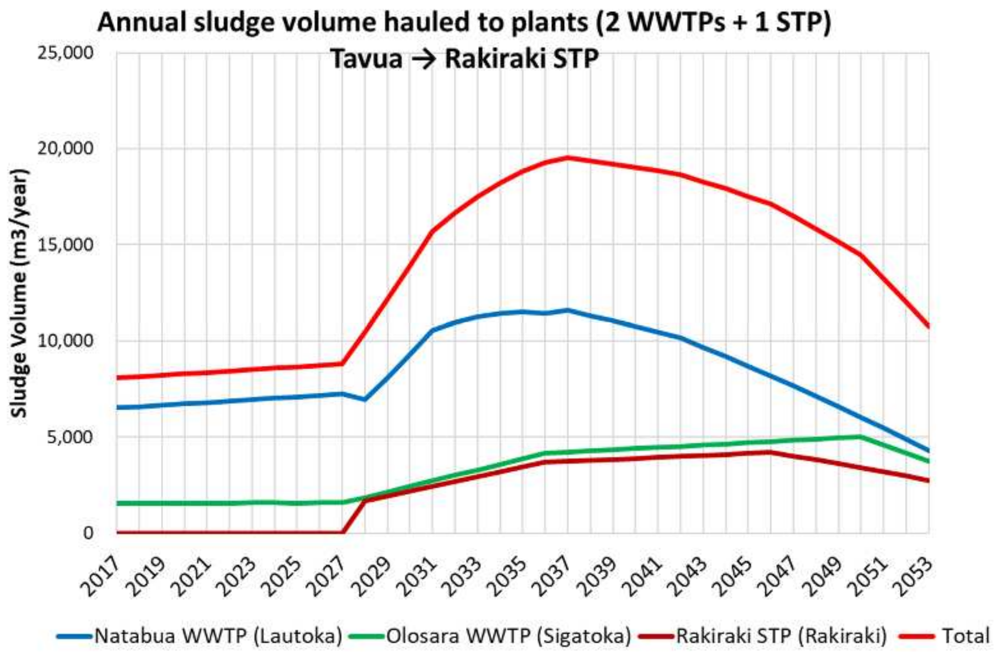


Figure A5-9. 1 Proposed Sludge Transportation Route (Alternative 2)
Source: JET

(2) Calculation of Sludge Volume

Sludge volume was calculated using the settings determined in Section 5-3-3 of the main report. As a result, the scale of the new sludge treatment facility will need to be approximately 18.8 m^3/day at the peak in 2046, as shown in **Figure A5-9. 2**. The peak amount of waste brought into the Natabua WWTP will decrease from approximately 61 m^3/day (2037) to 46 m^3/day (2037).



Source: JET

Figure A5-9. 2 Septage Volume Forecast (Alternative 2)

Table A5-9. 1 Sludge Volume to New Sludge Treatment Facility and Tavua WWTP

Collection area of the new facility	Sludge Treatment Facility	Year	Sludge Volume
Ra Province and Tavua	New Sludge Treatment Facility	2036	3,700m^3/ year (14.4 m^3/day)
		2046 (Peak)	4,200m^3/year (18.8 m^3/day)

※Daily septage volume is calculated based on 250 operation days per year
Source: JET

(3) Transportation of Bailed Septage

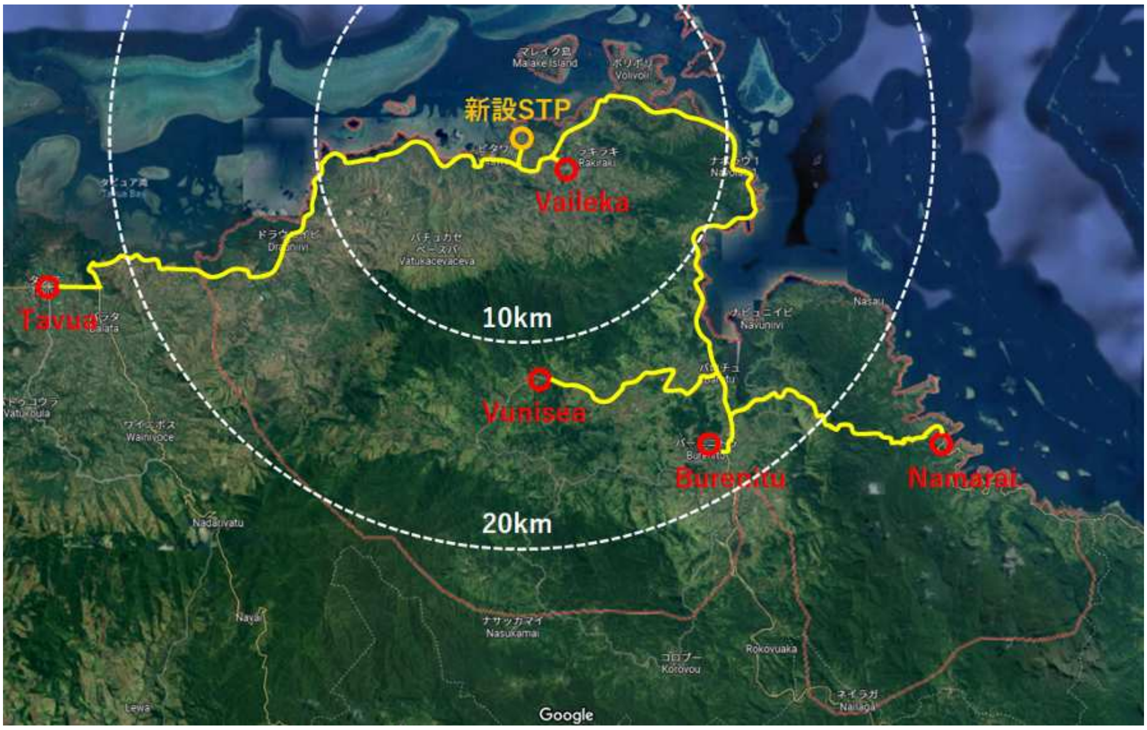
Taking into consideration the population distribution in Ra Province and the distance from Tavua, it was determined to construct the new sludge treatment facility in Rakiraki,

The table below shows the population of Tavua and each Tikina of Ra Province, and the transportation distance between the "representative village" and the sludge treatment facility. The "representative village" was defined based on road conditions and distribution of villages in each District (Tikina). A weighted average using the Tikina population yields an average trip distance of 33 km (66 km round trip) for sludge transport. In addition, if centralized sewerage development progresses in Rakiraki and Tavua, decentralized treatment will be used by those in the surrounding areas where the settlements are dispersed, and wastewater treatment is expected to come later. No major changes in transportation conditions assumed for this analysis are expected in the foreseeable future.

Table A5-9. 2 Population and Trip Distance of Each Sludge Collection District （Tikina）

Province	District (Tikina)	Population （2017）	Representative Village	Trip Distance
Ra	Rakiraki	13,908	Vaileka	6 km
	Saivou	7,184	Vunisea	46 km
	Nalawa	4,932	Burenitu	43 km
	Nakorotubu	4,392	Namarai	50 km
Ba	Tavua	23,269	Tavua	40 km

Source: JET, Google Maps referenced for trip distance



Source: JET, background image from Google Maps

Figure A5-9. 3 Sludge Transport Routes from Representative Villages of Each District（Tikina）

(4) Calculation of the Number Trucks Required

The calculation of the number of truck trips per day and the required number of trucks are shown below. In this calculation, it is assumed that one truck (capacity 6 m^3) can bail three locations (2 m^3/location) in one trip in the regular desludging proposed.

The average number of trips was 1.0 trips/day/vehicle. According to interviews with private companies, the average number of trips per truck was about 2 trips per day, indicating extremely low work efficiency. As a result, the required number of trucks will be four at the peak and three in 2036.

Average number of trips = Td / (T1 + T2 + T3 + T4 + T5) = 7 / (1.5 + 4.5 + 0.25 + 0.25 + 0.5) = 1.0

Td: Number of working hours per day = 7 hours

T1: Average trip time = Average trip distance / average speed (45 km/hour)

= 66 km / 45 km/hour = 1.5 hours

T2: Average work time (4.5 hours= 1.5 hours/location x 3 locations, based on interview surveys)

T3: Facility waiting time (= 0.25 hours, payment etc.)

T4: Facility unloading time (0.25 hours)

T5: Prep and cleanup (0.5 hours, pre-work inspection, cleanup)

Required number of trucks = Vs / Vt / Nt /η = 18.8 (m^3/day) / 6 (m^3/trip) / 1 (trip/day/truck)/ 0.8 = 3.9 ≒ 4 trucks

Vs: Sludge volume (m^3/day) (= 18.8 m^3/day, peak)

Vt: Bailed volume per trip (= 6 m^3/trip, septic tank volume 2m^3×3 locations)

Nt: Number of trips per truck per day (trips / day / truck) (= 1 trip/day/truck)

η: Truck utilization rate (= 0.8)

Calculation of number of trucks = Vs / Vt / Nt /η = 14.4 (m^3/day) / 6 (m^3/trip) / 1 (trip/day/truck) / 0.8 = 3 trucks

Vs: Sludge volume (m^3/day) (= 14.4 m^3/day, as of 2036)

Vt: Bailed volume per trip (= 6 m^3/trip, septic tank volume 2m^3×3 locations)

Nt: Number of trips per truck per day (trips / day / truck) (= 1 trip/day/truck)

η: Truck utilization rate (= 0.8)

(5) Reduction of Bailing Fee Disparities and Financial Feasibility of Operations

Looking at the calculation results for the number of trips per day per truck and the number of trucks required, it is estimated that it will be less efficient than the current operating conditions for private companies, and it will be difficult to ensure profitability. The reasons for the low efficiency are the long trip distances, the low sludge volumes per location, and the amount of time required for bailing.

Although there is a possibility that regular desludging will improve work efficiency by preventing caking of deposited sludge, work time per location is already set to 1.5 hours, including transportation time between locations. Significant reductions in work time cannot be expected. Additionally, if the construction and operation costs of new sludge treatment facilities are reflected in the bailing rate, the financial benefit to customers is expected to be small if tariff setting is mediated entirely by market principles between private companies and customers. In the end, bailing rates in Ra Province will continue to be higher than in other regions.

APPENDIX 7-1 FIRR EIRR Calculation

Table A7-1.1 Summarized Cash Flow Table for FIRR Calculation

Year	Expenditure Without Project	Capital Expenditure Total	O&M Expenditure Total	Incremental Expenditure Total	Incremental Income Total	Incremental Cash Flow for FIRR
2028	15,206	188,883	0	173,677	484	(173,192)
2029	15,206	221,216	0	206,010	536	(205,474)
2030	15,206	277,066	0	261,860	527	(261,332)
2031	15,206	282,944	0	267,738	543	(267,195)
2032	15,206	209,459	0	194,253	547	(193,706)
2033	15,206	306,422	2,867	294,083	3,507	(290,576)
2034	15,206	339,754	4,902	329,450	3,581	(325,869)
2035	15,206	397,328	6,997	389,119	4,390	(384,729)
2036	15,206	403,388	6,997	395,180	1,389	(393,791)
2037	15,206	327,633	6,997	319,425	1,365	(318,060)
2038	15,206	104,022	11,031	99,847	5,324	(94,524)
2039	15,206	115,493	13,681	113,968	6,081	(107,886)
2040	15,206	135,307	16,410	136,511	6,926	(129,585)
2041	15,206	137,393	16,410	138,597	3,668	(134,929)
2042	15,206	111,322	16,410	112,526	3,627	(108,899)
2043	15,206	58,546	17,483	60,823	4,967	(55,856)
2044	15,206	75,733	18,557	79,083	5,147	(73,937)
2045	15,206	94,557	19,662	99,013	5,379	(93,634)
2046	15,206	70,822	19,662	75,279	4,229	(71,049)
2047	15,206	53,518	20,580	58,892	5,244	(53,648)
2048	15,206	68,248	21,498	74,540	5,399	(69,141)
2049	15,206	84,382	22,444	91,620	5,583	(86,037)
2050	15,206	64,040	22,444	71,277	4,735	(66,542)
2051	15,206	0	23,098	7,892	5,403	(2,489)
2052	15,206	0	23,752	8,546	5,537	(3,009)
2053	15,206	(2,835,806)	24,426	(2,826,585)	5,688	2,832,274
					FIRR=	-2.1%

Source：JET

Table A7-1.2 Summarized Cash Flow Table for EIRR Calculation

Year	Cost Without Project	Capital Cost Total	O&M Cost Total	Incremental Cost Total	Incremental Benefit Total	Incremental Cash Flow for EIRR
2028	15,206	188,883	0	173,677	484	(173,192)
2029	15,206	221,216	0	206,010	819	(205,191)
2030	15,206	277,066	0	261,860	1,020	(260,839)
2031	15,206	282,944	0	267,738	1,319	(266,419)
2032	15,206	209,459	0	194,253	1,606	(192,647)
2033	15,206	306,422	2,753	293,969	22,091	(271,873)
2034	15,206	339,754	4,706	329,254	40,046	(289,201)
2035	15,206	397,328	6,718	388,839	62,073	(326,757)
2036	15,206	403,388	6,718	394,900	59,497	(335,392)
2037	15,206	327,633	6,718	319,145	59,966	(259,168)
2038	15,206	104,022	10,590	99,406	86,495	(12,896)
2039	15,206	115,493	13,133	113,421	109,962	(3,439)
2040	15,206	135,307	15,754	135,855	133,898	(1,934)
2041	15,206	137,393	15,754	137,941	131,346	(6,571)
2042	15,206	111,322	15,754	111,870	132,011	20,165
2043	15,206	58,546	16,784	60,124	141,764	81,665
2044	15,206	75,733	17,814	78,341	150,376	72,061
2045	15,206	94,557	18,876	98,226	159,097	60,899
2046	15,206	70,822	18,876	74,492	158,797	84,333
2047	15,206	53,518	19,757	58,069	166,393	108,354
2048	15,206	68,248	20,638	73,681	173,132	99,482
2049	15,206	84,382	21,546	90,722	180,061	89,371
2050	15,206	64,040	21,546	70,380	180,272	109,925
2051	15,206	0	22,174	6,968	185,723	178,788
2052	15,206	0	22,802	7,596	190,641	183,079
2053	15,206	(2,835,806)	23,449	(2,827,562)	195,667	3,023,264
					EIRR=	2.4%

Source：JET