CHAPTER 6 Modeling of Pilot Project

6.1 Project Objectives

Living in residences built over the sea is one of the traditional lifestyles in PNG. However, people living in these communities have been undergoing hardships such as not getting safe water, and being surrounded by a worsening environment due to the direct discharge of wastes, environment which pose a danger to the people in terms of deterioration of health and sanitation.
The pilot project is an program for the implementation of sewerage and water supply for a selected block of 20 houses built over the sea to initially examine/test the serviceability, validity, issues and sustainability of a proposed sewerage and water-supply system with a view for further expansion to cover and serve the entire water village community in Port Moresby.

6.1.1 Implementation plan of the Pilot Project

Initially, a target area and 20 houses were selected from 5 proposed areas for the execution of the pilot project, and then a plan for the sewerage and water supply to these houses constructed over the sea was developed for implementation of the project.
The Implementation plan for the pilot project involving the collection of wastewater from the selected houses of the water village was initially proposed based on a site survey and through discussions with the PNG government.
The Project area includes some 20 houses. The location of the project was reviewed again through discussions with IPBC/EDA RANU and to obtain the consensus of the local people, although the Hanuabada area had been proposed in a previous updating study.

The facility under the project was initially planned to include gravity sewers and a water supply facility. Introduction of a water tariff for the project was also proposed. Research into future perspectives of the over-the-sea houses and lifestyle were also conducted, in which the study team tried to reach an agreement for full understanding of the Project by carrying out research or conducting bwork shop/seminar as required.

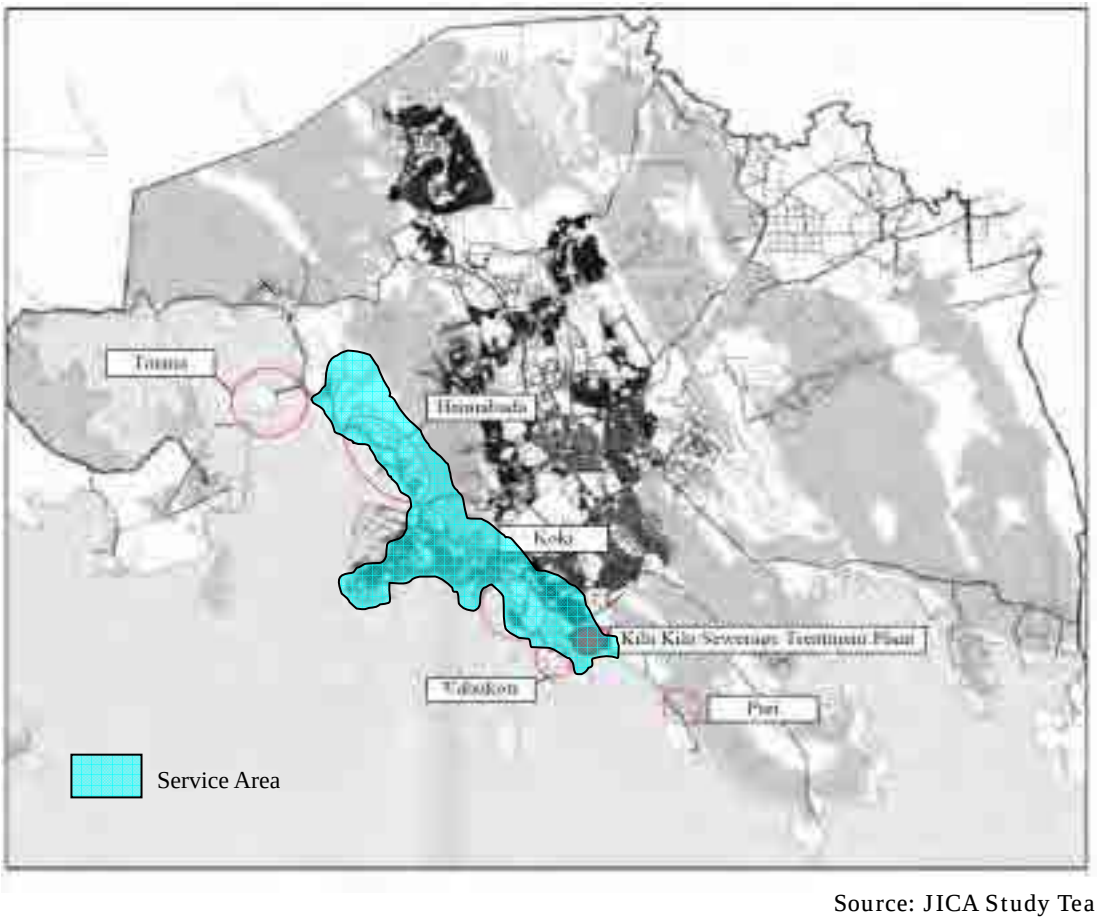
Houses over the sea have a fragile structure with a wooden floor supported by wooden piles. Exposed pipes hanging under the floor will be battered by sea waves and tidal changes. From O&M aspects, sewers under the floor of the houses are difficult to maintain. Under such conditions, sustainability of the pilot project would have been uncertain. In the basic design study, the team clarified the scope of the study through discussion with EDA RANU and local people during the meetings to determine the sanitary and environmental educational components.

Another concern for the project was the water source for the sanitary flush toilet. Since the pilot project includes a water supply service for people in the project area, charging a water tariff could be a

added burden for the residents. Due to the unwillingness to pay for water, people might use"free" sea water for flushing purposes instead of the supplied "charged for" water. This misuse will cause corrosion of the sewerage facilities, concrete and reinforcing bars of the STP's, mechanical and electrical facilities. It will also weaken/damage biological activity of micro organisms in the treatment processes. Consequently, an educational program to address such aspects would be needed as well.

6.1.2 Proposed Sites

There were initially five proposed sites, Tatana, Hanuabada, Koki, Vabukori and Pari as shown in **Figure 6.1.1**. The number of houses and populations of these sites are shown in **Table 6.1.1**..



Source: JICA Study Team

Figure 6.1.1 Proposed Sites for the Pilot Project

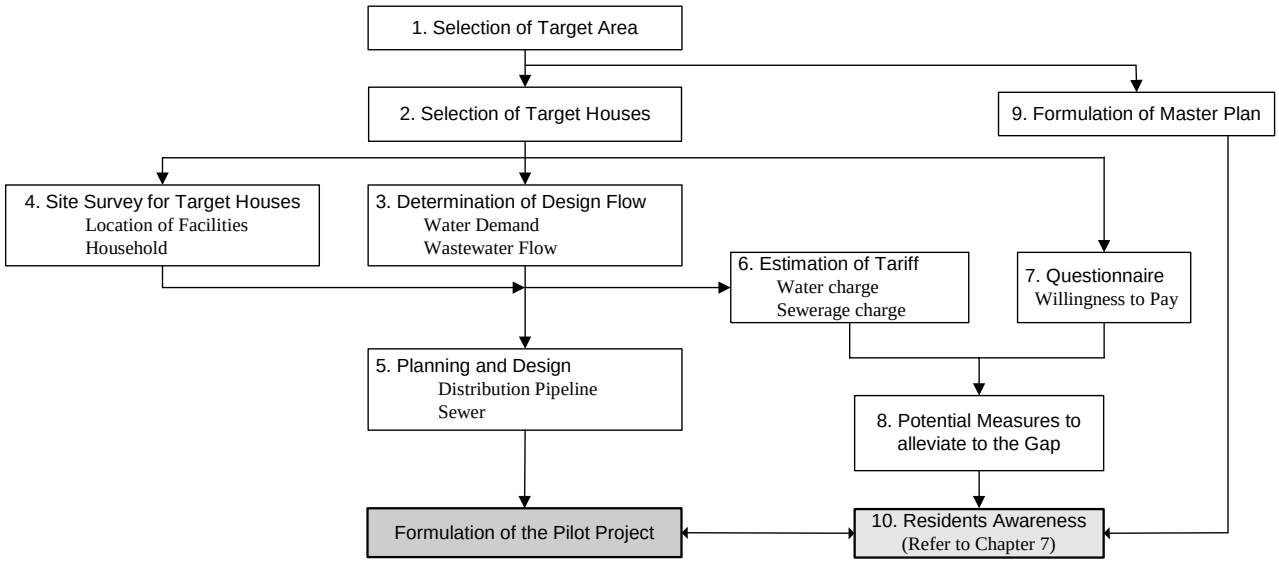
Table 6.1.1 Number of Houses and Population in the Study Area

	No. of Houses			Population			Person/House		
	Houses built on the ground	Houses built over the sea	Total	Houses built on the ground	Houses built over the sea	Total	Houses built on the ground	Houses built over the sea	Total
Tatana	58	196	254	216	1,448	1,664	3.72	7.39	6.55
Hanuabada	147	654	801	2,586	9,733	12,319	17.59	14.88	15.38
Koki	5	219	224	65	3,878	3,943	13.00	17.71	17.60
Vabukori	113	5	118	3,211	40	3,251	28.42	8.00	27.55
Pari	89	122	211	1,157	1,550	2,707	13.00	12.70	12.83
Sub Total	412	1,196	1,608	7,235	16,649	23,884	17.56	13.92	14.85

Source: EDA RANU, 2005

6.1.3 Workflow in the Pilot Project

Figure 6.1.2 illustrates the workflow implemented in the development of pilot project.



Source: JICA Study Team

Figure 6.1.2 Workflow

1) There are two proposed sites, Hanuabada and Koki in the service area.
   (a) Study for the possibility of connection to the existing sewer or planned sewer by gravity flow
   (b) No installation of a pumping station in order to minimize a construction cost and O&M cost
   (c) Confirmation of the houses and jetties strength and structure
2) Selection of the target houses in the pilot project area
3) Design flow for distribution pipeline and sewer planning
4) Survey the target houses for design flow and tariff estimation
5) Planning of installation methods, distribution pipes and sewers included in house connections
6) Estimation of Water and Sewerage Tariff for the target household
7) Implementation of a questionnaire survey to the target residents regarding the willingness to pay for the service charges
8) Proposal alleviation measure of the gap between the estimated tariff and willingness to pay
9) Formulation of the Master plan as a future vision in Hanuabada village built over the sea
   The sewerage master plan will cover the whole Hanuabada village. The pilot project is part of the master plan. As a future vision, the master plan is formulated, and it is not only overall sewerage plan but also has a role of avoiding conflicts between the beneficiaries and non-beneficiaries by implementation of the pilot project.
10) Social Environment and Education programs are referred in the Chapter 7.

6.2 Selection of Target Area

In the pilot project, selection of the target area was the first crucial step in the feasibility plan. It is a vital condition that wastewater generated from a house built over the sea will be conveyed to the existing/planned sewers by gravity flow without pumping stations. The gravity-flow sewer system involves moderate costs for construction and involves less maintenance and lower O&M costs compared to the pumping station system. Hence, it is an important factor that the target area is located close to the existing and/or planned sewer.

The following factors were considered in determination of the project site:

- Within the service area
- Appropriate/sustainable structures for installation the pipes such as the sewers and water distribution pipes
- Connection to existing or planned pumping stations/sewers by gravity flow

Since Tatana, Vabukori and Pari are located outside of service area, Koki and Hanuabada areas are studied as the pilot project.

6.2.1 Study for Structures of Jetties and Houses in Proposed Sites

Site surveys were conducted in both Koki village and Hanuabada village. Houses and support structures and jetty conditions for the installation of necessary pipes were studied. The results of the site survey for both villages are shown in **Table 6.2.1.**

The jetties and structures near the existing pumping stations in Koki village were narrow and fragile compared to Hanuabada village. If the pilot project was to be implemented at Koki village, reinforcement works for the jetties and decks would be required. The construction costs would incur extra expenses. Therefore, Hanuabada village was recommended for the pilot project site.

Table 6.2.1 Comparison of the Pilot Project Site

Items	Hanuabada	Koki	Remarks
Jetty conditions	Width: approx. 2.7m Enough space to install a sewer and a service pipe. The jetty in near entrance side is comparatively strong.	Width: approx. 1.5 m The jetty from an entrance is narrow and fragile. Weak and unstable walkway. Some decks are missing.	It may be difficult to install pipes under a narrow jetty at Koki village due to keeping walkway function.
House structures	Not much different between Hanuabada and Koki		Lifetime is shorter, approx. 5 years. They are rebuilt every 5 years.
Support structures	Not much different between Hanuabada and Koki		
Sewer length	Approx. 102 m From the 2nd jetty to the proposed main sewer.	Approx. 414 m From the 1st jetty to the existing SP.	The longest distance

Items	Hanuabada	Koki	Remarks
Distance of existing/planned sewer or pumping station (PS) nearby	Approx. 26 m distance to the planned gravity flow sewer.	To the existing PS: Approx. 300 m To the planned PS: Approx. 210 m	
Connection to a sewer through gravity flow	Possible in case of selection of houses in the entrance side from 2 jetties.	Impossible to the existing Koki pumping station through gravity flow. Possible to new pumping station constructed.	In new Koki PS, the pump pit depth can be adjusted under the design stage.
Evaluation	**Applicable**	Not applicable	

Source: JICA Study Team

6.2.2 Study for Connection to the Existing or Planned Pumping Stations/Sewers by Gravity Flow

In Koki and Hanuabada areas, the sewer connections from houses built over the sea to the existing or planned pumping station/trunk sewer were studied and shown below:

(1) Koki Area

Two cases are set for the studies of connecting by gravity flow. Case 1 is the route from residents to the existing pumping station. Case 2 is the route from residents to the planned pumping station. **Figure 6.2.1** shows two cases connecting sewer routes.

(a) In case of connection to the existing pumping station (Case 1)

Since there is no existing sewer around the Koki village, connection to the existing pumping station by gravity flow from the houses over the sea is studied.

L = 300 m, gradient: 0.67%, Pipe dia. 150 mm

The section of the existing pumping station is shown in **Figure 6.2.2.**

Existing pumping station: pit level GL-2.3 m

Minimum earth cover: 0.60 m

Sewer: 300 m × 0.0067 (0.67%) = 2.01 m

Connection level: GL -2.76 m (= 0.60 + 2.01 + 0.15) < -2.3 m: NG

Therefore, it is impossible to connect to the existing pumping station by gravity flow.

(b) In case of connection to the planned pumping station (Case 2)

L = 210 m, gradient: 0.67%, Pipe dia. 150 mm (**Figure 6.2.3**)

New pumping station: pit level GL -2.3 m (Tentative)

Minimum earth cover: 0.60 m

Sewer: 210 m × 0.0067 (0.67%) = 1.41 m

Connection level: GL -2.16 m (= 0.60 + 1.41 + 0.15) > -2.3m : Ok

Therefore, it is possible to connect to the planned pumping station by gravity flow.

Figure 6.2.1 Sewer Connecting Routes in Koki Area

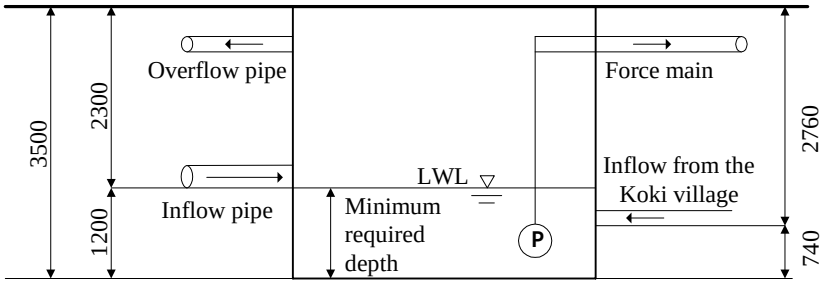


Figure 6.2.2 Existing Koki Pumping Station Section (Case 1)

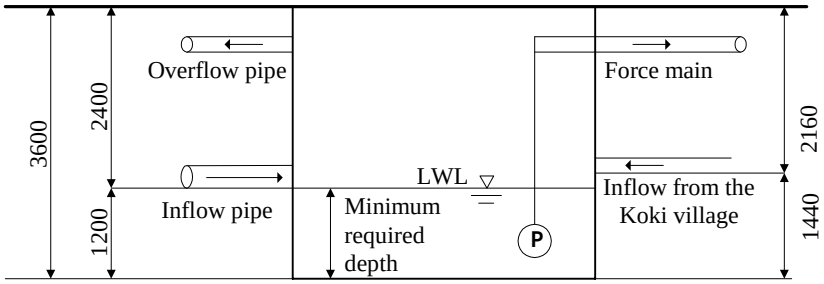


Figure 6.2.3 Planned Koki Pumping Station Section (Case 2)

(2) Hanuabada Area

20 houses are selected from residences located near the planned trunk sewer in Hanuabada village. Proposed locations for the pilot project and these residences are shown in **Figure 6.2.4.**

There are three cases of the targeted residents,

Case 1: 20 houses belonging to one jetty,

Case 2: 20 houses from two jetties,

Case 3: 20 houses from three jetties

The schematic depiction of these three cases is shown in **Figure 6.2.5.**

a) Hanuabada Village **b) Target Residences**

Figure 6.2.4 Target Residences on Case 1 to 3 at Hanuabada Area

(a) Study for Alternative Target Residents

The followings are important factors to be considered as engineering aspects of the pilot project.

a. To connect to the planned sewer by gravity flow
b. To avoid deeper sewer laying inland
c. To install pipes above sea level (not underwater) as much as possible.
d. Fewer inhabitants complaint between the beneficiaries and non-beneficiaries by the pilot project

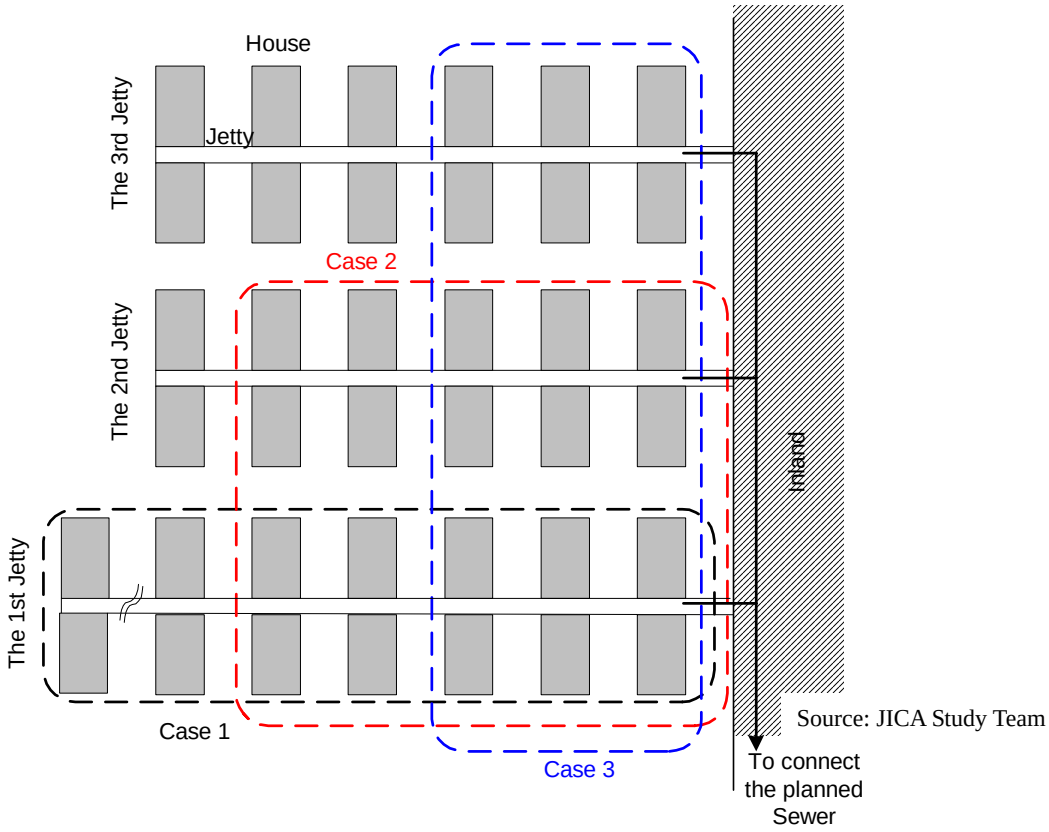


Figure 6.2.5 Alternatives of Target Residences in Hanuabada Area

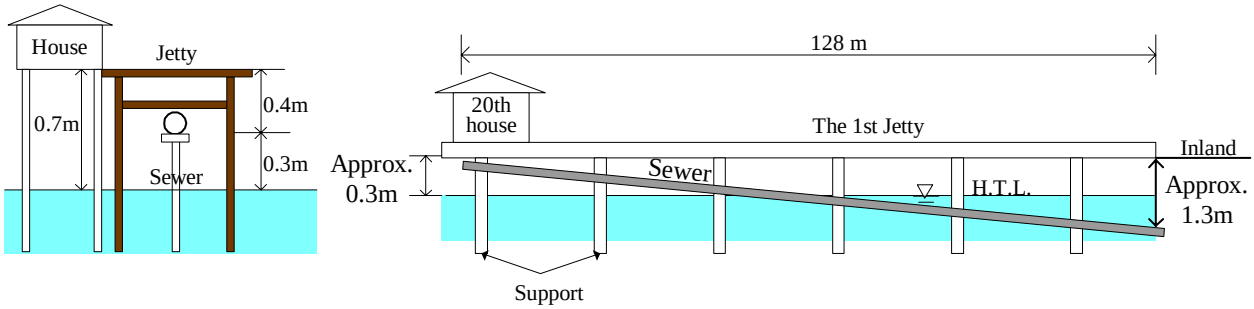
Table 6.2.2 Comparison of Alternatives

Items	Case 1	Case 2	Case 3
No. of houses	20	20	20
No. of Jetties	1 The 1st jetty	2 The 1st and 2nd jetty	3 The 1st to 3rd jetty
The jetty length	The 1st jetty: Approx. 128 m	The 1st jetty: 45m The 2nd jetty: 45m	The 1st jetty: 45m The 2nd jetty: 35m The 3rd jetty: 35m
The depth by gradient From the initial sewer position	Approx. 1.3m with 1% (Refer to **Figure 6.2.6**)	Approx. 0.5m with 1%	Approx. 0.4 – 0.5m with 1%
Sewer length underwater to H.T.L. (High Tide Level: 0.25 m)	Approx. 116 m	22 m on 1st jetty and 0 m on 2nd jetty	22 m on 1st jetty and 0 m on 2nd and 3rd jetty
Potential Risks	✓ Damage of the 1st jetty due to vulnerable and unstable structure at the interior part. ✓ Waves and tide change may have a great influence on sewer and house connections on the jetty.	✓ Waves and tide change may have a great influence on sewers and house connections on the jetty. However, the possibility of the risk occurrence is lesser than one of Case 1. ✓ Inhabitants (non-beneficiaries) except the target houses may feel unfair because of improvement of living environment by the pilot project.	

Items	Case 1	Case 2	Case 3
Earth cover at the connection point. Refer to **Table 6.2.3**	Approx. 2.4 m	Approx. 1.7 m	Approx. 2.8 m due to the waterway crossing.
Connecting to a planned sewer	It is more difficult to adjust to planned sewer than Case 2 due to deeper earth cover.	It is necessary to adjust to the earth cover of planned sewer.	It is more difficult to adjust to planned sewer than Case 1&2 due to deeper earth cover.
Inhabitants Complaint between the beneficiaries and non-beneficiaries by the pilot project.	Few complaints from the same jetty residents.	Fewer complaints than that of Case 3, but more than one of Case 1.	Most complaints from the same jetty residents among 3 cases.
Description	✓ 90 % of total sewer length may be underwater due to the long jetty. It will be difficult to maintain sewer and protect it from waves and tide change. ✓ Since the earth cover can be deeper, need to adjust the proposed main sewer in order not to increase construction cost.	✓ Since part of sewer may be underwater at H.T.L.(High Tide Level), sewer protections against infiltration and damage are required. ✓ The earth cover can be shallow compared with Case 1 & 3. It is easy to connect to the proposed sewer by gravity flow.	✓ Since part of sewer may be underwater at H.T.L.(High Tide Level), sewer protections against infiltration and damage are required. ✓ Since the earth cover can be deeper, need to adjust the proposed main sewer in order not to increase construction cost.
Evaluation	Not applicable	**Applicable**	Not applicable

Source: JICA Study Team

The longer the sewers, the greater part of the sewers under the jetty will be submerged underwater. (Refer to **Figure 6.2.6**) Since 90 % of total sewer length will be underwater in Case 1, then waves and tide change may exert harmful influences upon the structure of the sewers. As a result, sewers will be damaged and seawater will flow into the sewers underwater.



Source: JICA Study Team

Figure 6.2.6 Sewer Depth with Gradient (1%) on 1st Jetty in Case 1

(b) Study of the earth cover of the sewers to the proposed main sewer

The proposed Hanuabada pumping station will be located in approximately 150 m away from the planned connection point where two sewers meet. (Refer to **Figure 6.2.4**.) Deeper earth cover will affect depth of the pump pit increasing construction cost of civil portion.

Figure 6.2.7 shows the schematic depiction of the sewer routes to connect to the planned trunk sewer in Case 1 to 3. The studies of the earth cover depth for each case are shown in **Table 6.2.3**. The connection point of the planned trunk sewer should be deeper for proposed gravity flow. The gradient of the sewers is 1 % for 150mm pipe diameter and the minimum earth cover 0.6m according to *the Code of Practice for Water Supply & Sewerage, EDA RANU, 2001*.

In Case 1, the sewer route starts from the 1st jetty to the connection point A through the point B. The earth cover is 2.0 m at the point B and reaches approximately 2.4 m at the final point A.

In Case 2, the sewer route starts from the 1st and 2nd jetty to the connection point A through the point C and B. The earth cover is 0.62 m as the minimum earth cover at the point C and 1.26 m at the point B, and then it reaches approximately 1.7 m at the final point A.

In Case 3, the sewer route starts from the 1st, 2nd and 3rd jetty to the connection point A through the point D, C and B. Although the earth cover at the point D is 0.19 m, the sewer needs to pass under the existing waterway (W 0.5m × H 0.8m) to keep 150 mm clearance from the waterway bottom. Therefore, the earth cover is 1.76 m at the point C and 2.4 m at the point B and reaches approximately 2.8 m at the connection point respectively. The earth cover in Case 3 is the deepest among three.

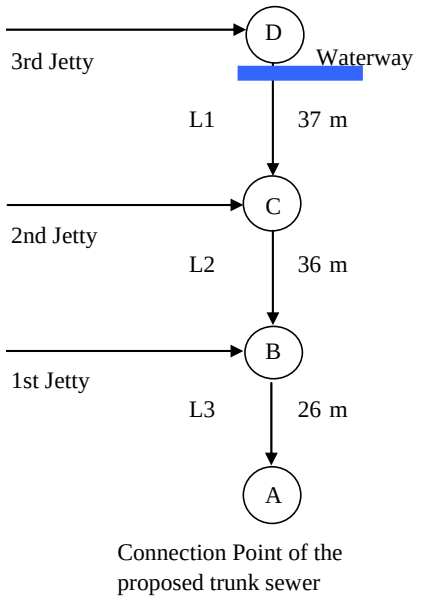


Figure 6.2.7 Earth Cover of Sewer

Table 6.2.3 Earth Cover of Sewer

Gradient 1.0%
Out side Dia. 0.17 m ϕ150mm uPVC

Case 1 1st Jetty only, Route: B - A

Point	GL (m)	Earth Cover	Pipe Top	Pipe Bottom
B	1.12	2.03	-0.91	-1.08
A	1.25	2.42	-1.17	-1.34

Case 2 1st and 2nd Jetty, Route: C - B - A

Point	GL (m)	Earth Cover	Pipe Top	Pipe Bottom
C	0.86	0.62	0.24	0.07
B	1.12	1.26	-0.14	-0.31
A	1.25	1.65	-0.40	-0.57

Case 3 1st ,2nd and 3rd Jetty, Route: D - C - B - A

Point	GL (m)	Earth Cover	Pipe Top	Pipe Bottom
D	0.62	0.19	0.43	0.26
Waterway	-0.21	0.30	-0.51	-0.68
C	0.86	1.76	-0.90	-1.07
B	1.12	2.40	-1.28	-1.45
A	1.25	2.79	-1.54	-1.71

Source: JICA Study Team

The water distribution pipeline will be laid under the road between the pilot project area and the proposed trunk sewer. Suppose that minimum earth cover is 900 mm, it is necessary that earth cover of the connection sewer is more than 1.25 m (= 0.9+0.2+0.15)between point B and point A due to distribution pipe diameter 200 mm with minimum clearance 150 mm. Since the earth cover is 1.26 m at point B, the connecting sewer will be laid under the distribution pipe.

6.2.3 Target Area and Target Houses

The results of selection of the pilot project area and the target residences are shown in **Table 6.2.4**. When the factors such as the jetty size and strength, easiness of pipe installation, distance to the existing/planned sewerage facility and connecting by gravity flow are considered to be important in the comparison, Hanuabada village is the most suitable for the pilot project rather than Koki village.
Regarding the selection of target residences, Case 2 which is 20 houses with two jetties is proper for the pilot project on account of shallow earth cover, shorter submerged sewers and fewer complaints among residents on the same jetty.

Table 6.2.4 Target Area

	Tatana	Hanuabada	Koki	Vabukori	Pari
Service Area	Out of scope	Project Area	Project Area	Out of scope	Out of scope
Structure Conditions	-	Proper	Improper	-	-
Gravity Flow	-	Possible	Impossible for the existing houses	-	-
Target Area	-	**Applicable**	Not applicable	-	-
Target Houses	-	**1st and 2nd Jetty (Case 2)**	-	-	-

Source: JICA Study Team

6.2.4 Main points of the Pilot Project Sewers

The pilot project layout is shown in **Figure 6.2.8**. Main points of connecting sewer in the pilot project are described below:

1) Adjustment of trunk sewer's earth cover

The adjustment of the earth cover of the planned trunk sewer (gravity flow sewer) is indispensable to connect to them from the pilot project area. The position of connecting manhole is to be also adjusted.

2) Invert level from the pilot project area at the connection point

The jetties and houses built over the sea in Hanuabada are rebuilt approximately every five years due to their short lifespan. There is a possibility that the elevation of the sewer pipe will change after rebuilding. Therefore, in case that the elevation of the branch sewer from the pilot project site at the connection point does not have enough of a margin, there will be a possibility that the branch sewer cannot be connected to the trunk sewer by gravity flow. Accordingly, the earth cover of the trunk sewer at the connection point is 2m and can be added to the foregoing earth cover of 1.7m with a margin of 0.3 m.

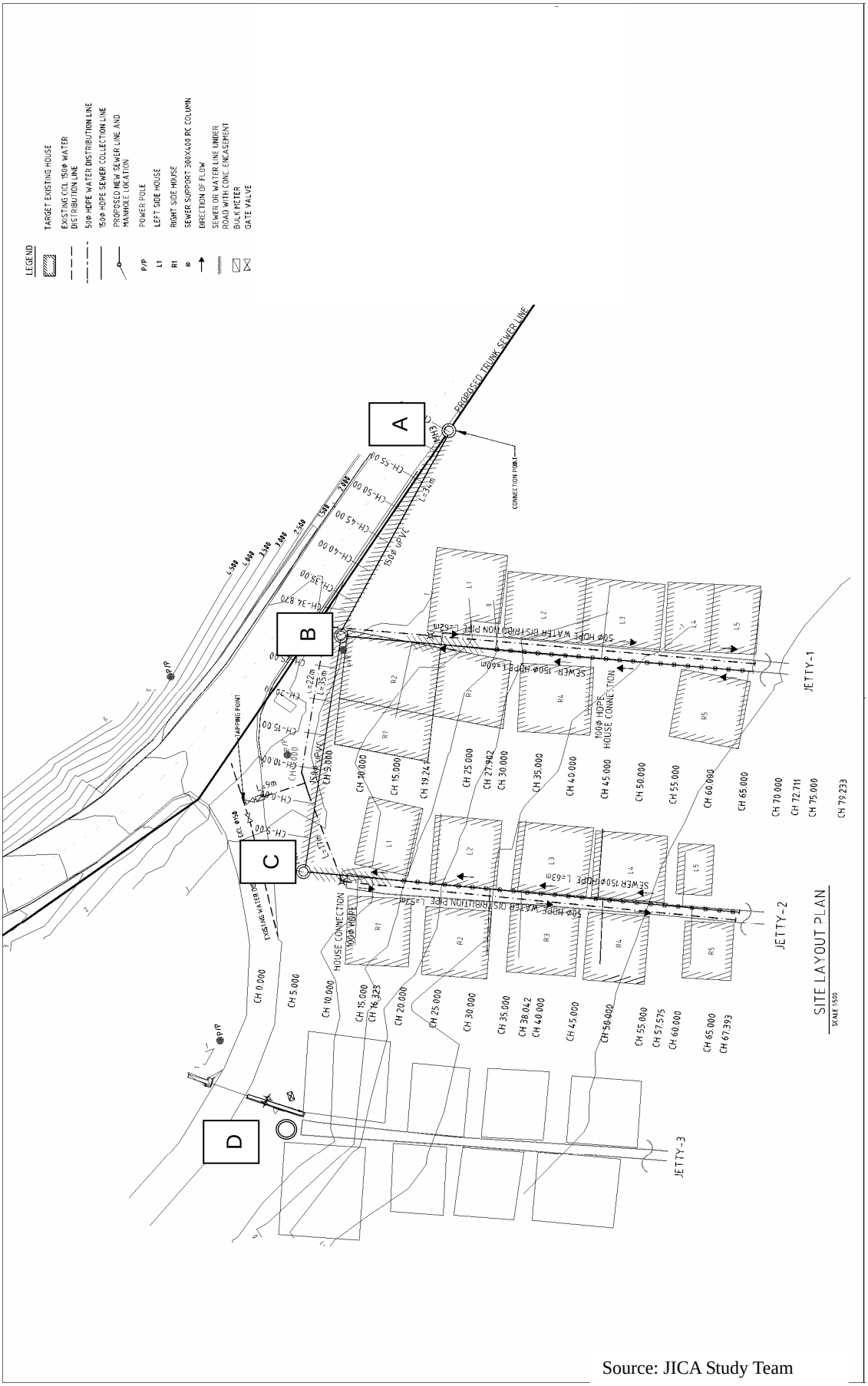


Figure 6.2.8 Pilot Project Layout

Source: JICA Study Team

6.3 Design Criteria and Wastewater Flow

(1) Design Criteria

1) Minimum Sewer Gradient

Table 6.3.1 Sewer Gradient

Diameter	Equivalent Population	Minimum Grade
150 mm	Less than 20 (23)	1 in 80 (1.25%)
	20 to 50 (23 to 56)	1 in 100 (1%)
	More than 50 (56)	1 in 150 (0.67%)
225 mm	More than 300 (338)	1 in 250 (0.4%)
The minimum gradient for 100 mm house connections shall be 1 in 40 (2.5%)		

Source: Code of Practice for Water Supply & Sewerage, EDA RUNU, 2001

Note: Parentheses ( ) indicates conversion number as unit rate 240 L/capita/day in equivalent population.

2) Earth Cover

The minimum earth cover to top of sewer shall be as specified in **Table 6.3.2**.

Table 6.3.2 Minimum Earth Cover

Location	Caste Iron, Ductile Iron	uPVC, Concrete
Under Major Roads	900 mm	N/A
Other roads, road reserves or where subject to traffic	750 mm	900 mm
Not subject to traffic	600 mm	600 mm

Source: Code of Practice for Water Supply & Sewerage, EDA RUNU, 2001

3) Other service pipe clearance

The minimum clearance shall be 150 mm for crossing with other service pipe. (Source: *the Code of Practice for Water Supply & Sewerage, EDA RANU, 2001*)

(2) Design population for the pilot project

Person per Household at Hanuabada village: 13 persons/house (based on the site survey results in March, 2011)

Target number of houses: 20 houses

13 persons × 20 houses = 260 persons

(3) Daily Design Wastewater Flow

Only domestic wastewater will be generated in the pilot project area, without industries or factories. Unit design daily wastewater flow is shown below.

Unit daily average = 240 L/capita/day

(4) Maximum daily design wastewater flow, Hourly maximum design wastewater flow

There are three kinds of design wastewater flow, average daily design wastewater flow, maximum daily design wastewater flow and maximum hourly design wastewater flow.

Average daily design wastewater flow is used for facility design and estimates of service charge and operation and maintenance costs.

Maximum daily design wastewater flow is used in reference to wastewater flow on the day of maximum wastewater generation in a year. This wastewater flow is used in the design of wastewater treatment plants which needs to cope with seasonal variations.

Design hourly maximum wastewater flow is 24 hours conversion numerical value (m^3/day) of a peak wastewater flow per hour on the day of maximum wastewater generation, and is used for the design of sewer pipes, pumping stations and rising mains.

Daily Max / Daily Avg. ＝ 1.00 (Daily Avg. = Daily Max)

Hourly Max / Daily Avg. ＝ 2.5

Unit design average daily wastewater flow, design maximum daily wastewater flow and design maximum hourly wastewater flow are calculated as below.

Unit average daily wastewater = Unit maximum daily wastewater

Unit maximum hourly wastewater = Unit average daily wastewater × 2.5

Unit wastewater flow is shown in **Table 6.3.3**.

Table 6.3.3 Unit Wastewater Flow

	Unit (L/capita/day)	Remarks
Daily average	240	
Hourly maximum	600	Ave.×2.5

Source: JICA Study Team

(5) Design Maximum Hourly wastewater Flow for Sewer Pipe

260 persons (design population) × 600 L/capita/day = 156 m^3/day = 0.00181 m^3/sec

Table 6.3.4 Wastewater Flow (Hourly Maximum)

No. of houses	1	6	8	10	20
Persons*	13	78	104	130	260
Flow (m^3/d)	7.8	46.8	62.4	78.0	156.0
Flow (m^3/sec)	0.00009	0.00054	0.00072	0.00090	0.00181
Pipe Capacity (m^3/sec)	φ100 mm	0.011 m^3/sec with 2.5%			
	φ150 mm	0.016 m^3/sec with 0.67 % 0.020 m^3/sec with 1.00 % 0.022 m^3/sec with 1.25 %			

Source: Site survey results, March 2011

(6) Distribution Pipeline

1) Average Daily Demand

There is only domestic water demand in the pilot project area. Unit design daily wastewater flow is 240 L/capita/day as aforesaid. Conversion ratio from water consumption to wastewater is 0.9 according to Code of Practice for Water Supply & Sewerage.

Therefore, average daily demand = 270 L/capita/day (= 240/0.9)

2) Peak daily demand

Domestic = Average daily demand × 1.5

= 270 × 1.5 = 400 L/capita/day

3) Hydraulic Design

The hydraulic design of pipeline shall be in accordance with Code of Practice for Water Supply & Sewerage. The Hazen Williams formula with a C value of 120 can be used.

Table 6.3.5 Distribution Pipe Diameter and Capacity

No. of houses	1	10	15	20	28
Persons	13	130	195	260	364
Demand (m^3/d)	5.2	52.0	78.0	104	145.6
Pipe Capacity	Length (m)	Flow (m^3/d)	Hydraulic gradient (%)	Velocity (m/s)	Head loss (m)
ϕ40 mm	45	52.0	1.08	0.48	0.48
Future connection*	154	145.6	7.22	1.34	11.13
ϕ50 mm	50	52.0	0.36	0.31	0.16
Future connection*	154	145.6	2.44	0.86	3.75

*In case of the 1st jetty in Hanuabada village

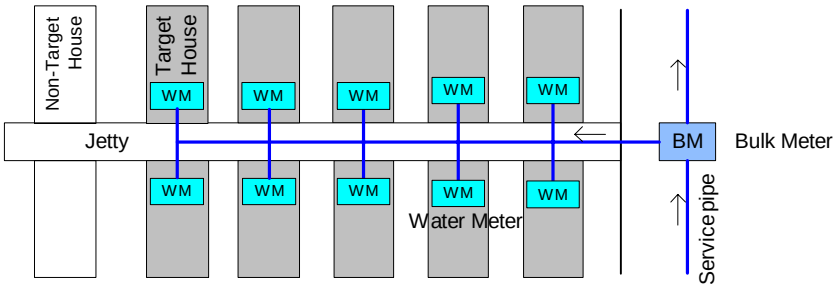
Source: JICA Study Team

The number of the target houses is limited to 20 in the pilot project. When water distribution pipes are connected to all residences on the whole one jetty, the pipe capacity should accommodate additional future demand. Therefore, for the distribution pipe diameter it was decided to use ϕ50 mm including it.

(7) Facility Component

- ✓ Individual water meters for 20 houses and a bulk meter for the block will be installed when the pilot project is executed, although no water meters have been installed until now.
- ✓ **Figure 6.3.1** shows the locations of service pipes, the bulk meter and water meters for target houses.
- ✓ Water distribution pipe capacity shall have future demand on the whole one jetty.
- ✓ Minimum sewer diameter is 150 mm. Smaller diameter will not be applicable as it would result in clogging inside the pipes with garbage or waste.

- ✓ Sewers, house connections and flashing toilet system shall be installed to each house in the pilot project.
- ✓ The meter (volumetric) rate system in tariffs for water and sewerage shall be adopted for the pilot project. Water and sewerage charges can be collected from each target house according to water meter reading.



Source: JICA Study Team

Figure 6.3.1 Service Pipe, Bulk Meter and Water Meter in the Pilot Project

(8) Material Selections

Due to the topographical configuration of the proposed pilot project site over the sea, aerial crossing for gravity flow sewer is required. Hence, special consideration is needed for the support types for the sewer and water distribution pipe. Piers are designed to support each pipe joints with provisions to prevent damage by corrosion, influence by tide change, sea waves, overturning and settlement.
Sewer and water distribution pipe materials shall also be selected with due regard to above mentioned factors.

In the pipe material selection, the following points are to be considered; prevention of seawater infiltration, especially for fittings, corrosion protection of pipes and its support, antiweatherability of the exposed pipes and firm pipe installation on the fragile jetty structure.

A comparison of support, sewer and water distribution pipe materials are shown in **Table 6.3.6**, **6.3.7** and **6.3.8**.

The pipe material of the main sewer, house connection pipe and water distribution pipe will be HDPE pipe as a result of the study. The house connection pipes shall be hung under the houses and jetties. It is difficult to fix the pipe supports under the floor since location of sanitary fixtures in a house is variable and life of a house is generally very short.
Conclusion of the selected materials for construction is shown below:

Support material:	Reinforced Concrete supports
Water distribution pipe:	HDPE pipe (φ50 mm as inside dia.)
Water service pipe:	Galvanized steel pipe, φ25 mm, Polyethylene pipe inside house, φ32 mm
Sewer pipe:	HDPE pipe (φ150 mm, inside dia.) on the jetty, uPVC (φ150 mm) underground
House connection:	HDPE pipe (φ100 mm, inside dia.)

Pipe joint: Fusion welding for water and sewer pipes

All joints shall be made by fully automatic butt fusion welding or by electrofusion welding or by mechanical restrained joints for use with HDPE pipe and fittings.

(9) Corrosion Protection

All the surface of the concrete and metal will be coated by vinyl-ester resin or equivalent against the metal corrosion by chlorine ion from brine water.

This treatment will be very important in terms of durability of the facilities. Reinforcing bars and metal fittings are main objectives for the protection. Concrete surface must be protected because of unavoidable generation of cracks. Maintenance work such as touch-up or repainting following periodical surveys must be made by EDA RANU for maintaining sustainability.

Table 6.3.6 Comparison of Support Materials

Classification	Items	Wood	Plastic	Reinforced Concrete	Stainless Steel	Steel
Characteristics	Strength	<(RC, S & SS)	<(RC, S & SS)	OK	OK	OK
	Stiffness	<(RC, S & SS)	<(RC, S & SS)	OK	OK	OK
	Toughness	<(RC, S & SS), Weatherization needed	<(RC, S & SS), Weatherization needed	OK	OK	OK
	Service Life	<(RC, S & SS)	<(RC, S & SS)	>(SS & S)	<(RC)	<(RC & SS)
	Judgment	NG	NG	OK	OK	OK
Protection From	Corrosion	Needs Protection	OK	OK	NG	Needs Protection
	Abrasion	Needs Protection	Needs Protection	OK	OK	OK
	Waves, Tide change	Needs Supports	Needs Supports	OK	OK	OK
	Fire[1)]	Needs Protection	Needs Protection	OK	Needs Protection	Needs Protection
	Judgment	NG	NG	OK	NG	NG
Handling/ Easiness	Weight	Light	Light	Heavy	Heavy	Heavy
	Transportation	Easy	Easy	Can be Easily transported.	Can be Easily transported.	Can be Easily transported.
	Construction	Easy	Difficult	Difficult	Difficult	Difficult
	Maintenance (check of the conditions, replacement)	Easy for check-up	Difficult to confirm the deterioration	Difficult to confirm corrosion of reinforcing bars	-ditto-	-ditto-
	Cost	Lowest	<Expensive	<(SS & S)	Expensive	<(SS)
	Judgment	OK	NG	OK	NG	NG
Evaluation/ Decision		・Shorter life and weaker materials ・Economical ・Frequent repair works ・Low sustainability	・Not suitable in terms of strength, economy and sustainability	・Corrosion protection to be provided ・Longer construction period ・Long life by proper measure	・Not suitable in terms of economy	・Corrosion protection needed. ・Short life
		Not Applicable	Not Applicable	**Applicable**	Not Applicable	Not Applicable

Note: <: Less than the attribute of the material, >: Greater than the attribute of the material

Table 6.3.7 Comparison of Sewer Materials

Classification	Items	Cast Iron	Re. Concrete	Stainless Steel	uPVC	HDPE
Characteristics		・Heavy weight ・Durable for both of high internal and external pressures ・Resistant to corrosion ・To have applicable joints for vibration and infiltration.	・Heavy weight ・Durable for external pressures ・Minimum pipe dia is 225 mm (Required sewer diameter is 150 mm)	・Durable for both of high internal and external pressures ・Resistant to corrosion ・To have ductility High cost material	・Light weight ・Easy handling ・Low roughness coefficient ・Resistance to corrosion	- Ditto -
Protection	Corrosion	OK	Needs Protection	Needs Protection	OK	OK
	Abrasion	OK	OK	OK	OK	OK
	UV light	OK	OK	OK	NG, Needs weather-resistant paints	OK
	Imperviousness	OK	OK	OK	OK	OK
	Waves, Tide change	・Pipe: OK ・Joint: Necessary to be flexible joints with flange adopters ・Vulnerable to movement by waves and tides	- Ditto -	- Ditto -	- Ditto -	・Pipe: OK. (flexible and tough against impact) ・Joint: OK. (Leak-proof by welding joints)
	Judgment	NG	NG	NG	NG	OK
Handling	Weight	Heavy	Heavy	Heavy	Light	Light
	Transportation	Easy	Easy	Easy	Easy	Easy
	Construction	Not easy	Not easy	Not easy	Easy due to light weight	- Ditto -
	Maintenance	Periodical check needed for joints	Periodical check needed for joints	Periodical touch up and check needed	Periodical touch up and check needed	Easy
	Cost	Expensive	Expensive	Expensive	Economical	Economical
	Judgment	NG	NG	NG	OK	OK

Table 6.3.7 Comparison of Sewer Materials

Classification	Cast Iron	Re. Concrete	Stainless Steel	uPVC	HDPE
Evaluation/ Decision	・High possibility of seawater intrusion by damage of joints.	・High possibility of seawater intrusion by damage of joints.	・High possibility of seawater intrusion by damage of joints.	・Vulnerable to UV under the sunlight ・High possibility of seawater intrusion by damage of joints.	・Resistant to UV under the sunlight
	Not Applicable	Not Applicable	Not Applicable	Not Applicable	**Applicable**

Note: OK: The material can be used for construction or can be recommended for construction

NG: The material can not resist or withstand or the material can not be recommended for construction.

1) Black HDPE pipe contains 2+% of carbon black. Carbon black is the effective single additive to enhance the UV characteristics of plastic.

2) Though heavy and difficult for transportation, it is easy to be carried since the project site is near the main road.

Source: JICA Study Team

Table 6.3.8 Comparison Water Distribution Pipe Materials

Classification	Items	Cast Iron	Stainless Steel	uPVC	HDPE
Protection	Corrosion	OK	Needs Protection	OK	OK
	Abrasion	OK	OK	OK	OK
	UV light	OK	OK	NG, Painting needed	OK[1)] UV light resistant
	Impervious	OK	OK	OK	OK
	Waves, Tide change	・Pipe: OK ・Joint: Necessary to be flexible joints with flange adopters ・High possibility of damage because of joint-parts movement by waves and tide .	・Pipe: OK ・Joint: Necessary to be flexible joints with flange adopters ・High possibility of damage because of joint-parts movement by waves and tide .	・Pipe: OK ・Joint: Necessary to be flexible joints with flange adopters ・High possibility of damage because of joint-parts movement by waves and tide .	・Pipe: OK. Flexible and tough ・Joint: OK. The joint strength is also equal to that of the pipe itself with fusion welding joints.
	Judgment	NG	NG	NG	OK
Easiness	Weight	Heavy	Heavy	Light	Light
	Transportation	Can be Easily transported.[2)]	Can be Easily transported.[2)]	Easy	Easy
	Construction	Difficult to handle due to heavy and flange joints	Difficult to handle due to flange joints	Easy due to light weight	Easy to handle, fusion welding can be curried inland.
	Maintenance	Periodical check of joints needed	Periodical anticorrosion paints and check of joints needed	Periodical weather–resistant painting and check of joints	Easy
	Cost	Expensive	Expensive	Economical	Economical
	Judgment	NG	NG	OK	OK
Evaluation/ Decision		High possibility of intrusion of seawater due to the damage of joint parts.	High possibility of intrusion of seawater due to the damage of joint parts.	・Vulnerable to the sunlight. ・High possibility of intrusion of seawater	・Resistant to UV. ・Easy handling and installation.
		Not Applicable	Not Applicable	Not Applicable	**Applicable**

Note: OK: The material can be used for construction or can be recommended for construction

NG: The material can not resist or withstand or the material can not be recommended for construction.

1) Black HDPE pipe contains 2+% of carbon black. Carbon black is the effective single additive to enhance the UV characteristics of plastic.

2) Though heavy and difficult for transportation, it is easy to be carried since the project site is near the main road.

Source: JICA Study Team

6.4 Wastewater Collecting Method

6.4.1 Study of Collection Type

There is a possibility that a pipe drops from a hook or the jetty becomes deteriorated. The following three cases are studied for sewers and installation of water distribution pipes.

Case 1: Single sewer with supports

Sewers are installed with supports under a jetty center, and are connected to both sides' houses through house connections. Water distribution pipes are set between a jetty deck and a beam.

Case 2: Parallel sewers with supports

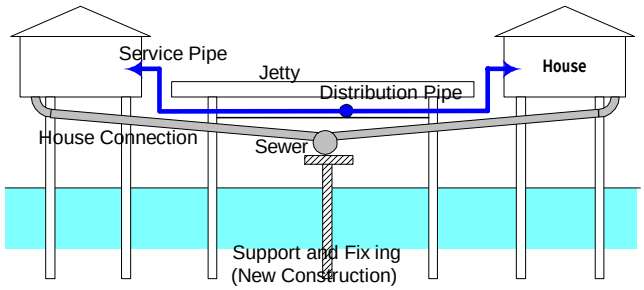
Two sewers, parallel lines, are installed with supports at both sides of a jetty, are connected to house connections. Two water distribution pipes are set between a jetty deck and a beam.

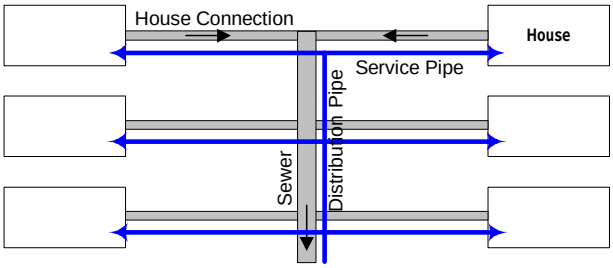
Case 3: Single Sewer with Sling Fittings

Sewers are hung by wires under a jetty center, and are connected to both sides' houses through house connections. Supports are not installed in this case. Water distribution pipes are set between a jetty deck and a beam.

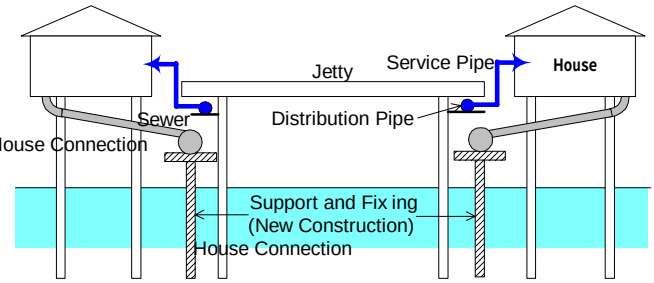
Diagrammatic illustrations of three cases are shown below:

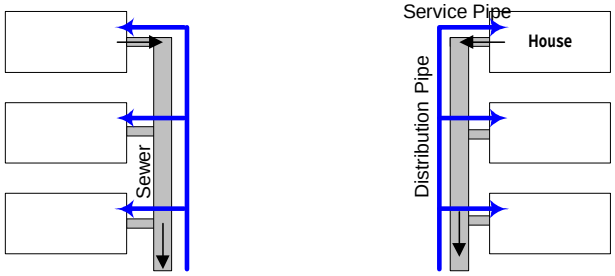
Case 1 Single Sewer with Supports





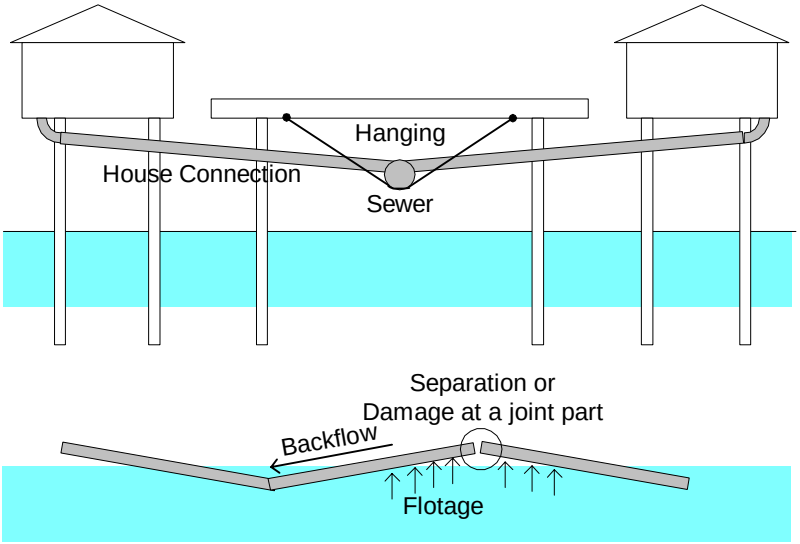
Case 2 Parallel Sewers with Supports





[Merit] ✓ One sewer type is cheaper than the parallel type ✓ Waves and tide level may have only a slight influence on sewer due to fixed sewer with supports. [Demerit] ✓ It is not easy to maintain sewers and difficult to find troubles of pipes. ✓ There is a possibility to damage pipes from the falling jetty	[Merit] ✓ It is easy to maintain sewers & distribution pipes and to find troubles of pipes. ✓ Waves and tide level may have only a slight influence on sewer fixed sewer with supports. [Demerit] ✓ Construction costs will be compared to single type, Case 1. ✓ It is difficult to construct the supports both sides of a jetty.

Case 3 Single Sewer with Sling Fittings



[Merit]
- ✓ The cheapest type among 3 cases
- ✓ It is easy to install the pipes and short construction period.

[Demerit]
- ✓ Waves and tide change will have a great influence on sewers. Sewers and fittings may be damaged by waves resulting backflow by flotage.
- ✓ There is a possibility of pipes dropping from hooks since the jetty or deck becomes deteriorated.

6.4.2 Applicable Installation

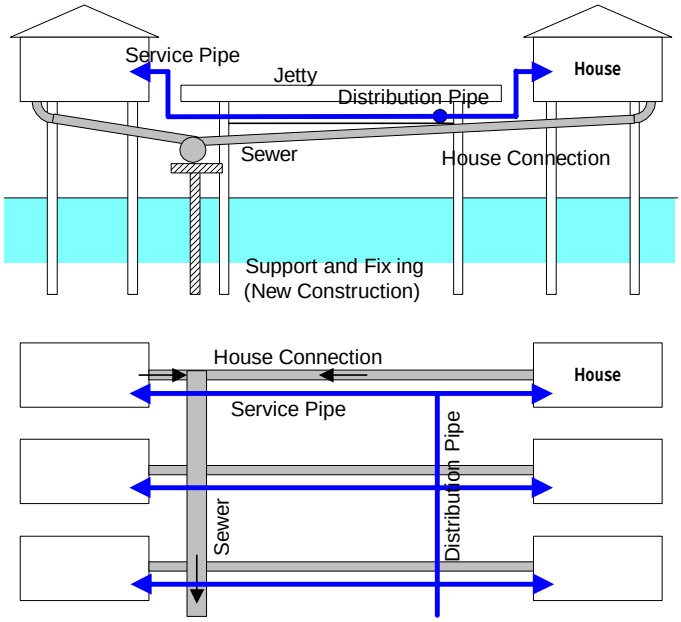
After due consideration of construction costs, pipe maintenance and durability of pipe support, the single sewer type which is the revised Case 1 is applicable. It is easy to construct and maintain the pipes by means of shifting pipe and support to one side of a jetty, it can also avoid damaging pipes from falling. Diagrammatic illustration of applicable installation method is shown in **Figure 6.4.1.**

- ✓ Easy maintenance of sewers & distribution pipes
- ✓ One sewer type is more economical than the parallel type.
- ✓ Independent supports for the pipes to secure durability (To avoid pipe damages by broken jetty)

Main points of pipe installation are described below:

- ➢ A sewer collects wastewater through house connections and conveys it by gravity flow to the planned trunk sewer.
- ➢ Water will be supplied for the residents through the service pipes.
- ➢ Sewers will be located away from the water distribution pipe to keep the drinking water safe for residents.
- ➢ To provide identification marks where the sewer material or its appearance may become confused with water distribution pipes.

- Spacing of supports for main sewers shall be approximately 2.0 m to avoid bending.
- Since the density of HDPE pipe is lighter than that of water, HDPE pipe will be floating in the sea water unless fixed to some support. Therefore, the pipe shall be fixed by a clamp on a support.
- HDPE pipe material expands and contracts when the temperature changes. HDPE pipe expands by approximately 0.2 mm per meter for every degree increase in temperature. Although the HDPE pipe is fixed by a clamp to avoid floating, the pipe is not fixed to horizontal direction because the pipe expands and contracts.
- Regarding spacing of hooks/guide brackets for water distribution pipes and house connections, the distance is equal to 10 times the pipe diameter. The spacing of hooks/guide brackets for a water distribution pipe (HDPE pipe, ϕ50 mm, inside dia.) is 500 mm, and that of house connection (HDPE pipe, ϕ100 mm, inside dia.) is 1000 mm.
- At the 1st jetty, sewer length 22 m shall be underwater at the time of High Tide Level (H.T.L.). The possible countermeasures are to raise the elevation of the houses, jetties and/or the height of a toilet position more than 0.25 m from current position when rebuilding and/or to maintain the part predominantly and periodically.
- Higher HDPE class, thick pipe shall be adopted for the exposed main sewer in the pipe specification in order to resist pipe deterioration and to prevent sewers bending on the supports.



Source: JICA Study Team

Figure 6.4.1 Applicable Sewers and Water Pipes Installation Method

6.5 Site Survey

Site survey of targeted houses was conducted in Hanuabada village, and the number of households, numbers of people and sanitary fixtures such as a toilet, a kitchen, laundry place and a bath/shower room were confirmed for each household.
The survey objectives are 1) confirmation of target residences, 2) calculation of design water demand and design wastewater flow for planning pipes, and 3) estimation of water and sewerage service charges.

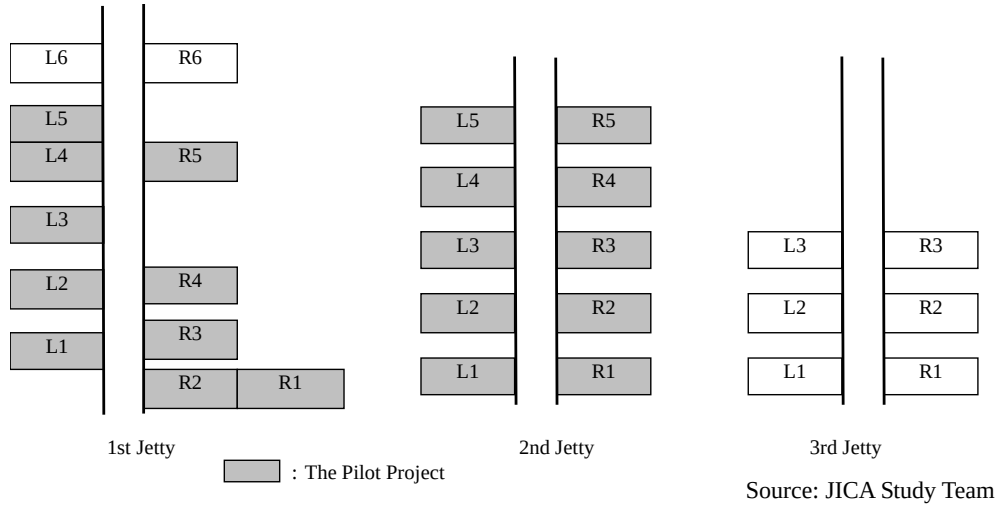
1) The number of households was confirmed by an interview survey. Regarding a count of houses, in cases where 2 families live independently in the same building and where they even share a kitchen or a toilet or a bathroom, it was counted as two in number because water meters would have to be set for each household to ensure that the treatment is fair.

2) Water demand and wastewater quantity was estimated by grasp of design population. Further, water distribution pipes and sewers was planned by estimated water demand and wastewater.

3) Water and sewerage service charges were calculated tentatively with using actual domestic water consumption data, 120 L/capita/day. Since water pressure is currently controlled by reducing valve under EDA RANU, residents can not use water with sufficient pressure. After completion of the pilot project, however, target residents will be able to use water anytime. Water consumption might be lower than actual domestic consumption data due to continuous using simple laundry and bath/shower equipment.

6.5.1 Estimated Design Flow

Surveyed houses and the targeted houses for the pilot project are shown in **Figure 6.5.1**.



Source: JICA Study Team

Figure 6.5.1 Targeted Houses for Each Jetty

Table 6.5.1 shows number of people and wastewater design flow for each house.

Table 6.5.1 Household and Estimated Wastewater

		Family	People	Wastewater Design Flow (m^3/d)			Scope
				Avg.	Hourly	Hourly (L/s)	
1st Jetty	L1	1	7	1.68	4.20	0.049	Pilot
	L2	1	12	2.88	7.20	0.083	P
	L3	3	30	7.20	18.00	0.208	P
	L4	3	10	2.40	6.00	0.069	P
	L5	3	12	2.88	7.20	0.083	P
	L6	3	7	1.68	4.20	0.049	
	R1	6	26	6.24	15.60	0.181	P
	R2	3	11	2.64	6.60	0.076	P
	R3		13	3.12	7.80	0.090	P
	R4	2	12	2.88	7.20	0.083	P
	R5	5	12	2.88	7.20	0.083	P
	R6	3	10	2.40	6.00	0.069	
2nd Jetty	L1	1	13	3.12	7.80	0.090	P
	L2	3	11	2.64	6.60	0.076	P
	L3	2	13	3.12	7.80	0.090	P
	L4	2	8	1.92	4.80	0.056	P
	L5	2	13	3.12	7.80	0.090	P
	R1	1	7	1.68	4.20	0.049	P
	R2	2	10	2.40	6.00	0.069	P
	R3	3	19	4.56	11.40	0.132	P
	R4	5	22	5.28	13.20	0.153	P
	R5	1	6	1.44	3.60	0.042	P
3rd Jetty	L1	4	15	3.60	9.00	0.104	
	L2	2	13	3.12	7.80	0.090	
	L3	2	17	4.08	10.20	0.118	
	R1	4	13	3.12	7.80	0.090	
	R2	1	6	1.44	3.60	0.042	
	R3	1	10	2.40	6.00	0.069	
Average		2.6	12.8	3.07	7.67	0.089	
Max		6	30	7.20	18.00	0.208	
Min		1	6	-	-	-	

Note: P means the target of the pilot project
People of R3 on 1st Jetty, use the average due to the vacant house

Source: JICA Study Team

Design wastewater, design water demand and estimated water consumption are shown in **Table 6.5.2**.

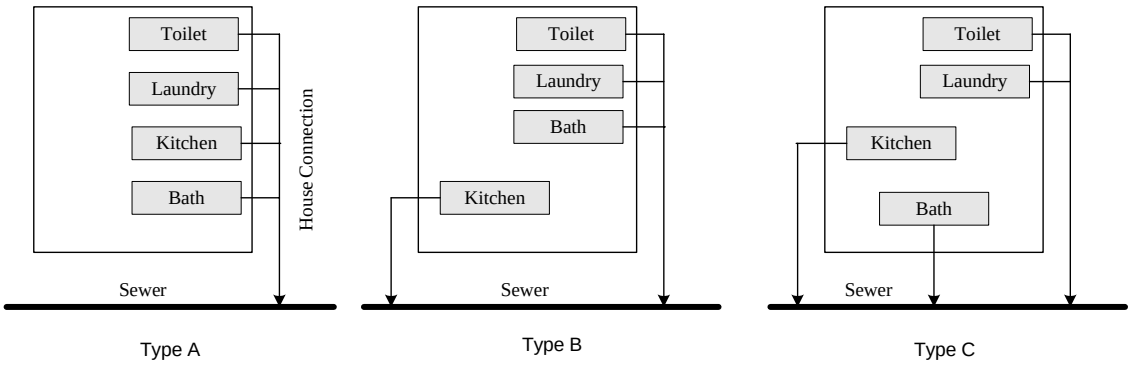
Table 6.5.2 Design Water Supply, Wastewater and Water Consumption

		1st Jetty	2nd Jetty	Total	Remarks
Population		145	122	267	
Design Wastewater Flow (m^3/d)	Daily average/maximum	34.8	29.3	64.1	240 L/capita/day
	Hourly maximum	87.0	73.2	160.2	600 L/capita/day (240L/c/d ×2.5)
Design Water Flow (m^3/d)	Daily average	39.2	32.9	72.1	270 L/capita/day (240L/c/d ÷ 0.9)
	Peak hourly	58.0	48.8	106.8	400 L/capita/day (270L/c/d ×1.5)
Water Consumption Daily Average (m^3/d)		17.4	14.6	32.0	120 L/capita/day Actual value in 2004

Source: JICA Study Team

6.5.2 House Connection and Service Pipe

Domestic wastewater generated at a house will be conveyed through a house connection and a sewer. Target for wastewater to be collected is toilet, kitchen, laundry and bath/shower. One of the survey objectives is to derive the arrangement of sanitary fixtures such as a toilet, kitchen, laundry and bath/shower room in order to design house connections. **Figure 6.5.2** shows house connection types. Construction cost of Type A is economical than one of type B & C, and maintenance is also easier. In case that sanitary fixture is located separately in a spacious house, however, type B or type C may be suitable for connecting to a sewer.



Source: JICA Study Team

Figure 6.5.2 House Connection Types

(1) Sanitary facility and House Connection Layout

Arrangement of sanitary facilities and house connection layouts for each house are shown in **Figure 6.5.3**. House connection type shall be type A to all target houses except R2 on the 1st Jetty. Service life of Jetties and residences is approximately 5 years according to the interview survey, and then they are partially repaired or rebuilt. Therefore, it seems that the sanitary fixture arrangement in a house differ from site survey and construction stages.

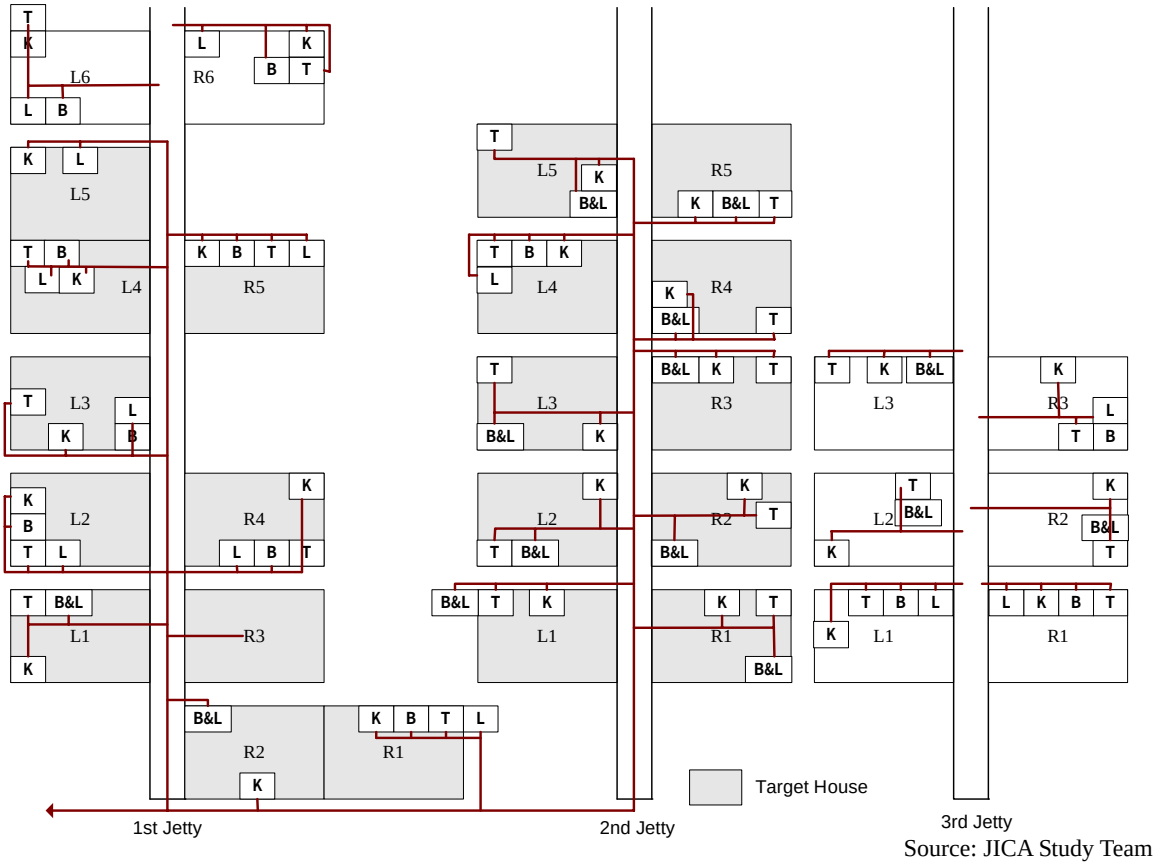
House inlet (sanitary chamber) is not installed on house connection due to prevention of clogging by garbage from outside and foul smell.

(2) House Connection Installation

House connections shall be installed to existing sanitary fixtures in each house despite it being on private property, and a flush toilet shall be also provided/installed to improve the living environment and sanitation.

Locations of sanitary fixtures are also moved in houses, with the locations not being fixed because of short service life. It is uneconomical to install a fixed pipe-support for a house connection under such conditions. Pipe material is HDPE pipe (φ100mm inside dia.) and the method of pipe installation is the hanging type or guide bracket type to deal with the movable fixtures. The spacing of hooks/guide brackets for pipes is approximately 1000mm. Although there is a possibility that hung pipes fall and

have influences with waves, it is not a great concern since the pipes are located comparatively high position just under the floors. Pipe joints are flexible type to accommodate displacement by waves and tide changes. Since the main sewers should be installed under the jetties which are immovable, reinforced concrete supports, fixed type, will be adopted. (Refer to section 6.4.)



Source: JICA Study Team

Figure 6.5.3 House Connection

(3) House Service Pipe

House service pipe shall be of galvanized steel pipes for corrosion protection. A water meter shall be installed for each target house (refer to **Figure 6.3.1**), a stop valve shall be also equipped with the water meter. In the pilot project, a service pipe, polyethylene pipe shall be connected up to taps such as a kitchen, a toilet, a bath and a laundry inside a house.

(4) Maintenance of sewer and house connection

In general, trunk and branch sewers which are public property will be maintained by EDA RANU, while house connections as they are private property will be maintained by residents and/or house owners. In the pilot project, however, it is proposed that IPBC/EDA RANU administer the house connections as well as trunk and branch sewers for at least for a year after completion of the construction for the sake of proper maintenance and a provide the necessary education to avoid misuse.

6. 6 Questionnaire Survey Results and Estimation of Tariff

6.6.1 Tentative Tariff Calculation

The collection of water and sewerage service charges shall commence after the scompletion of the pilot project. Tentative tariff calculation of average service charge per household has been made based on the current tariff. Water and sewerage tariffs are shown in **Table 6.6.1**, while the method used for of making preliminary calculations is given below.

The preliminary calculated value of the tariffs to be charged is about 60 kina/house/month. A Questionnaire Survey was conducted in the target houses to confirm whether the charge is expensive for the residents or not.

Conditions; Target: 20 houses, Number of Household members: 13 persons

Table 6.6.1 Water and Sewerage Tariff

Class 5.2: Low Covenant Residential	Water Prices (Kina)	Sewerage Prices (Kina)	Remarks
Access charge (per annum)	60.00	60.00	Not applicable in the Pilot
Mthly consumption 0.1 - 15 kL (per kL)	1.00	0.25	Not applicable in the Pilot
Rebate on lifeline tariff (upon application)	(0.50)	(0.25)	Applicable
15.1 – 35 kL (per kL)	1.00	0.47	Applicable
35.1 – 100 kL (per kL)	1.15	0.47	Applicable
100.1 – 150 kL (per kL)	4.00	0.47	Applicable

Source: EDA RANU Press Statement (February 10, 2011)

Unit daily average: Domestic Water Consumption 120 L/capita/day (Actual value in 2004)

Water consumption: 120 × 13 persons = 1,560 L/house/day → 46.8 kL/house/month

Water charge: 15 × 0.50 + (35 - 15) × 1.00 + (46.8 - 35) × 1.15 = 41.1 Kina/house/month

Sewerage charge: 15 × 0.25 + (46.8 - 15) × 0.47 = 18.7 Kina/house/month

Total Charge: 41.1 + 18.7 = 59.8 Kina/house/month

The value is equivalent to 4.8% (= service charge 59.8 k/monthly income 1,238 k ×100) of average monthly income.

6.6.2 Questionnaire Survey to Target Residents: Willingness to pay for Water Tariff

(1) Survey Objectives

Since nobody has been paying water service charges at the target area until now, Questionnaire Survey was conducted in the Pilot Project area in accordance with the following objectives:

Awareness on

- the connection of new water service pipe and new sewer in the targeted residences
- the economic condition (income)
- affordability and willingness to pay water and sewerage tariffs
- possibility to pay water and sewerage tariffs
- cooperation with the constructions of water service pipes and sewers

(2) Target Residences

Hanuabada Water village, 1st Jetty: 10 houses, 2nd Jetty: 10 houses

Total of sampling number is 20 houses. Respondents for questionnaire survey are shown in **Figure 6.6.1**.

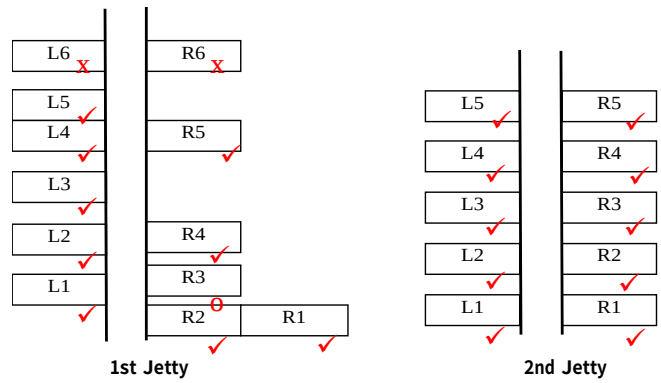
(3) Survey Results

The survey was conducted to target residences in Hanuabada village on 30th March and 1st April, 2011.

No. of Respondents: 19 residents (R3 in the 1st Jetty is vacant house.)

Questionnaire survey results are shown in **Table 6.6.2**.

- ✓ All respondents want to connect to the new water service pipe and sewer.
- ✓ All respondents will cooperate with construction for the pilot project.
- ✓ The service charges are calculated tentatively based on Low Covenant Residential Tariff (Class 5.2) without access charge and GST/VAT.
  *Low Covenant Residential is defined as "Unimproved Land Value (ULV) <= K12,000".
- ✓ Domestic water consumption 120 L/capita/day is actual minimum value in past five years, 2000 -2004.
- ✓ Average gap between tentative calculated tariff and willingness to pay may be 19 (= K63.2 – K43.9)Kina/house/month.
- ✓ Average gap between tentative calculated tariff and possibility to pay (maximum payment) may be 11 (= K63.2 – K52.6) Kina/house/month.
- ✓ There is the gap between tentative calculated tariff and the willingness to pay since most residents have not paid for water and sewerage charges ever.



✓ : Respondents o: Vacant house x: Out of scope

Source: JICA Study Team

Figure 6.6.1 Respondents in Hanuabada Village

(4) Measures of Mitigation for the Gap

The potential measures to alleviate the gap between the calculated tariff and the willingness to pay are shown below;

1) Awareness through education and workshops for the residents

After completion of the pilot project, water could be provided to the residents on a 24 hour basis with proper pressure, while the existence of sewerage could inprove their living environment. Maintenance will be required to maintain proper functions of water and sewerage systems. It is necessary to have awareness programs for the residents about the expenses involved in carrying out the maintenance activities.

2) Establishment of new tariff for the pilot project.

Current applicable tariff is Low Covenant Residential (Class 5.2) which is defined as "Unimproved Land Value (ULV) <= K12,000". It is necessary to review whether the definition is appropriate for Hanuabada village.

3) Possibility that Motu-Koita Assembly/NCDC subsidize service charges

The proposal No.2 & 3 are needed to be discussed with MKA, NCDC, IPBC and EDA RANU since MKA has responsibility to administer and assist local villages.

Table 6.6.2 Questionnaire Survey Results and Tentative Calculated Tariff

2011 Water & Sewerage Tariff (Class 5.2)

Kina/kL	Water	Sewerage	
0 - 15	0.50	0.25	Kina/kL
15.1 - 35	1.00	0.47	Kina/kL
35.1 - 100	1.15	0.47	Kina/kL
100.1 - 150	4.00	0.47	Kina/kL

120 L/capita/day

			Water Consumption		Water Charge (Kina/month)					Sewerage Charge (Kina/month)			Total Charge	Connection	Income	Willingness to pay (K/M)			Maximum	Cooperation
	Nouse No.	People	(m^3/d)	(m^3/month)	0-15	15.1-35	35.1-100	100.1-150	Total	0-15	15.1-150	Total	(Kina/month)		Kina/month	Water	Sewerage	Total	(K/M)	
1st Jetty	L1	7	0.84	25.2	7.50	10.2	0.0	0.0	17.7	3.75	4.8	8.5	26.2	Yes	600	20	20	40	50	Yes
	L2	12	1.44	43.2	7.50	20.0	9.4	0.0	36.9	3.8	13.3	17.0	53.9	Y	1,000	20	20	40	60	Y
	L3	30	3.60	108.0	7.50	20.0	74.8	32.0	134.3	3.8	43.7	47.5	181.7	Y	1,400	40	20	60	100	Y
	L4	10	1.20	36.0	7.50	20.0	1.2	0.0	28.7	3.8	9.9	13.6	42.3	Y	1,200	40	20	60	100	Y
	L5	12	1.44	43.2	7.50	20.0	9.4	0.0	36.9	3.8	13.3	17.0	53.9	Y	400	25	25	50	50	Y
	R1	26	3.12	93.6	7.50	20.0	67.4	0.0	94.9	3.8	36.9	40.7	135.6	Y	300	15	15	30	30	Y
	R2	11	1.32	39.6	7.50	20.0	5.3	0.0	32.8	3.8	11.6	15.3	48.1	Y	200	5	5	10	10	Y
	R3	13	1.56	46.8	7.50	20.0	13.6	0.0	41.1	3.8	14.9	18.7	59.8							
	R4	12	1.44	43.2	7.50	20.0	9.4	0.0	36.9	3.8	13.3	17.0	53.9	Y	1,600	50	20	70	100	Y
	R5	12	1.44	43.2	7.50	20.0	9.4	0.0	36.9	3.8	13.3	17.0	53.9	Y	120	20	20	40	40	Y
2nd Jetty	L1	13	1.56	46.8	7.50	20.0	13.6	0.0	41.1	3.8	14.9	18.7	59.8	Y	1,400	10	20	30	30	Y
	L2	11	1.32	39.6	7.50	20.0	5.3	0.0	32.8	3.8	11.6	15.3	48.1	Y	400	10	10	20	20	Y
	L3	13	1.56	46.8	7.50	20.0	13.6	0.0	41.1	3.8	14.9	18.7	59.8	Y	400	10	10	20	20	Y
	L4	8	0.96	28.8	7.50	13.8	0.0	0.0	21.3	3.8	6.5	10.2	31.5	Y	600	10	10	20	20	Y
	L5	13	1.56	46.8	7.50	20.0	13.6	0.0	41.1	3.8	14.9	18.7	59.8	Y	600	20	20	40	50	Y
	R1	7	0.84	25.2	7.50	10.2	0.0	0.0	17.7	3.8	4.8	8.5	26.2	Y	600	40	20	60	60	Y
	R2	10	1.20	36.0	7.50	20.0	1.2	0.0	28.7	3.8	9.9	13.6	42.3	Y	4,500	15	15	30	30	Y
	R3	19	2.28	68.4	7.50	20.0	38.4	0.0	65.9	3.8	25.1	28.8	94.8	Y	1,400	50	25	75	80	Y
	R4	22	2.64	79.2	7.50	20.0	50.8	0.0	78.3	3.8	30.2	33.9	112.3	Y	1,800	20	20	40	50	Y
	R5	6	0.72	21.6	7.50	6.6	0.0	0.0	14.1	3.8	3.1	6.9	21.0	Y	5,000	50	50	100	100	Y
Total		267	32.0	961.2	150.0	360.8	336.3	32.0	879.1	75.0	310.8	385.8	1264.8	Total	23,520	470	365	835	1000	
Average		13	1.6	48.1					44.0			19.3	63.2	Average	1,238	25	19	43.9	52.6	
Maxmum		30	3.6	108.0					134.3			47.5	181.7	Max	5,000	50	50	100	100	
Minimum		6	0.7	21.6					14.1			6.9	21.0	Min	120	5	5	10	10	

Note: Please treat as confidential document due to mention of monthly incomes

The gap between tentative service charges and willingness to pay: 19.3 Kina/month

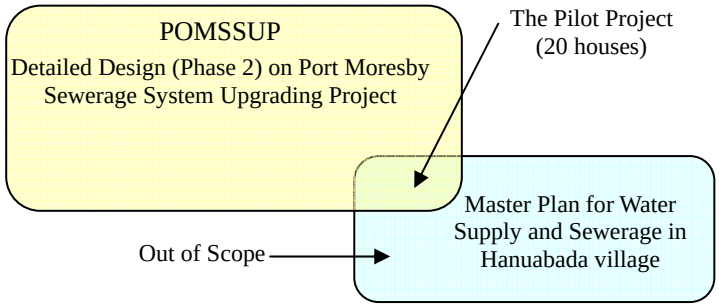
The gap between tentative service charges and affordability: 10.6 Kina/month

Source: JICA Study Team

6.7 Master Plan of Sewerage and Water Supply for Hanuabada Village

6.7.1 Status of the Master Plan in Hanuabada

In the pilot project, wastewater collection system and water supply system are planned for a limited selected block of 20 houses which were located in the Hanuabada village. Since such infrastructure is required for all residents of water villages in terms of health, hygiene, sanitation and marine environment, a master plan for the sewerage/water supply in whole Hanuabada village, especially for houses built over the sea is required as a future implementable program for both the executing agency and unserved residents in the village. In this context, the master plan of the sewerage and water supply in Hanuabada village is proposed for houses built over the sea, although it is out of scope of works in this D/D.



Source: JICA Study Team

Figure 6.7.1 Status of Master Plan in Hanuabada

The master plan will play a vital role in the dissemination process to concerned people in Hanuabada area in providing water and sewerage services. Further, it will be developed /expanded to other water villages such as the Koki area as well, enabling the living conditions of the resident people to become improved and safe.

6.7.2 Consideration and Methodology of Sewerage System in Hanuabada Village

The planning of the wastewater collection in a village over the sea is quite different from planning a similar venture on land. There are various and unique factors which must be considered in a water village.

Since most of Hanuabada village is located over the sea, it has potential difficulties for sewer installation. The exposed pipe over the sea will experience severe natural conditions such as the force experience from sea waves, the tide change and the infiltration of seawater. Therefore, the installation conditions confronting the pilot project is much different from those faced in underground installations.

In the formulation of the master plan for the Hanuabada sewerage system, the following points, are to

be noted for sewer/water supply construction; namely: prevention of seawater infiltration, the corrosion protection of pipes including supports, anti-weatherability of the exposed pipe and stable pipe installations made on the fragile jetty structure.

There are various eligible sewerage systems available for wastewater collection. The more important is as follows: gravity flow sewer system, pressure sewer system and the vacuum sewer system.

Location map of Hanuabada village is shown in **Figure 6.7.2**. The Jetty location and sewer routes are shown in **Figure 6.7.3**.

6.7.3 Scope of Master Plan

The master plan in Hanuabada village consists of sewerage system and water supply. In the target area, while there is not an existing sewerage at all, the existing water distribution pipelines are laid under the access road to the village. Both of sewerage and water supply are planned in this section.

The fundamental information of Hanuabada village is described below:

Location: Hanuabada Village (houses built over the sea)

Formulation of the plan:	Sewerage system and water supply
Population:	9,733 people
Number of Houses:	654
Number of Jetties:	43
Jetty length:	Longest 271 m, Average 118 m
High Tide Level:	0.25 m (source: Paga Point Sewage Outfall Drawing, DWS, 1980)

The typical jetty structure is illustrated in **Figure 6.7.4**. Design wastewater flow and design water demand for each jetty are shown in **Table 6.7.1**. The information of proposed sewer routes and design wastewater flow and design water demand are only for the houses built over the sea.

In the formulation of the master plan, since all the elevations of each jetty and the ground in the subject area are not measured by topographic survey, assumption was introduced that ground and jetty levels are the same without great gaps. The length of each jetty was obtained and measured on maps. At the detailed design stage and/or construction stage, pipe length and number and positions of pumping stations must be specifically surveyed and documented.

The objectives of the master plan would be to describe the overall sewerage/water supply system and technical aspects such as the method of water supply, wastewater collection, sewer routes, location of pumping station and the connection points to trunk sewers in the area, present construction/O&M costs, and to clarify issues for implementation.

Figure 6.7.2 Hanuabada Village Location Map

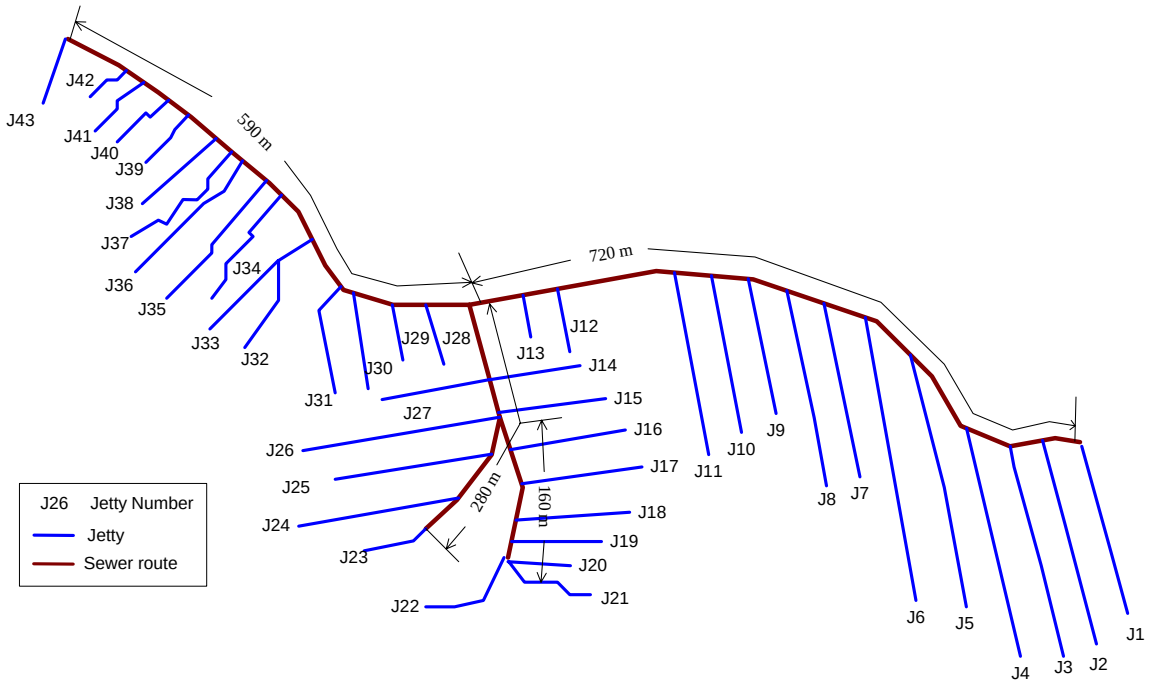
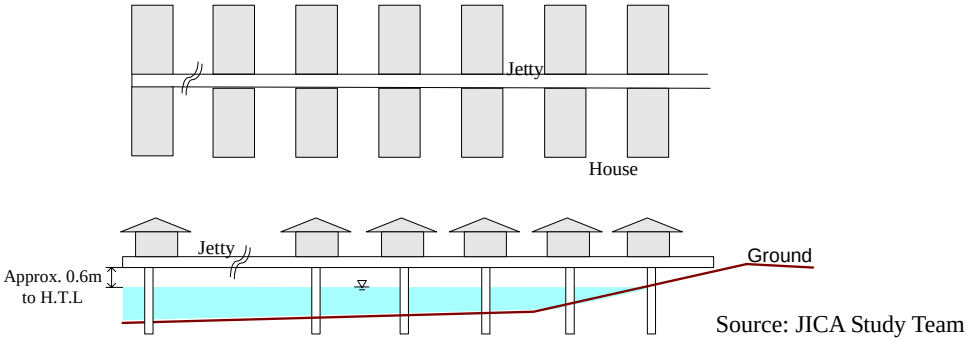


Figure 6.7.3 Jetties Location and Proposed Sewer Routes

Source: JICA Study Team



Source: JICA Study Team

Figure 6.7.4 Water Village Schematic Depiction Plan and Section

Table 6.7.1 Design Wastewater Flow and Water Demand for Each Jetty

Jetty	Jett Length (m)	No. of House	Population	Design Wastewater Flow (m^3/day)		Design Water Demand (m^3/day)	
				Daily Avg.	Hourly Max	Daily Avg.	Hourly Max
				240 L/c/d	600 L/c/d	270 L/c/d	400 L/c/d
J1	154	28	416	99.8	249.6	112.3	166.4
J2	187	25	372	89.3	223.2	100.4	148.8
J3	190	28	417	100.1	250.2	112.6	166.8
J4	215	30	446	107.0	267.6	120.4	178.4
J5	227	34	506	121.4	303.6	136.6	202.4
J6	271	29	432	103.7	259.2	116.6	172.8
J7	183	21	313	75.1	187.8	84.5	125.2
J8	198	22	327	78.5	196.2	88.3	130.8
J9	123	18	268	64.3	160.8	72.4	107.2
J10	153	21	313	75.1	187.8	84.5	125.2
J11	179	26	387	92.9	232.2	104.5	154.8
J12	56	11	164	39.4	98.4	44.3	65.6
J13	30	8	119	28.6	71.4	32.1	47.6
J14	88	13	193	46.3	115.8	52.1	77.2
J15	103	16	238	57.1	142.8	64.3	95.2
J16	112	19	283	67.9	169.8	76.4	113.2
J17	115	16	238	57.1	142.8	64.3	95.2
J18	106	12	179	43.0	107.4	48.3	71.6
J19	83	6	89	21.4	53.4	24.0	35.6
J20	60	4	60	14.4	36.0	16.2	24.0
J21	89	8	119	28.6	71.4	32.1	47.6
J22	103	4	60	14.4	36.0	16.2	24.0
J23	55	6	89	21.4	53.4	24.0	35.6
J24	151	21	313	75.1	187.8	84.5	125.2
J25	147	18	268	64.3	160.8	72.4	107.2
J26	192	21	313	75.1	187.8	84.5	125.2
J27	104	13	193	46.3	115.8	52.1	77.2
J28	42	8	119	28.6	71.4	32.1	47.6
J29	54	9	134	32.2	80.4	36.2	53.6
J30	89	10	149	35.8	89.4	40.2	59.6
J31	93	14	208	49.9	124.8	56.2	83.2
J32	65	4	60	14.4	36.0	16.2	24.0
J33	114	11	164	39.4	98.4	44.3	65.6
J34	116	13	193	46.3	115.8	52.1	77.2
J35	139	14	208	49.9	124.8	56.2	83.2
J36	140	13	193	46.3	115.8	52.1	77.2
J37	142	7	104	25.0	62.4	28.1	41.6
J38	80	12	179	43.0	107.4	48.3	71.6
J39	69	16	238	57.1	142.8	64.3	95.2
J40	67	14	208	49.9	124.8	56.2	83.2
J41	68	7	104	25.0	62.4	28.1	41.6
J42	46	9	134	32.2	80.4	36.2	53.6
J43	66	15	223	53.5	133.8	60.2	89.2
Total	5,064	654	9,733	2,336	5,840	2,628	3,893
Avg.	118	15	226	54	136	58	87

Note: Daily avg. water demand & peak factor 1.5 quoted from Code of Practice for Water Supply & Sewerage, EDA RANU

Source: JICA Study Team

6.7.4 Alternative Sewerage Systems in Master Plan

The following four cases present the alternative wastewater collection systems for the village over the sea:

Case 1: Conventional Gravity Flow Sewer System-1

Conventional gravity-flow sewers transport raw sewage through pipelines to a pumping station inland. The diagrammatic illustration of this system is shown in **Figure 6.7.5**. The minimum gradient for sewers on jetties is set at 1 % (1/100) to maintain the required minimum velocity. A part of the sewers may be submerged underwater and it will depend on the length of the jetty and seawater levels. In case that a jetty is 120m long, the sewer may descend approximately 1.2m downward with a minimum gradient of 1 %, where half of the sewer may be immersed underwater. Any manholes will not be installed for the sewers in order to avoid intrusion of brine (sea) water into the sewers. Instead of the manholes, cleaning plugs will be installed on the alignment above the sea level as required. On the assumption that the clearance of the jetty deck and H.T.L.(the High Tide Level: 0.25 m) is 1.0 m according to the highest recorded seawater level measured on March 18, 2011, the clearance of the beams and H.T.L. will be 0.6 m based on the 2nd jetty structure.

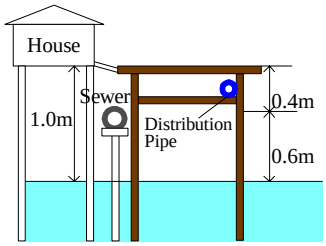
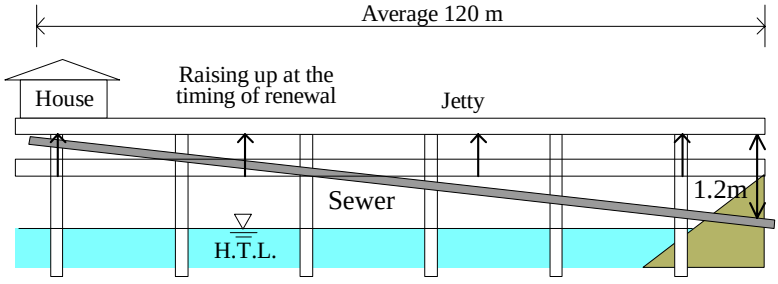


Figure 6.7.5 Gravity Flow Sewer System - 1

Source: JICA Study Team

Case 2: Gravity Flow Sewer System - 2

Method of Case 2 is basically the same as in Case 1. This method is that residences and jetties will be lifted up from present level above the water level. Since most of the residences and jetties and their supports in the water village are made of timbers and mangrove, their life are approximately five years only. Jetties and supports can be re-constructed at the time of rebuilding of houses. Consequently, the sewer level can be set avoiding submergence. Required lifting level will be about 0.6 to 1.0 m for jetty girders and supports from current positions for a jetty with 120 m length.



Source: JICA Study Team

Figure 6.7.6 Gravity Flow Sewer System - 2

Case 3: Combination of Pressure Sewer System and Gravity Flow Sewer System

A pressure sewer system (PSS) is appropriate for smaller and remote villages. A simplified diagram of the system is shown in **Figure 6.7.7**. The system is a combination of both the pressure sewer and the gravity sewer, and wastewater is lifted by a lift pump in the pump pit before the sewer becomes submerged in the seawater. However, lift pumps and manholes will be required for sewer installation. One or two pumps with manholes will be needed in the jetty of 120m length. Part of the manholes will be installed under the seawater level. Emergency generators will be installed for the system.

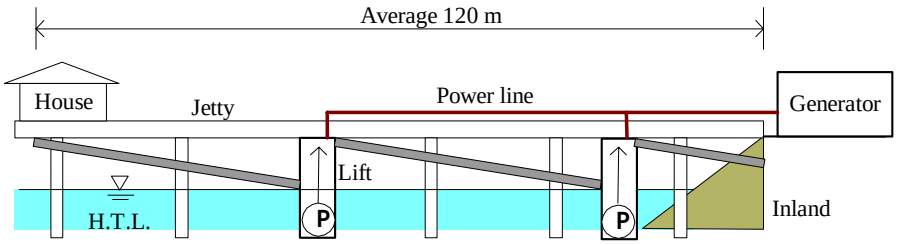
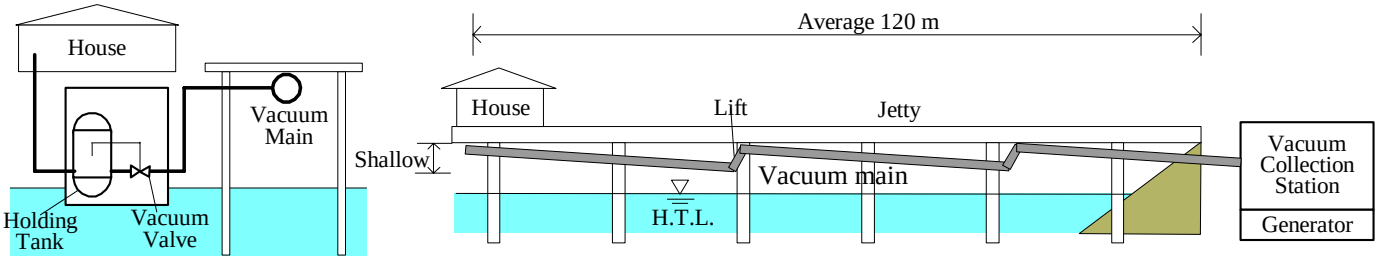


Figure 6.7.7 Combination of Pressure Sewer and Gravity Sewer Systems

Case 4: Vacuum Sewer System

A vacuum sewer system uses the differential pressure between atmospheric pressure, and a partial negative pressure maintained in the piping network and a vacuum collection station. **Figure 6.7.8** shows the diagrammatic illustration of the vacuum sewer system. Vacuum sewers take advantage of available slight slope in the flat terrain. A vacuum collection station is required on the ground, and the vacuum unit which consists of holding tanks and vacuum valves must be installed in a building to connect to vacuum mains. A vacuum unit may be shared by one or several houses, and a part of the unit pit will be located underwater.



Source: JICA Study Team

Figure 6.7.8 Vacuum Sewer System

Comparison of these collection systems is shown in **Table 6.7.2.**

Table 6.7.2 Comparison of Alternative Wastewater Collection System in Master Plan (Village over the sea)

Item	Gravity flow Sewer system		Pressure Sewer System	Vacuum Sewer System
Case	Case 1	Case 2	Case 3	Case 4
Construction	Conventional	Jetties to be lifted	Combination of gravity flow and pressure sewer	Vacuum system
Collection	Wastewater to be conveyed by gravity flow		To use pressure pipeline by lifting pumps to deliver wastewater to gravity flow pipe	Negative pressure of the pipeline to deliver wastewater from households to the vacuum main
Component of typical facilities	・ House connection pipe ・ Sewer		・ Lifting pump ・ Pump pit ・ Generator ・ Power line ・ House connection pipe ・ Sewer	・ Vacuum collection station ・ Vacuum main ・ Holding tank ・ Vacuum valve ・ House connection pipe
Main sewer diameter	Larger than 150 mm		Larger than 150 mm	Smaller than gravity flow pipe diameter
Sewer alignment	Some part of pipeline under the sea	Above the sea level	Above the sea level	Above the sea level
Manhole	Cleanout will be installed instead of manholes		Pump pit to be required for a lifting pump	Not required
Odor	No odor emission along sewers		Possibility to emit foul odour when a pump pit cover is opened	・ No odor along the closed vacuum sewers. ・ Deodorization to be needed for the vacuum station
Structures underwater	・ Supports for pipes ・ Part of sewer	・ Support for pipes	・ Support for pipes ・ Pump pit	・ Support for pipes ・ Chamber of a tank and a valve
Mechanical equipment	No mechanical equipment to maintain		・ Lifting pumps and appurtenances	・ Holding tank, vacuum valve, vacuum station, generator and appurtenances
Power Supply	・ Not needed		・ Lifting pumps ・ Emergency Generator ・ Power lines	・ Vacuum collection stations ・ Emergency Generator
Construction period	Shortest among 4 cases	Longest period including reconstruction of jetties and residences with the required sewer system	Longer than the gravity flow sewer system	Longer than the gravity flow sewer system
Construction Cost	Most economical among the systems	Including rebuilding costs, the cost to be much higher than conventional gravity flow system	More expensive due to equipment and appurtenances than conventional	Most expensive

Item	Gravity flow Sewer system		Pressure Sewer System	Vacuum Sewer System
Case	Case 1	Case 2	Case 3	Case 4
O & M cost	・ Low O&M cost. ・ In case of pipe clogging, flashing is needed	・ Generally low O&M cost. ・ In case of pipe clogging, flushing is needed	・ Lifting pumps to be properly operated and maintained. ・ The cost to be higher than the conventional gravity flow system	・ Vacuum valve pits and vacuum stations to be properly operated. ・ The cost to be the highest among the systems
Main Potential Risks	・ Seawater intrusion ・ Pipe joints damage ・ Corrosion of pipes ・ Infiltration of the seawater into the sewer to damage the facilities and weakening biological activity of the process due to chlorine ion contained in seawater.	・ Corrosion of pipes ・ Complaint by residents due to the long period of construction and shouldering the re-building cost	・ Seawater intrusion ・ Corrosion of pipes	・ Seawater intrusion ・ Corrosion of pipes ・ Complicated system
Residents' cooperation with the construction	・ Less effort to explanation to the residents than other cases.	・ Accountability required. ・ Residents' understanding and consensus needed for the construction ・ Agreement for the plan and expenses needed	・ Accountability required. ・ Residents' understanding and consensus needed for the construction Agreement for the plan and expenses needed	・ Accountability required. ・ Residents' understanding and consensus needed for the construction Agreement for the plan and expenses needed
Evaluation/Decision	・ The system to be the most economical among 4 cases with less maintenance work ・ Risk of seawater infiltration into the sewer ・ Risk of pipe damage by waves, tide change and floatage. ・ Flexibility, durability of pipe needed to resist severe conditions. ・ Service pipes required to connect to main sewers located in the underwater.	・ The plan needed to avoid waves and tide ・ Almost impractical in terms of consensus, cost and sustainability	・ The plan needed to avoid waves and tide ・ More expensive for both of construction and O&M costs than Case1 ・ Risk of intrusion of seawater to the manholes underwater. ・ Risk of pipe damage by waves, tide change and floatage.	・ This system to avoid influences from waves and tides ・ The construction and O&M costs to be the most expensive in 4 cases ・ Complicated O&M ・ Excessive investment to the water houses with 5 years life
	Applicable	Not Applicable	Not Applicable	Not Applicable

Source: JICA Study Team

The following factors were considered to select wastewater collection system in the target area:

1. High degree of feasibility
2. Applicability to the project area
3. Construction cost and O&M cost
4. Operational maintenance skills and experiences

In this context, the conventional gravity sewer system is recommended for Hanuabada village as the master plan of the sewerage system.

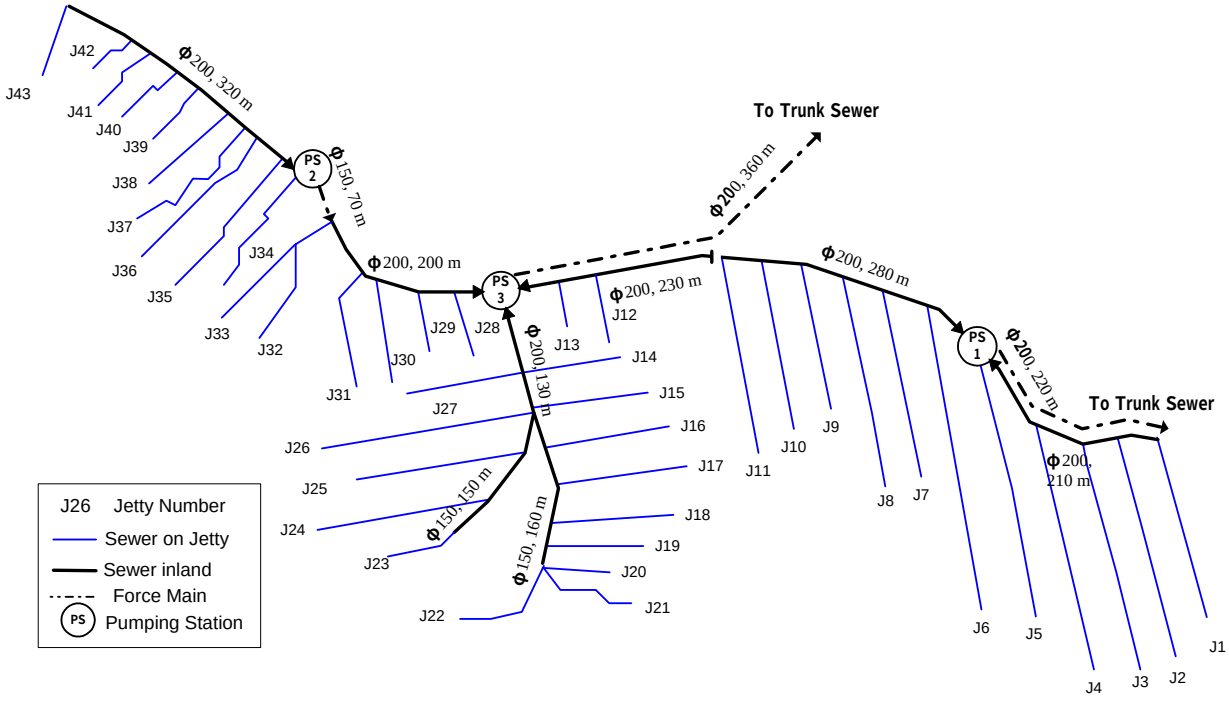
6.7.5 Master Plan in Hanuabada Village

(1) Sewerage System

Wastewater collection system is the conventional gravity flow sewer system as shown in **Figure 6.7.5**. Collected wastewater from each jetty will be conveyed to the trunk sewer through force mains from pumping stations. Sewer located inland is 200 mm diameter in consideration of generating domestic wastewater from houses built on the ground.

In the sewerage master plan, 3 pumping stations are proposed. Since capacities of the pumps are relatively small with less flow, emergency generators will not be installed for the pumping stations. In case of prolonged power failure, overflow wastewater will be drained to the sea through an overflow pipe.

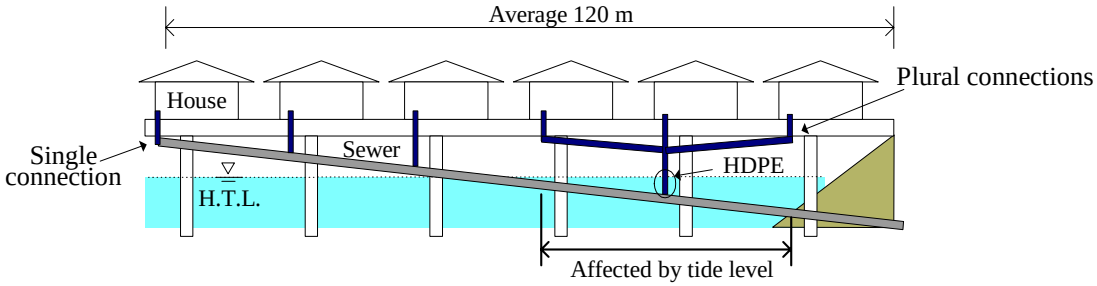
The overview diagram of the sewerage system is shown in **Figure 6.7.9.**



Source: JICA Study Team

Figure 6.7.9 Sewerage Master Plan in Hanuabada Village

House connection is also important facility. In longer jetty, more than 120 m, large part of the length of sewers will be immersed underwater. When a section of part of sewer lies above high tide level (H.T.L.), house connections for the sewer will be independent for each house, while in case lying below H.T.L., house connections will be a combined type with plural connections. **Figure 6.7.10** shows types of house connection. Material of the pipes shall be HDPE pipe below H.T.L.

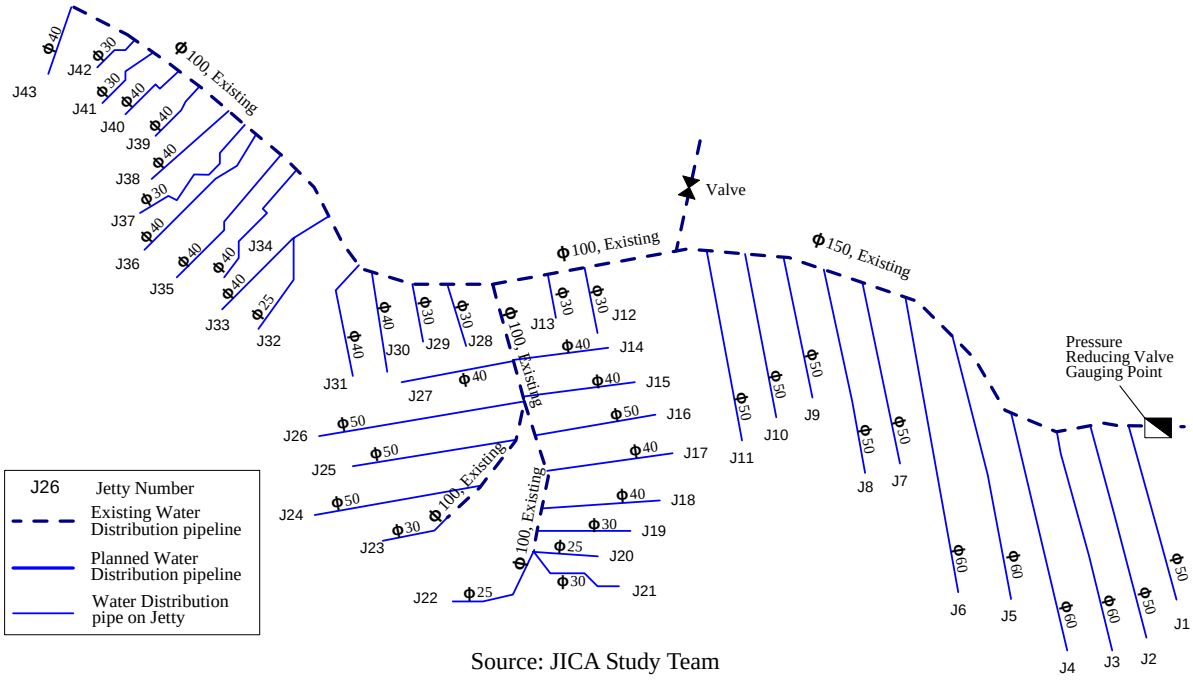


Source: JICA Study Team

Figure 6.7.10 Gravity Flow Sewer and House Connection

(2) Water Distribution Master Plan

There are existing cast iron distribution pipes with diameters of 100 mm to 150 mm. Water distribution pipes will be extended from the existing pipe to each jetty to supply water to each resident. Individual water meters will be installed for each house. **Figure 6.7.11** shows the overview diagram of water distribution pipelines.



Source: JICA Study Team

Figure 6.7.11 Water Distribution Pipeline Master Plan in Hanuabada Village

6.8 The Pilot Project and Social Development Program

It is necessary to conduct workshop, educational and awareness programs to the target residents to spread proper use of facilities and to improve their lifestyles. (Refer to Chapter 7 "Planning of Environmental and Social Consideration Program" for in detail.)

There are four concerned factors in the pilot project.

(1) Proper use of sewer and drainage

a) High possibilities of accidents by drainage misuse

- ✓ If people living over the sea use a toilet and a kitchen as ever, garbage and/or waste may be drained into pipe and sewer. As a result, the drain pipe might be clogged up.
- ✓ Inflow of bad wastewater quality such as boiling water, chemicals and metals can cause damage to sewer and treatment plant.

b) Education and awareness to the residents

Functional security and prevention of damages to sewerage facilities are high priority.

- ➢ Not to discharge garbage and kitchen waste into drainage.
- ➢ Not to use non-water-soluble such as a newspaper instead of a toilet paper.
- ➢ Not to discharge metals and chemicals into drainage due to difficulty to treat these substances.

c) Reference of the draft discharge standard for sewerage issued by EDA RANU

There is a draft discharge-standard which is established to restrict drainage of wastewater, since inflow of bad wastewater quality can cause damage to sewer and treatment facilities. This draft standard is the guideline limiting drainage of liquid trade (commercial) waste. It is not for domestic wastewater, further, all discharges must meet the acceptance standard. The draft guideline limits for acceptance of liquid trade waste is shown in **Table 6.8.1**.

However, the draft guideline can be referred as avoidance of domestic drainage misuse by residents as well. Parameters for temperature and oil & grease from guidelines are available for domestic and easy to understand for residents.

Explanation of restrict main discharging substance to residents is shown in **Table 6.8.2**.

Table 6.8.1 Guideline Limits for Acceptance of Liquid Trade Waste
- General Acceptance Guidelines -

Parameter	General Acceptance Guidelines
Flow rate	The maximum daily and instantaneous rate of discharge (kL/h or L/s) is set on the available capacity of the sewer. Large dischargers are required to provide a balancing tank to even out the load on the wastewater treatment works.
BOD_5 and **Suspended Solids (SS)**	Normally, approved at 300 mg/L each. Concentration up to 600 mg/L and in some cases higher concentration for low mass loadings may be acceptable if the treatment works have sufficient capacity and odour will not be a problem.
COD	Normally, not to exceed BOD_5 by more than three times. This ratio is given as a guide only to prevent the discharge of non-biodegradable waste.
TDS	Up to 4000 mg/L may be accepted. However, the acceptance limit may be reduced depending on available effluent disposal options and will be subject to a mass load limit.
Temperature	Less than 38℃
pH	Within the range 7.0 to 9.0
Oil and Grease	100 mg/L if the volume of the discharge dose not exceed 10 % of the design capacity of the treatment works, and 50 mg/L if the volume is greater than 10 %.
Detergents	All industrial detergents are to be biodegradable. A limit on the concentration of 50 mg/L (as MBAS) may be imposed on large liquid trade wastes.
Colour	No visible colour when the waste is diluted to the equivalent dilution afforded by domestic wastewater flow.
Radioactive Substances	The discharge must comply with standards specified by the PNG Department of Environment and Conservation.

Source: Port Moresby Trade Waste Policy (DRAFT), EDA RANU, December 2008

Table 6.8.2 Example for Explanation of Restrict Discharging Substance to Residents

Parameter	Guidelines[1)]	Explanation for Proper Usage to Residents
Temperature	Less than 38 ℃	Not to discharge hot-water /boiling water
Oil and Grease	100 mg/L	Not to discharge much cooking oil
Suspended Solids (SS)	Normally 300 mg/L Maximum 600 mg/L	Not to discharge garbage and kitchen waste

Source: 1) Port Moresby Trade Waste Policy (DRAFT), EDA RANU, December 2008

(2) Prohibition of seawater usage

a) High possibilities of accidents by seawater

The residents may use seawater for flushing toilets due to unwillingness to pay for water charge.

- ✓ The usage of seawater can damage and deteriorate the sewerage facilities, RC and steel structures and the biological activity of Sewage Treatment Plant (STP) in particular due to chlorine ion contained in seawater.

b) Education and awareness to the residents

- Not to use seawater for a flushing toilet.

(3) Needs to pay for water and sewerage charges

After completion of the pilot project, the obligation for payment will be imposed on the residents for water and sewage service charges. It is necessary to implement clarification activities and awareness program to target residents since the residents have never before had to pay such charges.

a) High possibilities of improper use of facilities

- ✓ To curb (restrain) illegal water connections.
- ✓ To remove a water meter.
- ✓ To neglect leakage of water from service pipes without repairing.

b) Education and awareness to the residents

- Comprehension of need for proper maintenance and operation of the water supply and sewerage facilities
- Water leakage is obviously wasting water, and causes low pressure.
- All bills for water and sewerage rates are to be paid within 14 days of billing. Failure to pay accounts within the stipulated period may lead to the service being disconnected and debt recovery action being taken. (source: *Notes to accompany Schedule 2 EDA RANU 2011 Water and Sewerage Tariffs*, clause 18)

(4) Mitigation of Inhabitant's complaints and conflicts between the beneficiaries and non-beneficiaries.

Non-beneficiaries may complain and/or conflict with other beneficiaries living on the same jetty or other jetties as their living environment will be selectively improved by the pilot project.

- To explain the future implementation plans or the master plan for other residents who live the same area.
- It is necessary to disseminate educational material and conduct awareness campaigns to target residents to promote the proper use of facilities and improvement of lifestyles.

CHAPTER 7 PLANNING OF SOCIAL AND ENVIRONMENTAL CONSIDERATION PROGRAMS

7.1 Background

The Environmental and Social Consideration Programs for the Detailed Design Study of Port Moresby Sewerage System Upgrading Project (POMSSP) is designed to support the infrastructure component of POMSSUP in order to maximize the benefits that can be derived from the project through heightened awareness on health and water pollution problems and its solutions. Consequently, it aims to enhance the health and lifestyle of the inhabitants and the improvement of environmental quality, especially on the marine environment.

The Government of Papua New Guinea (GoPNG) has made considerable improvements in the provision of water supply to the service area during the last decade. However, in water villages and informal settlers' areas, access to safe and reliable water supply as well as proper sanitation facilities and sewerage services still remains a major challenge. As a significant number of the households in these areas has no basic sanitation facilities such as toilets, people here mostly rely on the "drop method" with some children often practicing open defecation.[1]

The resulting effect is gross water pollution, which is compounded by the indiscriminate dumping of solid wastes together with both poor hygiene and sanitation conditions. It was reported for Hanuabada/Elavala (April 2010-January 2011) in the National Capital District (NCD), that two cases out of five deaths were due to cholera.[2] During this period, the majority of the suspected cases, about 540 (17%) out of 3,214 cases also came from Hanuabada/Elavala, the highest figure in the NCD.[3] This disease burden is directly attributable to the environment, including risks associated with unsafe water, lack of sanitation and poor hygiene.

To maximize the benefits that can be derived from this Project, social and environmental considerations were taken into account. Through an integrated approach involving sewage management and heightened awareness of health and water pollution problems and its solutions, the Project intends to increase coverage and effectiveness of water supply and sewerage services in the water village of Hanuabada through a pilot project designed to provide a safe and reliable water supply and sanitation services to 20 households. The Project also establishes the technical and financial viabilities of new approaches for sewage management in the water village areas. To reinforce hygiene promotion, a cholera management program will also be included.

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[1] Personal observation.
[2] Line listing from National Capital District Provincial Health, 2010.
[3] Ibid. Includes only symptomatic cases, estimated total number infected with cholera on NCD was 16,070.

Another consideration is the possible social/health impact of HIV and AIDs to the construction workers in the campsite and the surrounding communities during the construction phase of the Project. EDA RANU has a Workplace Policy on HIV and AIDS management as called for in PNG's law and policies. As a pioneering initiative of EDA RANU and reinforcing the policy to minimize the risk of HIV infection on these vulnerable groups, a Detailed Implementation Plan for an HIV and AIDS Prevention Program is being formulated. Sustaining EDA RANUs' commitment through the workplace awareness and prevention program will be a source of accurate information aimed at construction workers as well as the surrounding communities on HIV and AIDS.

The Enabling Environment

A number of related environmental protection laws spell out the basic principles and institutions of environmental protection in the PNG. Their implementation is supported by implementation regulations, policies and guidelines issued by the relevant ministries. In addition, national environmental standards and environmental protection plans are important components of the legal and administrative framework. These landmark laws, regulations and policies are as follows:

- Environmental Act 2000 (As amended 2002)
  - Environmental (Water Quality Criteria) Regulation 2002
- Environmental Planning Act 1998
- Water Resources Act 1982
- Public Health Act 1973
  - Public Health Regulation (Sanitation and General) 1973
  - Public Health (Infectious Diseases) Regulation 1973
  - Public Health (Sewerage) Regulation 1973
  - Public Health (Drinking Water) Regulation 1984
- HIV/AIDS Management and Prevention Act 2003
- National Capital District Commission Act 2001
- National Capital District Water Supply and Sewerage Act 1996

Policies

- National Poverty Reduction Strategy 2003 – 2020

  The provision of safe water supply and adequate sanitation has been incorporated into the National Poverty Reduction Strategy (2003 – 2020) as an immediate development goal. It recognizes that lack of a constant supply of safe drinking water in both urban and rural villages contributes to poverty.
- National Health Plan 2001 – 2010

  The National Health Plan 2001 – 2010 aims to achieve a national target of 50% coverage for safe drinking water by 2010. Policy directions and priorities on health protection provide the following general provisions for Water Supply and Sanitation, among others: water quality monitoring; a community-driven maintenance of water supply and sanitation; safe disposal of

human and animal wastes as an integral part of water supply; and provision of safe water supply and sewerage systems**.**

- PNG National Strategic Plan on HIV/AIDS 2011 – 2015 and PNG National HIV and AIDS Strategy 2006 – 2010

  The PNG National HIV and AIDS Strategy 2006 – 2010 has recently been superseded by the PNG National Strategic Plan on HIV/AIDS 2011 – 2015. The new strategic plan provides a strong focus on scaling-up a comprehensive prevention response, moving beyond awareness and prioritizing evidence-informed interventions. One of the policy directions is towards a comprehensive approach through the maxim "change behavior" in the areas of reduction of the number of concurrent sexual partners, delaying the sexual debut of young people, and promoting correct and consistent condom use especially for those at higher risk of HIV.

7.2 Approach and Methodology

7.2.1 Objectives

The overall objective is to prepare Social and Environmental Consideration Programs to alleviate the poor environmental conditions of the near-shore village inhabitants as well as to prevent the spread of HIV and AIDS. Social considerations aim to advocate a coherent approach in securing water supply and sanitation services that addresses existing issues and conditions and innovative approaches to address these issues for the sustenance of human well-being. Environmental considerations aim to promote the coordinated development and management of water, land and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital eco-systems.

Specifically, the following Programs will be prepared and implemented:

- A Social and Environmental Education Training Program for the Pilot Project in Hanuabada water village to supply safe water and sewerage services for 20 households; and
- A Detailed Implementation Plan of a workplace program for the prevention of HIV/AIDS as part of the Contractors' Plan/Contract.

7.2.2 Overall Approach

The need for appropriate programs designed for the acquisition of knowledge will contribute in ensuring efficient, effective and sustained operations of the facilities that are provided by the POMSSUP. The general approach adopted in this social awareness/environmental education programs will be stakeholders' training through focus group discussions (FGDs) for the target core issues, community meetings and educational seminars. The activities will involve the following:

- Identification of Social and Environmental Mitigation Measures

  The identification of mitigating measures has required close contact and input with the

stakeholders through cursory observations, questionnaire surveys, focus group discussions (FGDs) and key informant interviews (Basic Design Study 2011, Updated Feasibility Study 2010, SAPROF Study 2006).

- Participatory Approach and Stakeholders Involvement

  People participation and stakeholders' involvement would lead towards transparency and accountability in local governance. It can only be achieved in a community who is ready and willing to adopt change. On the other hand, willingness and readiness require interventions and decisive actions from the people who know and understand the process and at the same time are willing to be the catalyst of change and transformation. Through FGDs and community meetings/seminars that will be conducted in the pilot area and the campsite, stakeholder engagement in the development process is assured. It is a Government Policy that provision of basic social services including water supply and sanitation be driven by community participation (National Health Plan 2001-2010, Ministry of Health).

- Development and Implementation of the Social and Environmental Education Program for the Pilot Area in the Water Village of Hanuabada

  A training program will be developed and implemented to increase awareness on proper health and hygiene practices, the responsibility of maintaining the systems through efficient use of water, proper use of toilets and sewers, promotion of tariff charges for improvement of services, water-borne diseases, environmental management and others. Special mention is given to cholera control and management in which an epidemic just recently occurred. Prior to construction, a dialogue with the inhabitants of Hanuabada will be conducted to present the project as part of the social preparation process. This is intended to avoid any conflict with non-participants of the pilot project.

- Development of Information, Education and Communication Materials for the Pilot Area

  Through questionnaire surveys (Basic Design Survey 2011, SAPROF Study 2006), community diagnosis on the level of awareness, understanding, and the attitudes and behavior of the target partcipants on sanitation concerns as well as knowledge of environmental impacts was analyzed. Based on the analysis of the results of these surveys, IEC materials will have to be developed as part of the awareness campaign. Also, a Pre-consultation meeting will be conducted for all the inhabitants of the Hanuabada water village to promote appreciation and understanding of the pilot project. The presentation will cover the purpose of the POMSSUP and the Pilot Project, the selection process as well as the need for cooperation of the members of the community to ensure success of the project. In addition, the presenation will address potential complaints and conflicts that may arise due to the exclusion of some inhabitants from the chosen target households of the project.

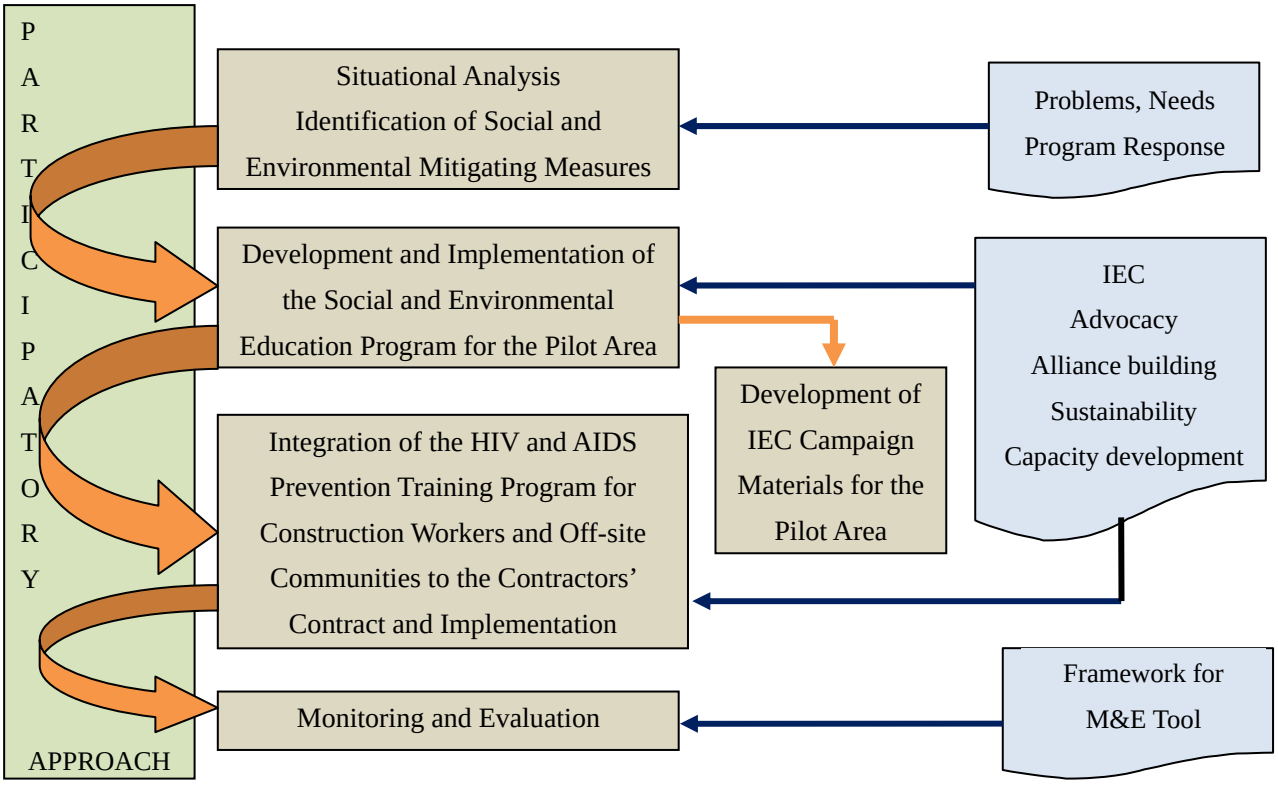
- Integration of the HIV and AIDS Prevention Training Program for Construction Workers and Off-site Communities to the Contractors' Contract and Implementation

  To promote prevention of HIV and AIDS in the workplace and to mitigate the social and economic impacts of the epidemic, a Detailed Implementation Plan of a workplace program

will be prepared. The Plan will be in conformity with the new national strategy plan (2011-2015) of GoPNG and offers practical programs to fight HIV and AIDS in the campsite and neighbouring communities. This Detailed Implementation Plan will be part of the Contractors' Plan/Contract and will be implemented by the Contractor and aimed at the construction workers and the residents in nearby areas of the campsite. The Contractor shall also conform to PNGs' laws and regulations applicable to HIV and AIDS and requirements specified in EDA RANUs' Workplace Policy[4] during the implementation of the Plan.

- Monitoring and Evaluation of the Program

  A monitoring and evaluation framework will be developed for the Implementation phase. This need is associated with selected criteria/indicators that will be the core measurement units in monitoring the success of both programs.



Over –all Approach of Social and Environmental Considerations Study

Source: JICA Study Team

[4] This policy was prepared in line with the PNG National Strategic Plan on HIV and AIDS 2006 – 2010 and is now being updated to conform with the new PNG National HIV and AIDS Strategy NHS), 2011 – 2015. The policy is expected to be finalized by June 2011. Meantime, the HIV and AIDS Prevention Training Program for this project adopts the top priority area of scaling up and improving the quality of prevention programs of the new NHS.

7.3 Main Problems and Challenges

The project has already conducted preliminary baseline assessments of the environmental as well as water and sanitation conditions of the Hanuabada water village (*Updated Feasibility Study, 2009*). These cover relevant data on sanitation and water assessments. Issues, gaps and measures were identified and formed the basis of this detailed study.

7.3.1 Health and Hygiene

The water village of Hanuabada is one of the water villages dotting the coastal waters of Port Moresby peopled by Motu-Koitas. The establishment of housing structures in these areas is authorized under customary law that is enacted in the national constitution of PNG. People living on customary land are permitted to build houses over the sea and connect to essential services like water, sewerage, electricity, telephone and television. However, the provision of these services is almost nil for water and absent for sewerage. [*The inset shows the water houses built over the sea with 3 to a high of 30 persons living in one housing structure.]*[5]

Untreated wastewater discharges affect human health through the spread of disease-causing organisms, such as gastro-enteritis, diarrhea, cholera, typhoid, and dysentery. Direct contact with polluted water may cause skin diseases and sore eyes. These affect work force productivity and consequently result in income losses to households. As was stated earlier, Hanuabada village had the highest percentage of cholera cases during the latest cholera outbreak. However, it was not reported as to whether the cause of this illness was related to water, food handling or the poor hygiene/environmental conditions. Approximately 83% of households believed that hygiene awareness and education was necessary (SAPROF 2006).

(1) Water Supply

Most of the houses built on stilts in Hanuabada have communal taps. In houses that have individual connections, these are improvised direct connections to the public water system (32%). About 36% used a standpipe located outside their house, 18% used tanker delivery, and 14% used rainwater collected in roof tanks (JICA Study 1998). [*The inset shows an improvised individual water supply connected to the public water system. In most cases, there is no control valve present which leads to wastage.]*

[5] House to House Survey, NCD Public Health – State of Emergency, Health Division, Community & Social Services Department, NCDC, June 2010.

The supply of water is not stable, and availability of water is only through a schedule set by EDA RANU and ease of getting water is not experienced by most of the inhabitants. The quality of the stored water is also subject to potential contamination since most of these containers are uncovered and located outside their houses. Meanwhile, a water system has two primary requirements: i) it needs to deliver adequate amounts of water to meet consumer consumption requirements including needed fire flow requirements; and ii) the water system needs to be reliable, the required amount of water needs to be available 24 hours a day throughout the whole year. *[The inset shows a typical way on how water is stored and left uncovered.]*

(2) Sanitation

Sanitation in this study refers to the hygienic and proper management, collection, disposal or reuse of human excreta (feces and urine) and community liquid wastes to safeguard the health of individuals and communities. In the case of Hanuabada village, the area is not connected to the sewerage system of the City. Most households have "drop type" toilets with no pits and therefore discharge directly into the water (sea). This type of toilet is considered as unsanitary and may lead to the transmission of diseases. Another method still being practiced by children is "open defecation", the lowest level of human waste disposal.

Untreated discharges also cause environmental pollution in the area; in the absence of appropriate disposal facilities the sea receives fecally contaminated wastewater. This is compounded during ebb tide when natural sea flows are minimal. Conversely, public health problems are created during high tide when the water table rises. Direct contact with contaminated water occurs when children play and swim as well as when fishermen wade in the water.

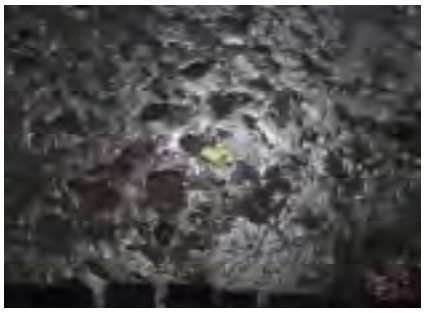
With these concomitant problems, the inhabitants in interviews indicated the need for a sewerage system and were even willing to pay for such a system (Updated FS 2010). The study also recommends conducting education and awareness campaigns to target residents and promote the need and proper use of facilities.

7.3.2 Environmental Degradation

The environmental condition in Hanuabada village is affected by waste disposal, both solid and liquid wastes. Its marine environment experiences severe stress due to organic pollution. Uncontrolled pollution comes from untreated domestic wastewater generated from toilets (feces, urine and water from bathing), laundry, cleaning, cooking, washing, and other household activities) and solid wastes being dumped directly

into the sea due to lack of systems in place to control environmental hygiene. When waste is not removed and treated properly, pollution leads to the spread of diseases. [*The inset shows the sea under the water houses near the shoreline entirely covered by trash due to indiscriminate dumping directly into the sea compounded by inadequate collection.*]

Due to this pollution, the sea is no longer productive. There is an almost total absence of fish and shells. The sea water is almost septic since there is little wave action and circulation. [*The inset shows the seabed further along the shore line already exhibiting blackish muck - an accumulation of organic pollution.*]



The need to improve the water quality of the sea through a reduction of domestic pollution loads must be ensured. The initiatives of NCDC to protect and improve the water quality must be supported by the inhabitants of the area.

7.4 The Proposed Social and Environmental Education Training Program for the Pilot Area of the Water Village in Hanuabada

7.4.1 Training Program

(1) Aim

To raise the level of awareness and concern of the participants about health and the total environment and its associated problems by providing knowledge, motivation and commitment to work individually and collectively towards the solutions of the current problems and the prevention of new ones.

(2) Target Audience

One member (woman or man) per participating household for a total of 20 household members

(3) Over-all Process/Design

The 20 households will be divided into two groups with each FGD participated in by 10 households. Participatory learning activities will be presented in four subject modules with each module to be conducted in one day. These four modules comprise: hygiene promotion; sanitation and systems' sustainability; health; and environmental management. Each module contains a sequence of educational information for each specific subject. Examples include personal hygiene, prevailing water-borne disease transmission routes, protecting and conserving marine water resources, and attitudes, behavior and norms towards payment for improved services and eventual improvement of lifestyle. Other than the formal education goals, focus will also be on the social life such as cooperation and mutual understanding and the linking and application of learning activities to the daily life of the participants.

During the FGDs, a variety of mediums will be used to convey the information such as : group discussions, demonstrations, role playing, stories, pictures and flip charts.

(4) Training Modules

There will be four (4) modules that will be developed:

- Training Module 1: *Hygienic Practices and Education & Promotion*

  Objectives

  i. To raise the level of knowledge awareness of the participants of good hygiene habits or practices to cover personal, domestic and environmental cleanliness.
  ii. To give an appreciation of the importance of everyone practicing good hand washing and to communicate effectively to others the value of hand washing at critical times.
  iii. To know the risks involve if personal hygiene is not maintained.

  Expected Results

  i. Improved hygienic behavior including hand washing that impact on health outcomes such as reduction in diarrhea, parasitic infections, morbidity and mortality.
  ii. Effective and replicable hygiene education strategies that promote behavior change and creating culturally acceptable and sustainable changes that benefit the health and well-being of the entire community.

- Training Module 2*: Human Wastewater Disposal Practices & Management and Facility Management (proper use of toilets, promotion of tariff for improvement of services - O&M fee)*

  Objectives

  i. To gain understanding of the characteristics, conditions, trends, issues and challenges of the water supply and sanitation sector including the role and responsibility of the community in water and sanitation development.
  ii. To adopt and promote desired environmental sanitation practices (excreta disposal, and liquid waste management.
  iii. To promote proper use of toilet facilities, the importance of paying a tariff for the maintenance of the system with ownership given to them.

  Expected Results

  i. Awareness of the issues and challenges on human waste-water disposal and the roles and responsibilities of each of the members of the community.
  ii. Development of understanding on the proper use and maintenance of the toilet facilities.
  iii. Willingness to pay for an improved service such as water and sewerage services.

- Training Module 3: *Water-borne Diseases including Cholera Prevention, Control and Management*

Objectives

i. To understand the source of infection, transmission (common routes), symptoms, prevention processes and treatment of water and sanitation related diseases including cholera.
ii. To understand the possible sources of contamination between the source and the mouth, about fecal-oral disease transmission, and the concept of germs.
iii. To communicate effectively to others about preventing water and sanitation related diseases as well as preventing and curing dehydration.
iv. To know the social and economic negative effects of contracting water and sanitation related diseases.

Expected Results

i. Receive knowledge and practices to reduce infections and deaths from water and sanitation related diseases.
ii. Encourage effective communication to others about water and sanitation related diseases.
iii. Impart knowledge on the social and economic consequences of water and sanitation related diseases.

- Training Module 4: *Solid Waste Management, Water Pollution/Water Quality Management and Its Impact on Health and Environment*

  Objectives

  i. To encourage active participation in community activities for environmental protection and conservation specifically on water quality management.
  ii. To identify negative implications of careless disposal practices and to develop the idea of waste as a resource.
  iii. To inform the participants on their responsibility to address water quality issues and encourage adoption of best practices on water quality management.
  iv. To increase accurate in-depth knowledge of the opportunities for better quality of life in relation to health and economic benefits by maintaining clean water bodies.

  Expected Results

  i. Environmental awareness and action towards a better environment.
  ii. Keeping the surroundings clean and reusing what is not thrown away.
  iii. Adopt best practices on water quality management.
  iv. Can outline environmental factors that result in water pollution that affect their health and cause negative economic impacts.

7.4.2 Public Information Program

The public information program in the water village of Hanuabada through IEC materials is designed not just as a passive activity disseminating information to the general public, but as an active way to

mobilize people and get them involved in hygiene, health and sanitation policies, and in advocating environmental (water) quality management initiatives in the Hanuabada village. This will serve to generate support from the inhabitants and help towards the implementation of an effective pilot project.

(1) Information

Relevant information dissemination will create general awareness of important aspects of hygiene, sanitation and health as well as environmental concerns. The current situation in relation to sanitation and its implications in relation to health, economy and environment including aesthetics of the community will be outlined. This will also include changes required in attitudes, behavior, and norms of the residents towards these aspects. Ensuring sustainability of the system will have to deal with promoting the need to pay for improved services (water and sewerage) and improved lifestyle.

(2) Education

This will involve increase knowledge towards better appreciation and understanding of the current situation and issues on water and sanitation by creating public interest to discuss these issues in relation to health, economic aspects, environment and aesthetics. This is also expected to develop community concerns to address the issues and implications with respect to water and sanitation as well as the sustainability of the systems involved.

(3) Communication

This will be a vehicle to influence attitude and encourage feedback mechanisms which will foster dialogue and interaction between the project participants by creating discussion groups through FGDs to address water and sanitation issues. Mobilizing people and resources to improve the current situation will facilitate mainstreaming water and sanitation concerns.

(4) Material for IEC

The IEC activities for POMSSUP also involve the preparation of a leaflet as an intervention material. The material would highlight the need to ensure clean water for public health and a sustainable environment. The leaflet would provide general information on how to prevent further deterioration of marine waters and other water quality management techniques/practices such as the provision of a sewerage system. As communication material, it is expected to increase exposure on the benefits derived from better water quality management. The brochure/leaflet would have the following features:

- 1,200 copies produced
- Paper dimension A5 (215mm × 148mm) on colored paper
- Back to back printing: 1 panel on each side

(5) Pre-consultation Meeting

This dialogue will provided a venue for the inhabitants of Hanuabada to have a better understanding and appreciation of the POMSSUP and the pilot project. The purpose of the project, selection

process, and the need for cooperation by all residents to achieve successful implementation of the pilot project will be presented.

7.4.3 Implementation Arrangements

The Program will be implemented by IPBC/EDA RANU in cooperation with Motu-Koita Assembly and the Health Department of NCDC. IPBC/EDA RANU will provide the overall coordination and financial requirements, Motu-Koita Assembly will facilitate the mobilization of the participants and provide the venue for training, and the Health Department will provide the training materials and trainers.

7.5 The Proposed Detailed Implementation Plan for the HIV and AIDS Prevention Program for Construction Workers and Off-Site Communities

7.5.1 Workplace HIV and AIDS Policy of EDA RANU and Relevant GoPNGs Policies

(1) Salient Features

In line with the seven focus areas in the PNG National Strategic Plan (NSP), 2006 – 2010, EDA RANU identified four of these as priority areas in developing its Workplace Policy on HIV/AIDS namely: i) Employment Conditions and Rights; ii) Treatment and Care; iii) Awareness and Prevention; and iv) Implementing and Monitoring. This policy is now being updated to conform with the new PNG National HIV and AIDS Strategy (NHS), 2011 – 2015. The policy is expected to be finalized by June 2011. Meantime, this HIV and AIDS Prevention Training Program adopts the top priority area of scaling up and improving the quality of prevention programs of the new NHS.

(2) Current HIV and AIDS Prevention Program of EDA RANU

EDA RANU implements the following in its effort to support the GoPNGs' coordinated response to confront and take up the fight against HIV and AIDS in the country.

- Employment Conditions and Rights
  Executes no discrimination policies towards persons/employees who are affected with HIV and AIDS including gender discrimination and testing; ensuring confidentiality and privacy; recognizing work performance and the right to reasonable accommodation; addressing termination of employment; as well as promotion of employees' well-being.
- Treatment and Care
  Provides access to treatments; health benefits; and care and support to all employees; As a preventive measure, EDA RANU provides free annual medical check-ups.
- Awareness and Prevention
  Conducts awareness programs consisting of regular seminars/trainings and referrals in cooperation with the Business Coalition Against HIV and AIDS (BAHA) on risk factors, post exposure prevention, personal responsibility and occupational health and safety; and promotion of safe sex including providing distribution counters for free condoms in the two offices.

- Implementation and Monitoring
  Undertakes workplace HIV and AIDS prevention coordination, preparation of annual activity plan and budget; and implementation and communication activities

(3) The New PNG National HIV and AIDS Strategy, 2011 – 2015

The new PNG National Strategic Plan (NHS), 2011 – 2015 provides a strong focus on "behavior change" by scaling-up a comprehensive prevention response and moving beyond awareness and prioritizing evidence-informed interventions. The three major priority areas are: i) scaling up and improving the quality of prevention programs; ii) counseling, testing, treatment, care and support services; and iii) systems strengthening. Behavior change[6] as a focal point in the success of the prevention program must consider the unique cultural and socio-economic environment of PNG, and especially the prevailing complex gender issues.

The comprehensive approach includes, among others, the reduction of the number of concurrent sexual partners, delay on the sexual debut of young people, and promotion on the correct and consistent condom use, especially for those at higher risk of HIV. Along this line, strategic priorities have been developed and two of these strategies for prevention will be pursued in this program, namely:

- Create supportive and safe environments for HIV prevention - HIV prevention in the workplace and in economic enclaves. Mainstreaming HIV prevention through workplace policy development and the promotion and provision of workplace HIV education programs such as increased awareness and understanding of contributing factors, driving forces and behaviors that contribute to the risk of HIV and other sexually transmitted infections (STIs); and
- Reduce the risks of HIV transmission – Sexual transmission of HIV and STIs. Significant improvement in the availability and accessibility of condoms through condom social marketing and distribution (this must include addressing stigma, myths and misinformation around condom use).

7.5.2 The Proposed HIV and AIDS Prevention Training Program for Construction Workers and Neighbouring Communities

(1) Rationale

The Training Program supports the provision of HIV and AIDS prevention services for construction workers and neighbouring communities on a pilot basis to develop a model intervention package for the projects of IPBC/EDA RANU. As stated earlier, HIV and AIDS interventions that can be provided include innovative educational and behavior change communication (BCC) campaigns and

[6] Personal communication with Director Wep Kanawi, National AIDS Council Secretariat.

social marketing of condoms. Sponsorship of community HIV and AIDS prevention activities not only contributes to corporate social responsibility and credibility but also adds to other initiatives to change social norms and beliefs which IPBC/EDA RANU have been conscientiously pursuing.

As such, IPBC/EDA RANU will provide guidance to its Contractors on the implementation of the programs as reflected in the Contractors' Contract. Prior to implementation of the training program, IPBC/EDA RANU will require all contractors to attend a one-day workshop on its HIV and AIDS workplace policies and programs.

(2) Aim

- To help contain the spread of HIV and AIDS in the workplace and surrounding communities to mitigate the social and economic impact of the epidemic.
- To improve the knowledge base and practices for the effective implementation of HIV and AIDS prevention interventions in IPBC/EDA RANU projects.
- In the implementation of the Plan, the Contractor shall conform to PNGs' laws and regulations applicable to HIV/AIDS and requirements specified in EDA RANUs' Workplace Policy.

(3) Target Audience

All construction workers, both skilled and unskilled, of the Project and the surrounding communities of the construction sites at the Kila Kila STP[7]

(4) Overall Process/Design

A series of four training sessions is designed for a period of 4 days and will be attended by about 40 to 50 participants. Each training session (one module per session) will be carried out and will be completed within one-day. For construction workers, the frequency can be that each of the four training sessions be conducted once a week. For the communities, a 2-day session in a month is appropriate to give more time for the local communities to attend to their personal economic activities.

The course conveys teaching messages mainly through interactive practical work by participants. Hands-on learning will focus on fictitious situations based mainly on real life conditions and challenges. The activities of the training modules involve aspects such as self-awareness, handling interpersonal relationships, coping with emotions and stress, critical and creative thinking, decision making, problem solving, communication, and empathy.

The training modules have activities that focus on the following: i) to correct misconceptions; ii) to influence high-risk behavior related to condom use and alcohol consumption; and iii) to build skills to help reduce risk taking behavior.

[7] During this stage, the number of construction workers has not yet been estimated.

(5) Training Modules[8]

There will be four modules that will be implemented:

- Training Module 1: *Basic Information on Reproductive Health and Information on HIV/AIDS and STI*

  Objectives

  i. To increase the participants' understanding when talking about reproductive organs, sexual behavior, and how that behavior is related to the spread of the virus
  ii. To provide information on HIV/AIDS/STI and the services available in their area

  Activities

  - Activity 1 – *Our Body*

  This activity prepares participants to feel more comfortable in talking about sexual activities by helping them find familiar terms for sexual organs, terms they can use throughout the training sessions. It provides information on male and female reproductive organs. This will help participants get a better understanding when talking about sexual behavior and how it is related to the spread of the virus.

  - Activity 2 – *Transmission of HIV*

  Introduces the HIV and AIDS issues. This is to gauge how much the participants already know about HIV and AIDS and understanding of high-risk behaviors for contracting HIV such as the reduction of the number of concurrent sexual partners and delay in the sexual debut of young people.

  - Activity 3 – *Persons who are HIV Positive and Sexually Transmitted Infection Identification*

  This set of activities provides information that anyone can be infected with HIV, and that it depends on their behavior, not on age, gender, or profession. It further provides understanding that they cannot self-diagnose sexually transmitted infections (STIs) and that self-treating STIs may cause drug resistance.

  - Activity 4 – *Risk Assessment*

  This activity seeks to convey an understanding of the body's orifices and bodily fluids related to HIV infection. It also provides opportunities to practice HIV risk assessment. It educates participants on the mechanism of HIV and the human body's immune system.

[8] Training modules adopted from the Asian Development Bank, 2009: For life, with love: training tool for HIV prevention and safe migration in road construction settings and affected communities.

- Activity 5 – *The Use of Condoms and Where to Find Condoms, Places providing HIV Testing and STI Check-ups in the Community*

Reviews information about condoms and HIV and AIDS, and assesses participants' attitudes. Participants identify where to find condoms and places providing HIV testing and STI checkups in their communities.

- Activity 6 – *Consequences of HIV Infection*

This activity presents an opportunity to learn about the consequences of HIV infection, especially the economic costs pertaining to the medicines, which results in having less money to support the family.

- Training Module 2: *HIV/AIDS and Attitudes*

Objectives

i. To have participants examine the pros and cons of attitudes contributing to using or not using condoms.
ii. To inform participants about the effect of alcohol on condom use.

Activities

- Activity 1 – *Reasons for Using or Not Using Condom*

This activity encourages participants to look at the positive and negative effects of attitudes toward condom use

- Activity 2 – *Effects of Alcohol*

This activity informs the participants about the effects of alcohol and how this increases the risk of HIV infection, especially when they decide to have sex and are unable to use a condom correctly.

- Training Module 3: *Communication and Dealing with Relationships to Reduce Risky Behaviors*

Objective

i. To build skills of critical and creative thinking, problem solving, decision making, and communication that will help contribute to the reduction of risky behavior.

Activities

- Activity 1 – *Logical Thinking, Problem Solving and Decision Making Formula*

This activity trains participants to practice their logical thinking skills and analyze the cause and effect of their actions. It will help participants learn about problem solving and decision making and provide the opportunity to practice the skills learned.

- Activity 2 – *Assessing Levels of Closeness and Risk*

  This activity seeks to provide the participants with learning on how to assess appropriate levels of intimacy with the opposite sex as well as on how to assess their high-risk behavior, especially their risk of HIV infection.

- Activity 3 – *Types of Communication*

  This activity increases participants' understanding of differences between the three types of communication—aggressive, passive, and assertive and prepares participants to practice communication skills for negotiation or refusal.

- Training Module 4: *Living with People with HIV*

  Objective

  i. To promote acceptance of people living with HIV/AIDS.

  Activities

  - Activity 1 – *I am HIV Positive*

    This activity raises participants' awareness about tolerance for persons living with HIV (PLHIV) and to help them realize how it feels to be discriminated against.

  - Activity 2 – *Basic Health Care for Persons Living with HIV*

    This activity provides an understanding of basic health care for PLHIV.

  - Activity 3 – *Needed Actions to Support PLHIV*

    This activity encourages participants to think of actions and/or contributions they can make to provide PLHIV with necessary support.

7.5.3 The Social Marketing and Distribution of Condoms

The second strategic priority for the prevention of transmission is making condoms available and accessible around the workplace and encouraging availability in shops of the surrounding communities. This activity must be supported by the training program that addresses stigma, myths and misinformation around condom use (Modules 1 and 2). Sexual transmission is the primary HIV transmission mechanism. Condoms can prevent infection by reducing the likelihood of transmission during sexual intercourse.

A two-pronged approach will be adopted in the implementation of this program: i) condom promotion in targeted distribution points and education/awareness training that encourages the use of condoms; and ii) distribution where condoms will be free of charge to the target groups in cooperation with BAHA. Condom promotion must be associated with behavioral change communication, e.g., sexual behavior.

Potential downsides of this intervention are increased sex frequency and an increase in high-risk sexual activities. This however can be mitigated through the available training/awareness program that will be implemented for the target groups.

7.5.4 Detailed Implementation Plan

This Detailed Implementation Plan for the HIV and AIDS Prevention Program has set of specific objectives and list of actions to be undertaken with output indicators, timetable, in-charge of the implementation, supporting laws and possible source of funds for the two strategic priority areas of interventions.[9] The Plan is divided into general and specific objectives indicating priority actions. The goal, ultimately, is to see that the proposed actions are implemented during the construction stage of the project. **Table 7.5.1 S**ummarizes the Detailed Implementation Plan for the HIV and AIDS Prevention Program.

7.5.5 Implementation Arrangement

In order to optimize available opportunities in the prevention of HIV and AIDS, the existing organizations working in the sector, NACS and BAHA must be coordinated by IPBC/EDA RANU during the implementation of the programs. NACS and BAHA have technical knowledge and experience regarding HIV/AIDS prevention in PNG. Currently EDA RANU is working together with BAHA in the operationalization of its workplace policy. Together with the Consultant, IPBC/EDA RANU may also get the services of NACS and BAHA to monitor the implementation of the programs.

The Consultant will prepare the bid documents to include the HIV/AIDS programs in coordination with IPBC/EDA RANU. The progress of the implementation will also be monitored by the Consultant in cooperation with IPBC/EDA RANU. The Consultant will report on the progress to JICA as part of the Monthly Progress Report.

The Contractor is responsible for executing the HIV/AIDS programs as provided for in the contract document. These programs are part of the Contractors' contract document. A reporting system to track the progress of implementation will have to be drawn up by both the Contractor and IPBC/EDA RANU. The Contractor may opt to hire the services of an NGO for the conduct of the training programs.

[9] No preliminary cost has been drawn up since it will be the responsibility of the Contractor to provide the detailed estimated cost.

Table 7.5.1 Detailed Implementation Plan for the HIV and AIDS Prevention Program

Problem : *High incidence of HIV and AIDS*

Objective 1 : Mainstreaming HIV prevention through provision of workplace HIV education/training programs such as increased awareness and behavioral change communication to the construction workers and neighbouring communities.

Specific Objectives	Actions	Sub-actions (Activity)	Output	Time Table	Implementation In-charge	Possible Source of Funds
1) To increase participants' understanding when talking about reproductive organs, sexual behavior, and how that behavior is related to the spread of the virus. 2) To provide information on HIV/AIDS/STI and services available in their area.	Training on Basic Information on Reproductive Health and Information on HIV/AIDS and STI	1) Our Body Prepares participants to feel more comfortable talking about sexual activities by helping them find familiar terms for sexual organs, terms they can use throughout the training sessions. Provides information on male and female reproductive organs. Participants get a better understanding when talking about sexual behavior and how it is related to the spread of the virus.	Knowledge/awareness of the functions of reproductive organs and sexual behavior and how it is related to the spread of the virus.	2013-2015	Contractor with supervision from IPBC/EDA RANU and NACS/BAHA. Consultants to monitor progress of implementation with reporting to JICA.	Part of Contractors' Contract
		2) Transmission of HIV Introduces the HIV and AIDS issues. This is to gauge how much the participants already know about HIV and AIDS and their understanding of high-risk behavior for contracting HIV such as the reduction of the number of concurrent sexual partners	Knowledge/awareness of HIV and AIDS issues and understanding of high-risk behaviors for contracting HIV.	-do-	-do-	-do-

Specific Objectives	Actions	Sub-actions (Activity)	Output	Time Table	Implementation In-charge	Possible Source of Funds
		and delay on the sexual debut of young people.				
		3) Persons who are HIV Positive and Sexually Transmitted Infection (STI) Identification Provides information that anyone can be infected with HIV, and that it depends on their behavior, not on age, gender, or profession. Provides understanding that they cannot self-diagnose sexually transmitted infections (STIs) and that self-treating STIs may cause drug resistance.	Knowledge/awareness on how to identify HIV positive persons and with STI	2013-2015	Contractor with supervision from IPBC/EDA RANU and NACS/BAHA. Consultants to monitor progress of implementation with reporting to JICA.	Part of Contractors' Contract
		4) Risk Assessment Understanding of the body's orifices and bodily fluids related to HIV infection and provides opportunities to practice HIV risk assessment. It educates on the mechanism of HIV and the human body's immune system.	Knowledge/awareness on how to practice risk assessment	-do-	-do-	-do-
		5) The Use of Condoms and Where to Find Condoms, Places providing HIV Testing and STI Check-ups in the Community	Knowledge/awareness on the attitudes and use of condoms	-do-	-do-	-do-

Specific Objectives	Actions	Sub-actions (Activity)	Output	Time Table	Implementation In-charge	Possible Source of Funds
		Reviews information about condoms and HIV and AIDS, and assesses participants' attitudes. Participants identify where to find condoms and places providing HIV testing and STI checkups in their communities. 6) Consequences of HIV Infection Presents an opportunity to learn about the consequences of HIV infection, especially the costs of medicine, which results in having less money to support the family.	Knowledge/awareness on the effects of HIV infection	2013-2015	Contractor with supervision from IPBC/EDA RANU and NACS/BAHA. Consultants to monitor progress of implementation with reporting to JICA.	Part of Contractors' Contract
1) To have participants examine pros and cons of attitudes contributing to using or not using condoms.	Training on HIV/AIDS and Attitudes	1) Reasons for using or not using condoms Encourages participants to look at the positive and negative effects of attitudes toward condom use	Awareness on the effects on attitudes towards condom use.	2013-2015	Contractor with supervision from IPBC/EDA RANU and NACS/BAHA. Consultants to monitor progress of implementation with reporting to JICA.	Part of Contractors' Contract

Specific Objectives	Actions	Sub-actions (Activity)	Output	Time Table	Implementation In-charge	Possible Source of Funds
2) To inform participants about the effect of alcohol on condom use		2) Effects of alcohol Informs the participants about the effects of alcohol and how this increases the risk of HIV infection, especially when they decide to have sex and are unable to use a condom correctly.	Knowledge/awareness on the use of alcohol and its effects on increasing the risk of HIV infection.	-do-	-do-	-do-
1) To build skills of critical and creative thinking, problem solving, decision making, and communication that will help contribute to the reduction of risky behaviors	Training on Communication and Dealing with Relationships to Reduce Risky Behaviors	1) Logical Thinking, Problem Solving and Decision Making Formula Trains participants to practice their logical thinking skills and analyze the cause and effect of their actions. Helps participants learn about problem solving and decision making and the opportunity to practice the skills.	Skills on critical thinking and decision making.	2013-2015	Contractor with supervision from IPBC/EDA RANU and NACS/BAHA. Consultants to monitor progress of implementation with reporting to JICA	Part of Contractors' Contract
		2) Assessing Levels of Closeness and Risk Provides the participants with learning on how to assess appropriate levels of intimacy with the opposite sex as well as on how to assess their high-risk behavior, especially their risk of HIV infection.	Knowledge on assessing high risk behavior	2013-2015	-do-	Part of Contractors' Contract
		3) Types of Communication Increases participants' understanding of	Knowledge and skills on communication	-do-	-do-	-do-

Specific Objectives	Actions	Sub-actions (Activity)	Output	Time Table	Implementation In-charge	Possible Source of Funds
		differences between three types of communication—aggressive, passive, and assertive and prepares participants to practice communication skills for negotiation or refusal				
1) To promote acceptance of people living with HIV/AIDS	Training on Living with people with HIV	1) I am HIV Positive Raises participants' awareness about tolerance for persons living with HIV (PLHIV) and to help them realize how it feels to be discriminated against.	Awareness and acceptance of PLHIV	2013-2015	Contractor with supervision from IPBC/EDA RANU and NACS/BAHA. Consultants to monitor progress of implementation with reporting to JICA	Part of Contractors' Contract
		2) Basic Health Care for Persons Living with HIV Provides an understanding of basic health care for PLHIV.	Awareness on health care for PLHIV	-do-	-do-	-do-
		3) Needed Actions to Support PLHIV Encourages participants to think of actions and/or contributions they can make to provide PLHIV with necessary support	Knowledge on how to support PLHIV	-do-	-do-	-do-

Objective 2 Reduction of risks of HIV transmission through significant improvement in the availability and accessibility of condoms.

Specific Objectives	Actions	Sub-actions (Activity)	Output	Time Table	Implementation In-charge	Possible Source of Funds
1) Condoms available and accessible around the workplace and nearby communities	Promotion	Condom promotion in targeted distribution points and education/awareness training that encourages the use of condoms	Behavioral change communication	2013-2015	Contractor with supervision from IPBC/EDA RANU and NACS/BAHA. Consultants to monitor progress of implementation with reporting to JICA.	Part of Contractors' Contract
	Distribution	Condom distribution to the target groups	Condoms available free of charge at strategic points in the workplace and shops in the communities	2013-2015	Contractor with supervision from IPBC/EDA RANU and NACS/BAHA. Consultants to monitor progress of implementation with reporting to JICA.	Part of Contractors' Contract

CHAPTER 8 Training Program for Personnel of Operation and Maintenance

EDA RANU has long experience in implementation of Operation and Maintenance (O/M) for the existing sewerage system in Port Moresby as one of the main responsibilities of its Sewerage Operation Division.

Current O/M Activities by EDA RANU are as follows:

STPs

- Inspection of facilities is carried out twice a week in principle. Basically, O/M works are contracted out as long as the budget is secured. The contract period is six months. However, if the budget is not available, the O/M work is done by the staff of EDA RANU This work includes removal and disposal of screenings, overgrown macrophytes (water lilies) in the ponds and mowing grass, etc.
- Due to budgetary constraints, dredging of the ponds has never been implemented so far. If the budget were to be secured, the works would be contracted out.
- The water quality of sewage is measured on a once monthly basis. The parameters measured include BOD, SS and Faecal Coliform. Nitrogen, phosphorus and oil & grease are not measured. Of the parameters listed above, the EDA RANU laboratory can measure only SS; other parameters are measured by out-sourcing. When the treated water quality has deteriorated significantly, the information is notified to all O/M staff and the cause of the deterioration is investigated.
- It is believed that most industrial wastewater is discharged into the sewerage system in the inland area in particular, if illicit industrial wastewater discharge is found, giving warnings to the factory concerned is the only countermeasure resorted to. However, no organization including DOH (Department of Health), DEC (Department of Environment and Conservation, has the actual data of industrial wastewater quality and quantity discharged into sewers. In addition, no organization has the appropriate equipment and capability of actually making the necessary measurements.

Pump Stations

- The frequency of inspection is once weekly. The inspector has a duty to report the inspection result to the Manager. However, a suitable checklist for inspection has not been prepared.
- EDA RANU outsources repairs for the pump units and for electrical works. EDA RANU even has no basic inspection equipment such as megohmmeters, vibration pens, etc., to check mechanical and electrical conditions at their facilities .

When a breakdown of the pump occurs, repair works are consigned to local companies. The period needed for the repair depends on a degree of the fault. If some important parts need to be changed, it may take more than six weeks for the repair since the parts have to be imported from Australia.

Sewers

- Periodical sewer cleaning is not carried out, and sewers are cleaned only in cases when customers complain about pipes clogging. The Base Room of the Division receives all complaints from customers and each complaint is summarized in a prescribed form. After following these procedures, the staff visits the site for inspection followed by the dispatch of a repair crew. The repair records are then documented and kept in the Division.
- The sewer cleaning works are implemented manually using the Rod. There is no particular machinery other than the manual Rod for carrying out O/M works.

From the facts mentioned above, it is clear that the current O/M activities carried out on the sewerage system by EDA RANU is neither appropriate or sufficient for the O/M of the proposed OD (Oxidation Ditch) wastewater treatment system because of the staff lack any conception of systematic operation and preventive equipment maintenance.

The OD system proposed for the Project is a more sophisticated treatment process and it needs more careful and skilled O/M technology compared to the existing stabilization pond system. O/M staff of the STP section in EDA RANU therefore need to be fully knowledgeable and trained properly in the area of sewage treatment by the OD system.

In this context, the following O/M training programs by skilled engineers from Japan and a third country needs to be implemented.

- Management of the Treatment Process/Pumping Station
- Pipeline Management
- Asset Management
- Water Quality Analysis

The training program shall consist of both classroom training and on-the-job training (OJT). It shall be implemented both in Japan and in Papua New Guinea by using JICA training courses. Before OJT in Papua New Guinea, training manuals, draft of SOPs (Standard Operation Procedures) with recording formats with appropriate instructions of how to use the data and information for evaluation shall be prepared. These shall be reviewed and modified where necessary during OJT in Papua New Guinea.

Classroom training on basic knowledge on sewage treatment and sewerage systems shall be provided in Papua New Guinea for all the staff and then long-term OJT training shall be implemented for the staff who have already acquired the basic knowledge, by using the commissioned sewerage facilities in Papua New Guinea.

In addition, relevant maintenance of main equipment such as blowers, sludge pumps, etc., will be

trained at the equipment manufacturers factories with the cost burden borne by the manufacturers.

The following outlines the contents of the training for each section.

8.1 Management of Treatment Process/Pumping Station

8.1.1 Management of Treatment Process

Basic knowledge on the OD process, including the differences among conventional activated sludge process, OD process and natural pond system, and equipment components with their roles/functions shall be provided through classroom training. The OJT for the treatment process shall include training for operation and control, water quality testing, inspection, recording and preventive maintenance, sludge disposal, trouble shootings, safety measures, etc. Specifically, practical training on optimized operation of reactor (OD tank) and clarifier, including control of the aerators, return sludge pumps and excess sludge withdrawal equipment based on actual water quality data and flow rate, is a minimum requirement for understanding and evaluation of the treatment process.

8.1.2 Management of Pumping Station

Basic knowledge on the functions of pumping stations and equipment components with its roles shall be provided through classroom training. The OJT for the pumping station shall include training for operation, inspection, reporting and preventive maintenance of the equipment, trouble shootings, cleaning work for the pump stations to remove debris, garbage, sand and scum accumulated in the pump pits, including safety measures, etc. The cleaning work will include removal of solid wastes accumulated and washing out the pits.

8.2 Pipeline Management

A sewer network will lose its principal function such as smooth sewage flow if blockage of sewer pipes occurs by accumulation of sludge, which will in addition result in the generation of offensive odors and/or toxic gases and even erode sewers. In this regard, periodical cleaning is indispensable to maintain smooth sewage flows.

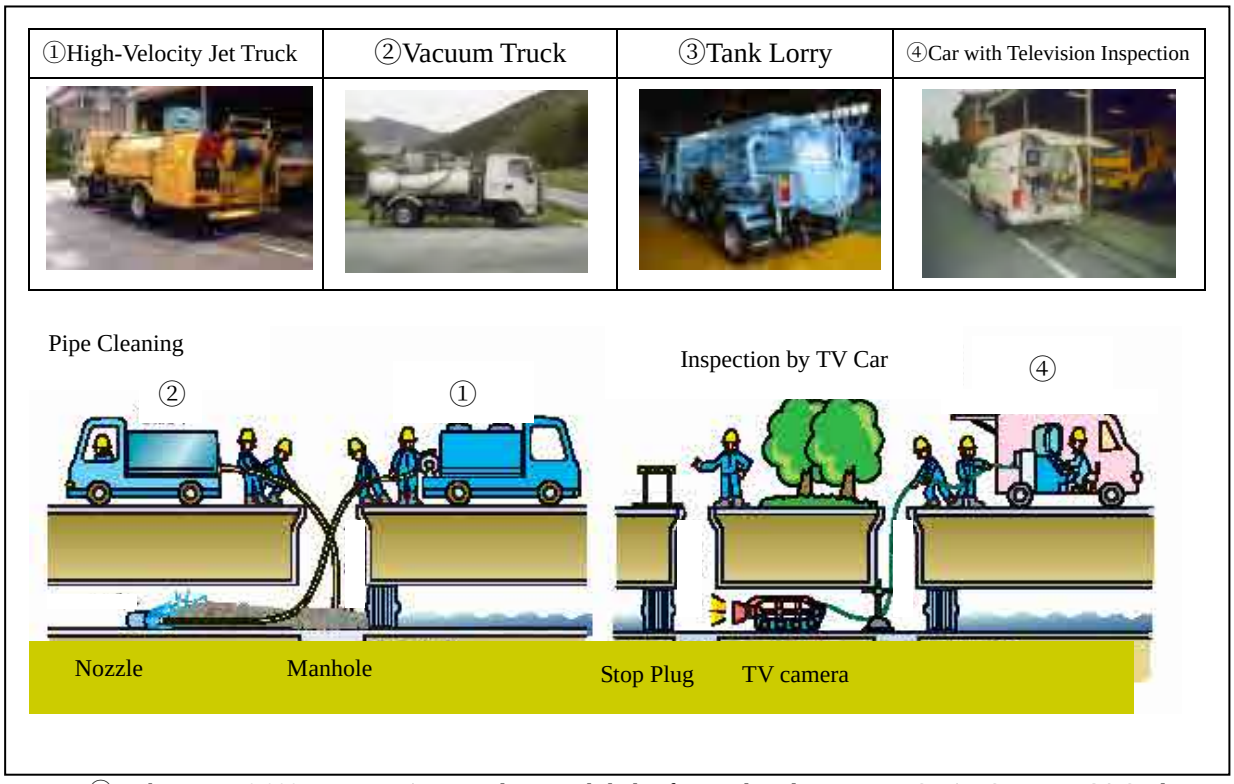
Generally, sewer cleaning is carried out by a combination of high pressure equipment, a vacuum cleaner and a water tanker which the Project will provide.

Basic knowledge on the functions of sewer and equipment components with its roles, cleaning technology and procedure, shall be provided through classroom training

The program shall include assistance for establishing a sewer cleaning plan to ensure preventive

maintenance. The OJT shall cover cleaning technology and procedures, trouble shooting, safety and hygiene control using the cleaning equipment provided by the Project.

Figure 8.2.1 shows outline of inspection and cleaning of sewer.



Note: ③Tank Lorry: 10,000L * 2 No.s (to carry dewatered sludge from Kila Kila to Morata STP) Source: JICA Study Team

Figure 8.2.1 Outline of Inspection and Cleaning of Sewer

8.3 Asset Management

When the proposed sewerage facilities are constructed, EDA RANU will own a significant quantity of sewerage assets. These assets need to be maintained and utilized adequately. For these purposes, all information regarding sewerage facilities including all records and drawings should be unified and centralized in a database system supported with a mapping system. It can be used as the fundamental logistics necessary for establishing efficient operation and maintenance,procedures in particular, for preventive maintenance, by the Sewerage Division.

Figure 8.3.1 shows the Outline of the Sewerage Management System Database.

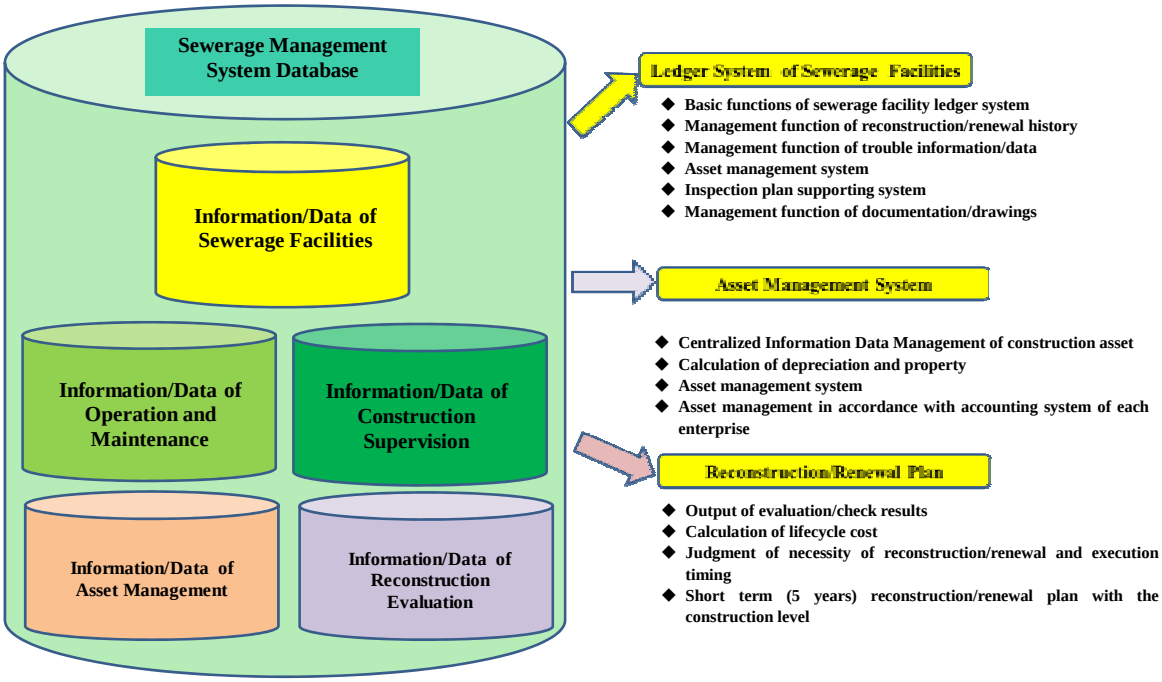


Figure 8.3.1 Outline of Sewerage Management System Database

(Source: Nakanihon Construction Consultant, Ltd.)

8.4 Water Quality Analysis

A sewerage project is an environmental improvement project, in particular, involving water quality improvement of water bodies, and thus effluent quality control in the Sewage Treatment Plant is very important.

The parameters necessary for optimized operation of the OD system are pH, ORP (Oxidation/Reduction Potential), EC (Electricity conductivity), DO (Dissolved oxygen), water temperature, BOD_5 (Biochemical oxygen demand in five days), COD (Chemical oxygen demand)[1], NH_4-N, (Ammonium nitrogen) NO_2-N (Nitrite nitrogen), NO_3-N (Nitrate nitrogen), T-N (Total nitrogen), T-P (Total phosphorus), SS (Suspended solids), MLSS (Mixed liquid suspended solids), SV (Sludge volume), VSS (Volatile suspended solids), Oil & Grease, return sludge solids, thickened sludge solids, dried sludge solids, residual chlorine and total coliforms[2].

Although all these parameters, except DO, SV, residual chlorine and biota, are measured regularly by

[1] In PNG, COD means COD_{Mn}

[2] EDA RANU may be required to monitor industrial wastewater quality and quantity in the future. However, the parameters to be measured for industrial wastewater are as yet not regulated. In the case that parameters to be measured are so many (as in Japan) including heavy metals, pesticides, halogenated hydrocarbons, cyanide, arsenic, etc., far more expensive analyzers and sophisticated techniques and environmental considerations are necessary. In this case OJT shall be executed as another project.

the Environment and Quality Control Section with official analysis methods, such parameters as pH, ORP, EC, DO, water temperature, COD_{Mn}, NH_4-N, NO_3-N, SS, MLSS, SV, return sludge solids, residual chlorine, and biota observation by microscope shall also be measured at the STP site by simple/portable analysis kits/meters for optimized process control with the cooperation of thye Environment and Quality Control Section.

The significance of the parameters, sampling points, frequency, pre-treatment, analysis procedures, advantages and disadvantages of the analysis procedures, what to pay attention to in measuring/analyzing the parameters, preparation of measurement/analysis flow sheets for each parameter analyzed, verification of installed measurement equipment and accuracy controls such as how to obtain the most accurate result, significant figures, etc. would be transmitted to the staff through classroom training and OJT.

Measurement/analysis data should be used for most optimized operations (Concept of quantitative process operation). Accordingly, OJT includes the understanding of the OD system, evaluation of the function of each unit process of the OD system, the relationships among the parameters and the analysis results between those obtained by official analytical instrumentation and by simple analysis kits using standard solutions, will be some of the topics covered.

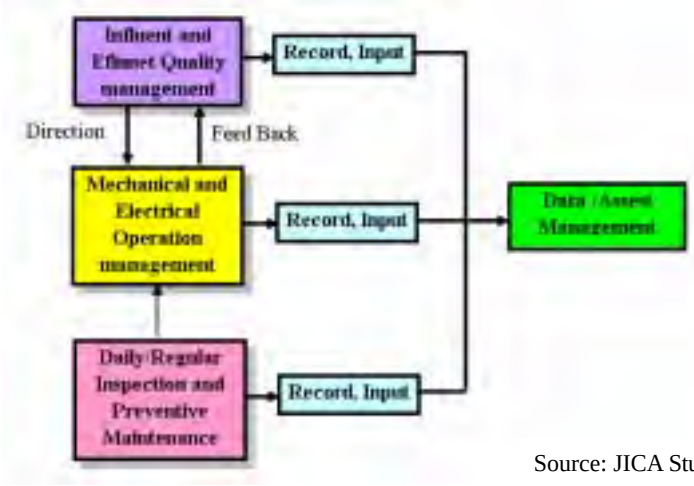
Trained staff of the Environment and Quality Control Section shall become the trainers to the staff at the Kila Kila STP.

8.5 Recommendations for Fruitful Training and Execution of Optimized O/M of Sewerage System

(1) To have the awareness of quantitative process operation and preventative maintenance.

Proficient engineering and operational knowledge are required by the staff for O/M of the proposed sewerage facilities. EDA RANU is required to have specialized engineers at each facility in order to attain total effective and efficient engineering with the concept of quantitative operation and preventative maintenance.

Figure 8.5.1 shows the concept of quantitative process operation and preventative maintenance in the STP (Sewage treatment plant).



Source: JICA Study Team

Figure 8.5.1 Concept of Quantitative Process Operation and Preventative Maintenance in STP

Quantitative process operation based on team work and cooperation among the STP operational staff is required to facilitate the way in which the STP achieves the designed effluent quality.

Quantitative process operation based on proper monitoring and control of sewage and sludge quality and quantity is the first step in overall STP quality control, which includes data/asset management and energy use optimization through optimized operation and maintenance of the equipment and facilities of the wastewater treatment plant.

Mechanical and electrical operations management is not only for wastewater treatment plants but also for the management of pumping stations and sewers. In order to sustain sound functions and to prevent accidents at the facilities, preventive maintenance is indispensable and an adequate maintenance plan needs to be established. As a result of implementing the planned maintenance, the plan needs to be periodically reviewed since there may be instances where the contents and frequency of some activities are not appropriate. Also, results of maintenance activities must be recorded so as to make full use of existing prior information for the repairs and rehabilitation in the future.. **Figure 8.5.2** shows the approach to preventive maintenance.

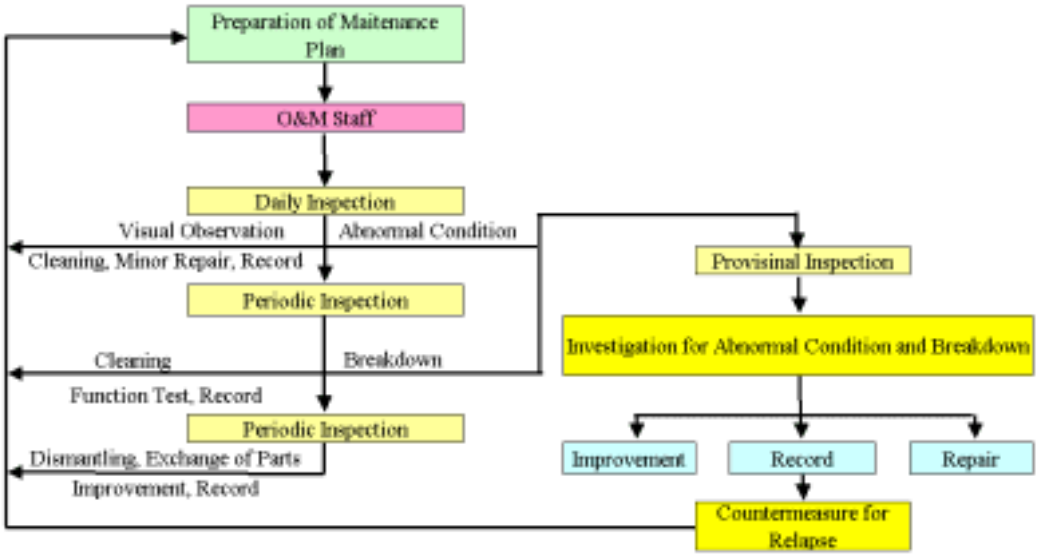


Figure 8.5.2 Outline of Preventive Maintenance Plan

Consideration of the current O/M activities by EDA RANU, shows that the existing O/M system is far short of these proposed concepts of quantitative operation and preventive maintenance.

Without maintaining an awareness of quantitative process operation and preventative maintenance, training will end in failure. The training program should focus on how it can make trainees comprehend and make a habit of these concepts. It is necessary to keep in mind that installation of asset management software will become meaningless without this awareness.

(2) To define and establish the policy of outsourcing

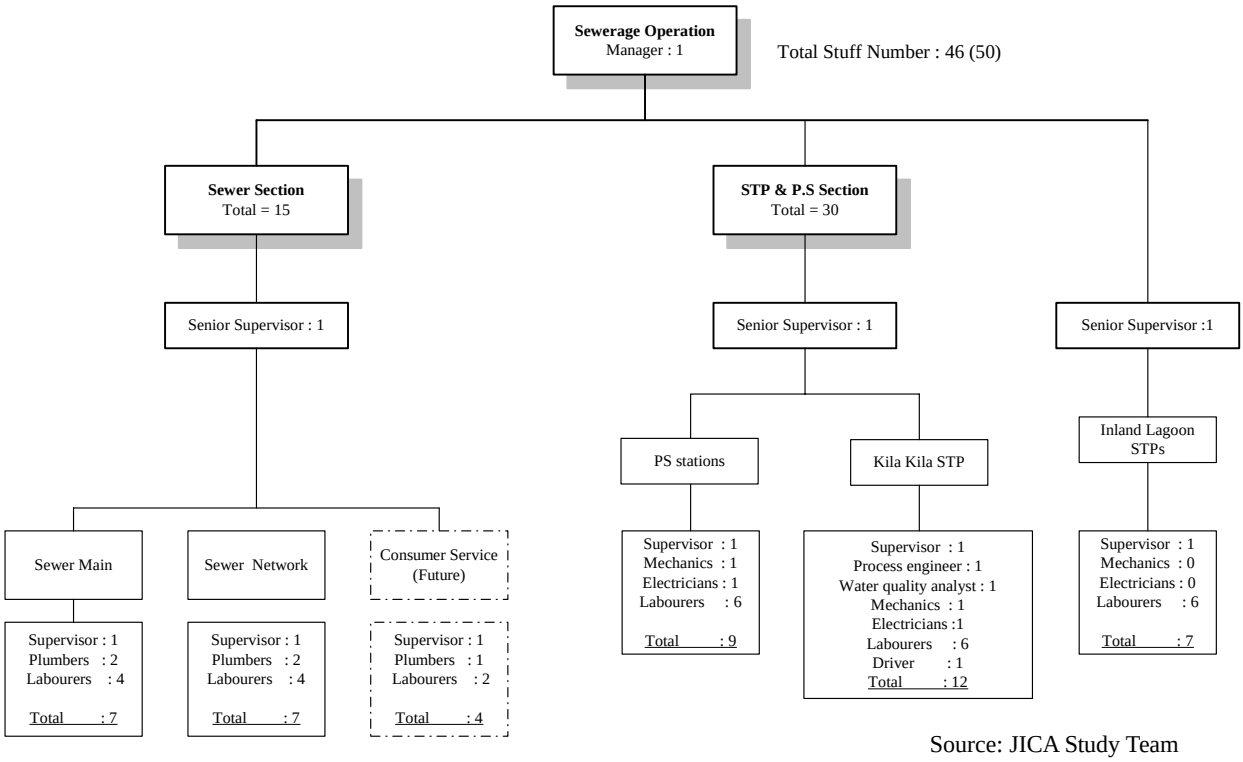
Currently most of activities for O/M of the sewerage system are implemented by outsourcing to local companies. EDA RANU itself has no basic inspection equipment to check mechanical and electrical equipment conditions such as megohmmeters, vibration pens, etc. If some important parts need to be changed, it may take more than six weeks for the repair a parts have to be imported from Australia. As for sewer repairs, EDA RANU waits for the customers complaints about pipes clogging before repairs are effected. Among the parameters to be measured for evaluating the performance of existing ponds, only SS is being measured by the Environment and Quality Control Section of EDA RANU itself and here again only once a month. The current O/M activities by EDA RANU and outsourcing companies are far short of what is actually needed from quantitative process control and preventative maintenance.

If EDA RANU wants to continue this system, training should be assigned to outsourcing companies.

In this instance it will be an ironic situation on who will execute pipe inspection and cleaning by high-velocity jet truck, vacuum truck and car with television which shall be provided by the Project, EDA RANU or the outsourcing company? Which organization/company will execute daily inspection of mechanical and electrical equipment of STP, pumping stations and sewers? Optimized operation & maintenance needs long-term commitment coupled with actual experience. With actual experience of trouble shooting by EDA RANU itself, EDA RANU will have its own know-hows and will improve and have better planning ability supported by these know-hows if it carries out essential O&M functions itself without outsourcing to local companies.

Proposed Manpower and Duties of the Sewerage Operations Division

Figure 8.5.3 shows proposed organization chart of EDA RANU for quantitative sewerage operation and preventive maintenance under the consideration of duties below:



Source: JICA Study Team

Figure 8.5.3 Proposed Organization Chart of the O/M of EDA RANU

The following specifies the proposed manpower and duties of each individual section in the Sewerage Operations Division.

1) Manpower and Duties of the Sewer Operation and Maintenance Section

This section will be responsible for two major operations, namely; sewer maintenance and consumer services.

The sewer maintenance section will be responsible for all sewer maintenance works, while the large-scale maintenance work such as new sewer pipe installations is to be contracted to the private

sector.

The consumer services group is to handle Y-junction installations and manhole connections, while the house connections discharge pipe installation from consumer premises to sewer main/sub-mains are to be carried out by the clients themselves.

The works proposed below are to be carried out by this section.

- Daily inspection of sewer mains/sub-mains
- Regular investigations of unexpected water influx into sewers and taking measures to prevent it.
- Fixing of broken pipes and/or replacing obsolete pipes.
- Regular investigations of severely polluted water discharged into sewers, and preparation of reports on preventive measures.
- Weekly inspection on the conditions of sewer main/sub-mains and sewage effluent facilities.
- Cleaning of sewers and manholes, as necessary.
- Installation of new sewer pipes and replacement of old/damaged sewer pipes with new ones (to be contracted out, where necessary). (Needs strict management of outsourced companies such as evaluation of the works, etc.)
- Installation of service connections: Y-Junction or manhole connection. (House connections up to sewer main/sub-mains are to be installed by the clients).
- Daily recording of operation and maintenance activities.

For an effective and efficient execution of responsibilities it is proposed that two maintenance units (one is for the sewer mains and the other for the sewer network) be set up as shown in **Figure 8.5.3.**

A two shift operation (each shift to include a plumber and two laborers.) is proposed to be established for each unit.

2) Manpower and Duties of Pumping Station Section

Under the control of the Operation Engineer for the PS, two staff shifts will be organized, one for operation and maintenance of the Paga Point Area, and the other for that of the Kila Kila Area.

The works proposed below are to be carried out by the EDA RANU staff for the pumping station operation and maintenance such as small scale and daily work. Works that requires special knowledge and skills are to be contracted out to private engineering companies. (Needs strict management of outsourced companies such as evaluation of the works, etc)

The following works are to be carried out by this section.

- Operation of pumping stations.
- Daily inspection of pumping stations
- Weekly cleaning of screens at pumping stations.
- Weekly inspection of pump station machinery
- Small scale repair/parts replacement of machines at stations, where necessary.
- Large scale maintenance of machinery is to be contracted out to engineering companies, where necessary.

For this section, a mechanic and an electrician will be assigned under the supervisor. In order to carry out the work three shifts, with six laborers (two laborers per shift) will be established.

3) Manpower and Duties of Sewage Treatment Plant Section

Under the control of the two supervisors (One for the STPs of the coastal area and the other for that of the inland area) for the STPs, the works to be carried out by the EDA RANU staff for the STPs are as follows:

- Daily inspection of the STP's condition.
- Daily recording of influent/effluent sewage volume for each STP.
- Daily water quality analysis/measurement of influent/effluent by simple/portable analysis/measurement kits/meters in the Kila Kila STP
- Evaluation of process performance and change of operating conditions of the Kila KIla STP, where necessary
- Daily removal of grit and screenings from pretreatment facilities
- Daily withdrawal of sludge from sedimentation tanks in the Kila Kila STP.
- Daily transportation of sludge from the Kila Kila STP to the inland STPs.
- Disposal of dried sludge from the inland STPs to the chosen land site.

Regular maintenance of sewage treatment plants, such as mowing, repair/replace works of big parts or equipment, regular big scaled-inspection and maintenance, etc., is to be contracted out. (Needs strict management of the outsourced companies such as evaluation of the works, etc)

It is noted that the oxidation ditch process is to be employed for the proposed STP of Kila Kila, and as this is a more sophisticated treatment system there will be a need more careful and skilled O/M technology compared to the existing STPs. Therefore, the unit of the Kila Kila STP is to be organized at its plant site to ensure proper/optimized O/M for the treatment plant. In the Kila Kila STP, a mechanic and an electrician shall be assigned under a supervisor. In addition for optimized operation based on water quality and quantity and evaluation of process, one process engineer and one water quality analyst shall also be assigned. A process engineer shall conduct water quality analysis as well, evaluate the process and direct any changes of operational conditions to the staff. In order to establish three shifts for an around-the-clock operation, six laborers (two laborers per shift) will be selected.

On the other hand, the inland Lagoon STPs unit is to be organized in the EDA RANU headquarters. Under a supervisor, six laborers will be positioned to engage in the O/M work such as removal and disposal of screenings, mowing grass, etc.

4) Manpower and Duties of Senior Supervisors and Sewerage Operation Managers

Two senior supervisors shall be assigned to the sewer section and STP & pumping stations (PS)

under one sewerage operation manager. Their duties will be asset management based on the data/information sent from each supervisor of each unit.

A sewerage operations manager will be responsible for comprehensive sewerage operation & maintenance such as data management including cost performance and public education, etc.

5) Manpower and Duties of Environmental and Quality Control Section

This section analyzes/measures the parameters aforementioned in 8.4, namely, pH, ORP, EC, DO, water temperature, BOD_5, COD_{Mn}, NH_4-N, NO_2-N, NO_3-N, T-N, T-P, SS, MLSS, VSS, Oil &, return sludge solids, thickened sludge solids, dried sludge solids, residual chlorine and total coliforms.

Some of the parameters listed above shall be analyzed/ measured at the Kila Kila STP site as well by simple/portable analysis/measurement kits/meters as mentioned in 8.4.

This section shall use international/official analysis procedures to check the results that will be obtained from the STP.

The staff shall have basic knowledge on the significance/meanings of the parameters, pre-treatment, storage procedures, sampling points, sampling procedures, analysis procedures, advantages and disadvantages of the analysis procedures, what to pay attention to in measuring/analyzing the parameters including preparation of reagents, measurement/analysis flow sheet of each parameter and accuracy control (like the concept of significant figures), and verification of installed measurement equipment and will be able to carry out and handle them, including executing instructions given by the process engineer and water quality analyst to be assigned at the Kila Kila STP.

All parameters listed above for the Kila Kila STP shall be analyzed/measured once a week. Considering the work volume with parameters and analysis/measurement frequency, the current number of staff (5) will be sufficient.

EDA RANU may be required to monitor industrial wastewater quality and quantity in the future, although the parameters to be measured for industrial wastewater are as yet not regulated. In the case the parameters to be measured become as many as those required in Japan including heavy metals, pesticides, halogenated hydrocarbons, cyanide, arsenic, etc., far more expensive and highly precise analyzers such as ICP-MS (Inductively Coupled Plasma Atomic Emission Spectrophotometry – Mass Spectrometry, EDA RANU owns an ICP-MS itself), GC-MS (Gas Chromatography-Mass Spectrometry), LC-MS (Liquid Chromatography- Mass Spectrometry), ion chromatography, pretreatment equipment for arsenic, mercury analysis set, pre-treatment equipment of GC-MS such as head space and trap & purge, more advanced photoelectric spectrometers, etc.) with much more sophisticated techniques, and water flow measurement equipment such as portable ultrasonic flow meters, flow measurement equipment for open channels, etc., analysis environment like clean rooms, purer water production equipment and regents, etc. and deeper knowledge of analyzers and analytical procedures, strictly accurate control of analyses, etc. shall be required. For OJT in this field it shall be implemented as another project with such materials as how to estimate raw water

quality and quantity of industrial wastewater, etc.

It is said that significant amounts of industrial wastewater is being discharged in the inland sewerage systems from the observations that the ratio of BOD_5/COD_{Mn} is 0.75 in inland areas compared to that of 2.0, in the coastal area.[3].[4] However, no organization has yet measured actual industrial wastewater generation and quality. If there is a doubt that "a significant amount of industrial wastewater is being discharged in inland sewerage systems", an actual survey for it shall be executed prior to the plan and design of the sewage treatment plant for the inland area.

To measure industrial water[5] generation and quality, reference is made to the following procedures.

① Prepare questionnaire for industry

The questionnaire shall include the following, but not be limited to;

- General Information of the industry such as the name of the company, and its industrial classification, contact persons, number of production employees, working hours per day, month, year, existence of bathrooms, restaurants; annual quantity of production and by-products and type of raw materials used with , purpose, capacity of production (monthly, seasonal and yearly, minimum and maximum).
- Water supply sources, average water consumption by category of use
- Existence of water supply or consumption measurement facility/equipment
- Where wastewater is discharged
- Wastewater generation amount: daily, monthly, yearly
- How wastewater generation amount is determined
- Quantity of recirculation
- Treatment facility/process, purpose of recirculation
- How wastewater quality is determined: own laboratory or outsourcing with parameters and analysis methods, frequency
- Typical wastewater quality at discharge point before sewer system or public water body
- Existence of wastewater treatment plant, treatment process with parameters
- How and where disposal of the waste from wastewater treatment plant is handled
- Organization of pollution controller, industrial wastewater management, including O/M of industrial water treatment plant and monitoring
- Existence of any associations among the similar or different categories of industries for the preservation of pollution, information exchange
- Possession of ISO9000 or ISO14000 series
- Preference to discharge wastewater to sewer or directly to the sea

[3] Table 4.15 and 4.16, Final Report in "Updated Feasibility Study on Port Moresby Sewerage System Upgrading Project, May 2010"

[4] In general, the ratio of BOD_5 to COD_{Mn} of influent municipal wastewater is said 1.5 -2.0. Therefore the ratio of it in the coastal area (target of this project) might be considered as the typical value for municipal wastewater.

[5] Industrial wastewater includes all wastewater except domestic wastewater,and wastewater from normal offices, public buildings such as schools,and assembly halls which do not discharge toxic substances,

- Willingness to pay for treatment service by EDA RANU and willing to invest in the construction of a pre-treatment plant

② Make a list of target enterprises and facilities
③ Select where to distribute the questionnaire
④ Confirm if any organizations have the information/data abovementioned And if any, use it.
⑤ Distribute the questionnaire and collect it
⑥ Analyze and evaluate it with other materials such as the list prepared in Japan[6]
⑦ If there is any doubt, confirm by actual measurement and analysis by official methods.

6) Manpower required for House Connection

For the POMSSUP, approximately a half of the total house connections already exists in the subject area. The Sewer Network section shown in figure 8.5.3 in the proposed organizational chart for O&M will work on house connections. Temporary workforces will be made available for the work, when needed.

7) Required Revision of the Organization of EDA RANU

In connection with the expiry of 15 years contract for with JC-KRTA Consulting Pty Ltd in 2019, EDA RANU is planning to establish two new sections for the billing/collection and O&M of the Mt. Eriama WTP within the EDA RANU organization by 2019.

- The billing/collection section will be controlled under Finance and Accounting Division under General Manager, since the section will handle both water supply and sewerage. Proposed organization is as follows:

Section Chief :	(1)
Supervisors :	(2)
Collection Staff:	(6)
Total:	(9)

- The Mt. Eriama WTP O&M section is proposed to have a section in the existing EDA RANU Water Operation. The proposed organization is as follows:

WTP Manager:	(1)
Mechanical Engineer:	(1)
Electrical Engineer:	(1)
Water Quality Specialist:	(1)
Driver:	(1)
General Workers:	(3)
Total:	(8)

[6] ⑥ and ⑦ need lots of experience, materials, expensive analyzers and measuring equipment with deep knowledge and experiences of analyzers and measurement equipment. Hire competent consultant(s).

How to secure competent staff

The Current number of staff in the Sewerage Operations Division is twenty eight (28). On the other hand, the proposed number of staff in the division is 50, including those in the consumer service section. Almost more than twenty (20) competent persons shall be recruited for sewerage operations division staff before the commencement of training.

It will not be easy to hire as many competent staff for sewerage works which is generally considered smelly, dirty and unbearable. EDA RANU will be required to show incentives and a clear vision to motivate them to join.

(3) Quality of Trainers/Lecturers

The Trainers/lecturers must have sufficient knowledge and actual experiences in their respective fields in order to supervise the OJT which will mainly be implemented by the Contractor.

It is suggested to invite eligible Japanese consultants who have such knowledge and actual experience to carry out these courses, as a wealth of experience and know-how in O/M of the proposed sewerage system are available in Japan and is capable of being spread overseas.

A sewerage project is generally an environment improving project. The technical project manager shall have not only have enough knowledge and experience for carrying out training on OD systems but also will need to have a wide and varied comprehensive knowledge and experience of environmental matters; waste management, environmental monitoring, industrial wastewater management, public education, etc. for example, in order to encourage trainees and give them motivation as to how important their work is for the society and PNG.

(4) Active participation of Counterparts

The current activities of operation & maintenance of sewerage systems will be far less than the required level of that of the proposed modernized sewerage system. Active participation of counterparts to absorb know-how from the trainers is a must for sustainable and optimized O/M.

Training overseas, in particular, seems to end only in sightseeing, in general. To avoid this situation, participants should have strong feelings of their responsibilities and provide valuable feedback about their performance during their training overseas to other staff . This is a must along with the trainers' quality.

(5) Keeping Records

Operation & inspection and maintaining records will help strengthen control over all works accomplished. The activity is very useful for reviewing the purposes and identifying past problems and solutions, serving as reference should similar situations occur in the future. It is recommended to prepare recording formats to meet the asset management software to be introduced by this project and input such important information/data into a computer database for future reference. These input

records shall be used for asset management.

Important records to be kept will include, but not be limited to the following:

- Sewer pipe, manhole inspections and maintenance records including sewer repair/replacement works
- House-connections.
- Treatment plant operations, inspection and maintenance
- Water quality analyses with process evaluation
- Pump station inspections, operation and maintenance
- Stock in-out records. In addition to the semi-annual stock records, an annual inventory should also be taken.
- Maintenance records of vehicles, machines, equipment, tools, etc.

(6) Development of SOPs

Sewage operating protocols (SOPs) are useful for the workforce to carry out efficient and satisfactory O/M activities. It should contain operation/evaluation procedures, maintenance plans, work schedules, procedures/checklists on how to execute jobs, teamwork, etc.

The SOPs to be developed will include, but not be limited to the following:

- House-connections.
- Sewer maintenance with safety measures.
- Pump station operation and maintenance with safety measures.
- Operation and maintenance for the STP with safety measures.
- Wastewater quality monitoring: Sampling points, parameters, sampling frequency, analysis methods, process evaluation procedures
- Procurement and inventory control.
- Asset management

Schedule, Location, Duration, and Target Personnel for Training, etc.

The training O/M program consists of the followings.

(1) Training in Japan using the JICA training course

(2) Training in Papua New Guinea

The training in Papua New Guinea consists of two stages;

1) The first (approximately 6 months) training for technology transfer from contractor and expert/consultant[7] to the EDA RANU staff

[7] OJT shall be executed mainly by the contractor. The contractor is to prepare training manuals and SOP. The Consultant shall then review and give advice on them and evaluate the training performance, etc.

2) The second (6 months) where the EDA RANU staff will self-manage O/M activities with support of the contractor and expert/consultant.

Table 8.5.1 shows the proposed field, main target personnel, training contents, duration, location and timing.

Table 8.5.2 shows proposed consulting services for training of O/M for EDA RANU.
Figure 8.5.4 shows proposed consultants' assignment for training of O/M of sewerage system.

Table 8.5.1 Proposed Training Schedule, Location, Target personnel

Field	Main Target Personnel	Content	Duration[8]	Location	Timing
Kila Kila STP and IPS	Sewerage operations manager, supervisor and process engineer, and Environment & Quality Control Section	Classroom and OJT	2 weeks	Japan	During construction of Sewerage System
		Classroom and OJT	5.5 months	Papua New Guinea	After commissioning of Sewerage System[9]
	Mechanics	Classroom and OJT	2 weeks	Japan	During construction of Sewerage System
		Classroom and OJT	1 week[10]	Manufacturer	During construction of Sewerage System
		Classroom and OJT	3.0 months	Papua New Guinea	After commissioning of Sewerage System
	Electricians	Classroom and OJT	2 weeks	Japan	During construction of Sewerage System
		Classroom and OJT	3.0 months	Papua New Guinea	After commissioning of Sewerage System
Sewer	3 Supervisors (Sewer main, sewer network, consumer service), Senior supervisor of sewer section	Classroom and OJT	2 weeks	Japan	During construction of sewer
		Classroom and OJT	3.0 months	Papua New Guinea	After handover of sewer
Asset Management	3 senior supervisors and sewerage operations manager	Classroom and OJT	2 weeks	Japan	During construction of Sewerage System
		Classroom and OJT	3.0 months	Papua New Guinea	After commissioning of Sewerage system
Water quality analysis	Environment & Quality Control Section	Classroom and OJT	2 weeks	Japan	During construction of Sewerage System
		Classroom and OJT	2.0 months	Papua New Guinea	Before commissioning of Sewerage System

Note : Oversea training/OJT shall be executed in Japan, by using JICA's training course based on request. It is preferable to participate in the training in Japan.

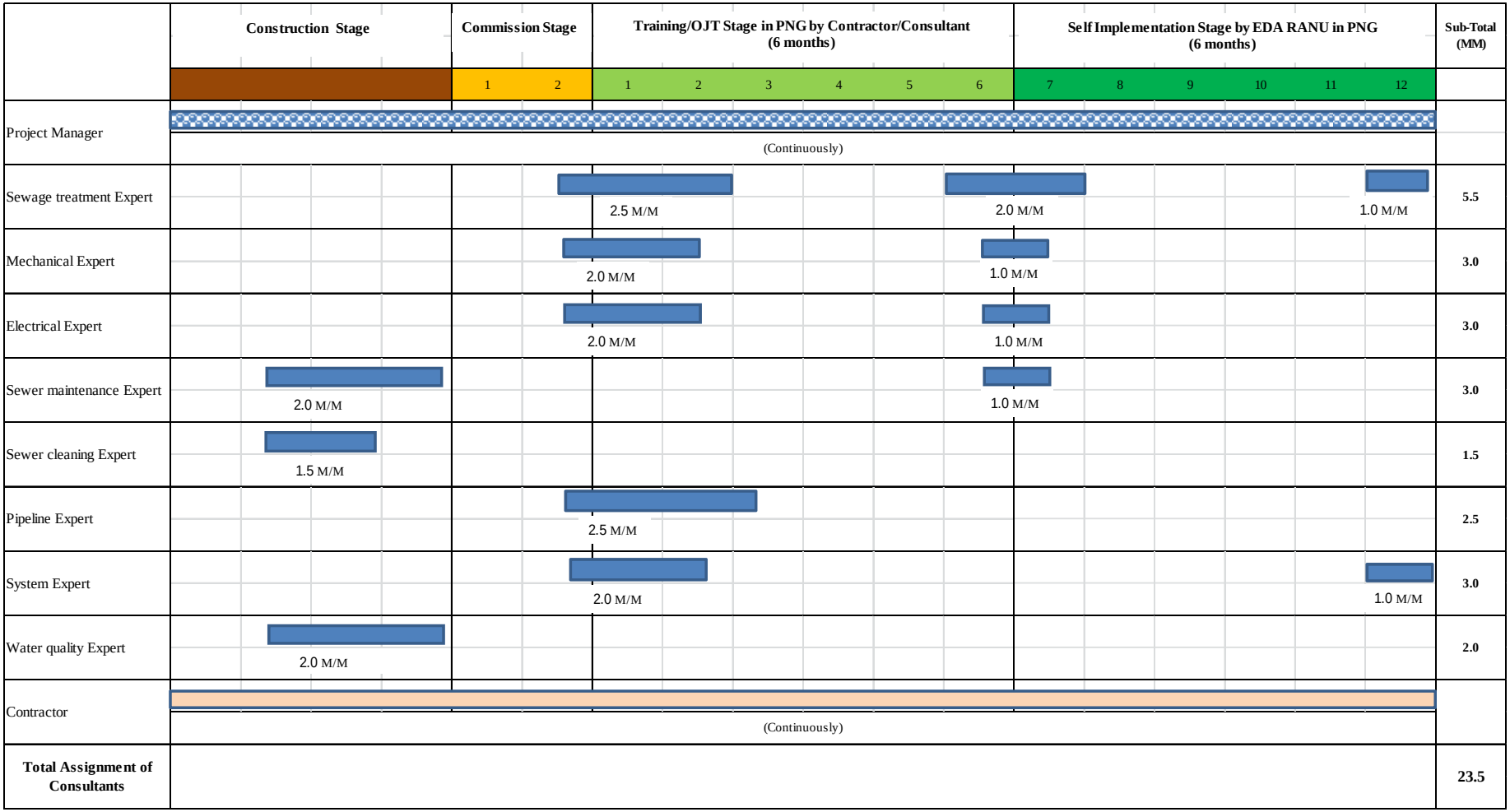
Source: JICA Study Team

[8] Duration: Consultant's assignment during training.
[9] Sewerage system means STP, IPS, sewer including house connection, and landfill by EDA RANU
[10] 1 week each for main equipment such as blowers, sludge pumps, etc. Cost burden to be borne by manufacturer in question

Table 8.5.2 Proposed Consulting Services for Training of O/M for EDA RANU

Program	Contents	Benefit	Input of consultants
1. O/M training program on the OD system	The program shall include preparation of a training manual and implementation of the training. The training shall include both classroom training and on-the-job training (OJT) and be implemented according to the manual. Basic knowledge on the sewage treatment shall be provided through classroom training. The OJT shall include training for optimized operation based on water quality and flow rate, including sludge disposal, inspection and recording for preventive maintenance, safety measures, etc.	Technologies and know-how on the optimized O/M of the OD system can be transferred to EDA RANU's O/M staff and this will ensure the system will be operated in a successful and sustainable manner.	Sewage treatment Expert: 5.5 MM Mechanical Expert : 3.0MM Electrical Expert : 3.0MM
2. O/M training program on the sewer networks	The program shall include assistance for establishing a sewer cleaning plan to ensure the preventive maintenance. The OJT shall cover cleaning technology and procedure, safety and hygiene control using the cleaning equipment provided by the Project.	Technologies for operating the sewer cleaning equipment such as high pressure cleaning equipment and a vacuum cleaner can be transferred to the O/M staff. Also, adequate and preventive maintenance for the sewer networks can be established.	Sewer maintenance Expert: 3.0 MM Sewer cleaning Expert: 1.5 MM
3. Building sewerage asset management system	This task is to build a sewerage ledger system. It shall include building of a database system and preparation of an instruction manual, as well as the data collection from existing facilities using design documents, such as building drawings and information of new facilities to be provided by the contractor. These data will be unified and centralized in the mapping database to be built. The system shall contain drawings and documents.	This system will be used for the management of sewerage assets which include such items as inspection and repair work of facilities, establishment of future rehabilitation plans. It will also be used for dealing with complaints raised by customers. This system is very beneficial for efficient implementation of sewerage management plans.	Pipeline Expert: 2.5 MM System Expert: 3.0 MM
4. Assistance for water quality analysis	This task is to assist EDA RANU in water quality management. It shall include providing advice in establishing a water quality monitoring plan and training on water quality testing.	It will help EDA RANU establish an adequate water quality monitoring plan and use accurate techniques for water quality testing. These matters are essential for implementing optimized operation of STP and environmental monitoring.	Water quality Expert: 2.0 MM

Source: JICA Study Team



Source: JICA Study Team

Figure 8.5.4 Proposed Consultants' Assignment for Training of O/M of Sewerage System

Cost Estimation for Training for O/M of OD system in Papua New Guinea

(1) Remuneration (×1,000 Japanese Yen): 58,750

1) Consultancy fee: 58,750

Total Assignment M/M	Unit cost (×1,000 Yen)/MM	Consultancy fee
23.5	2,500	58,750

(2) Out of pocket (×1,000 Japanese Yen): 23,656

1) Daily accommodation and allowance: 17,776

Accommodation			Daily allowance			Total
Unit cost	Total days	Sub-total	Unit cost	Total days	Sub-total	
22.3	677	15,097	3.8	705	2,679	17,776

2) International Airfare (Narita-PNG-Narita)

Total Nos. of Travel	Average air fare (×1,000 Yen)/travel	Accommodation and daily allowance
14	420	5,880

(3) Operation Cost for 2 months commissioning (×1,000 Japanese Yen): 14,550
(Refer to **Appendix 16.1**)

(4) Procurement of analysis equipment and regents[11]: (×1,000 Japanese Yen): 12,301
(Refer to **Appendix 16.2-1** and **16.2-2**)

(5) Total of (1) + (2) + (3) + (4) (×1,000 Japanese Yen): 109,257

(6) Allowance: 550

(7) Grand total of training cost (×1,000 Yen): **109,807**

[11] Chemical Reagents: required for 2months' training

CHAPTER 9 PROJECT COST AND IMPLEMENTATION PROGRAM

9.1 Project Scope

Port Moresby Sewerage System Upgrading Project (POMSSUP) contains Engineering, Procurement, Soft components and Consulting Services. Project Scope which was slightly revised according to the result of current status confirmed through the Basic Design Study is summarised in **Table 9.1.1**.

Table 9.1.1 Project Scope

Items	Contents
Construction	
1) Sewer	
Trunk sewer	17.6km (DCIP, PVC,RC Pipe, Dia 100~600mm)
Branch sewer	17.4km (PVC Pipe, Dia 100~200mm)
2) Pumping Station	
New Construction	8 complete sets for 8 Locations shown below: Kanudi, Idubada, Hagara, Hanuabada, Kila Police, Konebada, Gabutu, Horsecamp
Reconstruction / Replacement	9 Complete sets for 9 Existing Facilities: Konedobu, Old Yacht Club, Stanley Esplanade, Sea Park, Davara, Lawes Road, Koki, Badili, Kaugere
3) Sewage Treatment Plant (Kila Kila)	Treatment Capacity: 13,800m^3/day 3 units of Oxidation Ditch Process with 4,600m^3/day/unit with the ultimate capacity of 18,400m^3/day (4 units)
Access road	1.5km
Outfall to sea	1.6km
4) Access road to Morata STP	1.3km
Procurement	✓ High-Velocity Jet Truck (Water-Jetting Sewer Clear) × 1 no. ✓ Vacuum Truck × 2 nos. ✓ Water Tank Truck. × 1 no. ✓ Dump Tank × 2 nos. ✓ Car with Television Inspection × 1 no.
Pilot Project	1 Ls Implementation of water supply and sewerage service to the 20 houses built on the stilts in the sea with incidental structures and equipment in Hanuabada Area
Social Development (Sanitary Education and HIV/AIDS Prevention)	1 Ls Implementation of Sanitary Education in Hanuabada Area and, HIV/AIDS management and prevention program for the contractor and residents around the construction site.
O&M Training	1 Ls Implementation of O&M Training Program for Management of Sewerage System.
Consulting Services	✓ Preparation of Prequalification and Tender Documents ✓ Assistance IPBC/EDA RANU to evaluate Prequalification and Tender ✓ Assistance IPBC/EDA RANU to supervise the construction work ✓ Assistance IPBC/EDA RANU through Liaison with JICA

9.2 Project Cost

The Project cost is estimated based on the results of basic design and on unit cost as of October 2011 price level in PNG and Japan. The exchange rate adopted is JP yen 34.3 / Kina according to the interbank rate at the time.

The unit price for each construction item or material is quoted from local contractors and engineering consulting firms in Port Moresby. The adoption of the price was made after comparison of collected prices between the firms. JICA Study team collected at least three quotations for each item from different firms. The lowest price for each item in the table was selected as the unit price for estimating the project cost. Capital Expenditure and Operation & Maintenance Expenditure was studied and shown as follows.

9.2.1 Capital Expenditure

Table 9.2.1 shows capital cost of this project. Facility wise cost breakdown of each component is attached in **Volume IV** "Priced Bill of Quantity".

Table 9.2.1 Capital Cost

Components	Cost		Total Cost
	Foreign Portion	Local Portion	(JPY)
	(JPY)	(Kina)	
General requirements		7,433,100	254,955,330
Brunch Sewer	52,547,881	9,272,823	370,605,710
Trunk Sewer	232,174,811	7,333,129	483,701,136
Pumping Station			1,033,714,183
Civil / Build	7,597,372	5,387,288	
Mech. / Elect.	776,016,200	1,904,275	
Kila Kila STP			3,520,995,097
Civil	57,632,303	53,109,976	
Build.	0	6,460,359	
Mech. / Elect.	1,187,879,800	6,770,277	
Ocean Outfall	400,418,460	4,680,333	560,953,882
Access Road	0	27,312,717	936,826,193
Pilot Project	3,044,081	444,222	18,280,896
Social Development	0	300,000	10,290,000
Maintenance Equipment	124,854,700	0	124,854,700
O&M Training	46,456,978	0	46,456,978
Provisional sum	0	6,133,215	210,369,275
Total	2,888,622,586	129,108,614	7,572,003,380

9.2.2 Operation and Maintenance Expenditure

Table 9.2.2 shows O&M cost of this project.

Table 9.2.2 O&M Cost

Components	O&M Cost (Kina / Year)	Total Cost (Kina / Year)
(1) Pipes and Pumping Stations		2,043,000
Repair and Cleaning cost	125,000	
Power cost	1,543,000	
Others	375,000	
(2) Kila Kila STP		2,779,000
Personnel cost	622,000	
Power cost	1,232,000	
Chemical cost	213,000	
Others	712,000	
(3) Sludge Transportation to Morata STP		63,690
Personnel cost	36,000	
Sludge Transportation cost	21,900	
Others	5,790	
Total		4,885,690

9.2.3 Annual Fund Requirement

Table 9.2.3 shows annual fund requirement of this project. The annual fund is classified into eligible and non-eligible portion according to the loan agreement signed in January 2009. The fund includes price escalation cost, physical contingency cost and administration cost. Following conditions and assumptions are assumed for cost estimate:

Base Year : October 2011
Exchange Rate : Kina 1 = 34.3 Japanese Yen
Price Escalation Rate per annum :
Foreign Currency = 1.4%
Local Currency = 3.1%
Physical Contingency : 5% (Construction, Procurement)
5% (Consulting Service)
Administration cost : 3% of the eligible portion

Summary of the Total Project Cost
Total Project Cost: 10,797 Million Yen
JICA Portion: 8,256 Million Yen (L/A amount 8,261 Million Yen)
PNG Portion: 2,541 Million Yen (Original amount 2,541 Million Yen, approx. 74 Million Kina)

Table 9.2.3 Annual Fund Requirement

Annual Fund Requirement — **Attachment 2**

Base Year For Cost Estimation: October 2011 — FC & Total: million JPY — **Terms and conditions** — **0.2 %**
Exchange Rates: Kina = yen 34.3 — LC : million Kina — (STEP)
PriceEscalation: FC: 1.4% LC: 3.1%
Physical Contingency: 5% — 5% (Proccurement)
Physical Contingency for Consultant: 5%

Item	Total			2008			2009			2010			2011			2012			2013			2014			2015			2016			2017		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
A. ELIGIBLE PORTION			1,144																														
I) Procurement / Construction	2,535	135.5	7,183	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	272	19	928	1,415	46	2,990	778	42	2,230	71	28	1,035	0	0	0
Trunk Sewer	232	7.3	484	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39	1	81	77	2	161	77	2	161	39	1	81	0	0	0
Pumping Statioin	1,971	14.1	2,454	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	197	1	245	1,183	8	1,472	591	4	736	0	0	0	0	0	0
Sewage Treatment Plant including Access Road	104	94.3	3,339	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	15	514	32	29	1,027	32	29	1,027	24	22	771	0	0	0
Sludge Drying Bed in MORATA STP	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Base cost for JICA financing	2,308	115.7	6,276.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	252	17	840	1,292	40	2,661	701	36	1,925	63	23	851	0	0	0
Price escalation	107	13.3	564.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	1	44	55	4	186	40	5	199	5	4	135	0	0	0
Physical contingency	121	6.5	342.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	1	44	67	2	142	37	2	106	3	1	49	0	0	0
II) Procurement of Material for O&M	141	0.0	141	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	141	0	141	0	0	0
Maintenance Equipment	125	0.0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125	0	125	0	0	0
Computer system	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Base cost for JICA financing	125	0.0	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125	0	125	0	0	0
Price escalation	9	0.0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	9	0	0	0
Physical contingency	7	0.0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	7	0	0	0
III) Consulting services	404	13.3	859	0	0	0	0	0	0	0	0	0	0	0	0	13	0	13	68	3	163	99	4	244	112	4	256	88	2	161	23	0	23
Consulting service	365	10.8	737	0	0	0	0	0	0	0	0	0	0	0	0	13	0	13	63	2	144	91	4	212	101	3	216	78	2	132	20	0	20
Environmental Expert	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Social Development (HIV/AIDS)	24	0.6	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	4	0	0	6	0	0	6	0	0	0
Base cost	389	11.4	780	0	0	0	0	0	0	0	0	0	0	0	0	13	0	13	63	2	148	91	4	216	101	4	222	78	2	138	20	0	20
Price escalation	19	1.3	62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	7	4	0	16	6	0	21	6	0	15	2	0	2
Physical contingency	19	0.6	41	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	3	0	8	5	0	12	5	0	12	4	0	8	1	0	1
(II + III)	544	13.3	1,000	0	0	0	0	0	0	0	0	0	0	0	0	13	0	13	68	3	163	99	4	244	112	4	256	228	2	301	23	0	23
Total of Eligible Portion (I + II + III)	3,079	148.8	8,182	0	0	0	0	0	0	0	0	0	0	0	0	13	0	13	340	22	1,091	1,514	50	3,233	890	47	2,486	299	30	1,336	23	0	23
B. NON ELIGIBLE PORTION																																	
a Land Acquisition	0	13.5	464	0	0	0	0	0	0	0	0	0	0	0	0	0	14	464	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Base cost	0	12.5	429	0	0	0	0	0	0	0	0	0	0	0	0	0	13	429	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Price escalation	0	0.4	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Physical contingency	0	0.6	22	0	0	0	0	0	0	0	0	0	0	0	0	0	1	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
b Procurement / Construction																																	
Branch Sewer	53	9.3	371	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	2	74	21	4	148	21	4	148	0	0	0	0	0	0
Ocean Outfall	400	4.7	561	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67	1	93	133	2	187	133	2	187	67	1	93	0	0	0
Pilot Project in some Village	3	0.4	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	6	2	0	12	0	0	0
Social Development (HIV/AIDS)	0	0.3	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	7	0	0	0
Price escalation	6	0.5	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	2	0	8	2	0	8	1	0	2	0	0	0
Physical contingency	23	0.8	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	9	8	0	17	8	0	18	3	0	6	0	0	0
c Administration cost	0	7.0	241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	33	0	3	97	0	2	75	0	1	36	0	0	1
d VAT (1)	0	13.5	465	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	66	0	5	157	0	4	145	0	3	96	0	0	0
e VAT (2)	0	1.3	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	14	0	0	14	0	0	7	0	0	0
f Import Tax	0	8.6	294	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	34	0	4	151	0	3	89	0	0	16	0	0	2
Total (a+b+c+d+e+f)	486	59.9	2,541	0	0	0	0	0	0	0	0	0	0	0	0	0	14	466	82	7	322	164	18	780	166	15	694	73	6	276	0	0	3
TOTAL (A+B)	3,565	208.7	10,724	0	0	0	0	0	0	0	0	0	0	0	0	13	14	480	422	29	1,412	1,679	68	4,014	1,055	62	3,179	372	36	1,613	23	0	26
C. Interest during Construction	25	0.0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	9	0	9	14	0	14	0	0	0	0	0	0
D. Commitment Charge	49	0.0	49	0	0	0	0	0	0	8	0	8	8	0	8	8	0	8	8	0	8	8	0	8	8	0	8	0	0	0	0	0	0
GRAND TOTAL (A+B+C)	3,639	208.7	10,797	0	0	0	0	0	0	8	0	8	8	0	8	22	14	488	433	29	1,423	1,695	68	4,031	1,077	62	3,201	372	36	1,613	23	0	26

JICA = 8,256 — 10,797 — GoPNG = 2,541 \ million = 74.1 k million in Case of Excluding VAT and Import TAX
8,256 **100.00%**

Administration Cost = 3% of the Eligible portion
VAT (1) = 10.0% of the expenditure in local currency of the eligible portion for construction material and works
VAT (2) = 10.0% of the expenditure in local currency of the eligible portion for procurement of O&M material and consulting services
Import Tax= 10.0% of the expenditure in foreign currency of the eligible portion

Price Escalation																																	
Price Escale				1	1		1	1		1	1		1	1		1.014	1.031		1.028196	1.062961		1.0425907	1.0959128		1.057187	1.129886		1.0719876	1.1649126		1.0869955	1.2010248	
d Price Escal				0	0		0	0		0	0		0	0		0.014	0.031		0.028196	0.062961		0.0425907	0.0959128		0.057187	0.129886		0.0719876	0.1649126		0.0869955	0.2010248	

Loan interest during const.																																	
Financing rate	100.0%																																
Interest rate for YEN loan	0.20%																																
Temporaly alocation			10,724	0	0		0	0		0	0		0	0		13	13		1,091	1,091		3,233	3,233		2,486	2,486		1,336	1,336		23	23	
Debt at the end of term				0			0			0			0			13			1,104			4,340			6,834			0			23		
Interest during const				0			0			0			0			0			2			9			14			0			0		

9.3 Construction and Procurement Plan

9.3.1 Construction Scheme

(1)Branch Sewer

Branch sewer covers 9 areas in coastal area of Port Moresby by gravity flow system, total length of branch sewer is 17.4 km. Diameter from 100mm to 225mm of uPVC pipe and from DN160 to DN355 HDPE are adopted for the network. The purpose for the branch sewer is to collect wastewater from individual house, local factories and local markets and collected wastewater flows into trunk sewer.

In the detailed design, branch sewer is basically laid between 0.9 meters to 3.0 meter deep from the existing ground. Normally, open cut method is applied for all branch sewer lines. If the pipe is laid over 1.5 meters, earth retaining work such as sheet piles is needed to apply for safety measures during pipe installation work. Necessary excavation width has to be minimum requirement for not blocking through traffic on site. Earth compaction after pipe installation is done well by the Contractor for preventing land collapse.

Bruch sewer is installed most of narrow street. In some cases, it is difficult for secure the necessary carriage way, therefore, the Contractor has to provide a sign board that shows detour in accordance with NCDC and National Road Safety Council instructions. Even if there has enough carriage way on site, the Contractor has to provide safety measures. For the example of conducting the safety measure, a sign board, safety fence and security guards are needed to provide by the Contractor. At the construction stage, traffic management by the Contractor has to be done and the conflict between the Contractor and neighborhood has to be avoided during the construction on site.

(2) Trunk Sewer

Trunk sewer is divided for 19 stretches in proposed site, which total length is 17.6km, diameter is from 110mm to 710mm (nominal diameter) and HDPE is applied for the network. The Trunk sewer covers from the eastern edge of the line in Port Moresby, and the truck sewer goes through the coastal area and it flows into Kila Kila Sewage treatment plant. Wastewater flows into pumping stations is gravity line but most of trunk sewer is pressurized line.

The construction method is same as branch sewer, which is open cut method and is basically laid between 0.9 meters to 3.0 meter deep from the existing ground, and if the excavation depth exceeds 1.5meter, earth retaining wall such as sheet piling is needed to apply for pipe installation. Comparing with installation of branch sewer, trunk sewer is installed relatively wide road. Even if this condition, the contractor has to follow abovementioned safety measure.

(3) Pumping Station

Proposed 17 Pumping Stations include new construction and rehabilitation of existing pumping stations for replacement of M&E equipment. The existing pumping stations are located near the main streets and estimated average excavation depth of civil work is more than 5m. Most of pumping Stations are located along the main road. Careful excavation/temporary works for

rehabilitating/constructing pumping stations should be applied to prevent collapse of the road and traffic disturbance during construction term.
Replacing period of M&E equipment in the existing pumping station shall be minimized to shorten the period of temporary pumping.

(4) Sewage Treatment Plant (Kila Kila)

The Sewage Treatment Plant (STP) will be constructed on vacant land on the east side of Kila Kila Point located southeast of Port Moresby.
The construction works of Kila Kila STP will include site clearance, civil, mechanical, electrical, plumbing works and landscaping for all treatment units with construction of retaining wall along coastal line and access road to the facility.
The following temporary facilities will be also constructed near the site.

- Engineer's office
- Contractor's office
- Warehouse, Storage, Fabrication Yard, Toilet
- Storage Yard
- Construction Camp for the Worker

Major works of STP construction consists of the followings;

(a) Preparatory Work

Preparatory works will start from construction of temporary access road to construction site. It is a part of permanent access road of Kila Kila STP. During the construction, access road will be utilized with temporary pavement.

(b) Earth / Excavation work

Earth / Excavation work will be conducted mainly by backhoe. Clamshell will be also applied in case that excavation depth is more than GL - 5.00m.
Excavated soil will be transported by dump truck and kept in the treatment site for backfilling material.

(c) Structural work

Structural work of STP is construction of reinforced concrete structures of treatment facilities.
Main construction facilities are as follows:

- Grit Chamber
- Distribution Tank
- Oxidation Ditch
- Final Sedimentation Tank
- Sludge Pump Room
- UV Disinfection / Treated water Tank
- Wastewater Tank / Utility water Tank

Concrete placing will be conducted by concrete pump machine.
Concrete structures shall be constructed in combination with mechanical and electrical equipments

installation.

(d) Building work

Building work of STP is to construct following buildings.

- Administration Building
- Electrical Substation
- Blower / Local control Room
- UV Disinfection Room
- Chlorine Storage Building
- Sludge Treatment Building
- Guard House

Architectural works will also be conducted in combination with mechanical and electrical equipments installation.

(e) Mechanical and electrical works

Mechanical and electrical works are to install mechanical and electrical equipments into the STP Facilities. Installation of equipments shall be conducted according to drawings and specifications. Testing of works shall be done after all equipments installation.

(f) Backfilling and In-plant Yard Works

After structure construction, backfilling and In-plant yard work will be conducted.

In-plant work includes process pipe work, construction of retaining wall / sea water protection and landscape etc.

(5) Access Road to Morata Sewage Treatment Plant

Access road to Morata Sewage Treatment Plant (STP) will be constructed on this project. The existing access road will be paved by gravel.

The construction for access road includes in-plant yards work.

(6) Ocean Outfall

The Length of ocean outfall pipe is appprox.1.6km with HDPE ND 800mm Dia. The Ocean outfall pipe will be installed in Joyce Bay, which is divided underground section and undersea section. There are existing coral reefs in shallow part of the ocean; therefore, coral transplantation by the Contractor is needed before pipe installation. The construction scheme of each area is described in “5.3.2 Ocean Outfall”.

9.3.2 Construction Period

The construction period of each project component is shown in **Table 9.3.1**.

Table 9.3.1 Construction Schedule

Construction Works	2012			2013										2014											2015											2016			Remarks
	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
1. Branch Sewer (L=17.4 km)																																										
Preparatory Work																																										
a) Idubada & Hanuabada, 1.9 km																																										
Commissioning (Test run for (a))																																										
b) Kaugere, 1.7 km																																										
c) Gabutu, 1.6 km																																										
d) Kila Kila, 3.4 km																																										
Commissioning (Test run for (b, c, d))																																										
e) Touaguba & Ela Makana, 1.9 km																																										
f) Koki, 1.9 km																																										
g) Badili, 5.0 km																																										
Commissioning (Test run for (e, f, g))																																										
2. Trunk Sewer (L=17.7 km)																																										
Preparatory Work																																										
a) PS-1 to PS-4 (①②③, 3.4 km)																																										
Test run for (a)																																										
b) PS-13 to Receiving MH1 (⑭⑮⑯, 1.9 km)																																										
c) Receiving MH1 to STP (⑰⑲, 2.5 km)																																										
Test run for (b, c)																																										
e) PS-9 to Receiving MH1(⑩,⑪, 3.5 km)																																										
f) PS-11 to Receiving MH1(⑫⑬, 1.7km)																																										
g) PS-4 to PS-9(④⑤⑨, 2.9 km)																																										
h) Others (PS6, 7, 8, 16 and 17, 2.1 km)																																										
Test run for (e, f, g, h)																																										
Commissioning (Test on completion)																																										
3. Ocean Outfall (L=1.6 km)																																										
Preparatory Work																																										
Underground piping, L=428 m																																										
Exposure piping, L=266 m																																										Concrete protection
Coral reef transplant																																										
Underseawater piping, L=913 m																																										
Test run (Function test)																																										
Commissioning (Test on completion)																																										
4. Pumping Station (New construction: 8 places, Reconstruction: 5 places, Rehabilitation: 4 places)																																										
Preparatory Work																																										
PS-1,-2,-3 Civil&Architectural work																																										
PS-1,-2,-3 Mechanical&Electrical work																																										
Test run (Function test) for PS-1,2,3																																										
PS-13,-14,-15,-16,-17 Civil&Arch. work																																										
PS-13,-14,-15,-16,-17 Mech.&Elec. work																																										
Test run (Function test) for PS-13 to 17																																										
PS-9,-10,-11,-12,-4,-5,-6,-7,-8 Civil&Arch.																																										Construction order shall be
PS-9,-10,-11,-12,-4,-5,-6,-7,-8 Mec.&Elec.																																										start from PS-9, 10, 11.
Test run (Function test) for PS 4 to 12																																										
Commissioning (Test on completion)																																										
5. Kila Kila Sewage Treatment Plant (Q=13,800m^3/day)																																										
Preparatory Work																																										
Access Road							(Approach Road for Construction)																																				
Earth Work																																										
Structure Work for Civil																																										12 Block*4 Lot / 3 party
Building Work																																										
Yard Work incl.Retaining Wall																																										
Piping Work in Plant																																										
Landscape																																										
Mechanical & Electrical Work																																										
Assembly in manufactory																																										
Installtion																																										
Commissioning (Test run)																																										
6. Sludge Drying Bed in Morata STP																																										
Preparatory Work																																										
Access Road																(Approach Road for Construction)															(Pavement)												
Earth Work																																										
Structure Work for Civil																																										
Landscape																																										
Commissioning (Test on completion)																																										

9.3.3 Procurement Plan

The construction materials for civil works and construction equipment can be procured in PNG. However, most of the mechanical and electrical equipment shall be imported from Japan to secure the proper performance of Oxidation ditch system. The materials for O&M shall also be imported from Japan for quality of reliability, durability and safety as required. The procurement plan is shown in **Table 9.3.2**.

Table 9.3.2 Procurement Plan

Item		Within PNG	Outside of PNG	Import from Japan
Common Materials	Concrete	○		
	Cement	○		
	Re-bar		○	
	Gravel	○		
	Soil	○		
Pipe Materials	Ductile Cast Iron Pipe		○	
	HDPE Pipe		○	
	uPVC Pipe		○	
	Concrete Pipe	○	○	
Mechanical Equipment	For P.S & STP, Procurement			○
Electrical Equipment	For P.S & STP, Procurement			○
Construction Equipment	Truck Crane	○	○	
	Dump Truck	○	○	
	Bulldozer	○	○	
	Backhoe	○	○	
Materials for O&M	High-Velocity Jet Truck			○
	Vacuum Truck			○
	Water Tank Truck			○
	Dump Truck			○
	Car with Television Inspection			○

9.4 Project Implementation Schedule

The activities/schedule of project implementation in pre-construction and construction stage are presented in **Table 9.4.1**, **Figure 9.4.1**.

Table 9.4.1 Activities in Project Implementation

Project Activity	Anticipated time frame and/or duration
Preparation of P/Q, Tender Documents	4 months
P/Q (Concurrence in documents, Notice)	3 months
P/Q (Evaluation, Concurrence)	2 months
Tender (Concurrence in documents, Invitation)	2+3 months
Tender (Technical evaluation, Concurrence)	3 month
Tender (Price evaluation, Concurrence)	2 months
Contract Negotiation	2 month
Total period of Construction Work	39 months
Completion of the project and Plant trails	December 2015

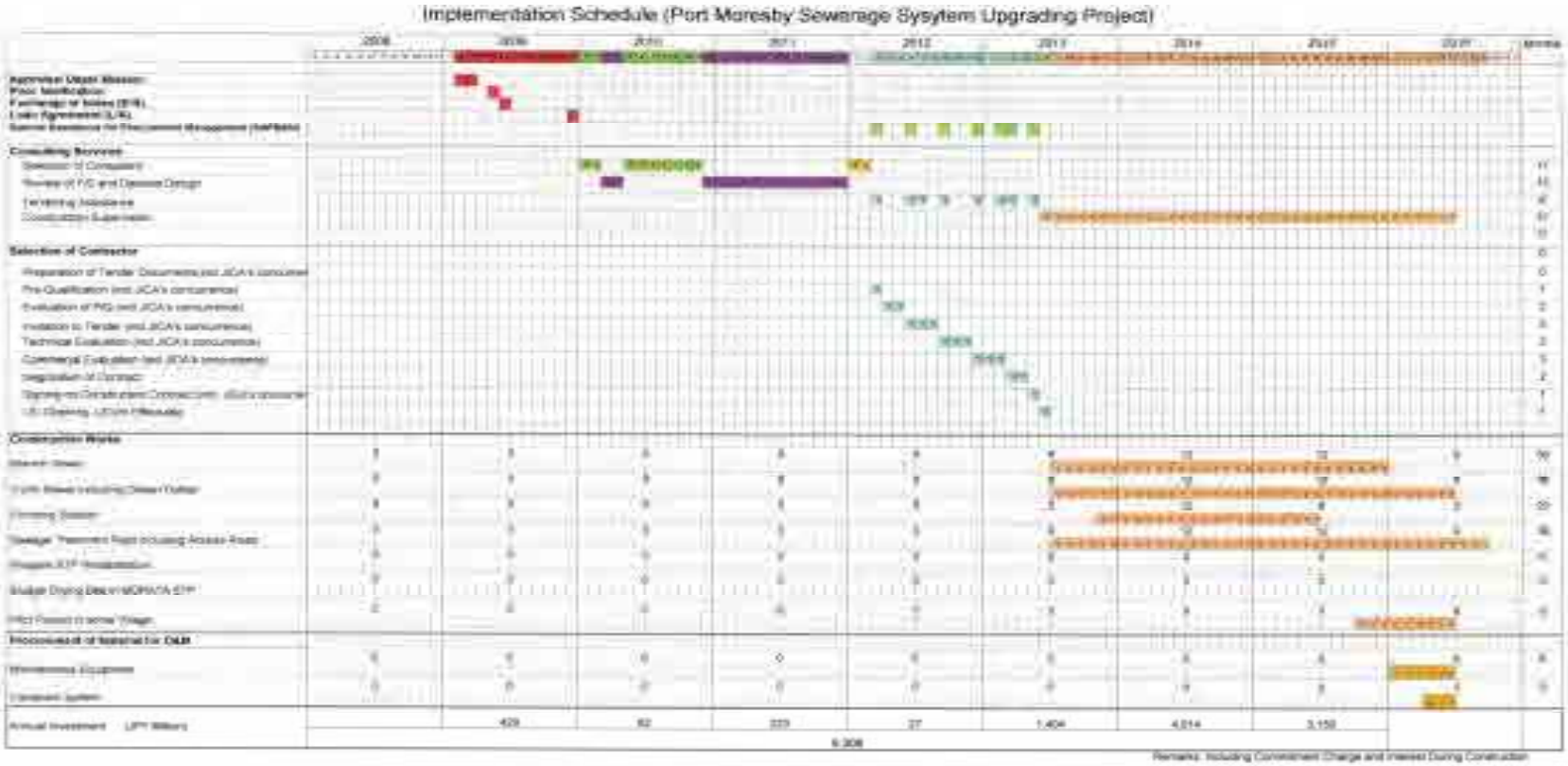


Figure 9.4.1 Project Implementation Schedule

9.5 Evaluation Criteria for Prequalification of Bidders

9.5.1 Background

The Port Moresby Sewerage System Upgrading Project, (hereinafter referred to as the "Project") will be financed with the Japanese ODA loan to be provided under the Loan Agreement No. PN-P9 concluded between Japan International Cooperation Agency (JICA) and the Independent State of Papua New Guinea at the date of 29th January 2010.

This Loan is provided under Special Terms for Economic Partnership (STEP). The Loan Agreement sets forth the conditions for the procurement of good and services to be financed out of the proceeds of the Loan as follows:

(1) Procurement shall be in accordance with the Guidelines for Procurement under the Japanese ODA Loans dated March 2009 (called "JICA Procurement Guidelines").

(2) The eligible nationality of the prime contractor shall be Japan. In case where the prime contractor is a joint venture, an eligible joint venture shall be such that the nationality of lead partner be in Japan and the nationality of other partners be Japan and/or the Independent State of Papua New Guinea and the total share of work of the Japanese partners in the joint venture be more than 50% of the contract amount.

(Note)

(i) The prime contractor or, in case of a joint venture, the lead partner and other partners regarded as the Japanese partners shall be nationals of Japan or juridical persons incorporated and registered in Japan, and which have their appropriate facilities for producing or providing the goods and services in Japan and actually conduct their business there.

(ii) In case of a joint venture, the partners except Japanese partners shall be nationals of the Independent State of Papua New Guinea or juridical parsons incorporated and registered in Japan or the Independent State of Papua New Guinea, and which have their appropriate facilities for producing or providing the goods and services in Japan or the Independent State of Papua New Guinea and actually conduct their business there.

(3) The total costs of goods and services procured from Japan shall not be less than 30% of the total price of contract to be financed under the Loan allocated for the construction works.

9.5.2 Bidding Procedure

In the Memorandum on the Project concluded between JICA and the Independent Public Business Corporation, the Executing Agency for the Project at the date of 29th January 2010, it was agreed that the bidding procedure for the award of contractor for the Project shall be as follows:

(1) International Competitive Bid (ICB) with prequalification
(2) Two envelope procedure defined in the JICA Procurement Guidelines
(3) One procurement package covering the whole works including the supply of all equipment and materials as well as the construction, testing, commissioning and training.

9.5.3 Application Form and Procedure for Pre-qualification

The prequalification of bidders, JICA advises to use the "Sample Prequalification Documents under Japanese ODA Loans Version 1.0" (called "JICA Sample Prequalification Documents) issued by JICA in April 2010, a copy of which is enclosed in Appendix 18.

Thus the prequalification documents for the Project will be prepared by using the JICA Sample Prequalification Documents.

9.5.4 Prequalification Criteria and Requirements to be Met by Bidders

JICA Sample Prequalification Documents defines the following four criteria for the prequalification:

(1) Eligibility
(2) Historical contract non-performance
(3) Financial situation
(4) Experience

The JICA Sample Prequalification Documents also set out the requirements to be met by applicants for prequalification. Described below are details of specific prequalification requirements to be applied for the Project that have been developed in accordance with the JICA Sample Documents.

(1) Eligibility

Applicants must meet the following eligibility requirements:

a. Nationality of applicants

The eligible nationality of the prime contractor, as stated in Paragraph 1-(2) above, shall be Japan. In case where the prime contractor is a joint venture, an eligible joint venture shall be such that the nationality of lead partner be in Japan and the nationality of other partners be Japan and/or the Independent State of Papua New Guinea and the total share of work of the Japanese partners in the joint venture be more than 50% of the contract amount. Thus applicants satisfying the above requirements will be eligible for the prequalification.

b. No conflict of interest

The JICA Sample Prequalification Documents set out that applicants shall not have a conflict of interest, and an applicant may be considered to have a conflict of interest with one or more parties in this prequalification process if:

(a) an applicant has been engaged by the Employer to provide consulting services for the preparation related to procurement for or implementation of the project;

(b) an applicant is any of its associates/affiliates (inclusive of parent firms) mentioned in subparagraph (a) above; or

(c) an applicant lends, or temporarily seconds its personnel to firms or organizations which are engaged in consulting services for the preparation related to procurement for or implementation of the project, if the personnel would be involved in any capacity on the same project.

c. Applicants determined by JICA to be ineligible

JICA will recognize a bidder or contractor as ineligible, for a period determined by JICA, to be awarded a contract funded with Japanese ODA Loans if it at any time determines that the bidder or the contractor has engaged in corrupt or fraudulent practices in competing for, or in executing another contract funded with Japanese ODA Loans or other Japanese ODA. Such applicants that have been determined to be ineligible by JICA will not be eligible for the prequalification.

(2) Historical contract non-performance

Applicants must meet the following two requirements:

a. History of non-performing contracts

Each applicant is required to clarify that non-performance of a contract did not occur within the last two [1] years prior to the deadline for application submission based on all information on fully settled disputes or litigation. A fully settled dispute or litigation is one that has been resolved in accordance with the Dispute Resolution Mechanism under the respective contract and where all appeal instances available to the Applicant have been exhausted.

b. Pending litigation

Each applicant is required to substantiate that all pending litigation shall in total not represent more than 50 % [2] of the applicant's net worth and shall be treated as resolved against the applicant.

[1] *JICA Guidelines indicate to be one year or two years.*
[2] *JICA Guidelines indicate to be within the range of 50% and 100%.*

(3) Financial Situation

Each applicant is required to satisfy the following requirements for prequalification:

a. Financial Performance

Each applicant is required to submit audited balance sheets or other financial statements acceptable to the Executing Agency, for the last five (5) years to demonstrate the current soundness of the applicant's financial position and its prospective long term profitability. As the minimum requirement, an applicant's net worth calculated as the difference between total assets and total liabilities should be positive.

b. Average Annual Construction Turnover

Each applicant is required to submit an annual construction turnover statement for the last five (5) years. Minimum average annual construction turnover should not be less than US$ 210 million [3] equivalent, calculated as total certified payments received for contracts in progress or completed, within the last five (5) years.

(4) Experience

Each applicant should have the experiences enumerated below for prequalification.

a. General Construction Experience

Experience under construction contracts in the role of contractor, management contractor, or subcontractor, for at least the last five (5) [4] years prior to the application submission deadline, and with activity in at least nine (9) months in each year

b. Specific Construction Experience

1) Experience exclusively in the role of prime contractor, in at least three (3) contracts within the last ten (10) years, that have been successfully and substantially completed and that are similar to the proposed Works.

The similarity shall be based on the physical size, complexity, methods/technology or other characteristics of the works as follows:

- Construction of Sewage Treatment Plant with the following treatment process and capacity:
  - Sewage Treatment Process: Oxidation Ditch Process
  - Treatment Capacity: 5,000 m^3/day or larger
- Construction of sewer pipeline system in a total length of 20 km or more

[3] *JICA Guidelines indicate to be not less than 1.5 of the estimated work costs for a large contract. It was calculated by multiplying 1.5 to the estimated work costs (i.e., US$140 millions).*

[4] *As per the JICA Guidelines.*

2) For the above or other contracts executed during the period stipulated in 1) above, a minimum construction experience, as prime contractor or management contractor in completion of at least one (1) sewerage treatment plant and sewer pipeline network as indicated in 1) above, including testing, commissioning, as well as operation and maintenance training, in a country out of Japan that is situated in conditions similar to the Project Site.

(Note)

The Sewage Treatment Plant shall be one having been operated for more than two years as at the date of deadline for the submission of application for the prequalification.

9.6 Framework and Main Points of Bidding Documents

9.6.1 General

(1) Background

Under the Loan Agreement PN-P9 dated 29th January 2010 between JICA and Independent State of Papua New Guinea (PNG) for the Port Moresby Sewerage System Upgrading Project (POMSSUP) and also the Memorandum on the Project between JICA and the Independent Public Business Corporation (IPBC), the Executing Agency for the Project, dated 29th January 2010, it has been agreed that the works for the POMSSUP shall be procured in the following procedures and conditions:

a) Procurement in accordance with the Guidelines for Procurement under the Japanese ODA Loans (called "JICA Procurement Guidelines")
b) International Competitive Bid (ICB) with Prequalification of Bidders
c) Single-stage Two Envelope Bid

JICA has published sample bidding document forms to meet the above conditions. The Bidding Documents for the POMSSUP have been prepared in the form of the latest version of these sample bidding document forms listed below.

a) Guidelines for Procurement under the Japanese ODA Loans dated March 2009
b) Sample Prequalification Documents under Japanese ODA Loan version 1.0 published in April 2010
c) Sample Bidding Documents under Japanese ODA Loan version 1.1 published in June 2009

(2) Special Conditions applied to the Procurement of Works for POMSSUP

The Japanese ODA Loan provided for the POMSSUP is a special scheme of loan named STEP (Special Terms for Economic Partnership), under which the Loan Agreement set forth special terms to be applied for the procurement. Thus the Bidding Documents have been prepared so as to meet the following special terms provided for in the Loan Agreement:.

a) Eligible nationality of the prime contractor : Japan

b) In case of Joint Venture (JV): - Nationality of lead partner to be in Japan
-Nationality of other partners to be Japan and/or Independent State of Papua New Guinea (Total share of work of the Japanese partners must be more than 50% of the contract amount.)

c) Total costs of goods and services procured from Japan:
To be not less than 30% of the total price of contract to be financed under the Loan allocated for the construction works.

(3) Bidding Procedure in accordance with Single-stage Two-envelope System

The bidding procedure in accordance with Single-stage Two-envelope System is as follows:

a) Prequalification of bidders

- Invitation for the submission of prequalification application by interested bidders through announcement in selected newspapers. Special consideration may be required for the method of announcement, since eligible nationality of the prime contractor shall be limited to Japan.
- Prequalification of bidders based on the evaluation of submitted applications for prequalification

b) Bidding among Prequalified Bidders

- Invitation for bids to the prequalified bidders
- Simultaneous submission by the bidders (prequalified) of technical bid and price bid in a separate seal
- Evaluation of bids in the following steps:
  - First Step: Opening of Technical Bids
    (Holding Price Bids unopened until the opening of Price Bids that will be conducted in the subsequent step.)
  - Second Step: Technical Evaluation
    To determine bids being substantially responsive to technical requirements; called **"Technically Responsive Proposals"** or **"Technically Responsive Bidders"**.
  - Third Step: Opening of Price Bid
    To open the Price Bids submitted by **"Technically Responsive Bidders"**
  - Fourth Step: Price and Commercial Evaluation
    To evaluate the price and commercial conditions offered by **"Technically Responsive Bidders"** to determine a bid offering the lowest evaluated bid price and also commercial terms that is substantially responsive to commercial requirements

- Fifth Step: Award of Contract

  To award the bidder who offered the lowest evaluated bid price and commercially responsive bid as the successful bidder.

(4) JICA Concurrence Required for Prequalification and Bidding Documents and Evaluation Results

All the documents for prequalification and bidding as well as the evaluation reports in the respective step of prequalification and bid evaluation are subject to JICA's review and concurrence:

- Documents for prequalification and bidding requiring JICA's prior review and concurrence
  - Invitation for prequalification
  - Prequalification documents to be provided to interested applicants
  - Invitation for bid
  - Bidding documents to be provided to prequalified bidders
- Evaluation reports to be submitted to JICA for their review and concurrence
  - Evaluation report for prequalification
  - Technical evaluation report for bid, recommending **"Technically Responsive Bidders"**
  - Price and commercial evaluation report for bid, recommending award of **"Successful Bidder"**
- Contract documents

9.6.2 Framework of Bidding Documents

(1) Bid Package

The bid for PMSSUP is considered as a single bid package covering all of the following six work components:

a) Construction of sewer network; comprising trunk sewer pipelines and branch sewer pipelines in a total length of approximately 35km,
b) Construction/rehabilitation of 17 pumping stations (PS),
c) Construction of a Sewage Treatment Plant (STP) with a treatment capacity of 18,400m^3/day, including the construction of ocean outfall in a length of approximately 1.4km for discharging treated effluent from STP,
d) Execution of a "Pilot Project" for providing water supply and sewerage facilities to a block of selected 20 houses built on the sea at Hanuabada village,
e) Procurement of vehicles to be used for the operation and maintenance of the sewerage system, and
f) Executing a "Social and Environmental Consideration Programme" aiming to maximize the benefits that can be derived from the Pilot Project in the near-shore village inhabitants and also preventing HIV/ AIDS from spreading.

(2) Composition of Prequalification and Bidding Documents

The prequalification documents and bidding documents prepared for the procurement of POMSSUP are composed of the following documents:

a) Documents for Prequalification
   - Invitation for Prequalification: To be used for public announcement in selected newspapers
   - Prequalification Documents: To be provided to interested applicants

b) Documents for Bidding
   - Invitation for Bid: To be notified to prequalified bidders
   - Bidding Documents: To be distributed to interested firms among the prequalified bidders
     i). Instructions to Bidders
     ii). Bill of Quantities (non-priced)
     iii). Technical Specifications (Standard Specifications and Particular Specifications
     iv). Tender Drawings

9.6.3 Application Documents and Evaluation Criteria for Prequalification

(1) Contents of Application Documents for Prequalification

The contents of application documents for prequalification are as follows:

PART 1 – Prequalification Procedures

Section I. Instructions to Applicants
Specifying the procedures to be followed by Applicants in the preparation and submission of their Applications for Prequalification (AFPs), and also providing information on opening and evaluation of AFPs.

Section II. Prequalification Data Sheet
Setting out provisions that are specific to each prequalification and supplement the information or requirements included in Section I, Instructions to Applicants

Section III. Qualification Criteria and Requirements
Defining the methods, criteria, and requirements to be used to determine how Applicants shall be prequalified and later invited to bid.

Section IV. Application Forms
Indicating the Application Submission Form and all other forms required to be submitted with the application

Section V. List of Eligible Countries of Japanese ODA Loans
Information in respect of eligible countries under Japanese ODA Loans.

PART 2 – Works Requirements

Section VI. Scope of Works
A summary description, delivery and completion schedules, technical specifications and drawings of the Works subject of this prequalification.

(2) Evaluation Criteria for Prequalification

In accordance with the JICA Sample Prequalification Documents, the following four criteria are applied for the evaluation of prequalification:

1) Eligibility
2) Historical contract non-performance
3) Financial situation
4) Experience

The requirements to be satisfied or met by applicants for passing prequalification were set up in accordance with the JICA Guideline and the provision of the Loan Agreement, as follows:

a) Eligibility

1) Nationality of applicants: defined as follows in accordance with the provision of the Loan Agreement
   - ■ Eligible nationality of the prime contractor: To be Japan.
   - ■ In case of Joint Venture (JV): - Nationality of lead partner to be Japan
     - Nationality of other partners to be Japan and/or PNG (Total share of work of the Japanese partners must be more than 50% of the contract amount.)

2) No conflict of interest: defined as follows in accordance with the JICA Guideline
   - ■ An applicant is considered to have a conflict of interest with one or more parties in this prequalification process if:
     i) an applicant has been engaged by the Employer to provide consulting services for the preparation related to procurement for or implementation of the project;
     ii) an applicant is any of its associates/affiliates (inclusive of parent firms) mentioned in subparagraph (a) above; or
     iii) an applicant lends, or temporarily seconds its personnel to firms or organizations which are engaged in consulting services for the preparation related to procurement for or implementation of the project, if the personnel would be involved in any capacity on the same project.

3) Applicants determined by JICA to be ineligible
   - ■ Bidder or contractor announced by JICA to be ineligible for award of a contract for a certain period due to JICA's determination that he has engaged in corrupt or fraudulent practices in competing for, or in executing another contract funded with Japanese ODA Loans or other Japanese ODA.

b) Historical contract non-performance: defined as follows in accordance with the JICA Guideline

1) History of non-performing contracts
   - ■ Each applicant is required to clarify that non-performance of a contract did not occur

within the last two [5] years based on all information on fully settled disputes or litigation

2) Pending litigation

- Each applicant is required to substantiate that all pending litigation shall in total not represent more than 50 % [6] of the applicant's net worth and shall be treated as resolved against the applicant

3) Financial Situation: defined as follows in accordance with the JICA Guideline

4) Financial Performance

- Each applicant is required to submit audited balance sheets or other financial statements acceptable to the Executing Agency, for the last five (5) years to demonstrate the current soundness of the applicant's financial position and its prospective long term profitability
- As the minimum requirement, an applicant's net worth calculated as the difference between total assets and total liabilities should be positive.

5) Average Annual Construction Turnover

- Each applicant is required to submit an annual construction turnover statement for the last five (5) years.
- Minimum average annual construction turnover to be not less than US$ 210 million [7] equivalent, calculated as total certified payments received for contracts in progress or completed, within the last five (5) years.

c) Experience

The following conditions are set in order to prequalify contractors who have adequate experience in undertaking the proposed works in an extent unreasonably limiting bidders.

1) General Construction Experience

- Experience under construction contracts in the role of contractor, management contractor, or subcontractor, for at least last five (5) [8] years prior to the application submission deadline, and with activity in at least nine (9) months in each year.

2) Specific Construction Experience

3) Experience exclusively in the role of prime contractor, in at least two (2) contracts** for the works indicated as (A) below and one (1) contract for the works indicated as (B) below respectively within the last ten (10) years, that have been successfully and substantially completed and that are similar to the proposed Works.

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[5] *JICA Guidelines indicate to be one year or two years.*
[6] *JICA Guidelines indicate to be within the range of 50% and 100%.*
[7] *JICA Guidelines indicate to be not less than 1.5 of the estimated work costs for a large contract. It was calculated by multiplying 1.5 to the estimated work costs assuming as US$140 million.*
[8] *As per the JICA Guidelines.*

The similarity shall be based on the physical size, complexity, methods/technology or other characteristics of the works as follows:

A. Construction of Sewage Treatment Plant (STP) with the following treatment process and capacity:
   - Sewage Treatment Process: Oxidation Ditch Process or Activated Sludge Process
   - Treatment Capacity: 5,000 m^3/day or larger

B. Construction of sewer pipeline system in a total length of 10 km or more

(Note)

**As for a contract covering the construction of STPs more than one STP, the number of contract can be accounted as per the number of STPs constructed under the contract

For the above or other contracts executed during the period stipulated in 1) above, a minimum construction experience, as prime contractor or management contractor in completion of at least one (1) STP and also sewer pipeline network construction as indicated in 1) above, including testing, commissioning, as well as operation and maintenance training of STP, in a country out of Japan that is situated in conditions similar to the Project Site.

(Note)

The STP shall be one having been operated for more than two years as at the date of deadline for the submission of application for the prequalification.

9.6.4 Contents of Application Documents for Prequalification

(1) Contents of Bidding Documents

The Bidding Documents are composed of the following four volumes:

- Volume 1: Instructions, Conditions of Contract, Bidding Forms
- Volume 2: Bill of Quantities
- Volume 3: Technical Specifications
- Volume 4: Tender Drawings

The contents of each volume are delineated below.

a) Volume 1: Instructions, Conditions of Contract, Bidding Forms

PART 1 – BIDDING PROCEDURES

Section I: Instructions to Bidders (ITB)

Providing relevant information to help Bidders prepare their technical and price bids, and also providing information on the submission, opening, and evaluation of technical and price bids and on the award of Contracts

Section II. Bid Data Sheet (BDS)

Setting out provisions that are specific to each procurement and that supplement the information or requirements included in Section I, Instructions to Bidders.

Section III. Evaluation and Qualification Criteria

Setting out the criteria to be used for the evaluation of technical bids to be conducted prior to the evaluation of price bids.

Section IV. Bidding Forms

Providing the forms which are to be completed by the Bidder and submitted as part of his Bid.

- Letter of Technical Bid
- Letter of Price Bid
- Schedule of Adjustment Data
- Bill of Quantities (see 2-2)
- Technical Proposal (Forms)
- Information on Bidders Qualification following Prequalification
- Acknowledgment of Compliance with Guidelines for Procurement under Japanese ODA Loans

Section V. List of Eligible Countries of Japanese ODA Loans

Providing information regarding eligible countries.

PART 2 – WORKS REQUIREMENTS

Section VI. Works Requirements

Providing description of the Works to be procured, including supplementary information, data and drawings.

PART 3 – CONDITIONS OF CONTRACT AND CONTRACT FORMS

Section VII. General Conditions (GC)

Providing for general clauses to be applied in all contracts.

- Using Bank Harmonized Edition of the General Conditions of Contract prepared by the International Federation of Consulting Engineers (*Fédération Internationale des Ingénieurs-Conseils*, or FIDIC), agreed among various Multilateral Development Banks and FIDIC.
- By virtue of a license agreement subscribed between JICA and FIDIC, JICA's Borrowers and their implementing agencies are authorized the reproduction and translation of the Bank Harmonized Edition of FIDIC's General Conditions of Contract for the exclusive purpose of preparing Bidding Documents in accordance with these Sample Bidding Documents.

Section VIII. Particular Conditions (PC)

Consisting of Part A, Contract Data, which contains data, and Part B,

Specific Provisions, which contains clauses specific to each contract.

Section IX: Annex to the Particular Conditions - Contract Forms

Providing forms which, once completed, will form part of the Contract, and also the forms for Performance Security and Advance Payment Security, when required, shall only be completed by the successful Bidder after contract award.

b) Volume 2: Bill of Quantities

1) Preamble to Bill of Quantities

Setting out the general conditions for quoting the rates/prices in the Bill of Quantities, and defining the costs to be included in the rates and method of measurement for the items on which only brief description is provided in the Bill of Quantities.

2) Daywork Schedule (Form)

Form of the rates to be quoted by Bidders for daywork to be executed under the Engineer's instructions

3) Schedule of Rates (Form)

Form of cost structure to be filled by Bidders for the respective rate quoted in the Bill of Quantities

4) Bill of Quantities (Form)

Form of Bill of Quantities to be priced by Bidders; indicating items, and unit and quantities for each item

5) Details of goods and services to be supplied from Japanese origin, including a subsidiary in PNG as defined in the Loan Agreement

c) Volume 3: Technical Specifications

1) Standard Specifications

Setting out technical requirements and specifications generally and commonly applicable to the works

2) Particular Specifications

Setting out particular requirements and specifications to be applied to the works in precedence over those specified in the Standard Specifications

d) Volume 4: Tender Drawings

Providing drawings showing relevant parts of the works specified in the Technical Specifications.

(2) Bid Evaluation Criteria

a) Evaluation of Technical Bid

The objective of the technical evaluation is to assess adequacy of Technical Proposal to satisfy the technical requirements and to determine that the Technical Proposal is substantially responsive to the technical requirements. The evaluation includes, but is not

limited to, the following aspects:

1) Satisfaction of the proposed scope of the works to meet the requirements stipulated in the Bidding Documents
2) Satisfaction of the equipment and materials offered for the Sewage Treatment Plant, sewer pipelines, pumping stations and other associated facilities to meet the requirements specified in the Technical Specifications and other requirements stipulated in the Bidding Documents
3) Reliability/capabilities of the proposed supply sources of the major equipment and materials, as proved with the submitted documents for substantiating on having adequate manufacturing experiences and also records that these equipment and materials have been successfully used in the projects out of the manufacturer's home country, as specifically defined in the Bidding Documents.
4) Reliability/capabilities of the proposed specialist subcontractor(s) and/or local contractor(s), if any
5) Adequacy of the proposed work methods
6) Adequacy of the proposed work schedule and execution programmes
7) Adequacy and appropriateness of the proposed safety plan
8) Adequacy and appropriateness of the proposed environment protection plan
9) Adequacy of the proposed site organization and manpower
10) Adequacy of the proposed arrangements for construction equipment proposed arrangements for construction equipment
11) Confirmation of the Bidder's financial resources and financial position based on updated information submitted by the Bidders

b) Evaluation of Price Bid

The price and commercial evaluation are limited to the evaluation of Price Bid submitted by the bidders who have been determined to be "Technically Responsive Bidders" as the result of the Technical Evaluation.

The price and commercial evaluation are conducted in the following three aspects:

Computation of Evaluated Bid Prices in the following methods as indicated in the Instructions to Bidders (ITB):

1) Correction of arithmetic errors
2) Extraction of Provisional Sums for comparison purpose
3) Conversion to Japanese Yen by using the base exchange rate pre-determined for the bid evaluation
4) Price adjustment due to quantifiable nonmaterial nonconformities

A. Comparison of thus computed Evaluated Bid Prices to determine the lowest Evaluated Bid Price.
B. Evaluation of non-price commercial terms proposed by Bidders to determine Commercially Responsive Bids.
C. Verification of the Bid Price that total amounts of goods and services to be supplied

from Japanese origin are not less than 30% of the total price of contract to be financed under the Loan allocated for the construction works which is the condition defined in the Loan Agreement.

The Commercially Responsive Bid with the lowest Evaluated Bid Price in which total amounts of goods and services to be supplied from Japanese origin being not less than 30% is awarded for contract as the successful Bid.

(3) Specific Conditions Assumed for Bid

The Bids are based on the conditions and requirements stipulated in General Conditions and the Technical Specifications and given in the Tender Drawings. Specific conditions assumed in the Bidding Documents are summarized below.

a) Time for Completion: within 1190 days (or 39 months) from the Commencement of Works
b) Defect Notification Period (or Defect Liability Period): 365 days after the Completion Date (Taking-over Date)
c) Engineer's authority: The Engineer shall be authorized to issue Variation Orders up to not exceeding 10% of the Accepted Contract Amount
d) Performance Security: 10% of the Accepted Contract Amount
e) Delay damages for the Works to be charged to the Contractor: 0.1% of the Contract Amount per day; provided that the maximum amount of delay damages to be 10% of the Contract Amount
f) Advance Payment: 15% of the Accepted Contract Amount (excluding Provisional Sums) payable in the currencies and proportions in which the Accepted Contract Amount is payable.
g) Repayment of the Advance Pay:
h) Repayment to commence in the next interim Payment Certificate following that in which the total of all certified interim payments (excluding the advance payment and deductions and repayments of retention) exceeds 30% of the Accepted Contract Amount
i) Repayment amortization rate to be 15% of the amount of each Interim Payment Certificate (excluding the advance payment and deductions for its repayments as well as deductions for retention money)
j) Retention to be 10% of every Interim Payment Amount; provided that the maximum retention amount to be 5% of the Accepted Contract Amount
k) Minimum amount of third party insurance per occurrence: Yet to be determined
l) Commencement Date
m) The General Condition Sub-clause 8.1 sets forth that the Commencement Date shall be the date at which the following precedent conditions have all been fulfilled:
   - signature of the Contract Agreement by both Parties, and if required, approval of the Contract by relevant authorities in the Country;

- delivery to the Contractor of reasonable evidence of the Employer's Financial arrangements; and
- receipt by the Contractor of the Advance Payment.

In order to accelerate the commencement by the Contractor as early as possible, In Particular Conditions this clause is amended as follows:

"The Commencement Date shall be the date at which the following precedent conditions have all been fulfilled and the Engineer's instruction recording the agreement of both Parties on such fulfilment and instructing to commence the Works is received by the Contractor:

- signature of the Contract Agreement by both Parties, and if required, approval of the Contract by relevant authorities in the Country; and
- Contractor's acceptance on commencing the Works within certain days after receiving the Engineer's instruction to proceed with the Works

n) Taxes

The General Conditions Clause 14.1 sets forth that the Contractor shall pay all taxes, duties and fees required to be paid by him under the Contract. However, in order to meet an agreement made between the government of Japan and PNG with regard to the taxation and also standard clause set out in the CSTB's Tender Documents, the Particular Conditions amend as follows:

"For the taxes, duties and levies payable by the Contractor under the Contract, the following conditions shall be applied:

1) Japanese companies operating as suppliers and/or contractors shall be exempted from all fiscal levies and taxes imposed in Papua New Guinea (PNG) with respect to income accruing from the supply of products and/or services to be provided under the Japanese ODA Loan (hereinafter referred to as the "Loan") in accordance with the Loan Agreement N. PN-P9 dated 29th January 2011 (hereinafter referred to as the "Loan Agreement").
2) Japanese companies operating as suppliers and/or contractors shall be exempted from all duties and related fiscal charges imposed in PNG with respect to the import and re-export of their own materials and equipment needed for the implementation of the Project.
3) Japanese employees engaged in the implementation of the Project to be exempted from all fiscal levies and taxes imposed in PNG on their personal income derived from Japanese companies operating as suppliers and/or contractors for the implementation of the Project.

Notwithstanding the above, the Contractor shall pay any taxes, duties and levies for which the above conditions are not applicable.

At the time of signing the Contract, the Contractor shall submit a current Certificate of

Compliance (COC) to the Employer. Failure to do so will result in the Employer withholding 12% of any payment made to the Contractor until the COC is submitted."

o) Import Duties

Assuming that IPBC will apply exemption of import duties and surcharges to be imposed on the equipment and materials imported for the POMSSUP, the following provisions are set forth in the Particular Conditions Sub-clause 14.1 (f):

"Equipment and materials imported for the Permanent Works under the Contract shall be exempted from import duties, import exercise and GTS to be imposed in accordance with the laws and regulations in force in the Independent State of Papua New Guinea. The Contractor therefore shall not be obligated to pay such duties, tax and levies; however, the Contractor shall make all necessary documentation and arrangements for custom clearance, including application for exemption of import duties and surcharges for the imported equipment and materials on behalf of and in the name of the Employer or the operator of the completed Permanent Works designated by the Employer, at the Contractor's responsibility and his own costs."

p) Price Adjustment

The General Conditions Sub-clause 13.8 sets forth that the monthly Interim Payment amount is subject to adjustment in accordance with price adjustment formulae based on published price indexes for selected representative items such as labour and some construction materials. However, as there are no price indexes for such items published in PNG, this clause is not applicable. Hence this clause is not applied to the contract for POMSSUP.

q) Bank Charge for Opening of Letter of Credit and Transaction for Payment to the Contractor

The Particular Conditions set forth that all of these bank charges shall be borne and paid by the Contractor.

CHAPTER 10 UPDATED ENVIRONMENTAL MANAGEMENT AND MONITORING PLANS

10.1 Background

For long-term sustainable development, environmental and social assessments of the project and other associated issues are important. To be most effective, the study needs to be recognized as a process, rather than merely an additional element of the over-all assignment to aid project design, since the environmental implications affect the project in its wider social, political, economic and institutional setting. The environmental and social study is therefore an interdisciplinary component that involves both "technical" considerations (such as the amount of pollution reduction in wastewater) and "human" considerations (such as public perceptions of, and reactions to, the effects of the scheme).

Environmental assessments are most successful if they form an integral part of project development from the earliest stages so that the issues are incorporated not only into the design adopted, but also in the options considered and the ways in which the environmental and social components are approached. In this way, the various experts involved in the project take into account the key environmental and social aspects at every stage of the study and design.

In the case of the Detailed Design (Phase 2) on Port Moresby Sewerage System Upgrading Project in Port Moresby (POMSSUP) in Papua New Guinea (PNG), environmental and social considerations have already formed an integral part of the project development from the earliest stages (Master Plan and Feasibility Study). A review, evaluation and updating of the environmental and social studies prepared in previous JICA studies (Environmental Checklist, 2010) and by EDA RANU (Environmental Management Plan [EMP], 2009) have to be made.[1] Both documents must be revised and updated once the scope has been fixed in the Basic Design (Phase 2).

Specifically, the EMP is established to manage all environmental risks of an activity, which includes: i) identification of risks; ii) internal and external monitoring and reporting; and iii) contingency planning and plans for corrective actions (Environment Act 2000). The EMP is a statutory requirement as per the Environmental Act 2000 for Level 3 project activities in PNG to meet legal obligations. The POMSSUP was classified as Level 3[2] by the Department of Environment and Conservation (DEC) in April 2005.

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[1] EDA RANU submitted the EMP to DEC in January 2009. However, this EMP has not fully covered the project components as well as the environmental/social impacts and management strategies. It also needs additional analysis and explanations based on the basic design plans and the requirements of DEC and JICA.

[2] Level 3 projects are large projects that require an EIR and EIS to be submitted to DEC prior to implementation. A permit is needed from DEC and the Environment Minister.

An Environment Permit (December 2007) was issued to the Project by the DEC. However, this permit had already expired in January 2010. DEC then issued a directive on April 2011 to EDA RANU to submit an Addendum Environmental Impact Statement (EIS) and Construction and Operation Management Plans[3] to ensure that the old Environmental Permit is validated, renewed, and remains current. These reports are to be updated to determine if environmental and social considerations are in place to avoid, reduce or remedy significant adverse impacts in the light of new development/s. There is also a need to validate the sufficiency of the submitted environmental and social considerations considering the regulatory requirements of the Government of PNG (GoPNG) and JICA. Parallel to this is the review on the conformity of the basic design plans on the legal systems, standards and guidelines of GoPNG.

It must be noted that relevant conditions stipulated in the old permit have to be considered in the updating, such as Condition number 4 that have to be complied with prior to the construction of Kila Kila STP, installation of marine outfalls and other requirements that the DEC identifies. The measures/countermeasures during the construction phase to address impacts identified in the updated EMP will be incorporated in the Bid Documents as a Construction/Contractor's Environmental Program. This is a crucial move to ensure that all activities related to construction that would be detrimental to the environment are addressed. Among the commitments to be undertaken by the Contractor include, among others, the provision of adequate temporary facilities such as housing, sanitation and waste disposal, provision of slope stabilization and soil erosion controls, as well as storm water and pollution control measures. The program will be implemented during the entire duration of construction activities.

The preparation of an Environmental Monitoring Plan (EMoP) will be based on the updated EMP. The EMoP basically covers monitoring activities during construction and operation phases. The proposed monitoring plan discusses the following elements: i) activities/parameters to be monitored; ii) specific areas to be monitored; iii) manner of monitoring; iv) frequency of monitoring; v) cost of carrying out the monitoring; and vi) responsible person/agency for monitoring and data management. Special attention has to be made in monitoring the effects of ocean outfall pipes on the marine ecosystem specifically the coral reef condition, and the quality of the treated water that is being discharged.

[3] This Updated Environmental Management and Monitoring Plans (ref. **Appendix 2** of this Report for details) refers to the Construction and Operation Management Plan.

10.2 Approach

In the updating of the EMP, five core elements were considered:

- Conformity with the legal system: laws, regulations, standards and guidelines, policies etc.
- Assessment and modification of the current EMP/EMoP relative to basic design plans, and requirements of DEC for a renewed Environment Permit
- Review and revision of the Environmental Checklist based on the Updated EMP/EMoP
- Inclusion of all project components in the renewed Environmental Permit and change of name of the permit holder
- Mapping survey of coral communities and location of coral conservation areas

10.2.1 Conformity with the Legal System: Laws, Regulations, Standards and Guidelines, Policies

The DEC is responsible for environmental matters as well as administering the regulations which affect the natural environment. The laws related to the EMP are: 1) Environment Act 2000 (as amended in 2002); and 2) Public Health Act 1973. Policies and Standards relating to the Environment Monitoring Plan (EMoP) are: 1) Trade Waste Policy for Port Moresby Papua New Guinea, 2008 (Draft Final Report); and 2) Environment (Water Quality Criteria) Regulation 2002. Other relevant Acts include the National Cultural Property Preservation Act 1974.

(1) Environment Act 2000 (As amended 2002)

Acquisition of the Environment Permit for construction works and operation and maintenance (O&M) of plant or equipment is required by Environment Act 2000. In the case of POMSSUP, a renewed Environmental Permit has to be acquired in accordance with procedures required in the Act. All components of the Project are to be covered by the Permit. With this, IPBC/EDA RANU has been dealing with formalities to acquire a renewed Environmental Permit under DECs' directions.

(2) Public Health Act 1973

Prior to the establishment of the PNG Water Board (PNGWB) and EDA RANU, the management of sewage services was vested with DOH as per the Public Health Act 1973. These functions were outlined in two regulations supporting the Act, namely: 1) the Public Health Sewerage Regulation 1973; and 2) the Public Health Septic Tanks Regulation 1973. With the legislation of EDA RANU and PNGWB, the section on Public Health Sewerage Regulation was transferred to these two organizations. Regulations of the Act including sewerage regulation are currently being revised.[4]

[4] Interview with Dr. Aaron Gwamatae, Manager - Environmental Health, NDOH.

(3) Trade Waste Policy for Port Moresby Papua New Guinea (Draft Final Report) 2008

EDA RANU is now preparing the "Trade Waste Policy for Port Moresby Papua New Guinea". The disposal of commercial/industrial liquid waste discharged into the sewers will be regulated under this new policy. The policy is expected to be published by August 2011.

Although the target area of the Project has no major industrial establishments and sewerage mainly originates from domestic households, water quality analysis of industrial establishments is expected to be done by EDA RANU in the future once changes of land use occur in the coverage area. This is in accordance with the new Trade Waste Policy to prevent toxic and hazardous substances from entering the sewerage system. The implementation procedures for industrial discharges testing by EDA RANU have not yet been clearly presented; however, the Trade Waste Policy states that "EDA RANU will conduct the monitoring".

(4) Environment (Water Quality Criteria) Regulation 2002

GoPNG has established the Environment (Water Quality Criteria) Regulation 2002 under the Environment Act 2000. The regulation clearly stipulates the water quality guidelines for both fresh water and seawater for protection of aquatic life. While the guidelines stipulate the inorganic and bacteriological parameters such as pH, Fecal coliform, toxic chemicals and heavy metals, they do not provide values for organic matter and nutrients in parameters such as BOD, COD_{Mn}, T-N, T-P. The water quality guidelines will be applied at the boundary of the mixing zone. Major water quality items in the guidelines were included in the proposed water quality monitoring plan for ambient water quality.

(5) National Cultural Property (Preservation) Act 1965

National Cultural Property (Preservation) Act 1965 is administered by the National Museum & Art Gallery. The primary purpose of the Act is to preserve and protect objects of cultural or historical importance to PNG. Where archaeological/historical objects or sites are uncovered during construction, work will immediately cease and appropriate actions will be taken in accordance with procedures required in the Act.

10.2.2 Assessment and Modification of Current EMP/EMoP Relative to Basic Design Plans and Requirements of DEC for a Renewed Environment Permit

In this study, the existing EMP/EMoP was modified relative to the scope of the Basic Design Plans, as per the requirements of DEC for a renewed permit and of JICA. The updated EMP covers physical, biological and socio-economic issues/impacts & mitigation/management measures during construction and operation phases. In addition, implementation methodology of the proposed Social and Environmental Education Training Program for the pilot project area in Hanuabada and the proposed HIV/AIDS Prevention Training Program for construction workers and off-site communities (ref. **Chapter7** for details) were also described in the updated EMP as part of the social program to enhance

the benefits that will be derived from the Project.

10.2.3 Review and Revision of Environmental Checklist based on the Updated EMP/EMoP

Environmental Checklist was revised based on the updated EMP/EMoP (**Table 10.7.1**). The revised Environmental Checklist is in accordance with JICA Guidelines. An environmental review of the projects was carried out based on the revised Environmental Checklist. In addition, forms for water quality and coral reef monitoring were prepared for both construction and operation periods.

10.2.4 Inclusion of All Project Components in the Renewed Environmental Permit and Change of Permit Holder

The renewed permit must cover all project components: i) Kila Kila STP, laborers' base camp, access road and ocean outfall; ii) Morata land fill site and access road; iii) trunk and branch sewers, and pumping stations; and iv) pilot project in Hanuabada water village. The renewed permit will have IPBC as the permit holder being the executing agency of the Project. According to DEC, any developmental activity must have a permit within four to six months before construction commences.

10.2.5 Mapping Survey of Coral Communities and Location for Coral Conservation Areas

In parallel with the topographic seabed survey, mapping of coral communities was conducted and included a 60 meters width strip covering both sides from the center line of the discharge pipe with a length of about 1km. (Refer to **4.5 Outline of the Result of Natural Condition Survey** for topography of sea bed and depth soundings of the sea.) Mapping involved the location of the coral communities to determine transplant quantity as well as potential areas for transplantation.

10.3 The Project and Project Phases

The proposed development (Level 3 classification) will comprise of the following major facilities:

- construction of a 13,800 m^3/day process capacity secondary sewage treatment plant;
- construction and laying of a 1.6km (700m in land, 900m in the sea) marine outfall pipe;
- upgrade and installation of sewerage mains (17.7km trunk and 17.4km branch);
- rehabilitation or reconstruction of 9 existing pumping station and installation of 8 new pumping stations;
- construction of 1.5km Kila Kila access road; rehabilitation of 1.3km Morata access road; and
- implementation of a pilot project in Hanuabada water village (provision of toilets, access to sewerage and water supply systems, and social/environmental education programs to 20 houses)

10.3.1 Construction Phase

The major activities during construction phase are as follows:

- mobilization of personnel and equipment;
- clearing and grubbing, when necessary;
- site grading and filling;
- construction of temporary facilities (camp house) including installation of temporary toilets, water and electrical system, etc;
- earthworks includes transplanting of corals;
- pile driving;
- structural excavation;
  - concreting and masonry works
  - mechanical installation
  - electrical works
- site landscaping and clean-up;
- demobilization; and
- commissioning and start-up

The construction of the proposed facilities will take about 39 months to complete. This schedule considers normal climatic condition in the locality.

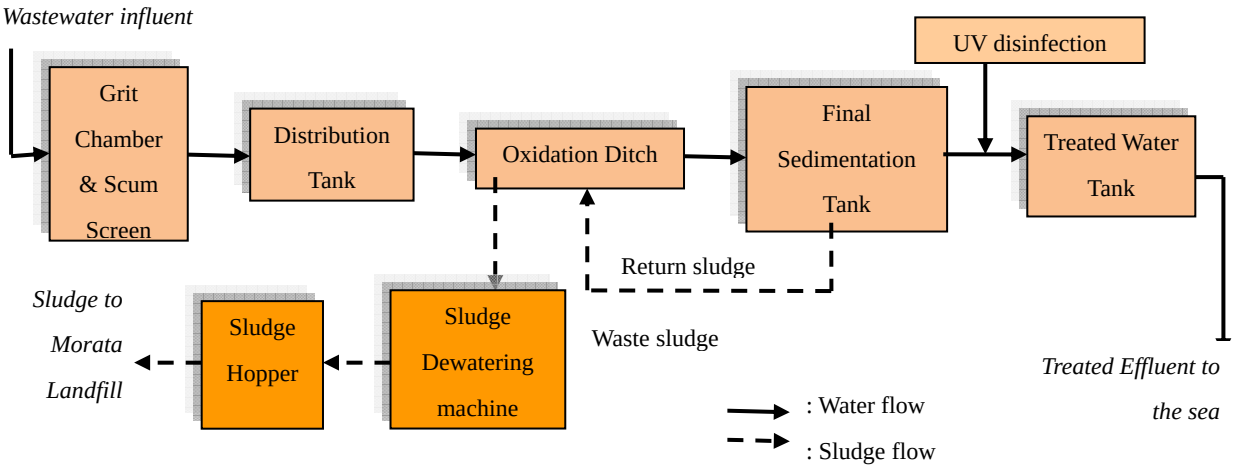
Upon completion of construction of the facilities, all temporary structures and construction debris will be removed and carted away for proper disposal. The site will be rendered to its original state as possible. All recyclable materials such as lumber and roofing materials will be brought to the yard of the Contractor. Spoils will be dumped into the 6-mile and Baruni dump sites by the Contractor.

10.3.2 Operation Phase

As indicated earlier, the proposed project is envisaged to provide sewerage facilities with a capacity of 13,800 m^3/day (immediate) and 18,400 m^3/day (ultimate-design year 2020). It is planned that domestic wastewater from the coastal area of Port Moresby will be collected by sewer pipelines and conveyed to the Kila Kila STP for treatment before final discharge to Joyce Bay through a 1.6km marine outfall (0.9km will be laid at sea). It is designed to operate year round on a 24-hour basis.

The proposed wastewater treatment process as well as sludge disposal process for the STP is presented below (ref. **Section 5.3**):

Wastewater Treatment Process



Expected dewatered sludge cake is on average about 27 m^3/day and will be conveyed by 10 tonne dump truck to disposal site in Morata STP. For the short-term (10 year period), the dewatered sludge cake shall be disposed at a landfill site within the Morata STP. As a long-term strategy, reuse for agricultural purposes, turf production, forestry, public parks, and road landscaping will be considered; however appropriateness on the reuse will have to be studied to comply with guidelines and restrictions.

The operation of the STP requires electro-mechanical equipment. Considering these electro-mechanical equipment, lighting and power requirements of the plant, PNG Power will supply 300 kW power at 11 kV to meet maximum demand. One set of a 630 kVA transformer is needed. A 350 kVA diesel-engine driven power generator will be installed to provide back-up power during any power interruption to maintain the service.

10.4 Environmental Management Objectives

Consistent with GoPNG's effort in promoting environmental protection and management, the POMSSUP strives to achieve a "low environmental impact" project which will become an "environmentally enhancing project" within the context of sustainable development. It aims to operate the sewerage system as an environmentally sound facility. Specifically, the objectives are:

- to avoid or minimize risks/impacts on the natural environment during construction and operation;
- to avoid or minimize risks/impacts on the socio-economic/cultural environment including health, safety and security of workers and local communities during construction and operation;
- to monitor the effectiveness in the implementation of mitigation measures; and
- to ensure long-lasting positive impacts by improving the lives of the beneficiaries after construction.

In general, the positive environmental impacts of the proposed project have several dimensions:

- improved wastewater treatment facilities and services;
- reduced surface and ground water pollution;
- reversing any reduction in marine ecological functions;
- reduced risks of exposure to disease vectors;
- improved urban living environment; and
- improved living conditions and quality of life.

After all mitigation measures are applied, the residual impact of the proposed POMSSUP is expected to be one that has low, not-significant environmental or social impact.

10.5 Mitigation/Enhancement Measures Plan

The purpose of impact mitigation/enhancement is to resolve negative impacts or reduce them to an acceptable level. In this Report, the impacts of the proposed undertaking are identified by project phase (construction and operation) and per environmental aspect, i.e., physical (land, water, air), biological and socio-economic environment. The recommended mitigating/enhancement measures are presented after every identified impact. A summary of these factors is presented in **Appendix 6, Table 5.1.** The Table provides the basis for the development and implementation of a detailed Environmental Management Plan (EMP) from construction to operation phases of the Project.

The construction management plan will be in the form of a construction contractors' environmental program; while social and environmental programs aimed at improving the sanitation and hygienic conditions of the pilot area in the water village of Hanuabada were also developed to be implemented by EDA RANU in coordination with the Health Division of the National Capital District Commission. Though not posing a risk, these programs will impact on the health and well-being of the inhabitants and on the ecological systems which sustain them.

10.5.1 Construction Contractors' Environmental Program

The Contractor shall have his own Environmental Program implemented during the entire duration of construction activities. The program will form part of the Bid Documents. The commitments to be undertaken by the Contractor shall include provision on the following:

- adequate temporary facilities such as housing, sanitation and waste disposal;
- slope stabilization and soil erosion control;
- storm water and pollution control measures; traffic management and road restoration plans; and
- safety measures taken on behalf of construction workers and a contingency response plan/emergency action plan.

As a social development program, the Contractor must also provide an HIV and AIDS Prevention Training Program for the construction workers and the residents of the neighbouring communities in conformity with EDA RANUs' Workplace Policy on HIV and AIDS.

In general, the impacts during this construction period will be temporary and localized, and if proper mitigation/management measures are implemented, the impacts on sensitive recipients can be minimized or even eliminated.

(1) Physical Environment

1) Land Environment

(a) Soil Displacement and Erosion

A considerable volume of soil and rock will be excavated for the foundation and site grading of the treatment plant, and landfill site, the Kila Kila access road and laying of transmission mains. Approximately 3.3 cubic meters of soil will be removed per day and embanked (cut and fill). The soil and rock to be removed can be used as fill materials for low-lying/or depressed areas within the project sites. However, this may cause erosion and increase in sediment loads downstream, especially during heavy rains if not properly placed and compacted.

Management Measures to be Undertaken:

- Excavated soil and rock shall be utilized as engineered fill materials for pipe trenches, site grading, road embankment and base courses, and concrete aggregates (necessary tests shall be made before use). This recommendation is not limited exclusively for use in this Project only.

- Coarse or rock fragments excavated shall be used as material for riprap/stone masonry works such as drainage canals, drain outfalls and retaining walls.
- Temporary barriers and trenches shall be made around the pile of excavated materials to prevent spread of soils by surface runoff with slight compaction to render the material more resistant to erosion.
- The contractor shall immediately dispose of excavated material in designated areas.
- Catch and drains shall be provided by the Contractor to ensure that run-off from the construction works is not directed into water courses.
- Sedimentation basins shall be constructed off-stream to remove sediment laden-run-off. The basins should be located at points where the terrain provides maximum storage benefits. Clearing (removal of vegetation and top soil) should be restricted to areas where the commencement of work is imminent to lessen the amount of silt that will find its way to the water bodies.

(b) Change in Landform

The sites of Kila Kila STP and access road as well as Morata landfill site are located in hilly areas. Minor alteration of topography is inevitable to put the proposed Kila Kila STP and access road as well as the Morata landfill site facilities in place. About 7.05ha will be utilized for the treatment plant. At present, both sites are on undulating terrain. The ground levels at the proposed Kila Kila STP site varies from 0 to 40m with average slopes of 10^{o}. Site grading will be done to level the sites**.**

Management Measures to be Undertaken:

- Limit leveling and filling to the exact limit of the proposed facilities.
- Select locations that will require fewer earthworks.

(c) Ground and Structure Stability

As with any significant construction activity , site geology is a critical consideration. The integrity of the proposed structure will primarily be affected by the characteristics of geologic materials in the area, type of prevalent geologic structures and the potential for occurrence of geologic hazards.

The project area is underlain by alluvial and beach deposits overlaid by Port Moresby Beds and Burns Peak Formation. These surface deposits are comprised of clay, silt, sand and gravels with some cobbles and occasional boulders (EDA RANU 2009). The rocks in the project area are acceptable with respect to intact rock strength. .

Natural factors may also influence ground and structure stability in the STP site. Ground motion due to earthquakes induces large lateral forces. This is a critical consideration in the design of structures. During earthquakes, the foundation of a structure undergoes

accelerations, which are largely horizontal. For the proposed STP site, there is no past history of major seismic occurrences. Port Moresby was identified to be in the lowest seismic zone though the City has a history of felt tremors generated by distant earthquakes in the New Britain Arc and Trench (subduction zone). The closest distance of the subduction system from Port Moresby is about 300 km (L. Anton et al).

(d) Solid Waste Generation

Construction and Demolition (C&D) debris is waste material that is generated in the process of construction, or demolition of pavement during the laying of trunk and branch sewers. Components of C&D debris typically include concrete, asphalt and wood. Land clearing debris, such as stumps, rocks, and dirt are also considered C&D debris.

It is expected that during construction, spoils and other debris will be generated. However, waste streams are difficult to estimate and composition varies widely. Considerable demolition work is expected for pipe laying since the ideal route for the transmission line is along the road pavement or in the road itself that is normally paved. For the treatment plant and landfill fill site, since it is largely a denuded landform, except for a very few trees in the latter area, generation of C&D debris will be minimal.

Access for construction equipment in the treatment plant would also displace surface materials. Soils removed from the ground become loose and can easily be washed away by surface runoffs. Although the overall materials that will be removed are negligible, it depletes fertile soil cover and contributes to siltation of natural waterways.

Management Measures to be Undertaken:

- The Contractor shall adopt an appropriate and adequate solid waste management scheme. It shall ensure safe disposal of all construction waste and rubbish from all sections of the construction site in accordance with local regulations.
- The Contractor shall identify site/s for temporary storage of construction spoils. Such sites shall be included in the solid waste management scheme.
- The Contractor shall, at all times, ensure proper storage (e.g., appropriate cover) of construction spoils.
- The Contractor shall provide garbage collection bins at the site to avoid the proliferation of wastes and the potential for escape of material off-site.
- Waste segregation shall be employed and all recyclable and reusable material shall be retrieved.

(e) Hazardous Products Disposal

Many materials found in construction sites may be hazardous to personnel and/or the environment. It is always important to read the labels of the materials or products kept in the

site. At the very minimum, one can consider that paints, acid for cleaning masonry surfaces, cleaning solvents, chemical additives used for soil stabilization (e.g. calcium chloride), and concrete curing compounds and additives to be hazardous substances.

2) Water Environment

(a) River and Storm Drains Pollution

Impacts on surface water quality would essentially be due to accidental or unforeseen release of construction debris such as excavated and filling materials, demolition debris and concrete mix that find their way to the water bodies. Accidental or unforeseen releases of these materials, including improper disposal, will affect water quality where storm water eventually drains.

The proposed treatment plant will involve concrete works. Usually, concrete is mixed off-site and delivered to the project site by mixer truck. The concrete is poured and residual amount of concrete remains in the mixer. There is time that excess concrete is delivered, or concrete is found to be unacceptable and rejected. It is necessary to clean and dump the residual or excess concrete before it hardens in the mixer. This necessitates the immediate disposal of the concrete mix and can cause surface water pollution.

The primary source of domestic wastes during construction is the worker's camp. Wastewater, sewage and fecal matter generated by the construction workers, if not properly treated, may add to the deterioration of water quality of storm drains and the nearby Joyce Bay. The Contractor will be required to institute the appropriate sewage management schemes.

Management Measures to be Undertaken:

- Excess concrete and wash water should be disposed in a manner that prevents contact between this material and the waterways.
- Dike should be constructed around the area to contain these materials until they harden, at which time they may be properly disposed off.
- The Contractor shall be required to ensure that all his employees are instructed in the necessity for the prevention of pollution. The Contractor shall immediately dismiss and remove from the construction site any employee who found to be polluting the site, water bodies or any water supply installations and shall take appropriate remedial measures such as disinfection of the area.
- The Contractor shall be required to provide adequate (temporary) and appropriate facilities for the use of the workers. Such facilities shall include porta-toilets or sanitary devices, bathing facilities, etc.

- The Contractor shall be required to install/construct temporary facilities that include the camp houses, toilets, bathing areas and waste disposal facilities for use by his employees. These facilities shall be maintained and cleaned daily by the construction workers themselves or the Contractor may opt to hire one utility worker to maintain the cleanliness of toilets and bathing areas, thereby eliminating the pollutants that may cause contamination of the water environment. Toilets shall be made fully available one week prior to the commencement of work.
- IPBC/EDA RANU shall approve the Contractors' waste disposal methods and areas.

(b) Marine Water Pollution

On-shore

Joyce Bay is a tidal flat or inner lagoon. The existing Kila Kila direct sewage discharge point in Joyce Bay contributes the highest pollution load in the coastal marine waters of Port Moresby. The outfall is short and water is stagnant due to the shallow bottom of the Bay. Significant deterioration of water quality is observed showing a high degree of contamination due to elevated fecal coliform concentrations. This area is shallow in depth; hence there is insufficient dilution and "flushing effect" of the untreated sewage discharged onshore.

Off-shore

The Papuan Lagoon is an enclosed water body with depths ranging from 5 to 15m at the western part and 20 to 30m at the eastern part. The lagoon is surrounded by barrier reefs and islands. The discharge point of the marine outfall with a length of about 900m (at sea) will extend up to a depth between 25-30m offshore of Joyce Bay where a higher dilution rate is expected. The sea floor (beyond 782m from shoreline) is characterized by mainly silts and pockets of sand. The biotic component of the sea floor is not well known beyond the 800 to 900m distance (EDA RANU, UPNG 2006).

High Levels of Turbidity

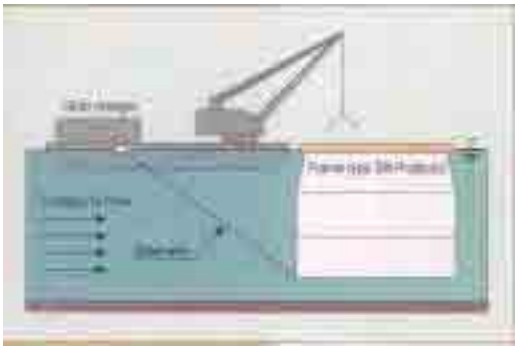
Agitation of the sea floor where some zones are basically composed of silts and other organic matters will result in increased turbidity. High levels of suspended sediments reduce light penetration and hinders the growth of organisms (refer also to impact on the Aquatic Flora and Fauna). Although right now heavy siltation/sedimentation occurs at the inner part of Joyce Bay due to organic pollution and other sources, the major impact will be on the coral reefs dotting the outer part of the intertidal zone.

Management Measures to be Undertaken:

- In order to mitigate siltation/ sedimentation and to protect the coral reef from silt during the laying of pipes, a Silt Protector/Frame will be provided. This will limit the area to be influenced by silt. Sediments will be confined within the Protector. The spoils may

either be deposited or released into the deep open sea, where they can settle harmlessly into the seabed. [*Following inset shows the Silt Protector/Fence. From Updated Feasibility Study of POMSSUP]*

- After the removal of corals within a width of 30m (15m for each side of the pipe) along the pipeline route, the pipe shall then be laid (refer to **section 5.3.2** on the installation method). However, in areas where trenchs dredging shall occur, excavation machines with crusher rock equipment shall be selected. The works shall be carried out for a short period so as to limit the time during which turbidity may be generated.



Introduction of Industrial Oil and Additives

The use of machines and equipment for the installation of marine outfall structure will also impact on the quality of seawater. Introduction of drilling fluids and additives may affect the marine water quality during the drilling/trenching works.

Management Measures to be Undertaken:

- Drilling fluid selection shall consider water-based additives to reducing toxicity to fish, algae and zooplankton. Oil-based drilling additives should never be used.

(c) Increase in Domestic Water Demand

Construction activities would require considerable amounts of water for concrete mixing and watering of the area, among others. In addition to this, potable water is also needed for drinking, washing, sanitation and general cleaning requirements of the construction workers. These are some of the anticipated water requirement during the construction phase of the project.

Management Measures to be Undertaken:

- It will be the responsibility of the Contractors to provide for the water requirements for their construction activities.
- The Contractor shall also be responsible in providing the construction workers with clean and potable water for their daily consumption so as not to cause any water-related diseases.

3) Air Environment

(a) Air Pollution and Noise

Site preparation, construction, and vehicular traffic are potential generators of dust during the

construction period. Aside from dusts, the operation of equipment (pile drivers, backhoes, dump trucks/hauler payloaders and plate compactors) may also lead to increased noise levels and levels of SO_2, NO_x, and CO. However, these impacts are temporary and limited to the duration of construction.

The location of critical recipients for air quality impacts (dusts and gaseous emissions) are the nearby houses. These people will be especially affected when wind direction is blowing in their direction. During these critical times, dust generation and gaseous emissions will be monitored. The Contractor shall implement additional measures if excessive dusts or gaseous emissions are noticed to occur.

Management Measures to be Undertaken:

For Dust Generation

- Prompt removal of excavated materials to designated stockpile area.
- Stabilization with temporary vegetation. A disturbed area that will be left exposed and not subject to any immediate construction works will receive temporary seeding.
- Sprinkling with water until the surface is sufficiently wet to suppress dust, particularly on temporary access roads.
- Dust emissions from vehicular traffic shall be controlled by limiting the speed of haul trucks within and in the vicinity of the construction site.

For Gaseous Emissions

- The Contractor shall minimize the generation of smoke, dust, vapors and noxious fumes from construction and other equipment by only using appropriate mitigatory equipment, which is in good condition and well-maintained at all times during work.
- Equipment or vehicles that are observed to be “smoke belchers” shall be replaced immediately. Regular maintenance of all ventilators and air contaminant control equipment shall be carried out.
- The Contractor shall not undertake any large scale burning of materials that would result in the production of toxic and noxious gases and fumes or other emissions which pose health hazards and be a nuisance to both workers on the construction site and the neighboring communities.

For noise and vibration

- The Contractor shall avoid the use of heavy noise and vibration making diesel-powered construction equipment for land preparation and clearing purposes.
- The Contractor shall regularly and adequately maintain equipment and vehicles.
- Construction activities will, as much as possible, be limited to daytime and early evening hours (7:00 AM – 7:00 PM). This is to avoid causing nuisance, trouble, damage or health problems in the nearby communities.

- If excessive noise is observed to occur, the Contractor shall implement corrective measures. Such corrective measures may include the use of mufflers and building of enclosures or baffles.
- The Contractor will provide all the construction workers with adequate hearing protection such as earplugs in areas with noise levels exceeding 75dBA.

(2) Biological Environment

1) Terrestrial Flora and Fauna

(a) Disturbance of Terrestrial Flora and Fauna

No trees of any significant values would be affected with the construction of the proposed sewerage facilities. Grass is the predominant vegetation in the proposed treatment plant and landfill sites. A few trees can be found in the Morata site and there are patches of gardens planted with peanuts, bananas, sweet potato and other root crops. These gardens are temporary and seasonal; wherein the farmers are allowed to till until such time that the land will be developed by EDA RANU for its intended use.[5]

No significant faunal species or endangered wildlife will be affected during the construction activities. At the Morata site however, water fowl and wild ducks can still be found but already diminishing in numbers due to human pressure (EDA RANU and Ecosystems Management Ltd. 2009).

Management Measures to be Undertaken:

- A permit to cut trees in the Morata site shall be obtained from the concerned agencies.
- The cutting of trees shall be minimized as far as possible.
- The Contractor shall landscape all areas disturbed by the works except in areas covered by structures, roads and other permanent features or works. Landscaping shall consist predominantly of providing suitably shaped final ground surfaces and the establishment of grass and shrubs or small trees. Landscaping shall be carried out in accordance with the requirements laid out in the "Technical Specifications".
- No cutting of trees shall be allowed within the vicinity of the construction site for firewood or for any other purpose.
- No hunting of water fowl and ducks for consumption or any other uses shall be allowed within the vicinity of the construction site.

[5] Personal communication with Engr. Lot Zauya, Project Manager – EDA RANU.

2) Aquatic Flora and Fauna

(a) Area of Influence

An area of likely influence was determined to set the limits of coverage of impacts to the marine life. Any impacts are likely to be confined to the immediate vicinity of the pipeline route, about 15m on each side. Considering the size of the pipe (dia.700mm), the high precision of pipe laying and the needed work space, the area of influence would be no more than a 30m corridor.

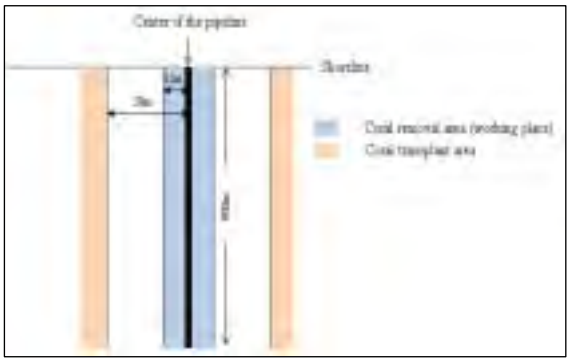


Figure 10.4.1 Area of Coral Removal and Transplant

Management Measures to be Undertaken:

- The Contractor shall minimize the extent of disturbance by strictly observing the boundaries of the influence area and also minimize the duration of disturbance.
- Laying of the pipeline along the design path as determined in the marine route survey must be followed.
- The Contractor shall observe best practices for operating vessels in proximity to the area of influence.

(b) Disturbance of Coral Reef and Benthic Organisms

The construction activities relative to the laying of the outfall pipes will have short term impact to sea grass beds and corals. The activities will have a localized short term impact on sea grass habitats, especially the zone located from 420 to 570m from the shoreline (EDA RANU, UPNG 2006). The pipeline will pass through this seabed area that will be disturbed when the seabed will be excavated in order to level the seabed or dig trenches for pipe installation. Studies indicate that the rate of recovery and re-growth of damaged areas of sea grass beds can range within months or take up to a year. The rhizome structure of the sea grasses which provides a mat of vegetation throughout the substrate also allows for rapid re-colonization of cleared areas. Also, organisms lodged within the bodies of water might be disturbed and may result in migration to other places with additional pollution from the construction site.

240 boulder corals from 50 to 750m from the shoreline along the 30m corridor on the proposed route of pipeline must be transplanted to nearby areas based on the result of the study. The proposed route of the pipeline will pass through these coral reefs before it reaches a drop of about 30m at 720m from the shoreline thereby avoiding impact to coral communities at this point.

Management Measures to be Undertaken:

- A topographic sea bed survey is to be undertaken to identify a gentle terrain for the alignment of the outfall pipe in order to avoid suspended segments of the pipe and trenching/excavation. As much as possible, the path must avoid large coral reefs.
- Parallel to this is a coral inventory survey and identifying the location area/s where the removed corals will be transplanted.
- In transplanting the corals, follow the coral transplant plan prepared by a Specialist.
- The Contractor must limit the working area to the designated 30m corridor to ensure that surrounding coral formations will not be disturbed.
- With reference to water quality and the impact of high levels of turbidity, the Contractor will install silt protector/frame to prevent dieback of corals and other marine organisms.

(3) Socio-economic and Cultural Environment

In general, construction of the facilities will generate employment opportunities for both skilled and unskilled laborers. During the peak construction period, jobs will be created. Furthermore, the construction would open prospects to suppliers and subcontractors. Indirect employment opportunities would also be created for service-oriented activities such as food business, security agency, transport establishments, etc. The effects of additional employment generated by the Project during construction phase will have a cascading effect on the economy of PNG as a whole. The affected population will for instance have more income at their disposal.

1) Social Structure

(a) In-Migration of Construction Workers

The implementation of the Project would bring several workers to the project sites from various districts, provinces, regions of the country. Construction supervisors and skilled workers may not come from the locality due to unavailability of required skills among the labor force in the area. Likewise, the Contractor may opt to utilize its personnel to maintain quality works and to complete the project on time. Unskilled workers may be sourced from the area.

Management Measures to be Undertaken:

- Coordination with the host communities on planned construction activities and on security of the project site and workers.
- The Contractor shall be required to issue identification cards to workers, while workers shall be directed to wear the card during working hours.
- The Contractor shall submit to the respective heads of the communities a list of its personnel for security purpose.

- In the safety orientation of construction workers, peace and order shall be emphasized.

(b) Living and Livelihood

During the installation of the marine outfall, the livelihood of subsistence fishermen and shellfish gleaners in Joyce Bay will be affected, though at present these fishermen have already extended their fishing ground further up to the inner part of the Nateara barrier of Papuan Lagoon. The effect on the livelihood will not be so significant because presently, the intertidal ecosystem of Kila Point is already found to be poor (SAFROF 2006). All food materials appear to have been removed; and only isolated coral patches, sea grass beds and a large amount of rubbish and other debris can be seen.

Management Measures to be Undertaken:

- The Contractor shall be required to adopt a Local Employment Program, which under this scheme, priority shall be given to competent or qualified local residents. The Contractor shall coordinate with community leaders to facilitate hiring of local workers.
- To provide alternative livelihoods the Contractor shall be required to coordinate with IPBC/EDA RANU in the operation of small businesses in the construction site (e.g., food vending) by displaced fishermen.

(c) Land Acquisition and Relocation [6]

Location of the project sites are in customary land and state land as follows:

Facility	**Ownership**	**Actions**
Kila Kila STP, base camp, stock yard	Customary land	No resettlement; Compulsory acquisition
Kila Kila access road	Customary land; State land	Resettlement of 18 households has been completed including payment of compensation
Effluent pipe to outfall	Customary land	No resettlement; same as above
Pump stations	State land except Kila Kila PS	No resettlement; Same as above for customary land
Trunk mains	State land	No resettlement
Morata landfill site	EDA-RANU owned	
Morata access road	For rehabilitation only	

Acquisition of customary land will be through compulsory acquisition. Procedures are

[6] This aspect is the responsibility of IPBC/EDA RANU and should be deleted from the Contractors' Contract

on-going for the processing of settlements to land owners.

Management Measures to be Undertaken:

- EDA RANU is currently negotiating with the land owners.

2) Public Health (including HIV and AIDS) and Safety of Workers

(a) Health and Safety

The potential health risks arising from the project during the construction phase is the dust/gaseous emissions that will be generated by the equipment and construction activities. Therefore, provisions to reduce the impacts on dust/gaseous emissions should be employed properly.

One aspect of safety is occupational hazards. As with any construction activities, the safety of workers and pedestrians are of utmost concern. The Contractor shall be required to institute safety protocols in all its working areas.

Another aspect of safety is the potential for vehicular accidents and people falling into excavated areas. This is a matter of major concern that should be addressed carefully by the Contractor.

Management Measures to be Undertaken:

- Contractor will be required to provide workers, particularly those operating close or those using equipment, personal protective gear such as hard hats, gas masks, ear muffs, gloves, protective boots, etc.
- Reduction of working hours and/or introduction of short pauses during the working day may also reduce the effect or consequences of noise pollution.
- Standard safety practices should be observed during construction to avoid accidents.
- Enclosures/walls around excavated portions of the area shall be provided.
- Signs, warning devices and other protective means shall be placed in conspicuous places within the working area.
- The Contractor shall ensure all workers are properly oriented on the safety procedures. Likewise, adequate safety or emergency equipment must be available at the construction site.
- The Contractor shall coordinate with local police and community officials on safety and security issues.
- The Contractor shall comply with all labor regulations on occupational safety.

(b) Prevention and Control of HIV and AIDS

The potential risk of HIV and AIDS exposure especially among highly vulnerable mobile

people such as construction workers has been recognized. EDA RANU has a workplace HIV and AIDS policy to help mitigate the social and economic impact of the epidemic.

Management Measures to be Undertaken:

- To promote prevention of HIV and AIDS in the campsite and neighbouring communities, the Contractor will conduct HIV and AIDS prevention training programs for construction workers and residents in nearby areas of the campsite.
- Complementary to the above program, the Contractor will also include hygiene and sanitary practices.

3) Traffic Congestion and Hazard

The construction of the trunk and branch sewer lines, pump stations and associated infrastructure may lead to impacts on existing road users and other sensitive recipients. During construction, materials will have to be delivered to the project site and excavations transverse to roads for pipe laying is inevitable. Potential impacts on the existing traffic conditions are expected especially during high traffic flows during the mornings; 7.30 am – 9.00am; lunch; 11.30am – 1.30 pm and afternoon; 4.00pm – 5.30 pm. These are peak periods where workers commute to and from the Central Business District (CBD) in Port Moresby, Boroko, Koki, Badili and other places of work.

Construction traffic will be generated by the following: i) the supply and movement of sewer lines and pump station materials, equipment and waste to/from the terminal site, working width and construction lay down areas; ii) the supply and movement of construction plant and secondary construction material to the terminal site, working width/spread; and iii) the supply and movement of wastes generated during excavation for the sewer lines and pump stations.

Management Measures to be Undertaken:

- The Contractor shall prepare a Traffic Management Plan (TMP) detailing alternative routes in coordination with the Department of Transport Enforcement Unit, the Traffic Division of the Police Department, Department of Works Road Division, Telikom, PNG Power, National Capital District Commission and the Chamber of Commerce and Industry. The Contractor should provide adequate signage, including provisions for traffic rerouting if necessary, during the construction period.
- The Contractor shall use the TMP as the basis for specific measures that will be implemented to mitigate any predicted impacts. The Contractors' TMP shall include detailed procedures that demonstrate how the impacts of traffic on city residencts and businesses have been taken into consideration.
- The Contractor shall regularly update their TMP as the excavation/construction method is developed and vehicle movement requirements are identified in detail.
- In the preparation of the TMP, the Contractor shall:
  - identify those responsible for carrying out and managing the procedures

- justify where a route has to pass through residential areas and the measures that will be used to ensure the safety of the community and minimize the nuisance impact of traffic movements
- identify work to be undertaken on the roads prior to construction activities to excavate sewer line trenches
- identify the routes that will be used with the estimated numbers of traffic movements, speeds and times of travel
- identify how existing road development plans have been taken into account in the identification of routes and road restoration measures
- identify the programm of road restoration measures that are likely to be required at post construction
- implement the road restoration program

4) Displacement/Disturbance of Basic Service Utilities

Disruption of basic utilities may happen during installation of proposed facilities, specifically the trunk mains and branch pipes. Water, power and telephone lines along the pipe route may be affected by accidental cut off.

Management Measures to be Undertaken:

- The civil works Contractor must inform the affected utilities about the schedule of construction.
- Announce schedule of disruption of services through media.

5) Contingency Response Plan

(a) Emergency Response Policy and Guidelines

The Contractor shall prepare an emergency action plan (EAP) for use in time of emergency. The EAP should describe the following: project sites hazard areas; explain the events or conditions that identify/indicate emergencies; identify those responsible for the implementation of the EAP; and describes the procedures for training participants, and reviewing, testing, and updating the EAP.

The EAP shall be posted conspicuously on the safety bulletin board and in the project office. In addition all employees shall be informed of the plan, and each employee shall be told what is expected of him/her in case of explosion, fire, or other emergency. Copies of the plan shall be given to the local fire or designated off-site rescue teams.

The plan shall include such items as maps, ventilation controls, firefighting equipment, rescue procedures, evacuation plans, and communications. The description of the facilities should likewise be provided, such as location, elevation, area, and major and critical components.

The Contractor shall establish a good communication system particularly in: passing on information and instructions; monitoring systems; the control of operations, such as lifting, transporting people, materials and plants; coordinating maintenance; and managing emergencies.

The communication system should be used to link major workplaces, site offices and safety critical locations on-site (e.g. first aid room or emergency control room). Ways of contacting the emergency services from the site should be available, manned and monitored at all times.

The communication system may also be used to pass on information on a variety of safety-related items, such as machine-condition monitoring, instrumentation monitoring, atmospheric monitoring and fire alarms.

The risk assessment should determine whether communication with all mobile vehicles, including personnel transporters, is required. Where electronic communication (non voice) methods are being relied on, the point of communication reception (e.g. control room), should be monitored at all times by people who have been trained in the EAP.

The relevant persons must be able to communicate requirements for materials and equipment, and raise the alarm and receive instructions in the event of an emergency.

A system of signaling by bells or by colored lights can be appropriate for routine communications. Details of any signal code adopted, whether audible or visual, should be communicated effectively to all those affected by the operations under way.

The communication system should be independent of the power supply and installed so that destruction of one unit or the occurrence of a collapse will not interrupt the use of the other units in the system. All wiring, especially that used to transmit warnings in an emergency, should be protected. All communication cables needed to transmit warnings in an emergency should have increased integrity under emergency conditions, such as fire, water or mechanical shock.

At all working sites, a standby means of communication should be available and able to be operated from any position throughout the sites. The codes for both audible and visual signals, as well as call signs and channel allocation, should be displayed at strategic locations for all operators.

(b) Personal Protective Equipment (PPE)

The use of PPE to control risks is the lowest form of control in the hierarchy of control, and

should only be used when other control measures are impracticable or when a residual risk remains after implementing other controls.

Where PPE is to be used, it should be appropriate for the risk and comply with the relevant standards. Workers should be competent in the proper selection, use and maintenance of the PPE, and be provided with proper supervision and monitoring conducted to ensure it is used properly. PPE should be regularly inspected, maintained and replaced as necessary.

(c) Hazard and Incident Reporting

Hazards and health and safety issues should be reported as soon as they are noticed so that the risks can be assessed and addressed as quickly as possible. Records of reported hazards should be kept and include details of the action taken to remove the hazard or to control the risk arising from the hazard.

(d) First Aid

To ensure adequate first aid provisions, the relevant person should: identify their potential injuries and illnesses; assess their first aid requirements; and consult with workers in the process.

When determining the nature, number and location of first aid facilities and equipment, and the number of trained first aid personnel needed, the relevant person must take into account the location and type of work being undertaken.

The type of work performed will influence the hazards and the possible harmful consequences for workers. For example, office workers may have different first aid requirements from construction workers.

Workplaces using hazardous substances may require specialized first aid facilities, such as eyewash stations and emergency showers. The risk assessment process will assist in identifying the particular needs of the workplace.

Where a first aid room is supplied, it should only be used for first aid or health and safety purposes.

(e) Site security

The site is to be secured by perimeter fencing that complies with the regulations. Signs showing the name and contact telephone numbers, including after-hours emergency numbers of the relevant persons, are to be erected around the site, and clearly visible from outside the site.

Additional consideration should be given to the security of authorized visitors visiting the site (e.g. delivery drivers or people attending meetings).

The following control measures should be considered:

- locating offices, parking and delivery areas away from potentially hazardous areas;
- isolating the potentially hazardous area with perimeter fencing, barricades, screens, barriers, handrails and/or covers, which are capable of preventing access or a person from falling;
- providing visitor tags, tag in and out or logged security card access for specific areas;
- removing or lowering ladders when not in use;
- installing hazard warning lights, signs, markers or flags;
- using security guards;
- locking fuel dispensers; and
- installing night lighting.

10.5.2 Operations Environmental Management Plan

Over-all, upon completion of the construction, the sewerage system would generate positive impacts. The coastal area of Port Moresby is the major recipient that will be benefited by the system. It will reduce pollution of both coastal water and groundwater and also bring about an improved health situation thereby reducing medical costs. Therefore, no major social problems are foreseen during the operation of the proposed undertaking.

For the sustainability of the project, there is a need for an efficient operation and maintenance of the STF and other facilities. An on-the job-training program of personnel that will be involved in the O&M is one of the planned activities to ensure the goals of the project are met.

(1) Physical Environment

1) Land Environment

(a) Handling of Sludge

Generated sludge from the process is not hygienically safe and needs to be treated properly. In an OD system, generated sludge from the system is stabilized and less in volume than the conventional activated system.

Management Measures to be Undertaken:

- Sludge produced from the Kila Kila STP will be properly transported in a closed type dump truck. Proper handling of the sludge cake during the transfer to the landfill site will be strictly enforced.

- Assure residuals are used/disposed of in accordance with applicable regulations
- Administer tracking system for residuals hauling and disposal; and if treated sludge will be sold, administer a program for point-of-sale and providing guidelines/education for safe handling and usage of treated sludge as soil conditioner/fertilizer

2) Water Environment

The secondary treatment at Kila Kila STP brings significant improvement of seawater quality in the whole area of Papuan Lagoon. At present, the pollution load generated in the coastal area of Port Moresby is discharged into the sea from seven locations, without being properly treated. In areas where input flows are high such as in Kila Kila, water near the discharge point is almost black due to organic pollution.

(a) Water Quality

The discharge of treated wastewater to Joyce Bay and the interception of untreated wastewater directly discharged from the outfalls will result in an eventual improvement of the water quality, which in turn will affect the viability of aquatic life. With the dilution of treated water, it is expected that marine water will once again become favorable habitats for a number of fish species.

Nitrification and Other Water Quality Issues

The Oxidation Ditch (OD) system provides a high removal rate of nitrogen and some removal can be expected with regard to phosphorous. The reduction in such nutrient loads will contribute to the prevention of the waters of Papuan Lagoon from becoming "euthorophicated".

The OD system also brings about a significant removal rate of sediments at about 85 -95% and treated water consequently exhibits high transparency.

Management Measures to be Undertaken:

- The location of the pumping stations was taken into consideration such that it will maximize the collection of untreated wastewater to be conveyed to the STP thereby reducing the pollution loads reaching the marine waters of Port Moresby. Establishment of water quality monitoring stations and conducting a program of regular water sampling to determine effectiveness of the treatment plant to attain an improved ecological status will be recommended (refer to **4.6.6** for the monitoring plan).
- Regular monitoring of nutrients and other parameters has to be conducted by EDA RANU on the effluent prior to discharge to the outfall to ensure that guidelines are met.
- Potential industries discharging wastewater to the system are required to meet the effluent

discharge standards[7]. Thus, they are not likely to impose major toxic effects to the micro-organisms and wastewater treatment processes. In case of non-compliance, EDA RANU will terminate the illegal discharge either by requesting the violator to voluntarily stop or by disconnecting the discharger's effluent pipe until compliance is confirmed.

System Failure

In the event that the plant fails to operate effectively due to mechanical or electrical failure, the quality of water in the receiving bodies is expected to degrade, specifically during low tide when dilution is less. The design of the STP provides a system back-up to handle such eventualities (refer to **Chapter 5** for details of the design).

Management Measures to be Undertaken:

- Comprehensive and continuous training of personnel on the operation and maintenance of the STP must be pursued by EDA RANU.

3) Air Environment

(a) Air Quality

During the operation of the proposed STP, no significant air quality hazard is foreseen since the equipment that will be used in the plant will work on electric power. However, the use of diesel power generators during power outages will emit various air pollutants such as suspended particulates, SO_2, CO and NO_x. Other possible source of air pollution is leakage of chlorine gas (a noxious gas) used for disinfection of treated water.

Management Measures to be Undertaken:

- EDA RANU shall minimize the generation of smoke, dust, vapors and noxious fumes from the operation of power generators by only using equipment that is in good condition and well-maintained at all times.

(b) Odor

Septage naturally produces putrid smells because of the biochemical breakdown of wastes. During the operation of the STP and sludge disposal, localized foul odors in the vicinity are to be expected. Screens, OD tanks and sludge processing units are all potential sources of offensive odors. However, this should not be a problem if the STP and disposal site are properly operated. Also, the two sites are located at some distance from the nearest settlements.

[7] As spelled out in the Draft Final Report on Trade Waste Policy for Port Moresby, PNG 2008.

Management Measures to be Undertaken:

- Mitigation measures include: (i) a greenbelt around the facilities and tree planting; (ii) adequate layout of the treatment facilities to minimize opportunities for odor to reach recipients; and (iii) timely transport of the dredged out sludge to designated sanitary landfills for final disposal.
- A Biological Odor Control (BOC) shall also be installed in the STP site. BOC has a removal efficiency of 97% for hydrogen sulphide (H_2S). H_2S removal and odor reduction appear to be strictly correlated.

(c) Noise

Noise generated in STP operations comes mainly from the operation of pumps and usually involves generation of low frequency noise that is mostly contained within the plant.

Management Measures to be Undertaken:

- Mitigation measures will include: (i) selecting low noise machines; (ii) installing noise enclosures or buffers; (iii) locating influent and effluent pump stations in a semi-underground setting; and (iv establishing a greenbelt buffer around the STP

(2) Biological Environment

1) Marine Flora and Fauna

(a) Disturbance to the Ecosystem

Relocating the coral communities may cause some damage to the fisheries and other marine organisms by reduction of their populations.

- The effects on fish and benthic organisms maybe be considered minor since the impact is only temporary. These organisms can propagate naturally afterwards when the sea condition stabilizes again and the source of pollution (sedimentation) is eliminated.

(b) Presence of Deleterious Substances

Deleterious substances present in wastewater would impair aquatic habitats. This generally occurs when oxygen is depleted by decomposition of organic matter. Likewise, toxic substances may harm fish and other aquatic life on which other larger fish feed. This affects the aquatic food chain and would lead to dwindling fish production. As mentioned earlier, the improvement of water quality of the Papuan Lagoon will enhance the prevailing aquatic eco-system and eventually, aquatic resources productivity will improve.

Management Measures to be Undertaken:

- Regular monitoring of water quality must be conducted to determine whether the project has

impact on aquatic resources.

(3) Socio-Economic and Cultural Environment

1) Social Structure

(a) Proximity to Residential Areas

The proposed STP is located adjacent to existing communities/residential areas at a distance of about 300m.

Management Measures to be Undertaken:

- Building of houses in the proximity of the STP should not be allowed. Buffer zone between the STP and built-up area should be considered.

(b) Environmental Aesthetics

This refers to harmony of the design, structures and style of the facilities with the environs.

Management Measures to be Undertaken:

- No major aesthetic problems are anticipated with the implementation of the project. Aesthetic gains that would be evident from the provision of STPs are: prevention of foul odor emanating from improper sewage disposal, maintenance of clean and healthy surroundings, and avoidance of open canals which become breeding ground for disease carrying insects.

2) Public Health Improvement in the Locality

One of the primary purposes of the STPs is the improvement of health and sanitation conditions in the locality. Social preparation is one of the important factors to be considered to attain this purpose. Without the cooperation of the public, the proposed project is futile. It should be an outcome of the collaborative efforts of the community and the local government.

Reduction of Medical Costs

The project contributes to reduction of water-borne diseases. Exposure to unsanitary condition results in the high incidence of water-borne diseases such as diarrhea, gastro-enteritis, intestinal flu, dysentery, cholera and others. Based on a survey, a significant proportion of the inhabitants (21.7%) in the near-shore villages have suffered from diarrhea and have to spend about K 432 per capita each year for treatment of the disease . It is expected that when sewage treatment is implemented, such medical expenditures will be cut down resulting in a reduction of medical costs which will serve to give economic support for the poorer class of residents in the coastal area (SAPROF 2006).

Management Measures to be Undertaken:

- Conduct sanitation and hygiene education programs. Regular maintenance of the treatment facilities must be undertaken.

3) Economic Opportunities

(a) Increase in Tourist and Recreational Activities

This impact is related to the improvement of the Papuan Lagoon sea water quality. At present, some portions of the coastal area have been developed as tourist and recreational areas. As soon as the sea water quality becomes improved, development could expand to cover the areas affected by the project.

Management Measures to be Undertaken:

- Proper operation and regular maintenance of the STP to ensure that the intended effluent quality is acheived.
- Regular water quality monitoring has to be done by EDA RANU in coordination with NCDC to ensure the effectiveness of mitigation measures put in place.

(b) Revitalization of Inshore Fisheries Industry

The Papuan Lagoon has been known to support subsistence and small scale artisanal fisheries. There is considerable fishing acivity within the lagoon and adjacent reefs. Fishing and other related activities are important components of the local economy, especially in the near-shore villages, With the degradation of water and sediment quality of the lagoon, including habitat destruction, the productivity of the lagoon, is greatly reduced and some marine resources are subjected to a severe risk of extinction. Former fishing spots near Joyce Bay are now about to disappear, forcing the fishermen to move further to identify new fishing spots located around the barrier reef (SAPROF 2006). As a result of the project when the sewage is treated by the secondary treatment process (OD process), the seawater quality will be greatly improved, and marine species in the coastal waters will be revived, raising its fish productivity.

Management Measures to be Undertaken:

- Regular water quality monitoring has to be done by EDA RANU in coordination with NCDC to ensure the effectiveness of mitigation measures put in place.

10.6 Environmental Monitoring Plan (EMoP)

10.6.1 Monitoring Plan

Environmental monitoring is designed to:

- Demonstrate the effectiveness of the proposed sewerage facilities construction and operational procedures in satisfying the service demands of consumers;
- Collect data which can be used to evaluate whether the assumptions used in the environmental assessments and technical basis are valid estimates;
- Ensure that quality assurance and quality control procedures are followed; and;
- Conduct additional monitoring to investigate any complaints or reports of adverse effects on public health, worker safety and environmental quality related to the construction and operation of the proposed sewerage facilities.

The monitoring plan basically covers monitoring activities during construction and operation phases since impacts are expected to occur during these stages in project development. The proposed monitoring plan discusses the following elements:

- Activities/parameters to be monitored;
- Specific areas to be monitored;
- Manner of monitoring;
- Frequency of monitoring; and
- Institutional responsibilities for monitoring and data management.

Monitoring work is generally expensive. It requires sampling, equipment, laboratory analysis and technicians/specialists. Hence, the parameters considered are those essential for protecting the environment, managing the system, and safeguarding the personnel and the population.

10.6.2 Activities During Construction Phase

(1) Water Quality Monitoring

During the construction phase, ambient water quality monitoring at the ocean outfall construction site will be conducted by the Contractor. Results of the analysis will be submitted to for validation and used for control. Validation to confirm the results will have to be undertaken by IPBC and EDA RANU as the need arises.

1) Monitoring methods (Items, frequency, number of water samples taken)

Monitoring items, frequency, method and the implementer are shown in **Table 10.6.1**.

Table 10.6.1 Water Quality Items during Ocean Outfall Construction

Item	Unit	Frequency	Method	Implementer
Transparency	-	Everyday	Visible Inspection	Contractor (self monitoring)
SS (Suspended Solids)	mg/L	Weekly	Mass Balance method, Dried 105~110 ^{o}C	Contractor IPBC / EDA RANU
Oil/Grease	mg/L	Everyday	n-Hexane extractable material method	Contractor IPBC / EDA RANU

Source: JICA Study Team

2) Locations of ambient water sampling points

Monitoring of ambient water quality during construction shall be carried out in at least four sampling stations located along the path of the ocean outfall construction sites.

(2) Coral Reef Monitoring

During the construction phase, transplanted coral and coral reefs along the pipe route will be monitored both by the Contractor and IPBC/EDA RANU.

1) Methods (Items, frequency, number of water samples taken)

Monitoring items, frequency, method and implementer are shown in **Table 10.6.2**.

Table 10.6.2 Monitoring of Coral Reefs during Ocean Outfall Construction

Item	Objective	Procedure	Frequency	Period	Implementer
Recovery rate of Transplanted coral reef	Rate of Recovery / Success of transplant	Visual inspection	Once a month for the first three months, every three months for next nine months, thereafter every six months	Three years from commencement of transplant activities	Contractor/IPBC-EDA RANU
Recovery rate of Corals along the pipe route	The effect of ocean outfall construction works	Visual inspection by quadrat method	Two times a year	During construction and one year after construction	Contractor/IPBC-EDA RANU

Source: JICA Study Team

2) Locations of coral reef monitoring points

Transplanted coral reef: Transplant site (ref. **Figure10.4.1**)

Coral and coral reefs along the pipe route: the whole stretch of the transplanted areas

10.6.3 Activities During Operation Phase

Water quality monitoring of inlet/outlet sewerage and ambient water (sea water) will be conducted during operation of Kila Kila STP. In addition, coral reef monitoring will be conducted at transplanted site, discharge point and vicinity of the pipeline route. Both monitoring activities will be implemented by EDA RANU Environment and Quality Control Department.

(1) Water Quality Monitoring

1) Method

Water quality monitoring items are:

- Inlet and Outlet Sewerage Water:
  pH, SS, Fecal coliform, BOD), COD_{Mn}, T-N, T-P and Oil/Grease
- Ambient water (sea water):
  pH, SS, COD_{Mn}, T-N, T-P, Total coliform, Oil/Grease, Temperature

Monitoring frequency, method and implementer of inlet/outlet sewerage and ambient water (sea water) are summarized in **Table 10.6.3**.

Table 10.6.3 Monitoring of Coral Reefs during Operation

Items	Frequency		Method
	Inlet/Outlet sewerage at Kila Kila STP	Ambient Water (sea water)	
pH	Everyday	Monthly	Glass-electrode method
Suspended Solid (mgL)	Everyday	Monthly	Mass Balance method, Dried 105~110 ^oC
BOD_5 (mgL)	Every 5days		Dissolved Oxygen Depletion
COD_{Mn} (mgL)	Everyday	Monthly	Titrimetric manual
Total Nitrogen (mg/L)	Weekly	Monthly	Colorimetric Automated Phenate
Total Phosphorus (mg/L)	Weekly	Monthly	Molybdenum blue absorptiometry method
Total coliform (MPN/100mL)	Weekly	Monthly	Most Probable Number (MPN)
Oils & Grease (mg/L)	Every 5days	Monthly	n-Hexane extractable material method

Items	Frequency		Method
	Inlet/Outlet sewerage at Kila Kila STP	Ambient Water (sea water)	
Temperature (^{o}C)	Everyday	Monthly	Attached with pH/ORP meter

Source: JICA Study Team

2) Locations of water sampling points

Water quality sampling points are:

- Inlet sewerage: at grit chamber
- Outlet sewerage: at treated water tank
- Ambient water: at boundary of the Mixing Zone[8] (50m offshore from the discharge point

(2) Coral Reef Monitoring

During the operation phase, recovery rate of transplanted, coral reefs along the pipe route and coral reefs near the outfall point, and recovery of benthic communities will be monitored by IPBC/EDA RANU Environment and Quality Control Department.

1) Methods

Monitoring items, frequency, method and implementer are shown in **Table 10.6.4**.

Table 10.6.4 Monitoring of Coral Reefs during Operations

Item	Objective	Procedure	Frequency	Period
Recovery rate of Transplanted coral reef	Rate of / Recovery Success of transplant	Visual inspection	Once a month for the first three months, every three months for next nine months, thereafter every six months	Three years from transplant commencement
Recovery rate of nearby discharge point	The effect of discharged water	Visual inspection by quadrat method	Two times in a year	Three years from start of operations
Recovery ate of Coral reef around the buried pipe zone	The effect of buried pipe	Visual inspection by quadrat method	Two times in a year	During construction and one year after construction
Recovery of marine biological community	Recovery confirmation of marine biological community	Visual examination	Once a month for the first three months, every three months for next nine months, thereafter every six months	Two years after construction of buried pipe

Source: JICA Study Team

[8] Mixing Zone: A discrete body of water into which waste is discharged and where the prescribed water quality criteria are not required to be met and the protection of aquatic life may not be guaranteed (Environment water quality criteria regulation 2002). In case of sewage discharge into sea, the Mixing Zone has been specified within a 50m radius surrounding the discharge point in the permit.

2) Locations of coral reefs/benthic communities monitoring points

Coral reefs monitoring points are:

- Transplanted area: refer to **Figure 10.4.1**
- Nearby discharge point: boundary of the Mixing Zone (50m offshore from the discharge point
- Corals along the pipeline route: 15 meters line on both sides of the pipeline route
- Recovery of benthic communities: at boundary of the Mixing Zone (50m offshore from the discharge point)

10.7 JICA Environmental and Social Consideration Guidelines

In the SAPROF study (2006), the project was identified and classified as Category A as it is "located in sensitive areas considered to require careful consideration by the country or locality, including habitats with important ecological value (coral reefs, mangrove wetlands and tidal flats, etc.)". This categorization is in accordance with JICA's Environmental and Social Considerations Guidelines, which was revised in 2010. As indicated in the JBIC Environmental Guideline, the following documents are prepared to carry out the environmental review and monitoring.

(1) Updated Environmental Checklist

The Environmental checklist was updated to conduct a review of environmental and social considerations and to confirm that the requirements are duly satisfied. Updated Environmental checklist is shown in **Table 10.7.1**.

(2) Monitoring Forms

Monitoring forms were prepared to confirm implementation of: 1) water quality monitoring; and 2) coral reefs monitoring during construction and operation phases. Monitoring forms during construction and operation are presented in **Appendix 2**.

Table 10.7.1 Environmental Checklist

Category	Environmental Item	Main Checklist of Items	Yes: Y No: N Not Applicable:N/A	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1. Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) Y (b) Y (c) Y (d) N	(a) The EIS reports was prepared and submitted to DEC (June 2006). Currently, IPBC/EDA RANU is updating the EIS reports since the Environment Permit issued (December 2007) had already lapsed (Jan. 2010). As a precondition set by DEC, an updating was necessary before the Permit will be renewed. (b) As stated above, an updated EIS reports are needed before the Permit can be renewed. (c) Some of the set conditions are still being worked on. (d)Wastewater Discharge Permit for existing outfalls at Paga Point, Badili, Kila Kila and the inland STP were issued in December 2007 under the old Environmental Act. The Wastewater Discharge Permit for the new Kila Kila STP has yet to be secured prior to the operation of the STP.
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected inthe project design?	(a) Y (b) Y	(a) Explanation/public consultations, focus group discussions, key informant interviews are very important components of this project. During the course of the Master Planning, Feasibility Study (F/S), Updating of F/S, Basic Design and EIS study, series of public disclosures through public awareness and feedback were undertaken. The updated EIS reports will be made available at public libraries for viewing and comments. During construction, meetings with the stakeholders (pilot project) are further planned. (b) Many positive comments have been obtained from the public as well as direct stakeholders and from regulatory authorities regarding the project.
2. Pollution Control	(1) Water Quality	(a) Do pollutants, such as SS, BOD, COD_{Mn}, pH contained in treated effluent from a sewage treatment plant comply	(a) Y (b) N	(a)Effluent from the proposed STP meets the water quality standards for public water bodies and contributes to the improvement of receiving seawater quality. (b) Inflowing sewage will mainly be domestic

Category	Environmental Item	Main Checklist of Items	Yes: Y No: N Not Applicable:N/A	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		with the country's effluent standards? (b) Does untreated water contain heavy metals?		waste., hence, no heavy metals is expected to occur. Discharge from industries will be strictly monitored by EDA RANU.
	(2) Wastes	(a) Are wastes, such as sludge generated by the facility operations properly treated and disposed of in accordance with the country's standards?	(a) N/A	(a)There is no regulation for sludge treatment and disposal in PNG. However, sludge generated in Kila Kila STP will be hauled to Morata disposal site by dump truck. For long term, the treated sludge shall be reused for agricultural purposes and other uses. .
	(3) Soil Contamination	(a) If wastes, such as sludge are suspected to contain heavy metals, are adequate measures taken to prevent contamination of soil and groundwater by leachates from the wastes?	(a) Y	(a) Strict water quality monitoring of industrial discharges will be done by EDA RANU in accordance with "Trade Waste Policy for Port Moresby Papua New Guinea" that will be published by EDA RANU in August 2011. Penalties will be imposed to those industries violating the Policy.
	(4) Noise and Vibration	(a) Do noise and vibrations generated from the facilities, such as sludge treatment facilities and pumping stations comply with the country's standards?	(a) N/A	(a)There is no regulation for noise and vibrations in PNG. However, there is no anticipated serious noise problem generated by mechanical facilities such as pumps (submersible pumps working under the sewerage water), generator, blowers. The Generator and blower will be installed in concrete structures and a silencer will be fitted at the exhaust discharge pipe. Proposed Kila Kila STP site is located 200m distance from residential areas.
	(5) Odor	(a) Are adequate control measures taken for odor sources, such as sludge treatment facilities?	(a) Y	(a) There are no residents within 200m of the boundaries of the proposed STP, where no anaerobic treatment facilities are planned. No serious odor impacts are expected. There are also no residents within 500m of the boundaries of existing Morata STP, where the sludge disposal is to be performed. Installation area for deodorization equipment in Kila Kila STP will be considered as future plans.
3.Natural Environment	(1) Protected Area	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a	(a) N	(a)There are no protected areas in/around the sites of the project.

Category	Environmental Item	Main Checklist of Items	Yes: Y No: N Not Applicable:N/A	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		possibility that the project will affect the protected areas?		
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Is there a possibility that the project will adversely affect aquatic environments, such as rivers? Are adequate measures taken to reduce the impacts on aquatic environments, such as aquatic organisms?	(a) Y (b) N (c)Y (d) Y	(a)Treated sewage at proposed Kila Kila STP will be conveyed by an ocean outfall pipe, a stretch of about 900m of the intertidal area and fringing reef needs to be excavated with a width of about 2m. The ocean outfall pipeline construction will involve transplanting of corals and can affect the marine ecosystem through access sedimentation/siltation. (b)There are neither protected species designated by the PNG's law nor by the international treaty in the affected area. (c)During the construction stage, some impacts are anticipated. To reduce impact of coral clearing, transplanting coral reefs to alternative safe marine environment before construction works will be implemented. Also, to protect coral reefs and its associated marine lives, silt trap (protector) methods to capture silts and sediments to prevent washout by ocean currents will be employed. No significant impacts are expected after implementation of the project. (d)By taking measures mentioned in 3), the impacts on aquatic species can be minimized.
4.Social Environment	(1) Ressettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and	(a) N (b) Y (c) Y (d) Y (e) Y (f) Y (g) Y (h) Y (i) Y (j) Y	(a) This proposed project will not cause any resettlement except for access road in Kila Kila site. Proposed access road to the Kila Kila STP required resettlement of 18 households. The compensation and agreement between land owners/settlers and IPBC/EDA RANU/NCDC were done properly. (b)Adequate explanation regarding relocation and compensation were held before relocation. (c)IPBC/EDA RANU carried out calculations of

Category	Environmental Item	Main Checklist of Items	Yes: Y No: N Not Applicable:N/A	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		resettlement given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Is the compensations going to be paid prior to the resettlement? (e) Is the compensation policies prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budgets secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is a grievance redress mechanism established?		Residential Properties and crops and adequate compensation paid to the squatter settlers. Once the Relocation/Resettlement has been completed, basic services such as water/sewerage and power supply will be provided. (d, e)Compensation and relocation plan were prepared by IPBC/EDA RANU. (f)The Resettlement plan considered vulnerable groups. (g)Agreements with the affected persons were obtained by the end of 2005 (h)Existing institutes such as State of Land Acquisition, Department of Lands and Physical Planning, IPBC/EDA RANU have been working towards this goal. The budget was prepared by NCDC and it has already been reimbursed. (i)Monitoring was carried out to determine the impacts of resettlement. (j)It was established.

Category	Environmental Item	Main Checklist of Items	Yes: Y No: N Not Applicable:N/A	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(2) Living and Livelihood	(a) Is there a possibility that changes in land uses and water uses due to the project will adversely affect the living conditions of inhabitants? (b) Is there a possibility that the project will adversely affect the living conditions of inhabitants? (c) Are adequate measures considered to reduce the impacts, if necessary?	(a) N/A (b) Y (c) Y	(a) As stated above, all the works for this project (except the proposed access road which required resettlement of 18 households were properly completed) will take place away from human settlements and dwelling places. Hence, there will be no significant changes to land uses and water uses which adversely affect the living conditions of the inhabitants in the project. (b) The living conditions of inhabitants may be affected due to the bad sewage odor from the STP in Horse Camp during transportation of solid sludge via the city to the disposal site. However, location of the STP is appropriate, as it is against the sea breeze and at a site where no residential areas are in the background. (c) Solid sludge will be transported appropriately in a purpose designed transport vehicle or machine that must be completely coverd to prevent bad odor during transportation. Standby solid sludge transporting vehicle or machine will be available at all times in an event of a breakdown of a vehicle or machine during transporting of sludge.
4..Social Environment	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? (b) Are adequate measures considered to protect these sites in accordance with the country's laws?	(a)N/A (b) Y	(a)No cultural heritage site of significance to the Motu-Koita people were identified in the project site. (b) If other archaeological/historical object or sites of significance are discovered during the course of construction, work will cease and the PNG National Museum and Art Gallery will be contacted for advice on appropriate action to take to preserve them.
	(4) Landscape	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the	(a) Y	(a) The landscape especially where the proposed STP is to be built at Kila Kila (land area:7.05ha) will be changed. The site is on mid hill which will be cut into and leveled out to built the STP. The site is uninhabited, savannah grassland. It is anticipated that construction work will not adversely affect the landscape.

Category	Environmental Item	Main Checklist of Items	Yes: Y No: N Not Applicable:N/A	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		country's laws?		
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are any considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all rights of ethnic minorities and indigenous peoples in relation to lands and resources respected?	(a) Y (b) Y	(a) Impacts on culture and lifestyle of local indigenous people were considered.. The project does not unnecessarily take up traditional land or penalise squatters for properties damage/loss. The majority of people are settlers from other parts of PNG, who reside in close proximity to the project site especially at Kila Kila. 18 households that will be affected by the Kila Kila STP access road has already been resettled and payment of compensation provided. (b) The rights of all the people indigenous to PNG are enshrined in the Constitution called "Mama Law" of PNG enacted in 1975. Under this constitution, all laws enacted through Parliament give protection to the rights of the people of PNG. However, the project will not affect the rights of ethnic minorities and indigenous peoples in relation to lands.
4. Social Environment	(6) Working Conditions	(a) Is the project proponent violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including	(a) N (b) Y (c) Y (d) Y	(a)The safeguarding of personnel and property will be carried out in a legitimate manner that avoid or limits risks to the worker's safety and security during constructions. (b)During construction works, potentially hazardous environments will be presented to workers. The potential hazards/risks will be determined. Potential impacts will be managed by providing safe and hygienic construction sites. Appropriate warnings and safeguards will also be installed to ensure that no accidents occur. Occupational Health & Safety Officer of EDA RANU is preparing OHS Policy that is expected to be published by June 2011. (c)Provision of appropriate training on safe work practices to all workers. In addition, HIV/AIDS and Cholera Prevention/Hygiene and sanitary education program will be implemented by the contractor to the construction workers. To ensure the effectiveness of the Program, the contractor will be monitored by IPBC/EDA RANU at regular intervals during the construction period. (d) Security guards will be involved to ensure

Category	Environmental Item	Main Checklist of Items	Yes: Y No: N Not Applicable:N/A	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards be involved in the project so as not to violate the safety of other individuals involved, or local residents?		safe practicess are followed and ensure safety of individuals.
5.Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)?	(a) Y	(a)To minimize generation of fugitive dust, loose earth shall be watered frequently in dry days. Noise and vibration are expected to be generated due to the loading of heavy earth moving equipment. However, noise mentioned above may be intermittent and of short duration mostly during daytime. Therefore, no significant impact is anticipated on account around the project site. To prevent runoff of the turbid water from construction sites, install appropriate sediment control structures (silt fences, bunds, sediment traps, basins and various sediment control or catch drains) prior to commencement of work. To minimize and mitigate siltation and sedimentation problems of solid and liquid wastes following measures will be conducted; Educate all workers of best waste management practices before construction works commences, Temporary waste disposal bins or sites in every construction work sites and to ensure all wastes are stock-piled in the waste disposal facilities provide or established, To ensure liquid wastes are stored in very safe containers to mitigate spillages and leaching. Wastes shall be removed from temporary stockpiles and bins on a regular basis, Waste materials needed/requested by individuals/public for reuse purposes shall be given away to minimize waste load.

Category	Environmental Item	Main Checklist of Items	Yes: Y No: N Not Applicable:N/A	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
5.Others		(b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts? (d) If the construction activities might cause traffic congestion, are adequate measures considered to reduce such impacts?	(b) Y (c)Y (d) Y	(b)Live corals along the outfall pipe route will be transplanted before excavation. Pipe laying work in the tidal flat area shall be carried out using a sheet protector to avoid the spread and sedimentation of silt and sand with the construction of the outfall pipe. (c) Production of waste products during construction will create some negative impacts. To minimize the risks, construction works waste materials will be removed immediately to designated disposal site. Activities of local communities such as fishing, crustacean harvesting and recreation would be affected during construction of ocean outfall. To minimize the disruption of the activities, advance notice of the project (including duration, date and time) will be given to the local communities as an awareness campaign. Construction work must be completed within schedule to avoid delays. Construction works and movement of heavy equipment can pose danger or risks to public health. To minimize the risks, appropriate training on safe work practices will be provided to all workers and engineering work safeguards must be applied. HIV/AIDS Prevention/Hygiene Training program will be implemented by the contractor to workers and the residents in nearby areas. (d)Existing roads in Port Moresby city will be temporarily affected in the sewerage pipeline and pumping stations construction process as well as by transporting of waste construction materials to the dump site. IPBC/EDA RANU will liaise with appropriate road authorities and take full responsibility for the maintenance.

Category	Environmental Item	Main Checklist of Items	Yes: Y No: N Not Applicable:N/A	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
5.Others	(2) Monitoring	(a) Are adequate monitoring measures being considered (b) Is effluent and ambient water quality being monitored? Will the corals be monitored as well? (c) Will there be a lead agency for monitoring? Who will carry out the monitoring? (d) Are there statutory requirements pertaining to the reporting system	(a) Y (b) Y (c) Y (d) N	(a) The Program would include water quality monitoring (effluent/Wastewater/Ambient Water), as well as coral reef monitoring (b)During the operation phase, the parameters monitored for effluent water quality will be total Coliform, pH, Fecal Coliform, Suspended Solid, BOD, COD_{Mn}, T-N, T-P, Oil. Monitoring items for ambient water quality will be pH, DO, COD_{Mn}, T-N, T-P, Oils and heavy metals. In coral reefs monitoring, transplanted coral, coral reefs near the outfall point and along the pipeline route and benthic communities will be monitored. (c) The Lead agency of the monitoring is EDA RANU. The implementer is EDA RANU's environmental officer and/or contracted environmental scientists/biologists. (d) There are no regulatory requirements pertaining to the monitoring report system in PNG.

1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are required to be made.
In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).
2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which the project is located.

Source: JICA Study Team

CHAPTER 11 Risk Analyses and Hazop Study

11.1 Scope of the Study

This document presents risk analyses, an assessment of the reliability and the HAZOP study of the proposed Port Moresby Sewerage System Upgrading Project (POMSSUP). Risks and hazards shown below must be avoided by careful attention to detail according to the safety manual for the plant operation and cautious maintenance work with operator's due awareness.

The scope of work for this Chapter is to identify Risks, to assess Hazards, Operability and Reliability for the entire system of the POMSSUP. The study includes a HAZOP Analysis and Reliability Study employing the method of FMEA for the recommended process.

The existing sewerage system in the inland area is excluded from this study.

11.2 Risk Identification

11.2.1 Outline of Risks and Required Measures

Potential principal risks associated with the construction and operation of the STP, PS and Network are identified and the measures recommended to mitigate and/or minimize the risks are summarized. The risks have been identified in the following areas:

(1) Construction
- (a) Conflicts in contractual relationships
- (b) Failure of temporary works necessary for construction
- (c) Safety of workers

(2) Operation
- (a) Structural failures
- (b) Process failure
- (c) Gas explosion or other accident
- (d) Toxic/chemical spills
- (e) Mechanical plant failure
- (f) Environmental quality control system failure
- (g) Control system failure
- (h) Power supply failure
- (i) System overload
- (j) Flooding
- (k) Fire

The detailed design has taken into consideration the risks identified above and where they are design related, features have been included, wherever possible, to mitigate or minimize the risks.

11.2.2 CONSTRUCTION RISKS

(1) Contractual Issues

The project involves a wide range of construction techniques, covering soil retaining structures, pump stations, open-cut method, and pipe laying work undersea. Installed equipment includes process plant such as aerators, mixers, sludge scrapers, and sludge dewatering, as well as pumps. There are contractual relationships between the suppliers, contractors and other parties that constitute the main potential impediments to on-time completion. In this project the intent is to minimize the contractual-relationship risk by implementing the work under one contract, with the principal contractor taking full responsibility for all relationship issues between sub-contractors, equipment suppliers, and other parties.

Measures taken to reduce the risks associated with contractual issues include:

- Stipulating that the Principal Contractor is totally responsible for the performance of all sub-contractors and equipment suppliers.
- Specifying the process equipment in the design and specifications in order to reduce the opportunity for bidders to offer lower-quality (and higher risk) alternative processes.
- Stipulating that the Principal Contractor identifies the process plant and equipment suppliers in the bid submittal document.
- Requiring the Principal Contractor to certify that the constructed facility will meet the effluent discharge criteria in accordance with the specified design conditions.
- Preparing Particular Specifications in addition to the General Specification that clearly identify the conditions relevant to the sub-components, covering such items as *inter alia*, ground conditions, site access, and coordination issues.
- Ensuring that all sub-contractors and suppliers meet the specified minimal levels of experience and financial stability laid down in the tender documents.
- Undertaking a comprehensive pre-qualification exercise to ensure that only those contractors with the desired experience as well as the necessary technical and financial resources will be invited to submit tenders.
- Adoption of a two-envelope bidding process with the technical submissions being evaluated in detail prior to opening the commercial bids, thereby ensuring that the bid price will only be assessed for those bidders who strictly satisfy the technical requirements of the project.
- Stipulating that the Principal Contractor submits and adheres to a Quality Assurance/Quality Control Plan that will serve as a basis for monitoring adherence to the quality requirements of the works.

- Stipulating that the Principal Contractor submits and adheres to an Environmental Management Plan that will specify actions to be taken to mitigate any adverse environmental impacts resulting from the construction activities.
- Insisting on strict adherence to reporting and inspection procedures with comprehensive maintenance of records required both by the contract and by the Contractor's own Quality Assurance/Quality Control programme.
- Providing through the Consultants a firm construction supervision and contract management team, including a team of design support personnel.
- Initiating regular construction meetings which will include not only the Principal Contractor but also representatives from the major sub-contractors and suppliers in order to both increase the awareness of all parties to potential problem issues, as well as to encourage a sense of cooperation among all parties to complete the works on time and within budget.

(2) Temporary Works Failures

The pump stations and the open-cut trunk sewer have the risk of temporary works failures because of the varying ground conditions and the relative lack of experience of local sub-contractors in this category of work. Although responsibility for temporary works design rests entirely with the Principal Contractor, the temporary works designs will be reviewed for completeness by the Consultants and suggestions made as necessary, but without any implied lessening of the responsibility of the Principal Contractor for the design.

Issues likely to be covered under such a review includes:

- Evidence of site-specific soil investigations by a competent, professional geotechnical engineer.
- Evidence of design calculations by professional engineers.
- Monitoring procedures for movement of earth retaining systems.
- Monitoring requirements for surface structures within the anticipated zone of influence of the underground works.
- Measures to mitigate planned and unforeseen interruptions to utility services, including underground services and traffic.
- Protecting the works from surface flooding and inundation of open excavations.
- Application of appropriate factors of safety to excavations, support systems, stability, etc.

(3) Risk to Workers

The Principal Contractor is responsible for the safety of workers on site, including those employed by sub-contractors, suppliers and other interested parties. The contract will stipulate that the Principal Contractor submit and adhere to a Health and Safety Plan that identifies the perceived risks, and

details the arrangements for the management of health and safety of the construction work, including the monitoring systems to ensure that the plan is being followed.

Key areas that will need to be addressed in the context of safety include the establishment of safe procedures for working in confined-spaces , provision of adequate ventilation, evacuation and emergency procedures, and control and monitoring procedures for all personnel entering and leaving the works area. The more general measures to be addressed will typically include storage of materials, control and disposal of waste, permit-to-work procedures, protection from falling materials, regular "tool-box" talks, training of workers in health and safety issues, exclusion of unauthorized people, etc.

11.2.3 OPERATION RISKS

The STP represents a modern and robust design that minimizes risk to the greatest practical extent. However, all wastewater treatment facilities involve some operational risks that cannot be totally eliminated, by virtue of the fact that the feedstock characteristics are not constant and because the key treatment processes are based on microbiological systems that are inherently sensitive to any changes in the operating environment. Rigorous supervision of construction to ensure compliance with the design will also reduce the likelihood of risks occurring.

Notwithstanding the above measures to control risk, there will inevitably be some occasions when problems do arise. The major potential operating risks and mitigation measures are summarized in **Table 11.2.1**, together with their expected frequency, impacts and mitigation measures.

The Detailed Design was conducted in order to minimize the risk in the **Table 11.2.1**. The rest of the risks will be avoided by monitoring of the operation and personnel trainings.

11.2.4 FIRE RISK

The facility is designed to the relevant fire protection codes and regulations current in PNG. Additional precautions will include:

- Regular fire safety training for all construction and operations personnel
- Provision of fire safety equipment and hydrants throughout the facility
- Use of non-sparking tools
- Storage of flammable consumables in separate fire-proofed areas
- Minimum use of combustible materials in construction
- Adequate ventilation of all spaces where people have access

Table 11.2.1 OPERATION RISKS

Potential Failures	Impact	Potential Frequency	Mitigation Measures
Structural Failure • Process structure foundation or trunk sewer failure through settlement or corrosion • Damage by third parties (typically to sewerage system during construction of other schemes)	• Differential settlement • Hydraulic problems due to settlement resulting in STP being unable to accept design flow • Leakage or infiltration into sewerage system • Leakage from process units • Rapid corrosion damage	• Improbable if mitigation measures stipulated in design are followed during construction • Frequency of damage to sewerage by third parties cannot be predicted	• Select concrete mix and coatings to withstand the aggressive conditions of raw sewage/sludge and carry out rigorous site supervision • Prepare accurate as built drawings showing locations of new sewers for information of third parties **< To be made in the Design Stage >**
Process Failure • Toxic or other incompatible substance enters plant from illegal discharge in service area • Secondary sludge not wasted • Sludge dewatering system does not achieve target 20% DS	• Could kill bacteria in activated sludge process, solvents could cause explosions • Sludge bulking with reduction in clarifier efficiency • Biomass escapes in effluent and discharge standard not met • Increase in sludge volume for disposal with consequent increased costs	• Likelihood of illegal manhole dumping of solvents or hydrocarbons • Relatively common problem due to operator error • Can be expected to occur at least annually if operators fail to maintain correct chemical dose rates	• Provide continual monitoring for explosive gases in pump stations and alarm system so that feed to the plant can be controlled and gases ventilated safely. • If toxics are found in the feed undertake stringent checks to ascertain source and take legal action • Manipulate RAS (return activated sludge) flow rates to lower or maintain sludge blanket depth in clarifiers. • Increase secondary sludge wastage rate • Ensure that chemical dosing system and feed lines are regularly flushed and that operating procedures for varying doses with feed sludge characteristics are followed **< To be handled by monitoring and personnel training >**
Chemical Spills or Other Accident • Process chemicals spill or are inadvertently mixed	• Poisonous gas or other hazard created at spill site	• Unlikely to occur because design provides for separation of chemicals	• Ensure that operations personnel are trained in emergency procedures and provide necessary safety equipment for handling chemicals • Provide separate feed pipes for chemical reception, overflow containment, and drain lines **< To be handled by monitoring and personnel training >**
Mechanical Plant Failure • Failure of key equipment items such as blockage of inlet pumps, or clogging of air diffusers • Grit/scum not wasted • Failure or inefficiency of ventilation equipment in dewatering building **Control System Failure** • Individual control loop or element therein fails • Central monitoring and control component failure • Instrumentation not calibrated **Power Supply** • Grid failure or Generator failure **System Overload** • Inlet pump station delivers more flow than STP can handle • Organic load more than design range **Flooding from Structural Failure** • Structural failure of process tank or inter-connecting pipework	• Inability to feed raw sewage or provide adequate oxygen • Odour released from grit chambers, scum pits • Localized odour generation • Performance deteriorates with risk of effluent standard non-compliance • Loss of overall performance control with deterioration in effluent quality and odour release • Effluent quality deteriorates, energy use not optimized • Long-term interruption may require process re-start • Process units over-top with site flooding • Deterioration in effluent standard and risk of odour generation • Flooding of STP site and loss of treatment efficiency	• Unlikely to be frequent because of design and rigorous equipment selection procedures, but need action plan just in case • Unlikely to occur unless failure of grit/scum removal mechanism • Likely to occur occasionally • Likely to be a common occurrence • Individual components will fail on occasions but should not result in total shut down • Likely to be a common occurrence • Short-term failures likely to occur, long-term only rarely • Highly improbable • Possible if industrial wastes are discharged into the sewerage system • Failure of pipeline more likely than failure of tank as a result of poor construction	• Ensure spare pump sets and diffusers are available on-site and staff trained in replacement procedures • Design for easy replacement procedures with minimal downtime • Provide instrumentation to monitor grit/scum removal status, and ensure regular maintenance of removal equipment • Provide stand-by ventilation equipment, line concrete surfaces and use non-ferrous metals • Use standard equipment and software for easy replacement and upgrade and provide manually adjustable controls as back-up • Provide multiple component units to back-up each other and provide instrumentation panels for local control • Calibrate instruments according to a strict schedule, provide multiple instruments in parallel, and provide an alarm system • Provide stand-by generators and reserve fuel to cover both short and long-term power outages • Provide monitors and alarms in process system • Provide stand-by unit process and interconnecting channel capacity • Provide feed valves before each unit as well as by-passes • Investigate sources of illegal discharges and prosecute • Provide maximum treatment possible without jeopardizing integrity of individual unit processes, by-pass excess load until problem is rectified • Provide multiple treatment modules, stand-by pumps to convey flow to downstream units, and rigorously monitor construction **< To be made in the Design Stage >**

11.3 HAZOP STUDY

11.3.1 GENERAL

A Hazard and Operability (HAZOP) study is a structured and systematic examination of a planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment, or prevent efficient operation. The risks during the design/operation stage are studied methodically and exhaustively. This method is effective to discriminate potential risks for certain systems.

11.3.2 OPERABILITY

For the Hazard and Operability Study, references below are utilized:

(1) General Sewerage Layout Plan

(2) Trunk Sewers Network Plan and Profiles

(3) Branch Sewers Network Plan and Profiles

(4) Pumping Station Network Plan

(5) Layout plan and Equipment Arrangement of PS

(6) PS Process Flow and Instrumentation Diagram

(7) Kila Kila STP and Morata STP General Layout

(8) STP Process Flow Diagrams and Instrumentation Diagrams

(9) Ocean Out fall Layout Plan and Profile

Each unit in the general layout and Process Flow Diagrams and Instrumentation Diagrams was investigated against a list of parameters such as flow or pressure, and then separately within those parameters for specific guide words such as high, low, no. An investigation is carried out for each for (say) high flow, low flow, high pressure, no pressure, vacuum.

11.3.3 HAZOP

(1) Pumping Stations

The main wastewater collection system is featured by 17 intermediate pumping stations which will be newly constructed or rehabilitated. Of the long trunk main pipeline, 90% is the force main, and the remaining 10% is the gravity flow. Each pumping station is equipped with an on-site generator as a countermeasure for frequent electrical outrages. Countermeasures against water hammer phenomenon and brine damage were made during the Detailed Design.

Pumping stations involve the process as follows:

1) LIFT PUMPS

The lift pumps would operate in an Auto mode upon detection of pre-set wastewater levels in the

wet well. Upon detection of a higher level in the wet well, a greater number of pumps would be set into operation. The lift pump operation under auto mode is achieved by the PLC in combination with the level meter and the flow meters.

Ultrasonic type or electrode level meter will be installed in the pump wet well and electromagnetic type flow meter will be installed on the force (rising) main(s) to monitor level and flow respectively.

2) STANDBY GENERATOR SETS

A diesel generator set will be installed as the standby power source. The generated power will be transmitted to the standby incoming circuit breaker to feed power to the loads.

The standby generator set comprises one diesel engine, one alternator mounted on a common base, one radiator cooling unit, engine exhaust silencer, one built-in service tank, one generator control panel, two fuel transfer pumps and ancillaries. One bulk storage tank and ancillaries will also be provided as common equipment to the standby generator. The standby generator set will be installed in the generator house. The standby generator set will start to run in an auto mode upon the under-voltage relay activated. The standby generator set can be operated manually at the associated generator control panel during trouble shooting or maintenance.

HAZOP for the pumping station was conducted for Kaugere PS including Bucket Screen, delivery valve and hoist in addition to the main equipment above. Hazop for other pumping stations is considered to be the same with Kaugere PS. Hazards regarding flow, pressure, level, time, startup/shutdown, draining/venting, blockage and no operation were examined according to strength, depth, length, and speed. (Refer to **Table 11.3.1**)

< Outline of the result of the Study >

A lifting pump is the main equipment with some potential for the hazard, however, no big issues were found since stand-by units are planned, the sequence is planned for missed step and SCADA will monitor the operation. Surging of the pump is solved by a fly-wheel, as required. Soundness of the back-up generator will be very important for risk reduction from the standpoint of avoiding wastewater discharge in an emergency situation.

Required action to remove the hazards will be monitoring of the status/alarm of the pumping stations, field inspection as required and periodical inspection of the emergency generator unit. The result will be the same with other pumping stations.

Table 11.3.1 **Kaugere PS HAZOP STUDY**

Facility		BACKET SCREEN	LIFTING PUMP	DELIVERY VALVE	MONORAIL HOIST	STANBY GENERATORS
Equipment/Function		Manual Course Screen	Submersible Pump	Motorized Sluice Valve	Manual Hoist	Standby Generator
Status		Backet Screen to be installed at the inflow pipe outlet. The backet to be hoisted by manual hoist.	3 Submersible Pumps of diameter 350mm, 15m head, 55kw with fly wheel for surging (1 stand-by) to be in stalled in the wet well. Type of submersible pump to be non-clog, constant speed. Opeartion	Normally open.	Lifting up Pumps and Backet Screen manually.	One diesel generator set to be installed as a standby power source. Generated power to be transmitted to the generator distribution panel to feed power in an emergency.
Flow	High Flow	No issue	Pumps designed for peak design flow. If flow in excess of this, then level of sewage will rise in wet well, and pumps can pump slightly more flow with reduced static head.	No issue	No issue	Valves normaly open. Fuel flow to be checked in the regular inspection.
	Low Flow	No issue	Potential for sewage in wet well to settle and sediment build-up. Flushing system to help prevent this. No issue to pumps.	No issue	No issue	Check to see that valves are fully open when low flow found in the inspection.
	No Flow	No issue	Potential for sewage in wet well to settle and sediment build-up. Flushing system to help prevent this. No issue to pumps.	No issue	No issue	Not applicable
	Reverse Flow	Not applicable	Non return on pump to prevent this. Only issue if non return valve does not operate.	No issue	No issue	Not applicable
Pressure	High Pressure	No issue	Not applicable	Not applicable	Not applicable	Not applicable
	Low Pressure	No issue	Not applicable	Not applicable	Not applicable	Not applicable
	Vacuum	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	Explosion	Not applicable	Not applicable	Not applicable	Not applicable	Bulk Fuel Storage Tank, fuel pipeline and Electrical Building to be isolated from fire or sparks.
Level	High Level	Not applicable	No issue	No issue	Not applicable	No issue
	Low Level	Not applicable	No issue	No issue	Not applicable	No issue
	No Level	Not applicable	No issue	No issue	Not applicable	No issue
	Variable Level	Not applicable	No issue	No issue	Not applicable	No issue
Time	Too long	Not applicable	Not applicable	Not applicable	Not applicable	Generator start-up time to be checked in the regular inspection.
	Too short	Not applicable	Operating for too short a period to result tripping (alarm for this). Needed to be reviewed.	Not applicable	Not applicable	Not applicable
	Sequence step skipped	Not applicable	Pumps are duty/duty/standby. They are set up to operate if a sequence step is skipped (e.g. second duty does not start) and identification of that missed step to be alarmed.	Not applicable	Not applicable	Sequential start-up of Fuel Transfer Pumps to be checked in the regular inspection.
Startup/Shut down	Too fast	Not applicable	Surging problem. Fly wheel to act.	Not applicable	Not applicable	Not applicable
	Too slow	Not applicable	To be checked	Not applicable	Not applicable	To be checked during the regular inspection.
	Actions missed	Not applicable	Next pump to start according to sequence	Not applicable	Not applicable	To be checked during the regular inspection.
Draining/ Venting	Too long	Not applicable	No issue	Not applicable	Not applicable	Not applicable
	Too short	Not applicable	No issue	Not applicable	Not applicable	Not applicable
	None	Not applicable	No issue	Not applicable	Not applicable	Not applicable
	Deviating pressure	Not applicable	Cavitation in pumps - use manufacturer recommendations for minimum depth of sewage over pump inlet and increase these if cavitation does occur.	Not applicable	Not applicable	Not applicable
	Wrong timing	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Blockage		Basket to be cleaned manually	If blockage occurs, alternate pump to operate.	Blockage of valve to be detected and alarmed.	Not applicable	Blockage of fuel pump and pipeline to be checked in the regular inspection.
Equipment does not operate mechanically or electrically.		No issue	Alarm, and next pump to operate. Or alarm and operator input required.	Not applicable	Not applicable	Manual operation.
Actions		Inspection by operators needed.	Installtion of limit switch	Manual operation	None	Periodical regular inspection for operation of engine, fuel pump and fuel level in the fuel tank needed to avoid break down of the generator during power failure from grid.

(2) Sewage Treatment Plant

The sewage treatment process employs the oxidation ditch method with comparatively deep reactor of 6m depth in which fine diffusers and mixers will be installed to secure efficient balanced oxygen supply even at the bottom of the tank. The alignment of the ocean outfall will be constructed to conserve the existing corals and minimize transplanting them as much as possible, since pipe alignment crosses coral breeding area of Joyce Bay. Process Description of the STP is shown as follows:

1) SCREENS

The manual course bar screen and mechanical fine screens will be installed in the screen channels to remove debris from the influent raw wastewater. The fine screens will run under an auto mode upon detection of pre-set differential levels between pre- and post-screen or a pre-set time relay, which are programmed in a PLC. The raw wastewater levels of the pre-screen and the post-screen in the screen channels will be continuously monitored by ultrasonic type level sensors/transmitters.

2) GRIT CHAMBER

Vortex type grit chamber will be installed for grit removal. The grit pumps will also be installed at a nearby location. The grit pumps will run continuously in an auto mode upon initiation by the supplier's PLC or the main plant PLC. Associated valves will open/ close in the auto mode in linkage with the grit pumps mode of operation.

3) BIOLOGICAL TREATMENT PROCESS

The biological treatment process comprises 4 lanes of oxidation ditches and final sedimentation tanks along with process air blowers, waste activated sludge pumps, and associated valves and piping. Process air will be supplied by the air blowers to the tanks through the fine bubble diffusers. Waste activated sludge will be removed from the tanks to maintain the desired solids retention time (SRT) and the intended MLSS concentration and sent to a sludge dewatering machine.

4) PROCESS AIR BLOWERS

The air blowers will be controlled automatically in the auto mode by the supplier's PLC targeting dissolved oxygen (DO) value obtained from the appropriate location of the tank based on the mode of operation. The DO set point will be given to the PLC through the STP SCADA HMI by the operator.

5) WASTE ACTIVATED SLUDGE (WAS) PUMPS

The WAS pumps will be controlled triggered by a start button of the dewatering machine. Waste sludge flow rate will be a controlled constant.

6) SLUDGE DEWATERING MACHINE

A mechanical dewatering machine will directly receive waste sludge from tanks of the oxidation ditch process. Two units of dewatering press machine with a capacity of 180kg-ds/hr/unit will be installed. Waste sludge will be dewatered without a thickening process. Polymer will be fed to the sludge in an auto mode before the dewatering process. Design solids concentration will be 15%. Dewatered sludge will be transported to sludge hopper through a screw conveyor.

7) UV DISINFECTION

UV disinfection will act as the main disinfection process. The equipment will be operated continuously in an auto mode. Back-up chlorination device will be installed in parallel.

8) STANDBY GENERATOR

A diesel generator set will be installed as the standby power source. The generated power will be transmitted to the standby incoming circuit breaker in the AMF to feed power to the loads.

The standby generator set comprises one diesel engine, one alternator mounted on a common base, one radiator cooling unit, engine exhaust silencer, one built-in service tank, one generator control panel, two fuel transfer pumps and ancillaries. One bulk storage tank and ancillaries will also be provided as common things to the standby generator. The standby generator set will be installed in the electrical building to back up the loads required in case of mains failure.

The standby generator set will start to run in an auto mode once the under-voltage relay is activated.

The standby generator set can be operated manually at the associated generator control panel during trouble shooting or maintenance.

HAZOP for Kila Kila STP was conducted for Screen, Grit Chamber, Treatment process, Blower, Sludge Dewatering Unit, UV Disinfection and stand-by Generator. Hazards regarding flow, pressure, level, time, startup/shutdown, draining/venting, and blockages were examined according to strength, depth, length, and speed. (Refer to **Table 11.3.2**)

Table 11.3.2 **Kila Kila STP HAZOP STUDY**

Facility		SCREEN	GRIT CHAMBER	OXIDATION DITCH/FINAL SEDIMENTATION TANK	PROCESS AIR BLOWERS	SLUDGE DEWATERING UNIT	UV DISINFECTION	STANBY GENERATORS
Equipment/Function		**Manual Course Screen + Fine Screen**	**Voltex Type Grit Removal + Grit Pump**	**Diffuser, Mixer, Clarifier and WAS pumps**	**Air Blowers for Aeration**	**Sludge Dewatering Unit and Sludge Cake Hopper**	**UV Disinfction with Back-up Hypochlorite Dosing**	**Standby Generator**
Status		The Course Bar Screens to be installed in two channels in both duty configuration to remove screenings debris from influent wastewater. The Mechanical Fine Screen operates in an auto mode upon detection of a pre-set differential water level between upstream and downstream. Operate continuously according to the flowrate. Clogging of the screen and over torque for the motor can occur.	Horizontal propeller for the rotation of sewage, Grit Pump and skip for the removed grit Installed. Operates continuously. Grit pump operates in an auto mode by time schedule control. Clogging of the grit pump can occur. Grit conveyor operates in an auto mode by time schedule control.	Aeration to be introduced to the tank by diffusers to treat sewage. Aeration to be controlled by DO concentration or duration time schedule for duty lane. WAS pumps to be operated by time schedule control and operation status of dewatering unit. Mixer will create the flow inside the tank by continuous operation.	Duty blower units to be operated continuously, controled by DO concentration or time schedule under an auto mode.	WAS to feed waste sludge dewatering unit from OD by linked control triggered by start button auto mode. Polymer feeding pump and Conveyor to operate by the same linked control. Polymer tank to be controled by time schedule. Hopper to be operated by mannually in the field.	UV lamp to be continuously ON. Only turned off for maintenance purpose or at the malfunction. In case of UV malfunction, back-up hypochlorite dosing unit will be operated manually. Ball Valve of chlorination tank to be normally open. Only closed for isolation of Pumps and Tanks for maintenance or replacement work. Injection pump to be operated manually.	One diesel generator set to be installed as a standby power source. Generated power to be transmitted to the generator distribution panel to feed power in an emergency. The standby generator sets to back up the plant loads. The standby generator sets to start in an auto mode upon the under-voltage relay activated. Capacity of Bulk Fuel Storage Tank to be equal to the 24 hours operation of generators.
Flow	**High Flow**	No issue	No issue	No issue	No issue	No issue	Check to see that pumps are working and valves are fully open at emergency.	Valves normaly open. Fuel flow to be checked in the regular inspection.
	Low Flow	No issue	No issue	Check to see that air valves are fully open or aerators are not clogged. Check to see the mixers on.	Check to see valve is fully open.	No issue	No issue	Check to see that valves are fully open when low flow found in the inspection.
	No Flow	No issue	No issue	Check to see that air valves are fully open or aerators are not clogged. Check to see the mixers on.	No air flow have potential for sediment build-up in the tanks. Remove it.	Not applicable	No issue	Not applicable
	Reverse Flow	Not applicable	No issue	Not applicable	No issue	Not applicable	No issue	Not applicable
Pressure	**High Pressure**	No issue	Not applicable	No issue, pressure will be controled at Blower constant.	No issue	Not applicable	No issue	Not applicable
	Low Pressure	No issue	Not applicable	No issue, pressure will be controled at Blower constant.	No issue	No issue	No issue	Not applicable
	Vacuum	Not applicable	Not applicable	Not applicable	Not applicable	No issue	Not applicable	Not applicable
	Explosion	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable.	Not applicable	Bulk Fuel Storage Tank, fuel pipeline and Electrical Building to be isolated from fire or sparks. Bulk Fuel Storage Tank to be installed underground and Electrical building to keep the sundries inside. No issue
Level	**High Level**	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Chemical fluid level to be controled by level sensor and over flow/drain	No issue
	Low Level	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	No issue
	No Level	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	No issue
	Variable Level	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	No issue
Time	**Too long**	Not applicable	Not applicable	Not applicable	No issue	Not applicable	Not applicable	Generator start-up time to be checked in the regular inspection.
	Too short	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	Sequence step skipped	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Sequential start-up of Fuel Transfer Pumps to be checked in the regular inspection.
Startup/Shut down	**Too fast**	Not applicable	Not applicable	Not applicable	Not applicable	No issue	Not applicable	Not applicable
	Too slow	Not applicable	Not applicable	Not applicable	Not applicable	No issue	Not applicable	To be checked during the regular inspection.
	Actions missed	Not applicable	Not applicable	Not applicable	Not applicable	No issue	Not applicable	To be checked during the regular inspection.
Draining/ Venting	**Too long**	Not applicable	Not applicable	Not applicable	Not applicable	No issue	Not applicable	Not applicable
	Too short	Not applicable	Not applicable	Not applicable	Not applicable	No issue	Not applicable	Not applicable
	None	Not applicable	Not applicable	Not applicable	Not applicable	No issue to pumps	Not applicable	Not applicable
	Deviating pressure	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	Wrong timing	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable.	Not applicable	Not applicable
Blockage		If blockage occurs, over torque/over load will be detected and the rake will stop.	If blockage of pump or conveyor occurs, over torque/over load will be detected and the unit will stop.	If blockage of diffuser occurs, DO censer will detect the DO level for confirmation.If blockage of pump or conveyor occurs, over torque/over load will be detected and the unit will stop.	Not applicable	If blockage of a pump occurs, then no or low flow will be registered during pump operation, and alarm will be raised, operating pump to be stopped and alternate pump to operate.	Not applicable	Blockage of fuel pump and pipeline to be checked in the regular inspection.
Equipment does not operate mechanically or electrically.		No operation. Repair needed.	No operation. Repair needed.	No operation. Repair needed.	No operation. Repair needed.	No operation. Repair needed.	No operation. Repair needed.	Manual operation.
Actions		Daily inspection by operators needed. Field manual operation possible.	Daily inspection by operators needed. Field manual operation possible.	Daily inspection by operators needed. Field manual operation possible.	Daily inspection by operators needed. Field manual operation possible.	Control to be triggered by start button of dewatering unit.	Daily inspection by operators needed. Field manual operation possible. Storage condition of hypochlorite for the emergency must be periodically checked.	Periodical regular inspection for operation of engine, fuel pump and fuel level in the fuel tank needed to avoid break down of the generator during power failure from grid.

11.3.4 Hazards for Health and Safety

(1) Hazards for Occupational Safety

Although efforts to remove the risks of the hazards for occupational safety in the STP must be made in the DD stage, they must be avoided in every operation works by the maintenance staffs. Most important factor is the appropriate operation of the system. Further it will be achieved by education of the staff – holding periodical safety workshops – and use of safety tools and equipment.

Hazards for occupational safety in the Pipeline/PS/STP and counter measures are listed up as follows:

1) Oxygen Deficiency:	Ventilation and Oxygen Mask
2) Hydrogen sulfide gas:	Ventilation and Oxygen Mask
3) Methane gas:	Ventilation and Oxygen Mask
4) Ammonia gas:	Ventilation and Oxygen Mask
5) Chemicals:	Safe Storage Depot for chemicals such as hypochlorite and caution in the work such as mixing
6) Fire/ Explosion:	By inflammable gases such as methane, hydrogen sulfide which can be produced in the biochemical reaction in the wastewater, and fuel for the generator
7) Injuries:	High rotating machine, heavy weight machine, high-voltage current
8) Rupture of Vessels:	Ruptures of Process Tanks, etc. causing flooding and environmental pollution
9) Bad odour:	Headworks, Sludge holding tanks

(2) Hazards outside the premises

Hazards shown below must be avoided by careful attention according to the safety manual for the plant operation and cautious maintenance work with operator’s awareness. No records of storm water flooding/storm surge/Tsunami in the area are available.

< Outline of the Study >

No big issue was found since a stand-by unit for any process is planned, the sequence is planned for a missed step and SCADA will monitor the operation. However, as frequent power failures are a big concern, soundness of the back-up generator will be very important for risk reduction. Even at the event of breakdown of back-up generator during the power failure of power grid, overflow from the tanks or containers to the outside will not occur since wastewater flow from one facility to the other is planned by gravity. From the beginning of a complete power failure up untill more than 27 hours, effluent will be fairly good because of the detention time of wastewater in the system. It will allow recovering the trouble of the system keeping environment of Joyce Bay clean. Even after this period, effluent will be discharged outside of reef at least after manual chlorination for disinfection. Required action to remove the hazards will be monitoring of the status/alarm of the process, field inspection as required and periodical inspection of the emergency generator unit is essential..

11.4 Reliability Study

11.4.1 General

A Reliability study was conducted using Failure Mode Effect Analysis method (FMEA). FMEA method is a structured and systematic examination for the followings:

1) To enumerate Failure Mode of each system component
2) To analyze each Effect of the Failures against the System
3) To discriminate the abnormal Events for equipment or facility
4) To prioritize the Failure by quantitative evaluation
5) To clarify necessary measures for the System

This method is a detailed and specific tool for the reliability study.

11.4.2 FMEA Study

For the FMEA Study, references below are utilized:

(1) PS General Layout
(2) PS Process Flow Diagram and Instrumentation Diagram
(3) Kila Kila STP General Layout
(4) STP Process Flow Diagrams and Instrumentation Diagram

In the FMEA STUDY, the followings are identified based on the design report:

1) Facility
2) Main Equipment
3) Life of the Equipment
4) Failure Mode
5) Cause
6) Detective Measure of the Failure
7) Type of Abnormal Events arising from the Failure
8) Effects to the System by the Abnormal Events

11.4.3 Scoring Rules for the Evaluation and Prioritization

A scoring system was developed for the quantitative evaluation of any Abnormal Events. Frequency of Failure, Degree of the influence of the Events and Probability/Difficulty of the Detection of the Failure were items raised in this connexion.

Scoring rules are shown in the **Table 11.4.1** Basic concepts for the scoring are as follows:

1) To use grading according to ten ranks
2) To categorize 3 items for the evaluation, namely Frequency, Degree and Probability
3) To multiply each score and get the total score as follows:

Total Score = (Score of Frequency) × (Score of Degree) × (Score of Probability of Detection)

4) It was decided to set a score for common equipment such as pumps in order to describe the equipment for which measures for any events are needed.

Table 11.4.1 Scoring Rules for the Evaluation and Prioritization of Failures

Score	Frequency	Degree	Probability of Detection
10	Once a week	Not allowable	Detected by outside
8	Once a month	Downtime more than a week	Detected by inspection
5	Once a 6months	Repair costly	Detected by observation
3	Once a year	Easy repair	Detected by alarm
1	zero	zero	Obvious

(Source: JICA Study Team)

11.4.4 Result of the FMEA Analysis

(1) Pumping Station

Refer to the **Table 11.4.2** for the result of the study. Results are summarized as follows:

1) Scores for the submersible pump was calculated as 45points and this score is considered to be indicative of common equipment.
2) Score of the standby generator was twice higher than that of the submersible pump indicating the seriousness in the event of a failure.
3) The standby generator needs careful monitoring and maintenance for this reason.

(2) Sewage Treatment Plant

Refer to **Table 11.4.3** for the result of the study. Results are summarized as follows:

1) Score for the submersible pump of 45 points from (1) was considered to indicate that of common equipment.
2) Scores of clarifier, blowers, dewatering unit, polymer feeder, and stand-by generator were higher than that of the submersible pump indicating the seriousness of any failure.
3) Counter measures for these are as follows: Hydraulic loading rate of the final sedimentation tank has some margin for additional flow during repair work, while the blower, the dewatering machines and polymer feeders are provided with a stand-by unit.
4) The stand-by generator unit needs careful monitoring and maintenance because of the seriousness at the failure of power grid.

Table 11.4.2 FMEA for Pumping Stations (1/2)

Facility	Main Equipment/Function	Life of The Equipment	Failure Mode	Cause	Detective Measure	Type of Abnormal Events	Effects to System	Evaluation of Abnormal Events				Recommendation	Action
								Frequency (Score)	Degree (Score)	Probability of Detection (Score)	Total Score for Prioritization		
01 KANUDI PS	Lifting Pump	15	*Mechanical failure *No operation	*Clogging by foreign body *Overloading *Power Failure	*Monitoring of operation *Alarm	*Flooding *Pollution	*Stand-by unit operation	5	3	3	45	Check of stand-by unit needed	
	STANDBY GENERATORS	15	*Mechanical failure	*Engine Breakdown *Fuel Pump Breakdown *No Fuel	*Periodical regular check *Alarm	*Power Failure	*Serious, Down of the PS when happening during blackout	3	10	3	**90**	Periodical Regular Check needed	
02 Idubada PS	Lifting Pump	15	*Mechanical failure *No operation	*Clogging by foreign body *Overloading *Power Failure	*Monitoring of operation *Alarm	*Flooding *Pollution	*Stand-by unit operation	5	3	3	45	Check of stand-by unit needed	
	STANDBY GENERATORS	15	*Mechanical failure	*Engine Breakdown *Fuel Pump Breakdown *No Fuel	*Periodical regular check *Alarm	*Power Failure	*Serious, Down of the PS when happening during blackout	3	10	3	**90**	Periodical Regular Check needed	
03 Hagara PS	Lifting Pump	15	*Mechanical failure *No operation	*Clogging by foreign body *Overloading *Power Failure	*Monitoring of operation *Alarm	*Flooding *Pollution	*Stand-by unit operation	5	3	3	45	Check of stand-by unit needed	
	STANDBY GENERATORS	15	*Mechanical failure	*Engine Breakdown *Fuel Pump Breakdown *No Fuel	*Periodical regular check *Alarm	*Power Failure	*Serious, Down of the PS when happening during blackout	3	10	3	**90**	Periodical Regular Check needed	
04 Hanuabada PS	Lifting Pump	15	*Mechanical failure *No operation	*Clogging by foreign body *Overloading *Power Failure	*Monitoring of operation *Alarm	*Flooding *Pollution	*Stand-by unit operation	5	3	3	45	Check of stand-by unit needed	
	STANDBY GENERATORS	15	*Mechanical failure	*Engine Breakdown *Fuel Pump Breakdown *No Fuel	*Periodical regular check *Alarm	*Power Failure	*Serious, Down of the PS when happening during blackout	3	10	3	**90**	Periodical Regular Check needed	
05 Konedobu PS	Lifting Pump	15	*Mechanical failure *No operation	*Clogging by foreign body *Overloading *Power Failure	*Monitoring of operation *Alarm	*Flooding *Pollution	*Stand-by unit operation	5	3	3	45	Check of stand-by unit needed	
	Motorized Delivery Valve	15	*Sewage Stoppage	*Blockage of Discharge Pipeline	*Site Inspection *Flowrate monitoring	*Flooding *Pollution	*Opertors to deal	3	3	3	27	Periodical Regular Check needed	
	STANDBY GENERATORS	15	*Mechanical failure	*Engine Breakdown *Fuel Pump Breakdown *No Fuel	*Periodical regular check *Alarm	*Power Failure	*Serious, Down of the PS when happening during blackout	3	10	3	**90**	Periodical Regular Check needed	
06 Old Yacht PS	Lifting Pump	15	*Mechanical failure *No operation	*Clogging by foreign body *Overloading *Power Failure	*Monitoring of operation *Alarm	*Flooding *Pollution	*Stand-by unit operation	5	3	3	45	Check of stand-by unit needed	
	STANDBY GENERATORS	15	*Mechanical failure	*Engine Breakdown *Fuel Pump Breakdown *No Fuel	*Periodical regular check *Alarm	*Power Failure	*Serious, Down of the PS when happening during blackout	3	10	3	**90**	Periodical Regular Check needed	
07 Stanley Esplanade PS	Lifting Pump	15	*Mechanical failure *No operation	*Clogging by foreign body *Overloading *Power Failure	*Monitoring of operation *Alarm	*Flooding *Pollution	*Stand-by unit operation	5	3	3	45	Check of stand-by unit needed	
	STANDBY GENERATORS	15	*Mechanical failure	*Engine Breakdown *Fuel Pump Breakdown *No Fuel	*Periodical regular check *Alarm	*Power Failure	*Serious, Down of the PS when happening during blackout	3	10	3	**90**	Periodical Regular Check needed	
08 Sea Park PS	Lifting Pump	15	*Mechanical failure *No operation	*Clogging by foreign body *Overloading *Power Failure	*Monitoring of operation *Alarm	*Flooding *Pollution	*Stand-by unit operation	5	3	3	45	Check of stand-by unit needed	
	STANDBY GENERATORS	15	*Mechanical failure	*Engine Breakdown *Fuel Pump Breakdown *No Fuel	*Periodical regular check *Alarm	*Power Failure	*Serious, Down of the PS when happening during blackout	3	10	3	**90**	Periodical Regular Check needed	
09 Davara PS	Lifting Pump	15	*Mechanical failure *No operation	*Clogging by foreign body *Overloading *Power Failure	*Monitoring of operation *Alarm	*Flooding *Pollution	*Stand-by unit operation	5	3	3	45	Check of stand-by unit needed	
	Manual Delivery Valve	15	*Sewage Stoppage	*Blockage of Discharge Pipeline	*Site Inspection *Flowrate monitoring	*Flooding *Pollution	*Opertors to deal	1	3	3	9		
	STANDBY GENERATORS	15	*Mechanical failure	*Engine Breakdown *Fuel Pump Breakdown *No Fuel	*Periodical regular check *Alarm	*Power Failure	*Serious, Down of the PS when happening during blackout	3	10	3	**90**	Periodical Regular Check needed	
10 Lawes Road PS	Lifting Pump	15	*Mechanical failure *No operation	*Clogging by foreign body *Overloading *Power Failure	*Monitoring of operation *Alarm	*Flooding *Pollution	*Stand-by unit operation	5	3	3	45	Check of stand-by unit needed	
	Motorized Delivery Valve	15	*Sewage Stoppage	*Blockage of Discharge Pipeline	*Site Inspection *Flowrate monitoring	*Flooding *Pollution	*Opertors to deal	3	3	3	27	Periodical Regular Check needed	
	STANDBY GENERATORS	15	*Mechanical failure	*Engine Breakdown *Fuel Pump Breakdown *No Fuel	*Periodical regular check *Alarm	*Power Failure	*Serious, Down of the PS when happening during blackout	3	10	3	**90**	Periodical Regular Check needed	

Table 11.4.2 FMEA for Pumping Stations (2/2)

Facility	Main Equipment/Function	Life of The Equipment	Failure Mode	Cause	Detective Measure	Type of Abnormal Events	Effects to System	Evaluation of Abnormal Events				Recommendation	Action
								Frequency (Score)	Degree (Score)	Probability of Detection (Score)	Total Score for Prioritization		
11 Koki PS	Lifting Pump	15	*Mechanical failure *No operation	*Clogging by foreign body *Overloading *Power Failure	*Monitoring of operation *Alarm	*Flooding *Pollution	*Stand-by unit operation	5	3	3	45	Check of stand-by unit needed	
	STANDBY GENERATORS	15	*Mechanical failure	*Engine Breakdown *Fuel Pump Breakdown *No Fuel	*Periodical regular check *Alarm	*Power Failure	*Serious, Down of the PS when happening during blackout	3	10	3	**90**	Periodical Regular Check needed	
12 Badili PS	Lifting Pump	15	*Mechanical failure *No operation	*Clogging by foreign body *Overloading *Power Failure	*Monitoring of operation *Alarm	*Flooding *Pollution	*Stand-by unit operation	5	3	3	45	Check of stand-by unit needed	
	STANDBY GENERATORS	15	*Mechanical failure	*Engine Breakdown *Fuel Pump Breakdown *No Fuel	*Periodical regular check *Alarm	*Power Failure	*Serious, Down of the PS when happening during blackout	3	10	3	**90**	Periodical Regular Check needed	
13 Kila Police PS	Lifting Pump	15	*Mechanical failure *No operation	*Clogging by foreign body *Overloading *Power Failure	*Monitoring of operation *Alarm	*Flooding *Pollution	*Stand-by unit operation	5	3	3	45	Check of stand-by unit needed	
	STANDBY GENERATORS	15	*Mechanical failure	*Engine Breakdown *Fuel Pump Breakdown *No Fuel	*Periodical regular check *Alarm	*Power Failure	*Serious, Down of the PS when happening during blackout	3	10	3	**90**	Periodical Regular Check needed	
14 Konebada PS	Lifting Pump	15	*Mechanical failure *No operation	*Clogging by foreign body *Overloading *Power Failure	*Monitoring of operation *Alarm	*Flooding *Pollution	*Stand-by unit operation	5	3	3	45	Check of stand-by unit needed	
	STANDBY GENERATORS	15	*Mechanical failure	*Engine Breakdown *Fuel Pump Breakdown *No Fuel	*Periodical regular check *Alarm	*Power Failure	*Serious, Down of the PS when happening during blackout	3	10	3	**90**	Periodical Regular Check needed	
15 Gabutu PS	Lifting Pump	15	*Mechanical failure *No operation	*Clogging by foreign body *Overloading *Power Failure	*Monitoring of operation *Alarm	*Flooding *Pollution	*Stand-by unit operation	5	3	3	45	Check of stand-by unit needed	
	STANDBY GENERATORS	15	*Mechanical failure	*Engine Breakdown *Fuel Pump Breakdown *No Fuel	*Periodical regular check *Alarm	*Power Failure	*Serious, Down of the PS when happening during blackout	3	10	3	**90**	Periodical Regular Check needed	
16 Horsecamp PS	Lifting Pump	15	*Mechanical failure *No operation	*Clogging by foreign body *Overloading *Power Failure	*Monitoring of operation *Alarm	*Flooding *Pollution	*Stand-by unit operation	5	3	3	45	Check of stand-by unit needed	
	STANDBY GENERATORS	15	*Mechanical failure	*Engine Breakdown *Fuel Pump Breakdown *No Fuel	*Periodical regular check *Alarm	*Power Failure	*Serious, Down of the PS when happening during blackout	3	10	3	**90**	Periodical Regular Check needed	
17 Kaugere PS	Lifting Pump	15	*Mechanical failure *No operation	*Clogging by foreign body *Overloading *Power Failure	*Monitoring of operation *Alarm	*Flooding *Pollution	*Stand-by unit operation	5	3	3	45	Periodical Regular Check needed	
	Motorized Delivery Valve	15	*Sewage Stoppage	*Blockage of Discharge Pipeline	*Site Inspection *Flowrate monitoring	*Flooding *Pollution	*Opertors to deal	3	3	3	27	Periodical Regular Check needed	
	STANDBY GENERATORS	15	*Mechanical failure	*Engine Breakdown *Fuel Pump Breakdown *No Fuel	*Periodical regular check *Alarm	*Power Failure	*Serious, Down of the PS when happening during blackout	3	10	3	**90**	Periodical Regular Check needed	

Table 11.4.3 FMEA for Kila kila Sewage Treatment Plant

Facility	Main Equipment/Function	Life of The Equipment	Failure Mode	Cause	Detective Measure	Type of Abnormal Events	Effects to System	Evaluation of Abnormal Events				Recommendation	Action
								Frequency (Score)	Degree (Score)	Probability of Detection (Score)	Total Score for Prioritization		
INLET CHAMBER	Slide Gate	15	*Sewage Stoppage	*Blockage of Discharge pipeline *Closed Gate	*Site Inspection *Flowrate Monitoring	*Flooding *Pollution	*Not serious to System	1	5	5	25		
FINE SCREEN	Medium Screen	15	*Mechanical failure *No operation	*Overloading by Clogging of Screens *Equipment Failure *Power Failure	*Monitoring of operation *Alarm	*WL rise in the channel *Flooding & Pollution	*Effect to Pump operation *Use of Stand-by unit	3	5	3	45	Check of stand-by unit needed	
GRIT CHAMBER	Voltex Type Grit Chamber	15	*Mechanical failure *No operation	*Equipment Failure *Overheat of motor *Overloading *Power Failure	*Monitoring of operation *Alarm	*Grit sedimentation	*Stand-by unit operation	3	3	3	27		
OXIDATION DITCH	Diffuser, Mixer, Outlet Gate	15	*Mechanical failure *No operation	*Breakdown of mixer *Breakdown of diffuser *Power Failure	*Monitoring of operation *Alarm	*Treatment stop for the unit	*Stop of the unit *Other units to treat by larger loading	3	5	3	45		
CLARIFIER	Sludge Scraper, Return Sludge Pump	15	*Mechanical failure *No operation	*Abrasion of Support *Overheat of motor *Overloading *Power Failure	*Monitoring of operation *Alarm	*Treatment stop for the unit	*Stop of the unit *Other units to treat by larger loading	3	8	3	72		
PROCESS AIR BLOWERS	Air Blowers, Control Valve	15	*Mechanical failure *No operation	*Equipment Failure *Overheat *Overloading *Power Failure	*Monitoring of operation *Alarm	*Treatment stop for the unit	*Use of stand-by unit	3	8	3	72	Check of stand-by unit needed	
WAS PUMPS	WAS Pumps	15	*Mechanical failure *No operation	*Equipment Failure *Abrasion *Overheat *Power Failure	*Monitoring of operation *Alarm	*Treatment stop for the unit	*Use of stand-by unit	3	5	3	45	Check of stand-by unit needed	
SLUDGE DEWATERING MACHINE	Sludge Feeding Pump, Dewatering Machine	15	*Mechanical failure *No operation	*Equipment Failure *Overheat *Overloading *Power Failure	*Monitoring of operation *Alarm	*Dewatering stop	*Use of stand-by unit	3	8	3	72	Check of stand-by unit needed	
POLYMER FEEDER	Polymer Feeder, Feeder Pump, Polymer Dissolving Tank	15	*Mechanical failure *No operation	*Abrasion of feeder *Overheat *Level Control *Power Failure	*Monitoring of operation *Alarm	*Dewatering stop for the unit	*Use of stand-by unit	3	8	3	72	Check of stand-by unit needed	
SLUDGE CAKE HOPPER	Sludge Cake Hopper, Conveyor	15	*Mechanical failure *No operation	*Overheat *Overloading *Power Failure	*Monitoring of operation *Alarm	*Temporary operation stop for the unit	*Temporary stop of sludge feeding	3	3	3	27		
PLANT DRAIN PUMPS	Submersible Pumps	15	*Mechanical failure *No operation	*Clogging by foreign body *Overloading *Power Failure	*Monitoring of operation *Alarm	*Flooding *Pollution	*Stand-by unit operation	5	3	3	45	Check of stand-by unit needed	
UV DISINFECTION	UV Device, UV Lump	15	*Electrical failure *No operation	*Life of UV Lamps *Overheat *Overloading *Power Failure	*Monitoring of operation *Alarm	*Treatment stop	*Use of stand-by chlorination unit	3	5	3	45	Check of stand-by chlorination unit needed	
STANDBY GENERATORS	Diesel Generator	15	*Mechanical failure *No operation	*Engine Breakdown *Fuel Pump Breakdown *No Fuel	*Periodical regular check *Alarm	*Power Failure	*Serious, Down of the STP in case of happening during blackout	3	10	3	**90**	Periodical Regular Check needed	
STAND-BY CHLORINATION FACILITIES	Chemical Container, Utility Water Supply Unit & Injection Pump	15	*Mechanical failure *No operation	*Equipment Breakdown *Storage of Hypochlorite *Power Failure	*Periodical regular check *Alarm	*Treatment stop	*Serious, No disinfection in case of happening during UV system down	3	3	3	27	Periodical Regular Check needed	
BIOLOGICAL ODOUR CONTROL	Biological Control Unit, Fan	15	*Mechanical failure *No operation	*Equipment Failure *Water unit Failure *Power Failure	*Monitoring of operation *Alarm	*Temporary operation stop for the unit	*Temporary stop of odor control	3	3	3	**27**		

(3) Outline of the Reliability Study

1) Expected failures of the equipment/facilities are considered to be covered by measures provided in the DD.

2) The stand-by generator unit needs careful monitoring and maintenance to avoid risks during power failure from the grid.

11.5 CONCLUSION AND RECOMMENDATIONS

11.5.1 Conclusion

Risks during the construction and operation phases were assessed and issues were identified. Detailed Designs were conducted to minimize the risks during operation. . Appropriate mitigation measures were proposed.

No big issues were found for the pumping stations in the sewer network, since stand-by units are planned, risks in the operation sequence is to be determined by missed step, and SCADA will monitor the operation. Surging of the pump is solved by a fly-wheel, as required. Soundness of the back-up generator will be very important for risk reduction from the standpoint of avoiding wastewater discharge at the emergency situation. Required action to remove the hazards will be monitoring of the status/alarm of the pumping stations, field inspection as required and periodical inspection of the emergency generator unit. The actions required will be the same with other pumping stations as well.

No big issues were found for the STP, since a stand-by unit for each process is planned, any risk sequence is planned for by missed step, and SCADA will monitor the operation. Soundness of the back-up generator will be very important for risk reduction.

Even at the event of breakdown of the back-up generator during the power failure of power grid, overflow from the tanks or containers to the outside will not occur since wastewater flow from one facility to the other is planned by gravity. If there is trouble in the treatment phase , effluent will be discharged outside of the reef at least after chlorination for disinfection. Expected failures of the equipment/facilities are considered to be covered by counter-measures provided in the DD.

11.5.2 Recommendation

Although various risks were minimized at the DD stage, careful operation and maintenance is essential to POMSSUP. The stand-by generator unit needs careful monitoring and maintenance to avoid risks during power failure from the grid in particular. Positive operation of the engine, sufficient fuel volume in the reserve tank must be checked and recorded carefully to avoid serious problems during power failure since there are frequent black-outs in Port Moresby.

CHAPTER 12 CONCLUSION AND RECCOMENDATION

12.1 Conclusion

12.1.1 Scope of the Project

Based on the survey work and study on the Basic Design, the scope of the project was discussed with TAC members for almost 4 months after the 2nd TAC meeting which was held on 9th June until 30th September 2011. The scope of the project was changed. These changes are summarized as follows:

1) Material for the pipe line

Material for the most part of the pipeline was changed to HDPE in consideration of its durability and cost which is becoming reduced recently.

2) Discarding Inverted Siphon

The proposed inverted siphon was discarded and changed to a normal sewage pumping up method by TAC members. Kaugere pumping station was re-designed for the change. Since the motor output of the pumps was increased significantly, construction costs and O&M costs also increased.

3) Disinfection

The proposed disinfection by Sodium Hypochlorite was abandoned and changed to UV disinfection by TAC members because of Trihalomethane generation in the sea, although there was no usage of sea water for drinking purposes. Because of this change, construction costs and O&M costs increased.

4) Sludge Treatment Process

The proposed Sludge Drying method was rejected by TAC members to decrease the frequency of sludge transportation by tankers. To tackle this issue, direct excess sludge dewatering was proposed without a sludge thickening process and sludge drying beds. Construction costs were thus kept at almost the same level as in the original plan.

5) Solar Power Generation

Solar power generation was initially proposed as a means of reducing green house gas emissions in the basic design, however it was omitted since the system could not lead to recovery of the capital investment in 15 years.

6) Minor Corrections

Minor corrections were made for pipeline length after examinations through the D/D work.

The total scope of the D/D in the engineering portion is shown in **Table 12.1.1**.

Table 12.1.1 Scope of the D/D

Items	Original Scope	Revised Scope
Sewerage Treatment Plant (Kila Kila)	13,800m^3/day 3 units of Oxidation Ditch Process with the ultimate capacity of 18,400m^3/day (4 units)	Ditto
Disinfection	Sodium Hypochlorite	UV, + Sodium Hypochlorite for backup
Sludge Treatment	Gravity Thickening	Direct sludge dewatering without sludge thickening
Sludge Drying Bed (Morata)	15 beds (15 beds of overall 20 beds, 14m×35m of 1bed) (Notes)	Cancelled
Access road	1.73km	1.50km
Outfall to the sea	GRP 1.64km	HDPE 1.6km
Sewer		
Trunk sewer	17.2km (from Kanudi to Kila Kila)	17.6km (from Kanudi to Kila Kila)
Branch sewer	17.7km (Kanudi, Idubada, Elavala, Hanuabada, Konedobu, Port Moresby CBD, Paga Hill, Koki, Badili, Kila police and Kila Kila district)	17.4km (Kanudi, Idubada, Elavala, Hanuabada, Konedobu, Port Moresby CBD, Paga Hill, Koki, Badili, Kila police and Kila Kila district)
Inverted Siphon	Employed	Discarded
Pipe Material	DCIP, RC pipe	HDPE, uPVC
Pumping Station		
Construction/8	Kanudi:1, Idubada:1, Elavala:1, Hanuabada:1, 1,Gabutu:1,Kila Police:1, Konebada:1, Kila Kila Horsecamp:1	Ditto
Replacement/9	Konedobu :1,Yacht Club:1, Stanly Esplanade:1,Paga Point:1, Davara: 1, Lawes Rd Ela:1, Koki: 1, Badili :1,Kaugere:1	Ditto
Pilot Project	1 Ls Implementation of sewerage service to the houses built on the stilts on the sea	1 Ls Implementation of sewerage service and water supply to the houses built on the stilts on the sea Design-Built was adopted for the component for easy adjustment to frequent reconstruction of jetties and water-houses.
Social Development (HIV/AIDS)	1 Ls Education and knowledge enhancement activities for the contractors and residents around the project site	Cholera prevention program was added to the original program.
Training Program	✓ Preparation of Prequalification and Tender Documents ✓ Training Program for O&M of STP and sewer network. ✓ Training Program for sewerage asset management system ✓ Training Program for water quality analysis	Ditto

Source: JICA StudyTeam

All the pumping station will be equipped with emergency generators in case of sudden blackouts.

The STP facilities are fully equipped with instrumentation devices with SCADA system via GPRS for operation and maintenance. A SCADA room will be installed in the administration building for control and operation. 17 pumping stations will also be connected to the control room via the SCADA system for operation and maintenance.

12.1.2 Ocean Outfall Design

A seabed topo-survey was conducted for a distance of 890m along the proposed alignment. According to the survey work of the ocean outfall alignment, 240 boulder corals were found along the 30m wide corridor. The undulation of the corridor and general distribution of the corals were clarified. An ocean outfall was designed buried under the ocean bed to protect it from the current in the shallow area within the reef. Obstacles such as embankments for pipeline fill on the seabed will intercept the current resulting to a big change to the ecosystem in the reef.

Since detailed ocean bed/coral survey is needed before a geo-survey in order to avoid accidents to coral life by drilling or trial pits, Design-Built was adapted for the Ocean outfall. The contractor shall be required to conduct detailed ocean bed surveys, geo-surveys and detailed design work for approval by the Engineer and Port Office in Port Moresby.

12.1.3 Operation Indicators and Effect Indicators

The population covered by the sewerage project will be 48,600 and the extent of the coverage will be 71.2% in 2018. As of November 2011, about 54% of the households were connected to the existing sewer network through which sewage has been discharged to the sea.

As connection change works on the outfalls and house connections progresses, this coupled, with the proper management of both septic tank users and settlement residents by EDA RANU, water quality in the bay will begin to improve shortly after the completion of the project.

Table 12.1.2 Operation Indicators and Effect Indicators

Indicators	Present (Yr2011)	Target (Yr2018)	Remarks
Population Treated (persons)	0	48,600	Total 68,200
Treated Sewage Volume (m^3/d)	0	13,100	
Sewage Facilities Usage Rate (%)	(Currently, 54% direct discharge to the sea)	71.2	48,600/68,200
Effluent BOD Level (mg/L)	190	20	

Source: JICA StudyTeam

12.1.4 Project Cost

Project cost were studied through unit cost research methodology. After the base year was reset to 2011, and fundamentals for the projection of project costs were set as indicated below, two examples of project cost were calculated.

Base Year :	October 2011
Exchange Rate :	Kina 1 = 34.3 Japanese Yen
Price Escalation Rate per annum :	
	Foreign Currency = 1.4%
	Local Currency = 3.1%
Physical Contingency:	5% (Construction, Procurement)
	5% (Consulting Service)
Administration costs:	3% of the eligible portion

Amount of loan agreement of JICA Portion made in 2009 Jan was 8,261 Mil JPY as shown below. Project cost was about 5 Mil JPY below the L/A amount

Project Cost (JICA Portion)

Engineer's Estimates:	8,256 Million JPY
Loan Agreement (Jan,2009) :	8,261 Million JPY

12.2 Recommendation

12.2.1 Utilization of SAPMAN

JICA is expecting to dispatch SAPMAN (Special Assistance of Procurement and Management) to PNG according to the request from PNG government to expedite the tendering procedure.

After the D/D, the PNG side has to be prepared for the selection of a Construction Supervision Consultant (C/S Consultant) as well as a Contractor for the construction work. After the selection of the consultant, pre-qualification and tendering will be planned for the project contractor and this will take about 15 months after the completion of tender document preparations. It is recommended that timely correspondence with JICA be instituted as needed regarding the SAPMAN dispatch.

Appendices

Appendix-1: Detailed Information of O&M Training

Appendix-2: Updated Environmental Management Plan

Appendix 1 Detailed Information of O&M Training

Appendix 1.1 Cost for 2 months' Commissioning Period (JPY)

1.	Peripheral equipment (Software for Asset Management) :	2,000,000
2.	Electricity cost	
(1)	STP Wastewater Treatment	
	1) Unit electricity consumption:	0.3 kWH/m^3
	2) Wastewater to be treated:	13,800 m^3/day
	3) Electricity consumption for 2 months (60 days): 1) x 2) x 60	248,400 kWH
	4) Unit electricity cost:	17 JPY/kWH
	5) Electricity cost of STP for 2 months: 3) x 4)	4,197,960 JPY
(2)	STP Sludge Treatment	
	1) Unit electricity consumption:	0.02 kWH/m^3
	2) Wastewater to be treated:	13,800 m^3/day
	3) Electricity consumption for 2 months (60 days): 1) x 2) x 60	16,560 kWH
	4) Unit electricity cost:	17 JPY/kWH
	5) Electricity cost of STP for 2 months: 3) x 4)	279,864 JPY
(3)	Pumping Stations	
	1) Unit electricity consumption:	0.2 kWH/m^3
	2) Wastewater to be treated:	13,800 m^3/day
	3) Electricity consumption for 2 months (60 days): 1) x 2) x 60	165,600 kWH
	4) Unit electricity cost :	17 JPY/kWH
	5) Electricity cost of STP for 2 months: 3) x 4)	2,798,640 JPY
3.	Chemical cost (STP)	
	1) Chlorine injection ratio:	0.03 kg/m^3
	2) Wastewater to be treated:	13,800 m^3/day
	3) Chlorine consumption for 2 months (60 days): 1) x 2) x 3)	25 ton
	4) Unit cost:	11,000 JPY/ton
	5) Chemical cost for 2 months : 3) x 4)	273,240 JPY
4.	Repair (include 2year Spare parts):	5,000,000 JPY
5.	TOTAL:	14,549,704 JPY
	Total (x 1,000 JPY)	**14,550** JPY

Appendix 1.2-1 Analysis/Measurement Equipment, Glass Wares and Chemicals (JPY)

No.	Name	Parameters/Purpose	E & Q Laboratory[1)]	Kila Kila STP
1	pH/ORP meter	pH and ORP	300,000	-
2	Potable pH/ORP meter	pH and ORP		110,000
3	EC meter	Electric conductivity	95,000	-
4	Potable EC meter	EC		30,000
-	Temperature meter	Water temperature[2)]	-	-
5	Transparency meter	Transparency	-	13,000
6	MLSS meter	MLSS	-	310,000
7	Auto burette	M-alkalinity	-	30,000
8	Simple COD analysis set	CODMn	-	400,000
9	BOD analysis set	BOD, respiration velocity	1,360,000	-
10	DO meter	DO	-	257,000
11	Soxlet extraction unit for 3 samples	Oil and grease	230,000	-
12	Nitrogen and phosphorus analysis set	NH_4-N, NO_2-N, NO_3-N, TN, T-P	800,000	-
13	Simple nitrogen analysis kit	NH_4-N, NO_2-N, NO_3-N	-	45,000
14	Coliform analysis set	Coliforms	660,000	-
15	Potable Residual chlorine meter	Residual chlorine	-	12,500
16	Pure water production equipment	Pure water (Fundamental of water quality analysis)	500,000	-
17	Distilled water production equipment	Pure water (Fundamental of water quality analysis)	-	370,000
18	Auto precise balancer	Weighing	200,000	200,000
19	Storage shelf	Store chemicals, glass wares	150,000	70,0000
20	Centrifugal	MLSS, return sludge SS and thickened SS	220,000	-
21	Shaker	Solvent extraction	210,000	-
22	SS analysis set	SS	-	500,000
23	Stirrer	Preparation of regents, standard solutions	42,000 (@21,000 x 2)	21,000
24	Dryer	SS, preparation of standard solutions	180,000	180,000
25	Digital microscope	Observation of biota	-	180,000
26	Electro balancer	Preparation of reagents	67,000	67,000
27	Dryer shelf	Drying glass wares	140,000 (@70,000 x 2)	70,000
28	Ultrasonic cleaning machine	Cleaning polluted glass wares	110,000	-
29	Desicator	SS, preparation of standard solutions	23,000	23,000
30	Distillation equipment	NH_4-N	300,000	-
31	Air pump	Verification of DO meter	-	3,000
32	Water bath	COD_{Mn}, MLSS	360,000	-
33	Muffle furnace	VSS	400.000	-
34	Hot plate	Preparation of regents	31,500	31,500
35	Gas detector[2)]	H_2S, CO, O_2, CH_4 gas for sewer, manhole inspection	400,000 (@20,000 x 2)	200,000
36	Glass ware	(Fundamental in analysis)	484,306	182,467
37	Chemicals	(Fundamental in analysis)	285,130	9,600
Total of 1 - 37			**7,667,936**	**3,315,067**
Transportation and spare parts, consumables (12 % of total of 1-37)			920,152	397,808
Grand total of analysis equipment, glassware and chemicals, consumables			8,588,088	3,712,875
Project cost of analysis equipment, glass wares, chemicals and consumables (x 1,000 JPY)			**12,301**	

1) Environment & Quality Control Section Laboratory
2) 2 detectors for sewer section, I for Kila Kila STP

Appendix 1.2-2 Glass Wares, etc. (JPY)

No.	Name	Specification	Unit cost	No. of Glass wares		Price	
				E & Q Laboratory[1]	Kila Kila STP	E & Q Laboratory[1]	Kila Kila STP
1	Conical flask	300 mL	770	10	4	7,700	3,080
2	Beaker	50 mL	399	4	2	1,596	798
		100 mL	430	4	2	1,720	860
		300 mL	556	4	2	2,224	1,112
		500 mL	840	2	2	1,680	1,680
		1,000 mL	1,617	2	1	3,234	1,617
		10 L, PE	2,468	-	1	-	2,468
3	Pipette	Mess 1mL	379	4	2	1,516	758
		Mess 2mL	388	4	2	1,552	776
		Mess 5mL	488	4	2	1,952	976
		Mess 10mL	598	4	2	2,392	1,196
		Mess 25mL	1,795	4	2	7,180	3,590
		Hole 50 mL	1,705	4	2	7,180	3,590
		Hole 100 mL	2,234	2	-	4,468	-
4	Messzylinder	20 mL with stopper	2,882	2	2	5,764	5,764
		50 mL with stopper	2,200	5	2	11,000	4.400
		100 mL with stopper	2,600	2	2	5,200	5,200
		250 mL with stopper	3,491	2	2	6,982	6,982
		500 mL with stopper	6,683	2	2	13,366	13,366
		1,000 mL	8,478	2	5	16,956	42,390
5	Messflask	20 mL	1,700	2	-	3,400	-
		50 mL	1,900	4	-	7,600	-
		100 mL	2,000	4	2	8,000	4,000
		250 mL	2,600	2	-	5,200	-
		500 mL	3,100	2	2	6,200	6,200
		1,000 mL	3,800	2	-	7,600	-
6	Plastic bottle (wide mouth)	100 mL	70	10	10	700	700
		250 mL	90	10	4	900	360
		500 mL	150	6	2	900	300
		1,000 mL	190	2	1	380	190
7	Wash bottle	250 mL	130	2	2	260	260
		500 mL	160	2	2	320	320
8	Others						
	Measuring/transfer pipette	25 mL	6,400	4	2	25,600	12,800
	Syringe	PE, 5 mL	400	2	2	800	800
	Pipette stand		2,800	2	1	5,600	2,800
	crucible 、melting pot	15 mL, high purified alumina for VSS	3,000	4	-	12,000	-
	Watch glass	Φ 9 cm	120	10	10	1,200	1,200
9	Evaporating dish	100 mL	780	10	10	7,800	7,800

No.	Name	Specification	Unit cost	No. of Glass wares		Price	
				E & Q Laboratory[1]	Kila Kila STP	E & Q Laboratory[1]	Kila Kila STP
	Tongs	21 cm	2,000				
	Spatula		80	2	2	160	160
	Nitrate reduction column	Cupper-Cadmium	12,100	4	-	48,400	-
	Auto burette	White 25 mL, 2,000 mL container	38,000	3	1	114,000	38,000-
	Auto burette	Brown 25 mL, 2,000 mL container	48,000	1	-	48,000	-
	No.5 A filter	Dia.110 mm	1,000	2	4	2,000	4,000
	Funnel	Dia.60 mm	500	2	4	1,000	2,000
	Pincet	Length 125 mm	77	2	2	154	77
	Mortar	Dia.60 mm with pestle	440	2	-	880	-
	Agate Mortar)	50 mm with pestle	7,350	1	-	7,350	-
	Separation funnel	500 mL, Pear shaped type 、 with PTFE cock	17,400	3	-	52,200	-
	Separation funnel stand		2,800	3	-	8,400	-
Total						**484,306**	**182,467**
Project cost of Glass ware, etc.						**666,773**	

1) Environment & Quality Control Section Laboratory

Appendix 1.3 Specifications of Analysis/measurement Equipment

No.	Name	Specifications			E & Q Laboratory	Kila Kila STP
		Power source	Dimensions	Other requirements		
1	pH/ORP meter	4VA	152(W) x 98(H) x 230(D), 0.8 kg	Digital indication, Glass electrode method, pH range: 0.00 - 14.00 ORP range: 0 - ±2,000 mV, Data memory: 300, water temperature indication, pH standard solutions (7 and 4), ORP standard solution, internal liquid	◎	-
2	Potable pH/ORP meter	Dry battery AA	-	Digital indication, Glass electrode method, pH range: 0 - 14 ORP range: 0 - ±2,000 mV, Data memory: 300, water temperature indication, cable 10 m with pH standard solutions (7 and 4), ORP standard solution,		◎
3	Potable EC meter	Dry battery AA	-	Range: 0- 2 S/cm、Data memory: 300, Water temperature indication, and standard solution	◎	-
4	Potable EC meter	Dry battery AA		Sato Shouji CD-4302 or equivalent	-	◎
5	Temperature meter	-	-	(Indicated in pH and EC meter)	-	-
6	Transparency meter	-	-	Glass made, 1,000 mm, with wooden support	-	◎
7	MLSS meter	Dry cell		Satou Shoji SS/interface meter MLSS-5Z or equivalent, Cable length: 11m, MLSS measurement: Near-infrared pulse method、Water depth： Semiconductor pressure censer. MLSS range: 0-20,000 mg/L, Water depth range: 0-5.00 m, Resolution ability：10 mg/L (0-10,000 mg/L) , 100 mg/L (10,000 -20,000 mg/L)、Water depth：0.01 m	-	◎
8	Simple COD analysis set	100 W	310(W) x 270 (D) x 300 (H), 5 kg	Central Kagaku C-607 or equivalent、Measurement principal： Coulometry、conical beaker x total 6	-	◎
9	BOD analysis set	115 VAC or 230VAC, 0.2 kW	Body: 350 (W) x266 (D) x 670 (H), 30 kg Incubator: 425 (W) x 600 (D) x 375 (H)	Central Kagaku OxiTop Control 12 or equivalent, Pressure censer method、with controller, Incubator 20±0.5℃、	◎	-
10	DO meter	Alkali C-cells		Dynamic luminescence quenching lifetime detection, DO range: 0 - 50 mg/L, Accuracy 0 to 20 mg/L, 0.1±0.1 mg/L, Data memory: 2,000, cable 15 m, weight for sinking	-	◎
11	Soxlet extraction unit for 3 samples	0.3 kW	520 x 260D x 75 H	3 sets of heating mantle, 3 sets of soxlet extraction unit, hexane (regent grade) x10、Methylorange solu. 100 mL x 1、Grade hydrochloric acid 500 mLx1	◎	-
12	Nitrogen and phosphorus analysis set	0.6 kW	Photo meter: 404W x 314D x 197 H	Central Kagaku TNP-6100 or equivalent, Photometric spectrometer 、Reactor 、Regents and	◎	-

No.	Name	Specifications			E & Q Laboratory	Kila Kila STP
		Power source	Dimensions	Other requirements		
			Reactor: 245W x 292 D x 180 H, 7.5 kg	equipment for T-N, T-P and Regents for NH_4-N 250 samples、regents for NO_3-N 250 samples, Reactor:		
13	Simple nitrogen analysis kit	-	-	Sato Shouji NH4/NOX-3Z Colorimetric tube square: plus 4 (total 6) and each regent: plus 150 samples (Total 200 samples each)	-	◎
14	Coliform analysis set	0.6 kW	370 (W) x 450 (D) x 515 (H), 28 kg	Incubator：SIC-20 or equivalent、Temperature control by PID 、 7-60 ℃ 、 Natural convection 、 Temperature accuracy：±0.5℃ at 37℃, Temperature distribution ±1.5℃, Stainless	◎	-
		1.4 kW	370 (W) x 300 (D) x 730 (H), 24kg	Auto crave: KTS-2346A or equivalent. Can body: Φ230 x 460、Effective capacity: 20 L、Temperature range to be used：110-127℃、Maximum pressure to be used: 0.18 MPa、 Stainless wire basket, receiver tank from exhaust gas drain cock	◎	-
		1.2 kW	590 (W) x 635 (D) x 810 (H) 50 kg	Dry heat sterilizer：STA420DA or equivalent, Inner capacity：approximately 95L、Natural convection, 40-270℃、PID control、Accuracy ±1℃, Stainless、with safety equipment、	◎	-
		-	-	Handy typed colony counter x1, Measuring flask 1L x 1, Petri dish: Glass made ф90 x20 x 20 units, Bunsen burner (for LPG、with cock Hose 1m、Test tube 15 x 150, 20 mL x 50 units、Measuring pipette 1mL scale at the edge x 5, 10 mL scale at the edge x 5、Pipette sterilization 65 x 80 x 400 x1, Test tube stand: SUS 5x10x1, Platinum loop：SUS loop 280mm; Deoxycholate agar culture medium 400 mL x 40, Potassium dihydrogen phosphate：Grade 500g、Grade sodium hydroxide：500g x1	◎	-
15	Potable Residual chlorine meter	-	-	Sato Shoji,DPD -7Z or equivalent, Color comparison method、Range: 0.05-2.0 mg/L, Measuring cell: Total 4 with caps), Carrying case、regent: Total for 200 samples	-	◎
16	Pure water production equipment	1.5 kW	600 (D) x 660 (W) x 780 (H), 55 kg	Ion-exchange+ distillation + filtration, 1.8 L/h, Product storage tank 30 L,	◎	-
17	Distilled water production equipment	2.6 kW	600 (D) x 270 (W) x 520 (H), 26 kg	3.5 L/h, Crystal heater, Fired anti-air	-	◎
18	Auto precise balancer	0.01 kW	217 (D) x 442 (W) x316 (H), 8 kg	Analytical electronic balance: HR202i or equivalent, Maximum weight: 220 g, Minimum indication：0.1 mg、plate size：ф90mm、Reproducibility: 0.1mg,	◎	◎

No.	Name	Specifications			E & Q Laboratory	Kila Kila STP
		Power source	Dimensions	Other requirements		
19	Storage shelf	-	1,760 (D) x 400 (W) x 880 (H), 51 kg	Yamato MC-125 G or equivalent, , Stainless	◎◎	◎
20	Centrifugal	0.5 kW	364 (W) x 384 (D) x 320 (H), 19 kg	Small tabletop centrifuge: H-19FM or equivalent, Maximum revolution speed: 4,000 rpm, Maximum centrifugal force: 2,600 G, Microcomputer control, Revolution speed: digital indication, with swing rotor, metal basket、centrifuge tubes with scale 50 mL x 4	◎	-
21	Shaker	2.2 kW	425 (W) x 460 (D)x 425 (H), 40 kg	Yamato SA300 equivalent or equivalent. Horizontal/vertical direction, Maximum number of frame: 1,000 mL, Separation funnel holder x 3, Shaking speed: 20-300rpm、Timer setting, Setting velocity: dial changing,	◎	-
22	SS analysis set	0.1 kW		Tabletop SS measuring unit: SS-1300 or equivalent. 47 mm, stainless filter holder, membrane: 0.45 μm x 200, vacuum bottle, vacuumed/pressurized pump, pressure resistance rubber hose, filter inset、	-	◎
23	Stirrer	0.2 kW	84 (W) x150 (D) x 60 (H) 1.1 kg	Mini stirrer MR standard or equivalent. 100-1,500 rpm, Mixing: 50 -1,000 mL with magnetic rotors: 10 mm x 3, magnetic rotors: 10 mm x 3 for 1 set	◎◎	◎
24	Dryer	1.5 kW	560 x 601 x 820, 48 kg	YAMATO dryerDS400 or equivalent. 40-260 ℃, Temperature distribution accuracy: ±10 ℃ (at 260 ℃), Maximum temperature reaching time; approximately 75 minutes, PID control by microcomputer, Capacity: 100 L	◎	◎
25	Digital microscope	DC12V, 1.5A	-	Biological Microscopes: AR-300BOO or equivalent. More than 3 million pixel USB camera (C mount CMOS), 600 times magnification, more than 2 inch LTPS LCD Display, SD card, USB cable, TV out cable, etc., with 20 slide glass and cover glass	-	◎
26	Electro balancer	Dry cell	200 (W)×270 (D) ×72 (H)	Electronic balance TE412-L or equivalent. Maximum: 410 g, Minimum.10 mg,	◎	◎
27	Dryer shelf	-	820 (W) x 540 (D) x 900 (H),	YAMATO Dry cart NDC-80M or equivalent. Assembly and mesh shelf., top plate：SUS 304m, mesh shelf：Chrome Plating wire、Mesh：100 x 50 mm x 1、150 x 100 mm x2	◎◎	◎
28	Ultrasonic cleaning machine	0.16 kW	381 (D) x 230 (W) x 240 (H)	Tabletop ultrasonic cleaner: US-104 or equivalent. Capacity: 5.8 L, Tank: SUS304, Body: Aluminum acryl coating and ABS, Frequency number: 38 kHz, Self-originating system	◎	-
29	Desicator	-	-	Plate diameter: 18 cm, total diameter: 27 cm, Height 21.5	◎	◎

No.	Name	Specifications			E & Q Laboratory	Kila Kila STP
		Power source	Dimensions	Other requirements		
				cm, with silica gel		
30	Distillation equipment	1.2 kW	670 (D) x 350 (W) x 1020 (H)	For distillation of NH_4-N, 3 set, , total 1.2kW	◎	-
31	Air pump	0.04 kW	-	5 L/min	-	◎
32	Water bath	2 kW	575 (w) x 320 (D) x 320 (H), 4 kg	COD water bath MWE-8 or equivalent. Stainless made, for 8 unit, Temperature control by Robert Shaw, Fired anti-air	◎	-
33	Muffle furnace	1.4 kW	340 (W) x 380 (D) x 490 (H), 20.5 kg	Range:100 -1,150 ℃, Setting temperature 0.5 ℃, Reaching time approximately 60 minutes to 1,150 ℃, 120 x 90 x 220 mm muffle inside, PID control	◎	-
34	Hot plate	0.55 kW	200 (W) x 265 (D) x 122 (H), 0.6 kg	Max 350 degree, body: aluminum (chemical finish baking), the top plate: white glass-ceramic, Heater control system: thermocouple ON / OFF control	◎	◎

Note :

① Required Power total:
Environment and Quality Control Laboratory: 15.72 kW, Kila Kila STP: 5.10 kW, with allowance Environment and Quality Control Laboratory: 22 kW, Kila Kila STP: 7.5 kW

② Both laboratories shall have 100 Voltage line. One for wiring, 230 Voltage line for BOD analysis set

③ Contractor shall consider and prepare the necessary spare parts, consumables (Regents) for 2 months' commissioning period at least.

④ Water, kitchen, electricity, gas supply facilities and tables for installation of analysis/measurement equipment during D/D stage.

⑤ Necessary room space will be approximately 50 and 30 m^2 for Environment and Quality Control Laboratory and site laboratory, respectively.

⑥ Space for Environment and Quality Control Laboratory may be reduced by using existing space.

⑦ Fans shall be installed. Three (4) (Above the place where dryer and muffle furnace, Water bath and Soxlet extraction equipment is to be located for Environment and Quality Control Laboratory, respectively) and two (2) (Above the place where dryer and simple COD_{Mn} analysis set is to be located) for site laboratory.

⑧ Tables and floor shall be finished with chemical resistance painting.

⑨ Manuals of all the analysis/measurement equipment shall be in English.

Appendix 1.4 List of Necessary Reagents, etc. during Training of Water Quality Analysis

Parameter	Regents, etc.	Consumption per one time	Unit	Total	Consumption during training	Unit	Unit price	Unit of unit cost		No. of Procurement	Cost	Breakdown		Remarks
												EDA RANU	Site	
pH	pH standard 7	50	mL	8	800	mL	2,800	500	mL	1	2,800	1,400	1,400	1 attached
	pH standard 4	50	mL	8	800	mL	2,800	500	mL	1	2,800	1,400	1,400	1 attached
SS	Glass filter for SS measurement, 47 mm	1	sheet	25	50	Sheets	2,800	100	Sheet	1	2,800	1,400	1,400	
VSS	Ammonium nitrate	Trace					1,500	500	g	1	1,500	1,500		
M-alkalinity	Grade Hydrochloric acid						1,680	500	mL	1	1,680	1,680		
	Methyl red	Trace					2,600	25	g	1	2,600	2,600		
	Bromocresol green	Trace					15,800	25	g	1	15,800	15,800		
	95 % grade ethanol						1,800	500	mL	1	1,800	1,800		
	0.1 mol/L hydrochloric acid standard	5	mL	25	250	mL	4,000	5,000	mL	1	4,000	4,000		
COD_{Cr}-Offal	Grade sulfuric acid	1.7	mL	25	42	mL	770	500	mL	1	770	770		
	Grade silver nitrate	1	g	25	25	g	28,000	500	g	3	84,000	84,000		
	Sodium oxalate(Volumetric analysis)	0.009	g	25	0.23	g	7,500	50	g	1	7,500	7,500		
	Potassium permanganate	0.012	g	25	0.30		2,800	500	g	1	2,800	2,800		
	5 mmol/L potassium permanganate standard solution	15	ml	25	375	mL	4,000	5,000	mL	1	4,000	4,000		
	0.05mol/l(N/10)-Sodium oxalate solution	10	mL	25	250	mL	12,500	20,000	mL	1	12,500	12,500		
COD_{Cr}-simple	A solution	1	mL	25	25	mL	1,200	100	mL	1	1,200		1,200	
	B solution	10	ml	25	250	mL	4,200	500	mL	1	4,200		4,200	
BOD_5	Hydrochloric acid						600	500	mL	1	600	600		
	Sodium hydroxide						800	500	g	1	800	800		
	Dipotassium hydrogenphosphate						1,600	500	g	1	1,600	1,600		
	Potassium dihydrogenphosphate						1,250	500	g	1	1,250	1,250		
	Disodium hydrogen phosphate						1,700	500	g	1	1,700	1,700		
	Ammonia chloride						1,300	500	g	1	1,300	1,300		
	Magnesium sulfate heptahydrate						900	500	g	1	900	900		
	Calcium chloride						2,000	500	g	1	2,000	2,000		
	Iron (II) chloride hexahydrate						2,300	500	g	1	2,300	2,300		
	D (+) -glucose	trace					1,500	500	g	1	1,500	1,500		
	L-glutamic acid	trace					7,900	1,000	g	1	7,900	7,900		
Hexane Extract	Grade Hydrochloric acid	trace					800	500	mL	1	800	800		
	Methyl orange	trace					2,500	25	g	1	2,500	2,500		
	Acetone	trace					670	500	mL	1	670	670		
	Sodium sulfate Anhydrous	5	g	10	50	g	950	500	g	1	950	950		
	Hexane	50	mL	10	500	mL	3,000	3000	L	1	3,000	3,000		

Appendix 1.4 List of Necessary Reagents, etc. during Training of Water Quality Analysis (Cont.)

Parameter	Regents, etc.	Consumption per one time	Unit	Total	Consumption during training	Unit	Unit price	Unit of unit cost	No. of Procurement	Cost	Breakdown		Remarks
											EDA RANU	Site	
NH_4-N (EDA)	Sulfuric acid			25			770	500 mL	1	770	770		
	Sodium hydroxide			25			800	500 g	1	800	800		
	Magnesium oxide	Trace		25			1,200	25 g	1	1,200	1,200		
	Phenol	5	g	25	125		1,350	500 g	1	1,350	1,350		
	Sodium hydrochloride (effective chlorine more than 5 %)				0		650	500 mL	1	650	630		
	Ammonium ion NH_4 1,000 standard solution	0.15	mL	1	0.15		6,100	500 mL	1	6,100	6,100		
	Reagent No.10683	1		25	25		14,400	100 sample	1	14,400	14,400		
NH_4-N (Site)	Reagent set	1		28	25		5,000	100 sample		-	-		
NO_3-N (EDA)	4-aminobenzenesulfonamide	0.05	g	25	1.25		8,900	100 g	1	8,900	8,900		
	N-1-naphthylene-diammonium dichloride	0.005	g	25	0.125		19,700	25 g	1	19,700	19,700		
	Nitrate ion standard solution 1000	0.2	mL	25	5		5,200	1 ampoule	1	5,200	5,200		
NO_3-N (EDA)	Ammonium chloride			25	0		1,300	500 g	1	1,300	1,300		
	Aqueous ammonia			25	0		620	500 mL	1	620	620		
	Nitrate ion standard solution 1000			25	0		750	500 mL	1	750	750		
	Disodium hydrogen ethylene-diamine tetra acetate dihydrate	3	g	25	25		8,500	500 g	1	8,500	8,500		
	Copper (Ⅱ) sulfate pentahydrate	0.5	g	25	12.5		900	25 g	1	900	900		
	Nitric acid			25	0		2,470	500 g	1	2,470	2,470		
	Copper-cadmium packing	200	mL	3	600		5,000	4 L	1	5,000	5,000		
	Glass wool			3	0		1,200	kg	1	1,200	1,200		
NO_3-N (EDA)	Reagent No. 09713	1		25	25		17,100	100 sample	0	-			Attached
NO_3-N (site)	Reagent set	1		28	25		5,000	100 sample	0	-		-	Attached
T-N (EDA)	Reagent No. 14763	1		5	5.00		20,800	25 sample	0	-	-		Attached
T-P (EDA)	Reagent No. 14543	1		5	5.00		12,500	25 sample	0	-	-		Attached
Coliforms	Desoxycholate agar culture medium	50	g	8	400		21,500	500 g	1	21,500	21,500		
	BGLB culture medium				0		6,500	100 g	1	6,500	6,500		
	Durham fermentation tube				0		550		10	5,500	5,500		φ18 x 230
	Durham fermentation tube cap				0		110		10	1,100	1,100		φ21.5 x40
	Total									**294,730**	**285,130**	**9,600**	

Note :

1 EDA RANU laboratory only can measure SS. Reagents, analysis/measurement equipment, glass wares, etc. to measure other parameters are of shortage or out of order/date. From this point, analysis/measurement equipment, reagents glass wares, etc. are considered.

2 Reagents, glass wares and necessary equipment are referred to JIS K 0102-1998 (English version).

3 Quality of reagents should be more than grade ones.

Appendix 1.5 List of Necessary Reagents, etc. during two months' Commissioning Period

Parameter	Reagent, etc.	Consumption per one time	Unit	Target samples	Analysis frequency of samples/day	Daily consumption	Consumption during 60 days	Unit	Unit price	Unit	No. of Purchase	Cost (JPY)	Breakdown		Remarks
													EDA	Site	
pH	pH standard 7	50	mL		1	7.1	857	mL	2,800	500 mL	2	5,600	2,800	2,800	Once a week
	pH standard 4	50	mL		1	7.1	857	mL	2,800	500 mL	2	5,600	2,800	2,800	Once a week
SS	Glass filter for SS measurement, 47 mm	1	sheet	2	2	4	480	Sheets	2,000	100 Sheet	5	14,000	7,000	7,000	
VSS	Ammonium nitrate	Trace		3	0.33	Trace	Trace	g	1,500	500 g	0	-	-	-	Every 3 days, still remain
M-alkalinity	Grade Hydrochloric acid	Trace		2	2	Trace	Trace	g	1,680	500 mL	1	1,680	1,680	-	
	Methyl red	Trace		2	2	Trace	Trace	g	2,600	25 g	0	-	-	-	Still remain
	Bromocresol green	Trace		2	2	Trace	Trace	g	15,000	25 g	0	-	-	-	Still remain
	95 % grade ethanol	50	mL	2	2	Trace	Trace	mL	1,820	500 mL	0	-	-	-	Still remain
	0.1 mol/L hydrochloric acid standard	5	mL	2	2	10	1,200	mL	4,000	5,000 mL	1	4,000	-	-	
COD_{Mn} Offsal	Grade sulfuric acid	1.7	mL	2	2	6.7	800	mL	710	500 mL	1	710	-	-	
	Grade silver nitrate	1	g	2	2	4	240	g	28,000	500 g	1	28,000	28,000	-	
	Sodium oxalate(c-ohmsonic analysis)	1.000	g	2	2	0.016	2	g	3,500	50 g	0	-	-	-	Still remain
	Potassium permanganate	0.012	g	2	2	0.016	2	g	2,000	500 g	0	-	-	-	Still remain
	5 mmol/L potassium permanganate standard solution	25	mL	2	2	80	1,600	mL	4,000	5,000 mL	1	4,000	4,000	-	
	0.05mol/L(1/4) (5)-Sodium oxalate solution	10	mL	2	2	40	2,400	mL	12,500	25,000 mL	0	-	-	-	Still remain
COD_{Cr} simple	A solution	1	mL	2	2	4	240	mL	1,200	500 mL	3	3,600	-	3,600	
	B solution	10	mL	2	2	40	2,400	mL	4,700	500 mL	9	37,800	-	37,800	
BOD5	Hydrochloric acid	Trace		2	0.2	Trace	Trace	mL	800	500 mL	1	800	800	-	Every 5 days
	Sodium hydroxide	Trace		2	0.2	Trace	Trace	g	800	500 g	0	-	-	-	
	Dipotassium hydrogen phosphate	Trace		2	0.2	Trace	Trace	g	1,600	500 g	0	-	-	-	
	Potassium dihydrogenphosphate	Trace		2	0.2	Trace	Trace	g	1,275	500 g	0	-	-	-	
	Disodium hydrogen phosphate	Trace		2	0.2	Trace	Trace	g	1,750	500 g	0	-	-	-	
	Ammonium chloride	Trace		2	0.2	Trace	Trace	g	1,200	500 g	0	-	-	-	
	Magnesium sulfate heptahydrate	Trace		2	0.2	Trace	Trace	g	900	500 g	0	-	-	-	
	Calcium chloride	Trace		2	0.2	Trace	Trace	g	1,000	500 g	0	-	-	-	
	Iron (II) chloride hexahydrate	Trace		2	0.2	Trace	Trace	g	2,500	500 g	0	-	-	-	
	D (+) - glucose	trace		2	0.2	Trace	Trace	g	1,000	500 g	0	-	-	-	
	L - glutamic acid	trace		2	0.2	Trace	Trace	g	7,900	1,000 g	0	-	-	-	
Hexane Extract	Grade Hydrochloric acid	trace		2	0.2	Trace	Trace	mL	680	500 mL	1	680	680	-	Every 3 days
	Methyl orange	trace		2	0.2	Trace	Trace	g	2,500	25 g	0	-	-	-	Still remain
	Acetone	trace		2	0.2	Trace	Trace	mL	870	500 mL	0	-	-	-	Still remain
	Sodium sulfate Anhydrous	5	g	2	0.2	2	120	g	950	500 g	1	950	950	-	
	Hexane	50	mL	2	0.2	20	1,200	mL	3,000	3000 T	1	3,000	3,000	-	
NH_4-N (EDA)	Sulfuric acid	Trace		2	0.07	Trace	Trace	mL	720	500 mL	1	720	720	-	Every 2 weeks
	Sodium hydroxide	Trace		2	0.07	Trace	Trace	g	900	500 g	1	900	900	-	Every 2 weeks
	Magnesium oxide	Trace		2	0.07	Trace	Trace	g	1,200	25 g	1	1,200	1,200	-	Every 2 weeks
	Phenol	5	g	2	0.07	0.71	43	g	1,350	500 g	0	-	-	-	Every 2 weeks, still remain
	Sodium hydrochloride (effective chlorine more than 5 %)	Trace		2	0.07	Trace	Trace	mL	870	500 mL	1	870	870	-	Every 2 weeks
	Ammonium ion NH_4 1,000 standard solution	0.13	mL	3	3	2.6	16		6,100	500 mL	0	-	-	-	Every day, still remain
	Reagent No.00683	1		2	0.2	0.4	23	sample	14,400	100 samples	1	14,400	14,400	-	Every 5 days
NH_4-N (Site)	Reagent set	1		3	3	4	240	sample	1,000	100 samples	3	25,000	-	11,000	

Appendix 1.5 List of Necessary Reagents, etc. during two months' Commissioning Period (Cont.)

Parameter	Reagent, etc.	Consumption per use time	Unit	Target samples	Analysis frequency of samples/day	Daily consumption	Consumption during 60 days	Unit	Unit price	Unit		No. of Purchase	Cost (JPY)	Breakdown		Remarks
														EDA	Site	
NO_3-N (EDA)	4-aminobenzene-sulfonamide	0.05	g	2	0.2	0.02	1.2	g	8,900	100	g	0	-	-	-	Every 5 days, still remain
	N-1-naphthylene-diamonium dichloride	0.005	g	2	0.2	0.002	0.12	g	99,700	25	g	0	-	-	-	Every 5 days, still remain
	Nitrate ion standard solution 1000	0.2	ml	2	0.2	0.08	4.8	ml	5,200	1	ampoule	0	5,200	-	-	Every 5 days, concentrated, still remain
NO_3-N (EDA)	Ammonium chloride	Trace		2	0.2	Trace	Trace		1,300	500	g	1	1,300	1,300		Every 5 days
	Arginine aminate	Trace		2	0.2	Trace	Trace		820	500	ml	0	-	-	-	Every 5 days
	Nitrate ion standard solution 1000	Trace		2	0.2	Trace	Trace		750	500	ml	0	-	-	-	Every 5 days
	Disodium dihydrogen ethylene-diamine tetra acetate dihydrate	1	g	2	0.2	0.4	24	g	6,500	500	g	0	-	-	-	Every 5 days
	Copper (II) sulfate pentahydrate	0.5	g	2	0.2	0.2	12	g	900	250	g	1	900	900		Every 5 days
	Nitric acid	Trace		2	0.2	Trace	Trace		2,470	500	g	1	2,470	2,470		Every 5 days
	Copper-cadmium packing	200	ml	2	0.2	80	1,800	ml	5,000	4,000	ml	0	-	-	-	Every 5 days, still remain
	Glass wool	Trace		2	0.2	Trace	Trace					0	-	-	-	Every 5 days, still remain
NO_2-N (EDA)	Reagent No. 0P13	1		2	0.2	0.4	24	sample	17,100	100	samples	1	17,100	17,100		Every 5 days
NO_2-N (site)	Reagent set	1		3	2	4	240	sample	5,000	100	samples	3	12,000		12,000	
T-N (EDA)	Reagent No. 1470	1		2	0.14	0.28	17.14	sample	20,800	25	samples	1	20,800	20,800	-	Once a week
T-P (EDA)	Reagent No. 1453	1		2	0.14	0.28	17.14	sample	12,500	25	samples	1	12,500	12,500	-	Once a week
Coliforms	Desorcholate agar culture medium	50	g	2	0.14	14.28	857	g	21,200	500	g	-	42,000	42,000	-	Once a week
	BGLB culture medium	Trace							4,500	500	g	0	-	-	-	Once a week, still remain
	Durham fermentation tube								550			0	-	-	-	# 18 x 23
	Durham fermentation tube (sg)								119			0	-	-	-	# 21.5 x 65
	Total												261,290	167,320	84,000	

Note :

1 The cost of reagents, etc. during commissioning period shall be burdened by contractor.

2 Frequency of samples and parameters may be reduced once correlations between the results by EDA RANU and site laboratories and among the parameters through OJT training before the commissioning period are obtained.

3 During operation period after commissioning, analysis frequency and parameters may be reduced once correlations between the results by EDA RANU and site laboratories and among the parameters through OJT training before the commissioning period and analysis/measurement to be executed by EDA RANU are obtained..

Appendix 1.6 Required specifications of Asset Management Software

Asset management system is used for the followings.

(1) Use for Maintenance: Centralized management of information of facility and operation & maintenance
To centralize the information of facilities and operation & maintenance such as reconstruction/renewal/repair, trouble shootings, material management, inspection plan, etc. by leader systems.

(2) Use for fixed asset management
To manage fixed assets based on the information of the ledgers of facilities and equipment and construction. It is possible to formulate invest plan, renewal/rehabilitation plan and balance sheet by establishment of the database of construction cost of the facilities and equipment, construction year, etc. and computing depreciation of each year.

(3) Use for support of reconstruction/renewal plan
It is possible to prepare checklist of the facilities and equipment to evaluate the necessity of reconstruction/renewal and timing of implementation by using the ledger system data to reconstruction/renewal plan. In addition, it is also possible to formulate reconstruction/renewal plan of short term (5 years) with consideration of construction level.

To meet the uses above mentioned, the asset management software shall have the following functions;

1) As an asset ledge including sewer and STP by using GIS system
2) As an ledger system of sewerage system
   - ✓ Basic functions sewerage facility ledger system
   - ✓ Management function of reconstruction/renewal history
   - ✓ Management function of trouble information/data
   - ✓ Asset management system
   - ✓ Inspection plan support system
   - ✓ Management function of documentation/drawings
3) As an asset management system
   - ✓ Centralized information/data management of construction and asset
   - ✓ Calculation of depreciation and property
   - ✓ Asset management in accordance with accounting system of each enterprise
4) As reconstruction/renewal plan supporting system
   - ✓ Output of evaluation/check results
   - ✓ Calculation of lifecycle cost
   - ✓ Judgment of necessity of reconstruction/renewal and execution timing
   - ✓ Short term (5 years) reconstruction/renewal plan with construction level

APPENDIX 2 UPDATED ENVIRONMENTAL MANAGEMENT PLAN

2.1 Introduction

Updated Environmental Management Plan (EMP) has been prepared for the Port Moresby Sewerage System Upgrading Project (POMSSUP) to fulfil environmental assessment requirements of the Government of Papua New Guinea (GoPNG) and the Japan International Corporation Agency (JICA). The POMSSUP is being undertaken by contractors under Overseas Development Assistance (ODA) arrangement with project execution by the Independent Public Business Corporation (IPBC) and EDA RANU[1] as the implementation agencies.

In 2005, a previous Environmental Impact Statement (EIS) was granted an Approval in Principle (AIP) from the Minister of Environment and Conservation on the 16th May 2006. An Environmental Permit was then granted on December 2007. Following on from that, an Environment Management Plan (EMP) was prepared (Ecosystems Management Ltd 2009) and contained both construction and operational phases of the POMSSUP. The basis of this study was the Master Plan and Feasibility Study reports (JICA 1998, 2003).

The Detailed Design Phase (Basic Design) of the project commenced in 2010. The Basic Design provided a more detailed scope and magnitude of the project. As a requirement of JICA, the EMP is to be updated to consider the scope fixed in the Basic Design (2011) and also to review on the conformity of the basic design plans on the legal systems, standards and guidelines of GoPNG. Meanwhile, the Department of Environment and Conservation (DEC) requested EDA RANU to submit an Addendum EIS and a Construction and Operation Management Plans[2] (April 2011) since the legality of the Environmental Permit issued was only until January 2011. This is to ensure that the Environmental Permit is validated, renewed, and remains current.

2.1.1 Aim of the EMP

The aim of this EMP is to specify the environment management measures required to be implemented in the POMSSUP so as to avoid or mitigate potential adverse environmental impacts and provide benefits where possible. These management measures cover potential adverse impacts and benefits within the right of way (ROW) for the sewer lines along the route of existing roads within the National Capital District (NDC), and at the proposed Kila Kila Sewage Treatment Plant (STP), marine outfall at Joyce Bay and at Morata Disposal Site.

The EMP will be used by the IPBC/EDA RANU Environmental Officer or a designated officer to monitor the activities of the project at a project baseline phase during the construction and operational phases. Officers from the DEC can also make compliance visits to the project facilities to ensure criteria for water and aesthetic quality are being complied with in the EMP.

[1] NCD Water and Sewerage Ltd, trading as EDA RANU.

[2] This EMP refers to the Construction and Operation Management Plan.

2.1.2 Structure of EMP

The EMP is collated according to the identified impacts that are envisaged to arise in the project and these are outlined in the Environmental Impact Statement (EIS) and Addendum EIS. The Report will be in six sections: **Section 1** (6.1 – 6.1.6) provides the aims, structure, purpose, statutory requirement and the organizational structure for the project.

Section 2 (6.2 – 6.2.2.4) contains the project descriptions, scope and type of work or activities that will occur, followed by **Section** 3 (6.3 – 6.3.3.3) which provides description of the biophysical and socio-economic environments. These covers an overview of the geomorphology, geology, seismicity, soils, flora and fauna and marine components, and the cultural, land tenure, land use together with socio-economic attributes.

Section 4 (6.4 – 6.4.4.8) covers the Environmental Impacts on the terrestrial environment where road works, excavation and clearing for trunk and branch sewers, together with pump stations and construction of STP, housing compound, and marine excavation for the ocean outfall will be done. The new road work of 1.73 and 1.3 km are planned to be sealed and potential impacts arising from these are stated.

Within the marine environment, impacts associated with the final discharge of treated effluent and the removal and transplanting of coral communities together with the laying of the STP marine outfall are mentioned together with the temporary impacts on the reefs and water quality. Social impacts are also covered here with land issues, disruption of traffic, settlement together with fishing and recreation and the status of the twenty households that will be piloted with the project.

Section 5 (6.5 – 6.5.4) mentions the environmental management plan within the project in the project development stages, namely the Construction and Operational Phases. It is noted that environmental management is often commenced during the design stages and this carried onto the construction and then the operational stage. The use of Environmental Management Guides (EMG) is suggested as management tools in this EMP and the supervision of environmental mitigation is crucial in the Project. The level of hazardous wastes and their production will be only during the construction phase of 39 months and this does not warrant a separate EMG. This is covered together with other EMGs. **Section 6** (6.6 – 6.6.6.2) then contains Environmental Monitoring covering for both the Construction and Operational Phases and the linkage between Sections 5 and 6 is through the EMG (ref. **Annex 1**). Annex 1 contains detailed EMG which provides environmental management procedures for the POMSSUP while **Annex 2** has further layouts of the project.

As an "environmentally enhancing" Project, it is expected that during the operation stage less impact to the environment is expected than during the construction stage.

2.1.3 Purpose and Objective of Development

Within the coastal areas of the National Capital District spanning from Kanudi, Hanuabada,Paga Point, Ela Beach, Koki, Gabutu, Konebada to Kilakila, the sewage collection systems comprising of pump stations, pipe network and shallow marine outfalls each of up to twenty or thirty metres. There are no treatment facilities hence direct discharge is being done. For the inland area, there are three aerobic and oxidation pond systems hereby referred to as the Sewage Treatment Plants (STPs). The short coastal sewage outfall with no treatment together with an increasing city population has placed pressure on the marine environment as well as on the health of the people. Total estimated population

in 2008 was just over 400,000 from 254,158 in 2000[3]; hence it has been increasing at about 7% per annum.

The proliferation of high rise block of flats and office complexes in the National Capital District as a result of the business boom from the PNG Liquefied Natural Gas (LNG) will also place pressure. Hence the purpose of the POMSSUP is to upgrade the existing facilities of the coastal area and to construct an oxidation ditch system at Kila Kila where, the treated effluent after aeration and disinfection will be disposed by pipeline 0.9 km offshore.

The primary objective of the Project is for IPBC/EDA RANU to upgrade the existing sewerage system for the NDC, particularly for the surrounding coastal communities and also the Central Business District in Port Moresby. In addition, a pilot project of 20 selected households in Hanuabada will have water and sewerage installed to trial out this connection from the normal sanitation practices in the coastal villages. Furthermore, this will improve the quality of sea water and marine ecosystem; and in doing so improve sanitation, fisheries and tourism according to the Basic Design (Project Inception Report 2010). Lastly, the Project will provide capacity building for EDA RANU in the training and operation for the new STP.

2.1.4 Study Methodology

An earlier EMP on the POMSSUP in 2009 (Ecosystem Management Ltd) was consulted and reviewed together with discussions with the project design team, EDA RANU and DEC. This consultation provided the major source of information as well as field work to verify and confirm locations of the project infrastructure and the route of the sewer and trunk lines and rapid appraisal of the environmental condition. Input for the socio-economic and awareness programme was obtained through consultation, secondary information and literature review.

2.1.5 Statutory Requirements, Standards and Guidelines

This EMP is collated according to the Environmental Act 2000 and Amended Environmental Act 2002 in particular Section 65, Condition of Permit where;

1) d) states “preparation and carrying out an environmental management program. This EMP satisfy (k) where Information reported here relate to study or surveys and reporting the results prior to commencing operations”.

Other legislations that may be applicable to this EMP include the National Cultural Property Preservation Act 1974 for possible discovery of artifacts and the Public Health Act 1978 for water quality. It will also need to comply with the Environmental Code of Practice for Sanitary Landfill Sites – Papua New Guinea 2001 for the sludge disposal site and the Draft Environmental Impact Statement Guidelines for Roads and Bridges 1997 for the access roads besides getting the other building board approval for the construction which will be coordinated by IPBC/Eda Ranu.

2.1.6 POMSSUP Organisational Structure

[3] Office of Urbanisation, 2010, National Urbanisation Policy 2010 – 2030, Port Moresby.

The funding arrangement is between the Government of Japan – ODA through the JICA and the GoPNG through the IPBC[4]. IPBC as executing agency will assign Environmental Management Tasks to EDA RANU who will be the operator of the POMSSUP. A Project Management Team (PMT) has been set up under the Water and Sewerage Section and the PMT will liaise with IPBC, JICA and the Design Team.

EDA RANU currently has a number of discharge permits as it relates to the pump stations and the shallow outfalls into the Papuan coastline and also for sewage discharge into the Morata Swamp. It is expected that the permit that will be obtained under this Project will cover all components (ref. **Section 2.2**). For environmental management, EDA RANU has a management structure and the primary management responsibilities for the POMSSUP will be with the PMT (ref. **Figure 1**). The PMT involves coordination between the Managers of Sewerage Operations and Environment and Quality Control who will delegate to officers to undertake management and monitoring roles.

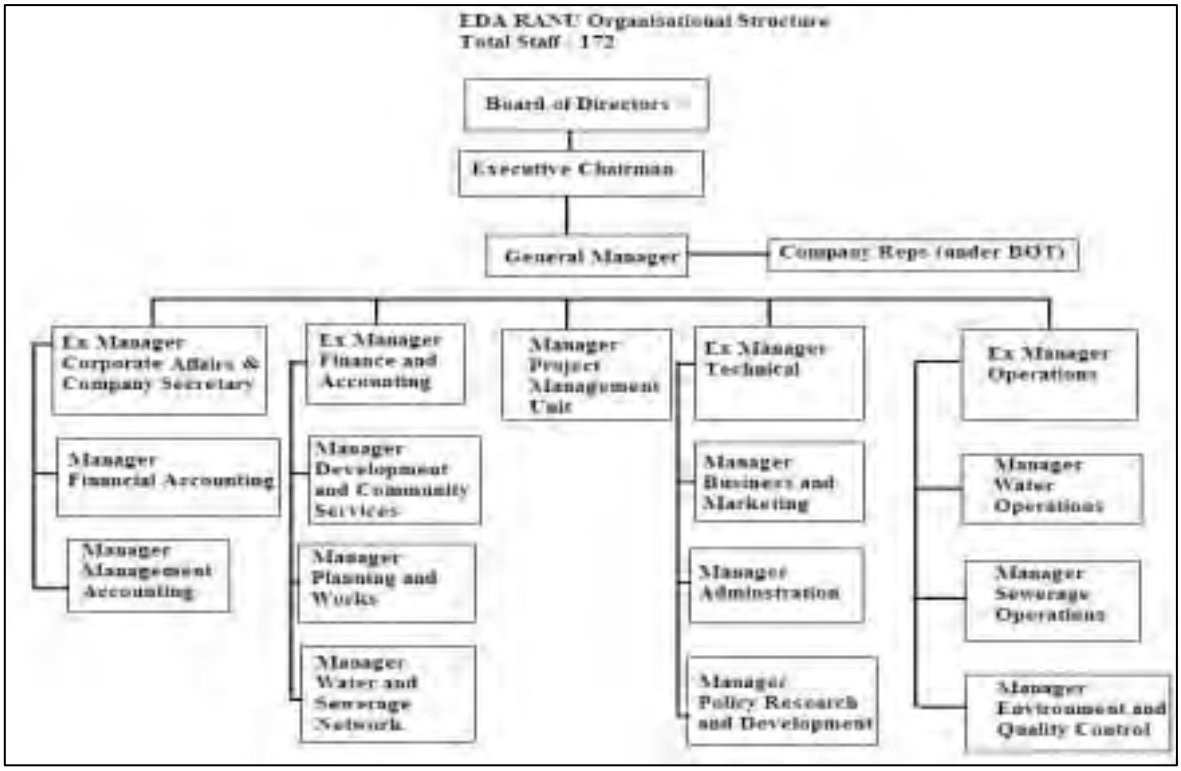


Figure 1: EDA RANU Management Structure (Source: EDA RANU)

2.2 Project Description

[4] IPBC is the PNG Government Holding Corporation that overseers State Owned Enterprises (SOE) and EDA RANU is one of the SOE.

2.2.1 Type of Works Proposed

The proposed Project will concentrate mainly along the coastal region catchment areas, from south to southwest of NCD; covering part of Town/Hanuabada, Kila Kila /Kaugere, Boroko/Korobosea and Hohola/Tokarara and Kanudi, Idubada, Hagara, Hanuabada, Konedobu, Stanley Esplanade, Sea Park, Davara, Lawes Road, Koki, Badili, Kila Police, Gabutu/Konebada, Kaugere and Kila Kila area. The total catchment area to be covered is 1,586 hectares.

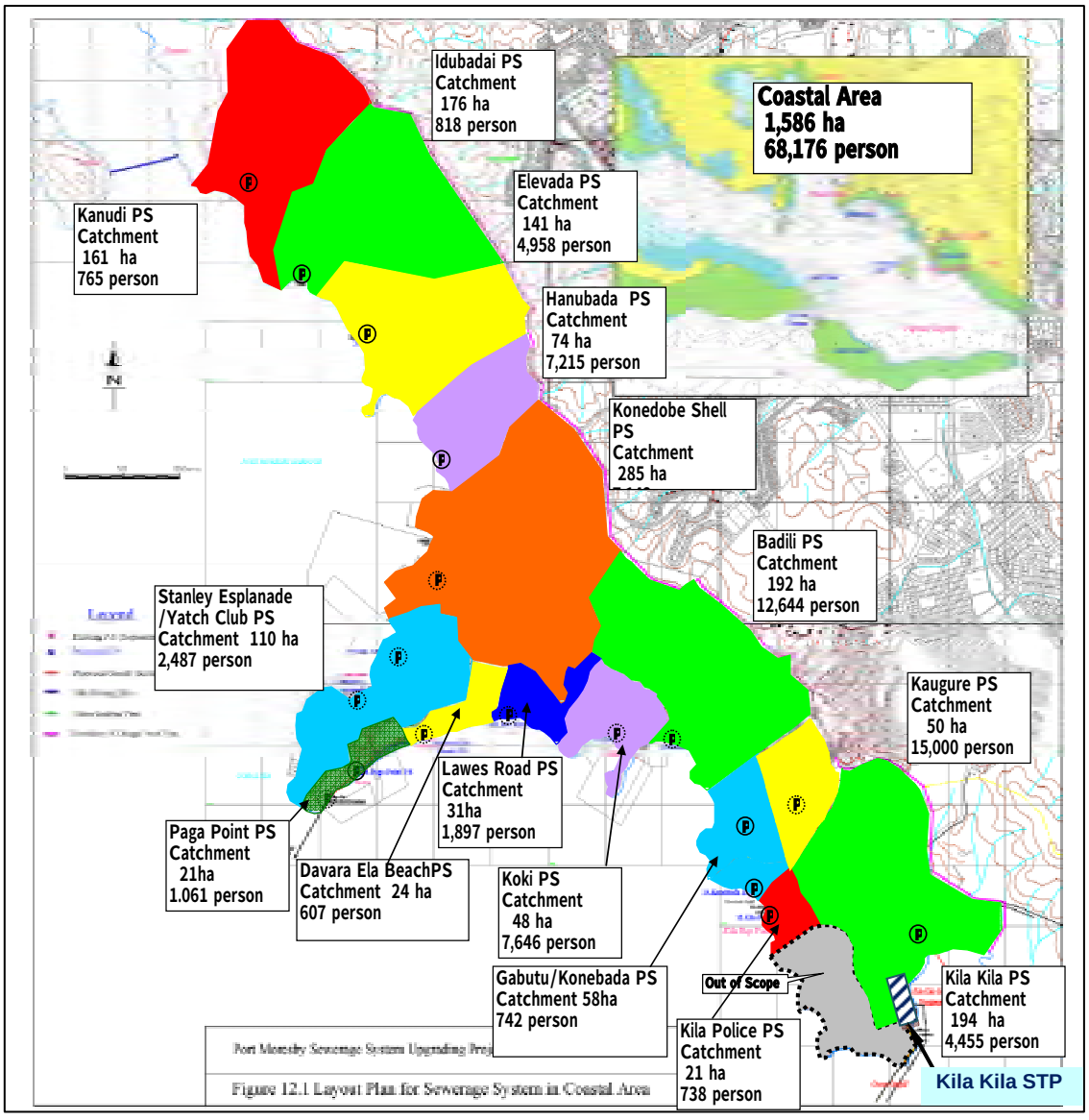


Figure 2: Catchment and Service Area (Source: JICA Study Team)

2.2.2 Scope of Works

The four years Project (mid 2012 – mid 2016) will involve:

(i) Installation of sewer pipelines (trunk sewer: L=17.7 km, branch sewer: L=17.3 km)

(ii) Pumping stations (new construction: 8 PSs, rehabilitation/reconstruction of existing 9PSs)

(iii) Construction of new Kila Kila sewage treatment plant (daily ave. 13,800 m^3/day)

(iv) Ocean out fall pipes for treated sewage discharge (L=1.4km)

(v) Construction of access roads (Kila Kila STP: 1.5km; Morata STP: 1.3km)

(vi) Pilot project at Hanuabada water village (installation of sewerage and water supply services for 20 selected households)

2.2.2.1 Sewer Pipelines and Pumping Stations

Trunk and branch sewer (17.7 km + 17.3 km) will be newly installed along the coastal region, from south to southwest of NCD. For the 17 km of branch sewer, only the collection pipe under public road will be catered for and from the house to the branch will not be covered under this Project.

The main sewage collection system features 17 pumping stations (8 PSs will be newly constructed and 8 existing PSs will be rehabilitated or reconstructed. (**Table 1**) Of the long trunk main pipe, 90% is the force main pipe, and the rest 10% is the gravity pipe. Since steady and reliable operation of the pumping stations is strongly required, each pumping station will have an on-site generator to accommodate the frequent power outage.

2.2.2.2 Proposed Kila Kila STP

At Kila Kila STP, a secondary treatment process, Oxidation Ditch (OD) will be employed (**Figure 3**) where final effluent will be disinfected and then discharged into Joyce Bay. The expected design sewage quality is shown in **Table 2** where this will be very beneficial to the marine coastline. Total area for the STP will be 7.03 hectares.

Table 1: Status of Pumping Stations (PS) （Source:JICA Study Team）

Name of Pumping Stations			Design Flow (m^3/min)
PS-1	Kanudi	New	0.36
PS-2	Dubada	New	0.60
PS-3	Hagara	New	1.60
PS-4	Hanuabada	New	3.80
PS-5	Konedobu	Reconstruct	6.80
PS-6	Old Yacht Club	Reconstruct	0.65
PS-7	Stanley Esplanade	Rehabilitated	1.10
PS-8	Sea Park	Rehabilitated	0.50
PS-9	Davara	Rehabilitated	8.70
PS-10	Lawes Road	Reconstruct	9.50
PS-11	Koki	Reconstruct	2.00
PS-12	Badili	Rehabilitated	5.20
PS-13	Kila Police	New	0.36
PS-14	Konebada	New	0.55
PS-15	Gabutu	New	0.70
PS-16	Horsecamp	New	1.20
PS-17	Kaugere	Reconstruct	3.80

Table 2: Design Sewage Quality

	Water Quality Parameter				
	BOD (mg/L)	SS (mg/L)	T-N (mg/L)	Coliform group (MPN/100 ml)	Oil & Grease (mg/L)
INFLUENT	190	180	45	-	-
EFFLUENT	20	20	20	3,000	10

（Source:JICA Study Team）

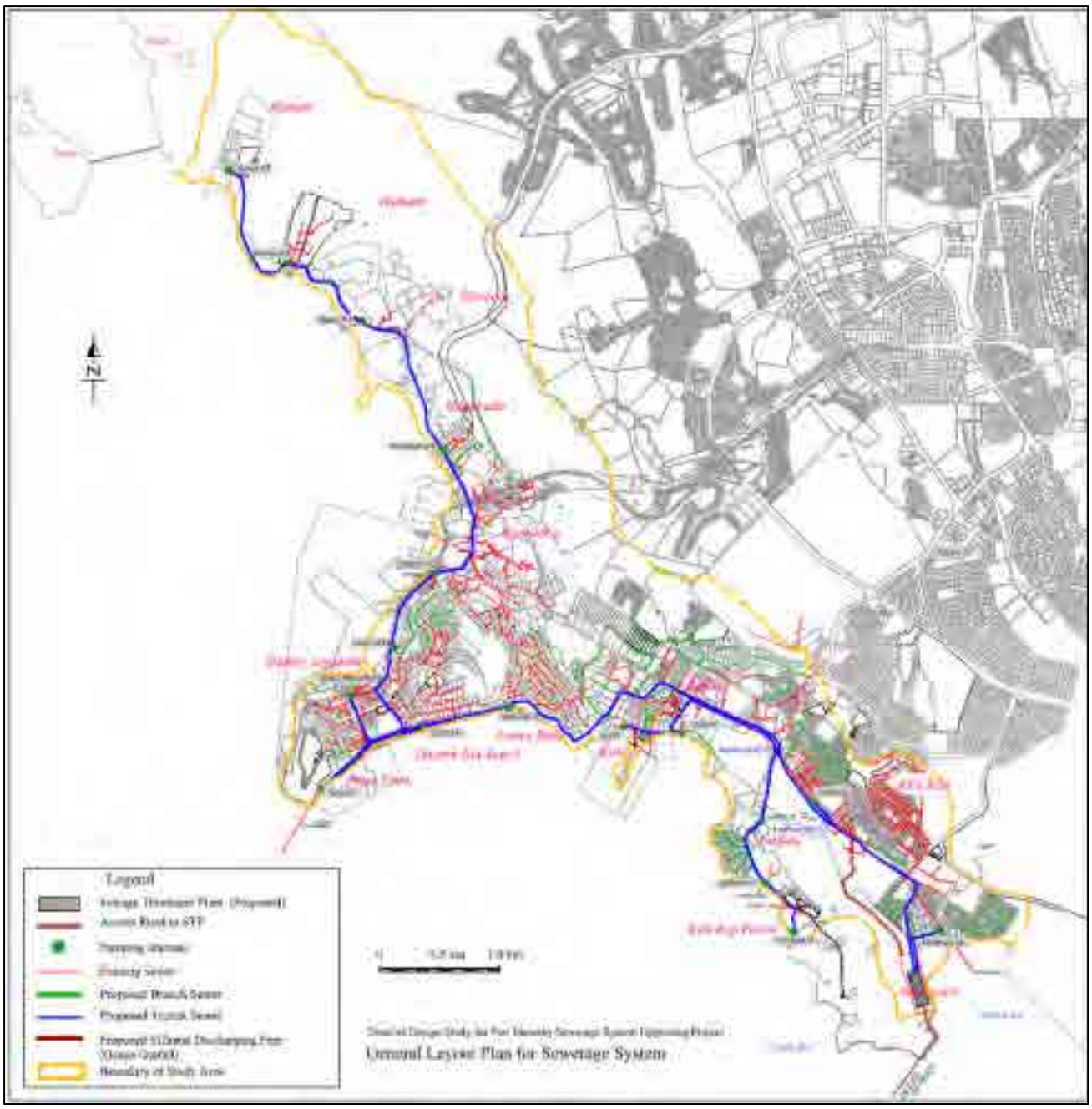


Figure 3: POMSSUP General Layout Plan (Source:JICA Study Team)

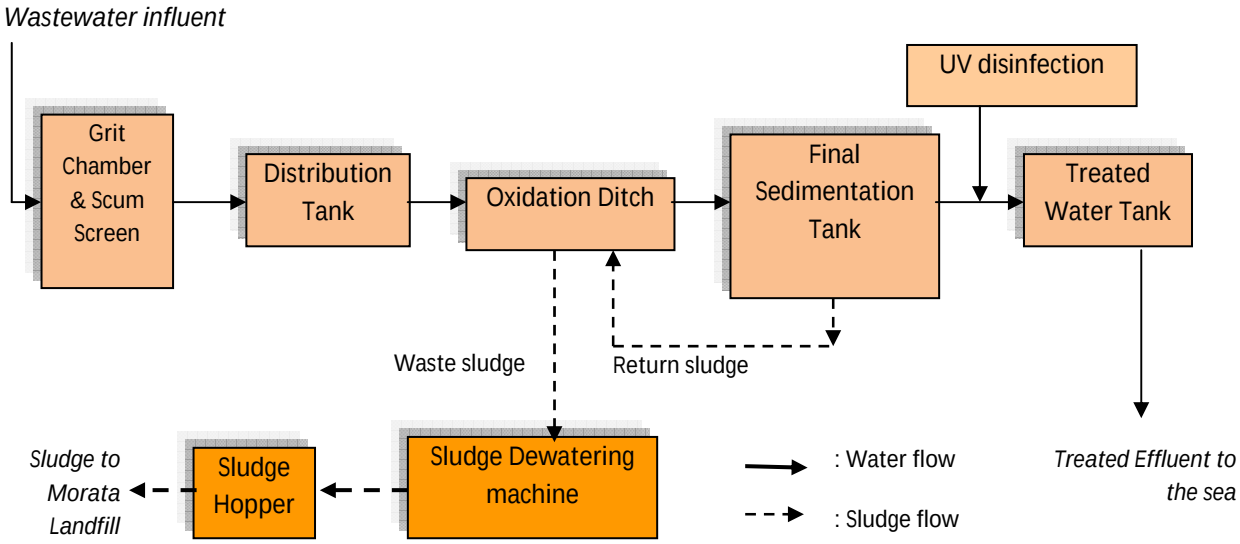


Figure 4: Process Flow of Kila Kila STP （Source:JICA Study Team）

2.2.2.3 Construction of Access Roads

The first proposed access road (L=1.5 km) will link existing main Scratchley Road through a newly-constructed street before connecting to the proposed Kila Kila STP. A second access road will stretch for 1.3 km from existing sealed Morata's Talapia Street to the proposed sludge dumping and disposal sites at Morata STP. Discussions by contractors will need to be with the Department of Work – Roads Branch together with the National Roads Authority (NRA) and the draft guidelines for Roads and Bridges will need to be adhered to.

2.2.2.4 Pilot Project at Hanuabada Water Village

As part of the POMSSUP, a pilot project intends to increase coverage and effectiveness of water supply and sewerage services in the water village of Hanuabada. This will be through the provision of safe and reliable water supply and sanitation services in 20 households. The project seeks to establish the technical and financial viability of sewage management in the water village areas. In addition, it will reinforce hygiene and cholera management, accompanied by a social/education awareness program.

2.3 Existing Biophysical and Socio – Economic Environment

A brief description of the biophysical and socio – economic environment of the project is presented to illustrate these aspects.

2.3.1 Physical Environment

2.3.1.1 Physical Setting

The project area comprising of approximately 1,586 hectares as an elongated "eagle with outstretched wing " covering the coastal regions from south to south west of the NCD (**Section 2.1, Table 2.1 & Figure 2**). Kila Kila STP will be located within approximately 7 hectares (**Figures 2,3 & Annex 2**). From the Kila Kila STP will be an effluent outfall that extent out 900m from the Joyce Bay.

2.3.1.2 Landscape and Geology

The bulk of the 1586 hectares consists of undulating hills, valleys and ridges which are aligned along a series of north west – south east features. These features run from Kila Kila through to Papa Lea Lea area. Over time, these have weathered but also more excavated to display the intricate folding and thrusting within the bedrock.

The geology of Port Moresby and the project area is represented by the Paleocene (66 – 60 mya) Burns Peak Formation consisting of calcareous mudstone, red cream micritic limestone. These are overlain by the Eocene (55 – 38 mya) Port Moresby Beds consisting of chert, argillite, calcarenite and coarse bioclastic rocks. Within these two beds are pockets of the Middle to Late Oligocene (33- 23 mya) Dokuna Tuff consisting of mafic to intermediate ash flow, ash fall tuff, lavas, argillite and mudstone (Rogerson et al 1981). These represent the volcanic activities that would have given rise to the Variarata plateau and numerous agglomerate around Rouna Power Station area. The Port Moresby Beds dominate the geology within the project area, while at Morata are Quaternary or recent sedimentary deposits which are undifferentiated and mixed given rise to the savannah grassland and weathered soils which are favourable for gardening.

2.3.1.3 Seismicity

From emerging earthquake patterns in PNG since 1964, much of the PNG landmasses have a very high level of earthquake activity. Exceptions include the southern part of Papuan Peninsula region (including the National Capital District and city of Port Moresby), the central PNG Highlands, and the southwestern part of PNG mainland (Western Province). The southern part of the Papuan Peninsula and Western Province has been identified as part of the stable Australian craton.

However, there is a low frequency of seismicity in Port Moresby compared to much of the PNG landmass with strong earthquakes. No significant earthquake has occurred within 200 km of Port Moresby but there were four in the distance range 200-300 km from Port Moresby. Two magnitude 6+ earthquakes occurred within 100 km of Port Moresby and six magnitude 6+ earthquakes occurred within 200 km of Port Moresby since 1900 and these are attributed to New Britain Arc and Subduction zone, 300kms away in a north easterly direction[5]. In these instances, tall buildings are vulnerable to shaking with minor damages.

Building code zones correspond to the seismic zone where Port Moresby is in Zone 4 which receives accelerations of 0.4[6]g while Zone 1 in East New Britain represents accelerations of 0.68g or greater[7]. Hence buildings in East New Britain must follow Zone 1 building requirements compared to Zone 4

[5] Anton, L. and G.Gibson 2007, Earthquake Hazard In Papua New Guinea: Problems And The Way Forward. Available from http://www.aees.org.au/Proceedings/2007_Papers/Anton_et_al.pdf

[6] g refers to gravity force hence the greater the figure refers to an intense acceleration that will be received .

[7] Anton,L Mcue, K, and G. Gibson, 2009. Earthquake Hazard of Port Moresby, Papua New Guinea: An Intra-Plate Setting, Available from http://www.aees.org.au/Proceedings/2009_Papers/Anton_et_al.pdf

in Port Moresby. Overall, the POMSSUP project site will not be in any way be seriously affected by seismicity.

2.3.1.4 Soils

The soils fall in a number of classes. Troporthent on the broad ridge of plateau overlaying limestone and Eutropept and Rendolls., Fluvaquents are found in the flat to moderately flat coastal lands. Eutropepts are slightly moderately weathered soils with an altered B – horizon and high sub soil base saturation values. Rendolls are shallow, dark, weakly acidic to neutral soils formed from on calcareous parent materials. Fluvaquents are poorly drained, undifferentiated soils with high organic contents while Troporthents are undifferentiated, mostly shallow soils typically found in wet climates on moderate to step soils as classify[8]. These mixture of soils, gives rise to well drained to poorly drained soils that are very productive for the Motu Koitas, settlers and urban gardeners who provide vegetable to the markets around Port Moresby. These soils are vulnerable to erosion if exposed to rain and a heavy downpour can result to flash floods that clog up storm water drains around the city.

2.3.1.5 Climate

Port Moresby and the surrounding area have been classified by MacAlpine et al 1981 as a lowland dry humid area. The temperature of the area ranges from a low of 23^{O}C to a high of 30^{O}C with a range of 19 – 32 ^{O}C. The mean annual rainfall is from 1000 – 1500mm with seasonally having below 100mm and ranging from 100 – 200mm. There is a distinct wet monsoon season that predominates from December to April with the prevailing north west winds, and the dry monsoon period which is more pronounced between May and November. This supports the low seasonal rainfall (< 100mm) and moisture drought conditions. In addition, there is a very high percentage of humidity and this is more pronounced in the wet season, where it can reach 80% in the morning and drops down to about 60%. This provides a very unpleasant atmosphere for construction activities in the daylight hours.

2.3.1.6 Hydrology

The project area does not contain rivers or perennial creeks, however beginning from Kanudi to Kila Kila are ephemeral creeks that flow during the heavy down pours of the monsoon period in Port Moresby. Around Morata STP area are discharges from the storm water drains which drain north west into the Laloki River.

2.3.2 Biological Environment

2.3.2.1 Flora

Flora within the Port Moresby and project area is dominated by savannah grassland with *Eucalyptus Alba and Papuan* and *Confertiflora* together with occasional other tree species such as *Alostonia Scholaris* and *Rubiacea*. The palm, *Cycas campestris* is a noted species and the grassland is dominated by kunai (*Imperata cyclindrica,)* with Kangaroo grass *(Themada australis)* and occasional Spear grass (*Heterogen contorts*).

[8] PNGRIS 2001, Papua New Guinea Resource Information System Handbook 3rd Edition, PNGRIS Publication No 7: E. Bryan and P.L. Sherman (comp).

Along Kanudi coastline are remnants of mangrove species (*Rhizophora apiculate* and *stylosa*). sWithin Morata, there is also savannah grassland with the Eucalyptus trees together, and a lot of these have been cleared for gardens by settlers, together with kunai and speargrass and other shrubs.

2.3.2.2 Fauna

In the past, the hill areas and kunai grass were habitats for wallaby (*Macropus agilis; Dorcopsis luctuosa*). However this has changed with urbanisation, hunting and removal of habitats for these animals. The bulk of the project area does not contain any protected fauna, although the Papuan Black snake (*Pseudechis papuensis*) and python (*apodora papuana*) are sometimes visible in the savannah grassland. The former is very poisonous. Birds such as the Kingfisher and Grey plover and *Pluvialis dominica* may be visible however slingshots has decreased their number quite drastically. Around Morata and the STP ponds, water fowls and wild ducks are abundant and their population has also decreased as hunting by the settlers has increased. In the ponds are also eels, mosquito fish (*Gumbusia affinis*), tilapia, carp, tortoise and crocodiles.

2.3.2.3 Coral Reefs and Benthic Communities

From Kanudi to Hanuabada and to the Port Moresby wharf, the sea has been heavily polluted by the sewage, oil and storm water run offs into the harbour. However, there are inter tidal fringing reefs which border the inner shore line and are usually comprised of coral growing on old coral rubble or some discarded artefacts or wrecks.

A fringing reef exists within Joyce Bay where the Kila Kila STP outfall will be. This reefal assemblage consists of zones namely the inter tidal, lagoon, back reef, reef flat, reef crest, reef slope and the deeper lagoon seabed (Mungkaje & Maniwavie 2005[9]). A recent marine survey noted the ecosystem in the Joyce Bay to be heavily polluted especially along the coastline because of improper waste disposal practices and increased human activities (Lili 2011[10]). The sea was murky to about 350m offshore before it became clearer. Dynamite fishing in the past had led to the majoring of corals degraded and evidence of broken coral has been noted out to 950 metres from the shoreline. In addition, storm events and other fishing practices have added to impacts on the coral ecosystem. During the survey, a number of fishing boats and canoes were observed using spear guns, fishing lines and nets while on the reefs were crowds of people fishing and frolicking. The burrowing invertebrates (crustaceans and molluscs, echinoderms within the intertidal zone have diminished. Notable brown algae *Sargassum sp* together with sea grasses such as (*Thalassa hemprichii* and *Enhalus acoroides)* and damsel and butterfly (*Chromis atripes,Chromis ciridis* and *Chaetodon rafflesi*) and other fish species dominate in in around corals and at the reef edge. Surprisingly, the numbers have been low.

The presence of abundance sea urchins in the shallow reef beds indicate damage to these reef as there is overfishing of predatory fish such as the trigger fish *(Sufflamen chrysopterus* and *Sufflamen bursa*).

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[9] Mungkaje, A and T. Maniwavie 2005,Environmental Implications of the Port Moresby Sewerage Upgrade Project on the Joyce Bay Marine Ecosystem and surrounding Areas, Consultants report to Ecosystems Management Ltd.

[10] Lili,Pochon, 2011, Biological Survey and Marine Impact Assessment of STP Pipeline Ocean Outfall at Joyve Bay, Consultants Report to POMSSUP.

The survey transect up to 1041m from the shoreline indicate a dominance of boulder corals (Porites sp) while there is sparse branching (*Acropora grandis* or *A.tenuis*) or leather coral (*Sacrphyton sp*) together with associate coral rubbles or skeletons. This is not the thriving biodiversity as recorded in 2005. An overview of the alignment for the STP ocean fallout together with a record of the survey transect are in Annex 2.

2.3.3 Socio – Economic Environment

2.3.3.1 Socio – Economic

The Motu – Koita urban villagers are mostly engaged in the National Capital District in employment through both public and private sectors, while some are self employed and those not employed are supported by relatives and some live off the sea and land although this may be a very small number. Those in the higher salary brackets build permanent houses with electricity and modern amenities and there is also a trend for all families to contribute to build permanent houses.

Family ties are strong and this is often seen during bride price payments where relatives contribute amounts up to PNGK50, 000.00[11] or more. This is reciprocated when other families do likewise. Funeral feasts and birthday celebrations are all part of the bigger family unity. Motu Koitans live on their customary land and the bulk of these land are not registered although the Department of Lands and Physical Planning and Office of Urbanisation in recent years have encouraged customary land owners to register their land so that they can be developed and attract the development value that city real estates' are enjoying..

Within the NCD, there are limited jobs and this has proved the recipe for unemployment which is quite high. Within the settlements, crime together with other social evils such as prostitution, gambling and adultery are prevalent. HIV and STD cases are also prevalent in the city. This is not to say that all communities within PNG are exempted from these. Within the settlement, communities have also been entrepreneurial by buying and reselling of fresh market goods. Often women would approach rural vendors who bring their food items in bulk to sell at the main Gordons market. After a price is agreed, the urban women would then re bundle the food items to take to the smaller markers within the city to sell. Land being scarce is also a limiting factor and all available land appropriate for gardening have also been taken over by settlers on a first in basis.

In the project area, most Motu Koita villages and the settlement are serviced by the National Capital District Commission and EDA RANU where water is often available to them. Other services are still inadequate such as the garbage and sanitation services. These areas have schools, health and churches which play an important social and services role in the community.

2.3.3.2 Cultural & Archaeological

In PNG, cultural and traditions are often maintained among all clan groups. In rural areas, these seem to be more actively embraced than those in the urban areas. These are still passed onto the younger generation for their identity. In the project area, the Motu – Koita villages represent the coastal

[11] 1PNGK ~ US$ 0.3938 10th October 2011

communities besides the other ethnic groups that live in the settlement such as Horse Camp,Vabukori and Kila Kila. Along the project route, no archaeological significant artefact has been noted.

2.3.3.3 Land Tenure and Land Use

The bulk of the land in the trunk and branch sewer line work will be on State land while some will be customary land. Most of the area for the proposed STP at Kila Kila, effluent outfall pipe, access road and housing compound is under customary ownership. Under this Project, land will be acquired and it is essential that appropriate benefit packages for loss of land and relocation are mutually agreed to between the GoPNG through IPBC/EDA RANU and the customary landowner(s). The sludge disposal sites at Morata will be located on approximately 8 ha of State land at Morata, away from residential, commercial and industrial areas (EML[12] 2006).

[12] Ecosystem Management Limited 2006: POMSSUP EIS.

2.4 Environmental Impact

Environmental impacts of the POMSSUP will be described under four categories; Benefits; Terrestrial, Marine and Social. Impacts on the land will be stated following the Scope of Work (section 2.2). In the marine component, the transportation of corals, water quality and the dredging and removal of sediments will be elaborated. Lastly, social impacts will be stated as it covers land acquisition and settlement, cultural/ archaeological sites, fishing and recreation, traffic impacts and the selected Hanuabada households.

These impacts will then be elaborated in section 5: Environmental Management Plan, together with Environmental Management Guides (EMG). The majority of the physical impact will be during the construction period of 39 months (3.25 years).

2.4.1 Benefits

It is essential that the benefits of this project will create a ripple effect through the population in the coastal areas and shorelines. The removal of all effluent outfall currently pumped into the Papuan lagoon will remove the concentration of pollution in the sea and as this clears up, the sea will be enjoyed by everyone.

Benefits will be firstly to the beach lovers who at the moment are very apprehensive over taking a family outing to Ela Beach and surrounding beaches. The second group of beneficiaries will be the recreation and professional fishermen who will see that the clearing of marine life will ensure fish and other species will return and in doing so the marine food chain and web will be maintained. Hence the larger fish will return to the shoreline in search of available prey.

The third group of beneficiaries are the coastal villagers who have a high incident of water borne diseases such as diarrhoea, gastro –enteritis, flus, cholera and typhoid (SAPROF 2006). These villagers have considerable medical expenses and this project will reduce the incidents and with awareness will lead to general hygiene and cleanliness and a healthy population. Finally, resort developers and guest house operators may consider ventures that feature the beautiful shoreline and prices will be a premium with beach side views for tourists or holiday makers. Hospitality jobs will be created from these ventures.

2.4.2 Terrestrial

The natural environment along the right of way will be modified therefore there will be impacts on the natural environment. In addition, there will be some erosion and sedimentation on the exposed road surface brought about by the weather. The impacts brought about from this project are in these areas; Terrestrial, Marine and Social. Under terrestrial, the bulk of activities will be earth works for the sewer lines, STP and housing facilities, and disposal site.

2.4.2.1 Earthworks

Earthworks will involve excavation along the right of way for the sewer pipes totalling 35 km. The depth for excavation will be at four metres**.** Excavated spoil will need to be carted away along the road section of 50 metres to designated sites. In most cases, it may be worthwhile to ask neighbouring households if they may require spoil as filling material for depressions within their area.

Earthworks will also be carried out for the construction of the new Pump Stations, where each site will be excavated down to a depth of 5 metres and three possible types of pump stations will be installed (Type A: 4.91 m^2; B: 20m^2 and C: 28.91m^2). The type of pump station to be excavated will determine the volume of spoil material that will need to be carted away to designated areas or as stated to ask if people require it or could be used for a community recreation field. Hence, this volume of overburden must be cleared promptly to avoid possible erosion and runoff during the heavy monsoon season. Besides the spoils are construction material and machine or pump parts which must be taken to designated areas for disposal or storage. During the operational phase, monitoring is required to ensure there is no build up of hydrogen sulphide gas (H_2S) and sulphuric acid in the pumps and mitigation measures would need to be in place.

Another area requiring Earthworks would be at the Kila Kila STP site and housing facilities covering around 7 hectares, and sludge landfill around 8.05 hectares and the construction of access roads at Kila Kila and at Morata. Within the site, clearing and grubbing will commence with spoil and rocks excavated for the STP foundation. Similarly, the Morata site will have levelling of hills to create a stable and level foundation for the disposal site.

In all these areas, spoil and overburden would need to be disposed at designated sites so these are not in any way in drainage works that will have the potential of being eroded off down storm water runoff impacting the total discharge. The land is government owned, however the removal of garden products and fruit trees will need to be settled between the project proponents and the subsistence gardeners.

For the access roads, dust creation from the exposed and unsealed road surface is obvious and the noise and exhaust fumes from construction machines is unavoidable and this would need to be managed. Construction noise will be a nuisance to the Horse Camp community during the construction of the Kila Kila STP and this will need to be managed to minimize impact. Similarly, the 1.3km road from Talapia street to the Morata Sludge Disposal site will involve minor road realignment where structures such as market stalls or stores too close to the road will need to relocate away from the right of way.

2.4.2.2 Pavement Work

Pavement Work will involve the containment of the road base and sub base material. These materials mostly in stockpiles would likely end up in the drains, hence the need for mitigation measures.

A total of 2.8km of access road will be paved from the Stratchley Road/ newly constructed Street down to the Kila Kila STP and from Talapia Street in Morata to the Land Fill Areas.

The road contractor and its engineer will need to ensure that road base and sub base materials are kept in stockpiles and away from drainage areas limiting the potential for gravel and sediment run off during the rainy season. Given the short distances, road base and sub base materials may be hauled from the Rouna or Nebiri Quarry sites. Dust will also be a minor hazard within the stockpiles during the gathering on windy days.

2.4.2.3 Drainage Works

Along the 2.8 km of access road, drainage work may be undertaken where side drains may be established, together with drainage structures and lined drains. These activities will involve the

removal through excavation of soil and debris, and when not cleared would result in blockage of waterways**.** Sedimentary basins may be needed along this stretch of road access to contain sediments from the road works, although the total distance is small by highway standards.

2.4.2.4 Bitumen Works

Bitumen Works will be for the 2.8 km where spillages from bitumen heating kettles and poorly stored bitumen and fuel drums provide the opportunity for leakages. The transportation of the sealing aggregate and bitumen drums does pose a risk of spillage. Proper care in the usage of heated bitumen and any paint material on the road surface for sealing and or for road marking respectively will prevent pollution from hazardous materials.

2.4.2.5 Erosion Control

Erosion protection ensures that all materials within construction area, right of way and through all the earthworks, drainage works and bitumen works are well maintained as to clearing out sediment build up and to allow for natural vegetation to contain exposed surfaces.

2.4.2.6 Kila Kila STP & Housing Complex

Besides the earthworks for the Kila Kila STP and Housing Complex, there is also the need for building area management. Management involves good housekeeping managements in the beginning, mobilization of personnel and arrival of equipment. This then progresses to the setting up of the camp site and then its operation. Wastes and rubbish must then be disposed at assigned sites. The potential of fuel and oil drums not in a proper bund would mean the potential for spillage into the soil and into the Kila Kila beach proximity. The issue of waste management cannot be avoided here and therefore unmanaged wastes resulting from the construction activities have the potential to pollute the natural environment.

2.4.3 Marine

2.4.3.1. Pre-Mitigation Impact Issues

Within the impacted areas along the pipeline alignment, the subsistence fisheries are expected to be lost along the 30m-wide corridor where the corals will be removed and therefore the refuge and local habitats will become decimated. Fish, shellfish and other marine resources will be similarly affected. During the pipeline construction, vessels associated with the pipeline construction and trench dredging, tugs and barges will interfere with local fishing activities within the 500m radius. This may prevent local people adjacent to the area from fishing during the construction phase if access to and from the reefs is restricted. Fishing or harvesting will be limited and a reduction in the size of available fish and shellfish stocks. Significant reductions in yields of fish and shellfish are predicted.

The local people of Vabukori who traditionally fish on the coastal fringing reefs will be most affected by the constructions and laying of the pipeline. There will be hazards to local communities and users from project constructions and safety implications for the people fishing on the reefs.

2.4.3.2 Direct Loss to Marine Habitats

Issue

The marine habitats along the pipeline route will be removed or buried during construction activities. Adjacent areas will be affected by construction-induced increases in sedimentation. This will mainly affect marine habitats between the shore and 26m water depth. Where the pipeline is to be constructed

and laid, seafloor and shoreline habitats along and immediately adjacent will be disturbed immediately. The types of the near shore habitats to be affected include submerged and intertidal sandy or silty shoreline.

2.4.3.3 Pre-Mitigation Impact Assessment

Magnitude of Impact

The extent of loss of marine habitats due to construction and laying of the pipeline will be limited to the 120m width of the corridor and its immediate vicinity. The pipeline laying requires excavation and removal of corals across the sand and silt seafloor with seagrass macrobenthic communities associated with it. The magnitude of impact is assessed as HIGH (local impact generally up to 500m from impact site).

Sensitivity of Resource or Receptor

The narrow subtidal shoreline and seagrass and coral environments provide nursery habitat for many juvenile fish species and marine invertebrates. All of the corals and seagrass will be removed from the pipeline corridor, affecting the source of subsistence to the local villagers. For these reasons, the sensitivity of the resource/receptor of marine habitats for the pipeline development is considered as HIGH.

Assessment of Significance

Based on the criteria set out in the matrix of significance, the significance of this potential impact to the marine habitats in the vicinity of the pipeline alignment is assessed as HIGH. (see Lili 2011 for impact categories)

2.4.3.4 Other Assumptions

There are other likely potential impact issues during and after the construction phase of the project. The recent survey work did not cover these areas and their effects can only be measured as and when they occur**.** However, the general remarks below reflect the concerns that such issues should not be left unattended and future studies commissioned to address them and appropriate recommendations in their mitigation.

2.4.3.5 Changes to Coastal Processes and Sediment Transport

Issue

Potential changes to coastal processes and sediment transport will occur once the construction of the pipeline is complete and during the operational life of the project.

The construction and laying of the pipeline will become mostly buried, however, this will increase suspended sediments and turbidity during the construction work where the seafloor is directly disturbed, particularly that this is a rather shallow reef and degraded coastline area. The extent of sediment suspension in the water will also depend on the source and size characteristics of the material used for construction and the amount of fines contained. The existing patterns of tidal inundation will determine integrity and normal alongshore sediment transport processes which will need to be monitored constantly.

The Joyce Bay area is important for ecological processes and is also utilized by local communities for subsistence fishing, collection of shellfish and building supplies. Although there will not be

significant impact on the marine communities in the vicinity of the pipeline corridor, continued monitoring will determine the need for mitigation action.

2.4.3.6 Increased Suspended Sediment and Sedimentation Rates

Issue

Sedimentation effects can lead to smothering of adjacent sensitive seafloor habitat and seagrass, and reduce light availability within the water column. Seagrass that rely on photosynthetic processes require adequate light penetration.

Several activities associated with project construction will cause increases in suspended sediment in the water column and sedimentation rates and these include the following:

- Dredging (Excavation). Dredging for trenching purposes will disturb the seafloor and stir up sediment leading to increased suspended sediment and turbidity in the water column within the immediate area and down current from the source.
- Marine traffic. Shipping traffic especially work boats and barges within project area will potentially cause re-suspension of seafloor sediments through the generation of currents from propeller action. Suspended sediments will disperse according to particle sizes and the strength of prevailing currents.
- Construction and laying of the pipeline. Activities associated with the construction of the pipeline will disturb the seafloor and stir up sediment leading to increased suspended sediment and turbidity in the water column.

2.4.3.7 Disposal of Dredged Material

Issue

Disposal of the spoil (dredged material) will cause temporary impacts from sediment plumes in the water column and deposition on the seafloor. The dredged material is likely to consist of sand, silts and clays and most probable will be disposed to very deep water off the continental shelf. Some of the dredged material will be used to fill in the trench.

2.4.3.8 Exclusion Zone

Issue

A 500m exclusion zone may be enforced around the marine facilities for safety and security purposes where only authorized personnel will be allowed to access this zone. Subsistence fishing is a major source of food and income for local villages situated along the coast of Joyce Bay. As such, fishing pressure on resources is relatively HIGH. The exclusion zone will act as a ‘no take zone’, and the local people will be excluded from fishing or travelling within the exclusion zones around the pipeline facility during construction. Without mitigation, given the ongoing nature of the exclusion, the magnitude of impact perceived as a HIGH impact by people whose fishing activities are directly affected. The impact category method used in determining these rating are in (Lili 2011).

To ensure the survival rates of corals, coral monitoring procedures are stated in Section 6.6.1.2. The coral substrate along the ocean floor in the pipeline construction zone will be severely impacted and the sedentary organisms such as the star fish and micro algae, together with invertebrates such as the annelids, mollusc, sea grass, sea urchins, gastropods and soft coral will be severely impacted. Their population may be re-established after the construction period. Fish and other swift moving species are able to escape the impact as they move to other areas within the bay.

2.4.3.9 Water Quality

During construction work in the laying of the ocean outfall pipe, it is expected that water quality in the immediate area will be very turbid and this will last during the construction period. Along with that, possible oil and grease from machines and excavators will be discharged in the water column. This will be great on the turbidity index and also impact on BOD, although this is not a closed environment and so this will not be a real concern. Silt Trap as stated by the JBIC- SAPROF Team in 2005 will be employed to limit silt from extending beyond the zone of construction.

2.4.3.10 Dredging, Removal of Sediments, Nutrient Enrichment

Dredging on the sea floor along the 900m will be to a depth of 2 metres hence the total volume that will be dredged will be (4 metres wide x 900m length x 2 metres depth = 7200m^2 or 0.72 hectares) There will be the inevitable removal of epi benthic biota including the sedentary species, coral and coral substrate. The 2011 survey estimates that 240 coral boulders will be removed as they are within the alignment of the pipeline hence the total area of 6,000 square meters will be impacted. The corals that are transported will be placed at other areas within the Joyce Bay and later transplanted after the pipe has been buried. Appropriate mitigation measures are specified in section 6.5.3 and EMG 8. Nutrients within the water column such as planktons will be impacted and will not be available to fish within the dredging zone however they will be established once the construction ceases.

2.4.4 Social

Socio cultural and economic impacts will surface when construction begins and when the project is in operation, these will need to be absorbed within the community. The potential impacts identified are;

- Land Acquisition and Settlement
- Cultural, Historical/Archaeological
- Fishing and Recreation
- Disruption of Traffic
- Public Infrastructure and Safety
- Public Health Issues
- Occupational Health and Safety

2.4.4.1 Land Acquisition & Settlements

The bulk of the trunk and branch sewer lines and pump stations construction work are within the existing right of way and on public land, hence there will not be issues in relation to land acquisition. However where fruit trees have been planted together with gardens on that land may be an issue and the project implementer – Eda Ranu will need to liaise together with the contractor is addressing this.

All the locations of Pumping Stations were certified through the official meetings with local authorities. The land for the Kila Kila STP is under negotiation for the payment. Houses within the Horse Camp settlement that will be affected by the project will also need certain agreements between the project implementers and the affected settlers. In addition, portions of a cemetery in Horse Camp settlement will require similarly mutually agreements.

Land at Morata is State owned hence this will not be an issue for the Sludge Cake Disposal Area.

2.4.4.2 Cultural/Historical/Archaeological

Apart from the cemetery at Horse Camp, there will be minimal impacts to cultural and historical/ archaeological sites. Should there be artefacts identified during the construction of the Kila Kila STP or any of the Pump Station or at the Morata Sludge sites then the PNG National Museum and Art Gallery will need to be notified for advice.

2.4.4.3 Fishing and Recreation

Construction work for the outfall pipeline at Joyce Bay, will temporary affect fishermen or divers, who frequent the area to fish and dive there. The construction debris if not contained by the silt trap will also travel along the Joyce Bay to Vabukori causing silting of coral and sea floor. These will be determined by the sea currents. An effective communication strategy from the project is essential to inform the community so that they can adapt to seek other areas for their activities.

2.4.4.4 Disruption of Traffic

The construction of the trunk and branch sewer line, pump stations and associated infrastructure in the POMSSUP may lead to impacts on existing road users and other sensitive receptors. A Traffic Management Plan (TMP) is proposed in **Annex 1** and will identify the potential impacts and appropriate measures to mitigate them.

There is no known traffic survey along the proposed routes of the layering of the trunk and branch sewer lines. Hence to provide an accurate transport management plan would be not possible. However, it is known that traffic flows during the mornings; 7.30 am – 9.00am; lunch; 11.30am – 1.30 pm and afternoon; 4.00pm – 5.30 pm are often peak periods where workers commute to and from the Central Business District (CBD) in Port Moresby, Boroko, Koki, Badili and other places of work.

The lunch hour is where workers leave officers to have lunch or other engagements such as bank runs and going on errands as office hours do not allow them. With that in mind, it would be sufficient to say that the project engineer and contractor for the excavation work for the sewer lines must administer a TMP so as to allow minimal disruption to the traffic for the workers and general public.

Already the Poreporena Freeway has been the scene of numerous accidents involving heavy semi trailers and trucks and the proposed trunk sewer passes through it and so mitigation measures are essential. There is also a need to consult with the business houses through the Port Moresby Chamber of Commerce that may suffer from their business and the Liquefied Natural Gas (LNG) project on significant increase in traffic in order to identify alternative routes, or appropriate mitigation measures.

At the planning and detailed design stage, the contractor and project engineer will liaise firstly with the Independent Public Business Corporation (IPBC) as the executing agency for the project, and Eda Ranu as the project implementer followed by appropriate authorities for road safety and management, in particular the Department of Transport Enforcement Unit, the Traffic Division of the Police Department, Department of Works Road Division, Telikom, PNG Power, National Capital District Commission and the Chamber of Commerce and Industry, besides the Department of Environment and Conservation

For the 1.3km road work along Talapia Street to Morata Disposal site, the community will be temporary affected with road works along the route although in the end, the benefits will be tremendous for them as they commute into Waigani. Continued dialogue between the stakeholders

will ensure that appropriate awareness and information is given to the public through the news media, through the radio stations, print and television. An effective communication strategy will provide enough information to the public constantly during the construction phase of the sewer lines along the Right of Way (ROW).

2.4.4.5 Public Infrastructure and Safety

Work on the trunk and branch sewer lines will temporary affect traffic and also the potential for the disruption to telephone cable pipes. Hence it is essential for all public utilities and the National Capital District Commission together with the Chamber of Commerce and Industry to have regular discussions to have strategies in place and to communicate that to the general public. Port Moresby does not have gas lines running underground such as in Australia or other countries hence the risk for public disruption will be only limited to the telephone and sewer agencies. There is also a possibility for disruptions to foundations of power lines, oil lines and bus stops and again discussions with the concerned utilities well in advance will ensure the public infrastructures will be least disrupted.

2.4.4.6 Public Health Issues

Port Moresby and the surrounding Motu Koita villages and National Capital District are areas where there have been reported cholera outbreaks however the incidents are isolated but are within the marine coastal areas. Hence it is essential that Eda Ranu and its partners with the National Department of Health do have an awareness of the POMSSUP. It will be beneficial as it will reduce the possibilities of cholera as there will be a reduced environment for the bacteria to survive. Other benefits of the project are stated in 6.4.1. Through the pilot project, additional awareness for this and other diseases such as typhoid and dysentery can be highlighted to the population reiterating that a clean environment is essential for health living.

2.4.4.7 Occupational Health and Safety

Contractors have a duty of care and will have an occupational health and safety program that workers will have to adhere to during the construction and operational phase of the project. Some aspects are stated in **Annex 1** and these can be further defined depending of the extent of the hazardous material that might be within the possession of the project. The workers will need to undergo an induction to be made aware of these potential hazards and risks and what steps should be taken to mitigate or contain them.

2.4.4.8 Hanuabada Sewerage - Households

At this stage, the twenty households at Hanuabada have not been selected yet and this must be made certain quickly by the project because this may create anxiety and animosity amongst the neighbours who may feel left out. The criteria to select the twenty households must be made known to the community in a transparent manner. Initial discussions with the community have come up with the question of why only twenty households. These are issues that may need to be dealt with by the project implementer together with the Motu Koita Assembly and Ward Councillors. In doing so, an amicable arrangement together with the planned awareness program can be achieved.

2.5 Environmental Management Plan

2.5.1 Construction Phase

During the construction phase, a lot of activities will be on going where earthworks at the Kila Kila STP and excavation along the right of way, together with pump stations and access roads (section 2.2 & 4.0). Hence, environmental management is imperative during the 39 months and the Environmental Management Guides (EMG) provides the management procedures and tools for effective management during this phase. The main substance impacted will be soil and debris together with concrete, waste oil and diesel, solvents and acids which are hazards and EMG 7 has measures to contain them, together with the other EMGs.

For the marine ecosystem impacts, impacts will be associated with;

Construction and laying of sewage pipeline across the shallow water coastal fringing reefs and marine habitats;
Construction of the pipeline and associated infrastructure; and
Construction of the STP pipeline from Kila Kila landfall.

2.5.2 Operational Phase

After the construction phase and decommissioning of the infrastructure and facilities, the focus will be monitoring, although monitoring is essential also during the construction phase and this is stated within the EMGs and in Section 6 for the marine area.

Section 2 and 4 stated the scope of the project and the areas that will be impacted. The proposed earthworks will be within the Right of Way for most of the project, except for the gardens, a cemetery and structures that may be in the way of the branch and trunk sewer lines. The new access roads (total of 2.8 km) is short, however the management measures would be the same as dealing with a longer road section of 10 or 50 km.

For the marine component, the general activities of the operation phase (from the project design) that could potentially impact marine ecosystems are:

- The management of sewage and treatment facilities through the secondary treatment plant utilizing the oxidation-ditch method requiring separation pits, sumps and retention ponds;
- Discharging of the treated effluent from the STP via the pipeline to the ocean outfall at 25 m depth;
- Alterations to coastal hydrology and sedimentation processes due to the presence of the pipeline which may lead to potential siltation of the coastline;
- The use and maintenance of pipeline infrastructure;
- The movement of support staff (and potentially non-support staff) into and out of the project area.

The placement of the pipeline (if it is not buried sufficiently) has the potential to disrupt coastal current flow, the influence of wave action and thus, coastal sediment transport and deposition. There is a risk of sedimentation and sediment build-up on the project site causing damage to the marine environment and the fishing grounds.

Within the construction of the STP and associated facilities, mitigation measures would be taken to ameliorate and maintain the occupational health and safety. Socio – economic and traffic issues have been stated and this section states how the overall environmental management of the project should be.

The following is a list (with descriptions) of the main activities involved in the physical project works and identifies the expected impacts as a result of these activities. These are detailed in Annex 1 as Environmental Management Guides (EMG). It follows on from the scope of work and Environmental Impact Assessment. The EMG is based on the activities listed in the preceding section, associated anticipated environmental impacts and recommended mitigation measures. The anticipated impacts are based on experiences on other projects of a similar nature in PNG, although the upgrading of branch and trunk sewer lines and the removal of sludge and disposal is a new activity and this will set a benchmark for other such projects in PNG.

For each of the mitigation measures presented, a method of implementation is proposed. Timing is extremely important with respect to effective implementation because some of the recommendations involve additional cost to the contractor and can affect the project budget. The recommended methods of implementation include the following:

As a Design Guideline or Recommendation

This means that the mitigation measure should be included in the initial design of the project. Often, on road maintenance projects where anticipated environmental impacts are minimal, effective mitigation is simply a matter of ensuring that the roads are designed properly to control negative effects. In general, if the design is properly done (as should be the case on this project), there will be minimal impacts. In a few cases, slight changes to design will eliminate the potential for impacts.

As a Suggested Clause in the Contract

This suggests that there should be a clause in the Contract Document referring to this particular mitigation measure. There are a number of ways of addressing this. A common method is to simply refer, in the contract, to the Environmental Management Guidelines in existence, detailing any specific aspects not already in the guidelines. The main problem with this is that it assumes that IPBC/EDA RANU, DOW and contractors are familiar with and understand how to implement these guidelines. This is not the case at this time in Papua New Guinea. Therefore the option of providing very specific clauses in the contract detailing measures and actions required on the part of the contractor is probably the best way to proceed.

To be Included in the Bill of Quantities (and usually also in the Contract)

The recommended mitigation measure should be included as an item in the Bill of Quantities. This will ensure that the item has been budgeted for and will be implemented as required.

There are two approaches to deal with the incorporation of environmental management costs into the bids prepared. One is to request that the contractors include these costs in their rates. Although this works well in some instances, in many cases the contractors, in the interests of remaining competitive, will not adequately reflect the real cost of environmental mitigation in their bids.

The second approach, recommended above, presents the mitigation measure as a line item in the Bill of Quantities. There is an identified extra payment in the contract to ensure that the work is carried

out by the contractor as specified. An example of clauses that could be included in the Bill of Quantities is as follows:

- quantity of exactly how many cubic meters of spoil and excess material in cubic meters that must be disposed
- the number of hectares that must be replanted or revegetated and the cost per hectare (or m2)
- cost of recommended erosion control structures (if over and above those that would normally be constructed as part of normal engineering design)

The specific mitigation measures should also be assigned estimated costs and included in the bidding documents. This could be undertaken by the staff of IPBC/EDA RANU and the agency concerned, e.g. DOW and DEC. The potential impacts identified in the Environmental Impact Assessment are then addressed through mitigation measures in the Environmental Management Guidelines (EMG).

Earthworks

Clearing of ROW

There will be clearing of the existing ROW for the excavation of trenches for the sewer lines and pump stations sites. There will be a significant loss of vegetation or gardens along the roadside as a result of the clearing exercise. Where it is necessary to remove large trees and other desirable vegetation local landowners should be consulted and the cleared material made available to them for disposal. If any stakeholders experience loss of crops or fruits trees, they must be appropriately compensated based on an agreed rate in most cases to the Valuer Generals Compensation List.

Earth Works Relating to Excavation and Cut and Fill Activities in Flat Areas

These activities consists of excavation work for the sewer lines, pump stations and cutting and filling activities on the access roads and could include the removal of roadside vegetation. In addition, construction and demolition debris with pavement debris, concrete, asphalt and wood stumps will need to be carted away to designated dumps or be reused as fill material. The main environmental impacts would relate to possible increased sedimentation and erosion.

Earth Works in the Vicinity of Settlements along the Roadside

This could disturb local market activities and affect pedestrian walkways. Even though the earthworks would be undertaken within the ROW, there is the possibility that illegal structures have been constructed, which could be affected. If so, users and owners of these structures would need to be compensated.

Kila Kila STP & Morata Disposal Site

At Kilakila, extensive excavation will be required for a firm foundation for the STP and the associated housing compound for workers for a longer duration. Hence, appropriate mitigation measures are required for the disposal of spoil, waste rock and construction equipment debris. There may be blasting of rock surfaces and the resultant noise and dust pollution. Handling of explosives is an activity to be carried out by licensed persons.

Pavement Work

Construction of Base or Sub-Base Course, Re-gravelling

This involves the use of heavy, noisy equipment and can cause noise and air pollution disturbances.

Material Transport

This includes the transport of all construction materials such as rock, gravel, bitumen, concrete or other material as well as the transport of equipment or machinery. Again, minor environmental impacts would include noise and dust pollution.

Drainage Work

This includes all drainage works such as culverts and drainage ditches. The main anticipated impacts are the possible effects of increased sedimentation in surrounding water bodies as a result of inappropriate deposition of excavated materials and associated disturbances.

Bitumen Works

Establishment and Operation of Asphalt Plants or Asphalt Preparation Areas

This refers to the activities associated with the preparation of the concrete or asphalt and could involve a large production plant with conveyors, oil fired aggregate heaters and dryers and batch mixers, or it could simply involve the heating of bitumen over wood fires and hand mixing. Some of the potential environmental problems include spills or improper handling of bitumen and contamination of nearby water sources may also result in air pollution, particularly dust and smell.

Bitumen Overlay

This includes the laying down of the various bitumen sealing or resealing surfaces such as single bituminous surface treatment (SBST), double bituminous surface treatment (DBST) or asphaltic concrete.

Erosion Protection - see Earth Works

Kila Kila STP and Housing Complex

Equipment Mobilisation

Includes the delivery of materials, plant and equipment to the site and involves large transport vehicles which cause air and noise pollution. May also result in traffic and safety problems and damage to vegetation where separate haul roads are provided.

Mobilisation of the Labour Force

Refers to the arrival of an outside labour force for construction activities. These newcomers may be culturally or ethnically different from people in the area and in Papua New Guinea this can have significant impacts. Potential health impacts are also possible.

Establishment and Operation of Workforce

This refers to the camp established to house the non-resident workforce. The major problems with the labour camps are the pollution caused by waste and sewage disposal and the potential use of local resources in an unsustainable manner (for instance, fishing activities).

Establishment and Operation of Project Camps

The project camps are where the equipment and machinery is stored when not in use, and where fuels, oils and other materials are stockpiled. The project office may be located here. Occasionally the labour camp and the base camp are one and the same, but they have been examined separately for the purpose of this EMP. The main potential problems here include contamination of water through spills of oils and fuels or improper storage. Within the camp, the wastes from garbage and all construction debris will need to be collated and disposed off at appropriate landfill sites. Waste segregation is essential with the practise of the three Rs, Recyclable, Reduce or Reuse.

Marine, Fringing Reef and Water Quality

The dredging, removal of sediments for the laying of the effluent pipe will create temporary siltation in the water column and silt traps are proposed for mitigating these impacts. Monitoring for oil and grease has been put in place in the monitoring section.

Corals will be removed and transplanted before pipes are laid. Monitoring of water quality will also be part of this EMP to ensure marine community returns after the construction period and to ensure the STP is functioning as designed.

Social, Traffic and Occupational Health and Safety issues are addressed through appropriate environmental management guidelines.

6.5.3 Environmental Management Guides (EMG)

The scope of work and activities within POMSSUP is focused on the laying of branch and trunk sewer lines, the rehabilitation and upgrading of pump stations, constructing the Oxidation Ditch Sewage Treatment Plant at Kila Kila and Disposal Sites at Morata. In addition sealed access roads to and from Kila Kila and Morata are needed. In the marine area, the laying of sewage outfall pipeline out to the Joyce Bay is an addition major works within the POMSSUP. The project work covers a period of four years from 2012 to 2016 and it is essential that appropriate management and mitigation measures are in place. There will be construction work on traditional land, settlement houses and land and hence the mitigation measures for this are stated here.

Besides these areas and their mitigation measures, there is also the need for environmental mitigation measures that are not part of the engineering design and will assist in ameliorating impacts. These would be such tasks as having water carts on the road to suppress dust during construction, the removal of camps and infrastructure after completion of work. In the latter task, it may be included in the mobilisation costs that contractors submit within their bid, hence it may not be considered an issue. However, some costs were obtained for these items and are in the specific EMGs. The following EMGs are listed here which are specific to the activities as identified in Section 4 and 5 of this EMP. To guide the user, Table 3 provides a summary of the EMP where the environmental impacts from the POMSSUP and its mitigation measures are stated.

EMG 1: Land Acquisition, Clearing of Right of Way, Resettlement and Social Issues
EMG 2: Earth Works
EMG 3: Pavement Work (refer to EMG 6)

EMG 4: Drainage Work (refer to EMG 2)
EMG 5: Bitumen Work
EMG 6: Dusts and Noise Control
EMG 7: Kila Kila STP and Housing Management
- Equipment Mobilisation (refer to EMG 6)
- Mobilisation of the Labour Force (refer to EMG 16)
- Establishment and Operation of Labour Camps
- Establishment and Operations of Base (Construction) Camps
- Material Transport (refer to EMG 6)
- Explosives, Combustibles and Toxic Materials Management

EMG 8: Marine Works
EMG 9: Traffic Management
EMG 10: Occupational Health and Safety
EMG 11: Transportation of Sludge

Table 3: EMP Summary Showing Activities, Potential Impacts, Mitigation Measures and EMG (Source: JICA Study Team)

Activities	Potential Impacts	Mitigation Measures	EMG
1.Land Acquisition, ROW Clearing, Resettlement & Social Issues	• Disturbances on part of affected landowner, community • Disturbance from construction activities • Safety problems and issues • Cultural and archaeological areas including cemeteries uncovered	Community consultation and participation; early surveys; use agreed community relations network established by Eda Ranu, NCDC and Department of Lands. Consult National Museum for artefacts excavated.	EMG1
2. Earthworks Excavation of trenches for sewer lines;Excavation of area for pump stations Excavation for STP and Disposal Sites Excavation for access road	• Spoils and material that could erode into drains, nearby structures and catchment areas; • Damage to and removal of trees, vegetation and topsoil; Disruption to natural drainage systems; Surface water pollution and increased sedimentation Vibrations, noise and dust generation, traffic and safety problems and damage to roadside vegetation. Disturbance of natural land contours; Accelerated erosion and sedimentation; landslides and slope stability; noise vibration and dust; accidents	a. Limit spoils, not into sensitive areas, stockpiles to be secured to be stable. See EMG2. b. Use conventional civil engineering structures to contain fill material eroding, clear drainage c. Refer to b; Spoil to be discarded after consultation with community; Bare areas to be vegetated. Area to be vegetation to be encouraged after ceasing of activities; consultation with communities Site to be stable with proper drainage of rainwater, order of activities to avoid traffic accidents	EMG2 EMG 2 EMG 2 EMG 5 EMG 6
3. Pavement Works a. Base and Sub Base Construction & Re-gravelling	• Vibrations, noise and dust generation, traffic and safety problems and damage to roadside vegetation. Runoff from sub base and road base material; Disruption into creeks or drains and increased sedimentation	Similar measures as in 2a; Stockpiles to be covered and used immediately; avoid huge storage so as to minimise run off into creeks and rivers Regular dust suppression on roads and on quarry area; Equipments with mufflers and activity, only during normal working hours.	EMG 6
4. Drainage Works	• Scouring of valley slopes resulting in landslide; Damage to and removal of trees, vegetation and topsoil; Disruption to natural drainage systems; Surface water pollution and increased sedimentation Scouring of surface and spoil, concrete and other materials into creeks and catchment	Measures to be that of ensuring less spoil to be in the way of drains, properly constructed and allows for water to flow and flushed out sediments. Limit spoils; drainage work to be down during dry season to avoid rainy season that will interfere with concrete works.	EMG 2
5. Bitumen Works a. Asphalt Plants and Preparation Area b. Bitumen overlay	• Release of bitumen into the environment and runoff of bitumen into surface water causing water pollution; deforestation resulting from the use of fuel wood to heat bitumen; air pollution, smell • Improper use of bitumen drums e.g. as drinking water storage containers. Adverse health impacts of solvents and chemicals	a. Proper siting of the plant away from settlement or village, use asphalt only on fine days; bitumen drums in bunded area; clean up of areas after activity. b. Similar to a: Ensure proper preparation for gravel layout and application for bitumen Educate the users of old bitumen drums about the dangers of using these as drinking water storage drums.	EMG 5 EMG 5

Activities	Potential Impacts	Mitigation Measures	EMG
6. Noise and Dust Control	• Runoff from sub base and road base material; Disruption into creeks or drains and increased sedimentation	Regular dust suppression on roads and on quarry area; Equipments with mufflers and activity, only during normal working hours.	EMG 2
7. Kila Kila STP Management a. Equipment Mobilisation b. Labour Force Mobilisation c. Labour camps d. Base (construction) camps e. Material transport Increased Traffic and Operating Speeds f. Explosives, Combustibles and Toxic Material	a. Vibrations, noise and dust generation, traffic and safety problems and damage to roadside vegetation. b – d) External labour force with different attitudes; introduced STD and HIV;Deforestation, use of fuelwood; competition for scarce natural resources;pollution of surface and ground water from unsanitary waste disposal practices; illegal hunting and fishing by camp residents. e. Vibrations, noise and dust generation, traffic and safety problems and damage to roadside vegetation. f. Increased traffic speeds along the road with likely accidents g. Fire and explosive hazard; ground and surface water pollution from pollution runoff; infiltration from spills and/or leaks; improperly discarded oils and lubricants	a. Similar to 1e; Equipment (including aggregates, spoils, fill materials) to be well contained on transport so as not to be an hazard to people and the environment b. Maximise local labour, provide appropriate training and familiarization for outsiders; rules and regulations enforced. c. Similar to b: Camps away from villages; not impact on local drinking water; good waste management practices d. Good waste management practices; buildings properly constructed with well contained storage areas; removal of waste at the end of activity and clear up area. e. Similar to 1 a: Material could mean aggregates or chemicals or other equipments, that must be well contained so as not to impact on the environment. f. Measures outlined in 1e;2a;5a and 5e. Road improvement will mean reduced driving times and appropriate signs and speed humps to be in place during construction phase. g. Management of storing hazardous materials in marked areas to avoid possible impacts within the camp and to humans. h. Provision of proper sanitation facilities.	EMG 6 EMG 7 EMG 7 EMG 6 EMG 7 EMG 7 EMG 7
8. Marine Work, Fringing Reef & Water Quality	Sediment scouring; impact on sea floor, fringing reef marine sedentary species; water quality in immediate water column to be impacted	Silt fence to be in place during construction of pipe trench; sediment excavated to be taken and released into deeper sea so sediments can sink to the ocean floor; corals to be relocated before construction; appropriate monitoring plan in place; see section 2.6 Also appropriate consultation with community and commercial fishermen.	See Monitoring section, section 6.7 and EMG 8
9. Traffic Management	Temporary increase in traffic flow on the road network leading to potential for delays and congestion; short term closure and diversion of roads; traffic accidents	Appropriate traffic management plan with responsibilities for contractor to liaise with appropriate authorities during detailed design and construction. Communication through media to inform general public	EMG 9: Traffic Management Plan
10. Occupation Health & Safety	Worker subject to health and unsafety practices	Appropriate induction to be given to workers before construction and periodically during the duration of construction.	**EMG 10**
11. Transportation of Sludge	Bad odour from truck transporting sludge to Morata	Appropriate containment of sludge in compartments that contain and seal in odour. Appropriate signs on vehicle to inform public and awareness to be done through media	**EMG 11**

2.5.4 Supervision of Environmental Mitigation

The main objective of environmental supervision is to ensure that the recommended mitigation measures are implemented as required by the contractor. In the POMSSUP, the IPBC as the executing agency together with EDA RANU, as the implementer will need to supervise and oversee the activities from the detailed design phase and then through the construction and operational phase. Environmental management and mitigation measures are spelt out in the detailed Environmental Management Guidelines (EMG) and the appropriate manager and officers will need to ensure that these measures are effectively implemented by contractors or by themselves in the operational phase. The EDA RANU organisational structure in **section 1.7** indicated the appropriate division would be between the Sewerage Operation and Environment and Quality Control.

The Project Engineer is responsible for the day to day supervision, quality control, contract management, management meetings and certifying payments for work done. Any environmental queries or concerns can be addressed to the Project Manager who will liaise with the Environmental and Quality Control Manager and have environmental officers attend to them.

EMGs in **Table 3** and **Annex 1** of the EMP provide detailed monitoring and supervision recommendations for the engineer in charge of supervision. By including clauses into a contract document and specific items in the Bill of Quantities forming part of the contract, monitoring and supervision of the application of mitigation measures is automatically included in the normal engineering supervision of the contract on a day-to-day basis.

2.6 Environmental Monitoring

Environmental monitoring is essential in any project activities and it is designed to ensure that the mitigation measures designed to contain impacts are minimized or contained. Monitoring will be stated here within the two main phases of this project, namely Construction and Operational. A lot of impacts are envisaged during the construction phase as this will be numerous construction activities with carting and removal of debris or equipment, machinery and their accessories from within Kila Kila STP, the pump stations around the coastal area (**Table 1**). In addition, monitoring will be also in the marine section in Joyce Bay associated with the laying of sewage effluent pipeline. This will be to ensure impacts are contained within the pipeline corridor.

The monitoring of traffic along the main road for trunk and branch lines is essential and the Traffic Management Plan when developed will have mitigation measures. During operations, monitoring will be focused on the marine component. In addition, there is a need to ensure that toxic gases (H_2S) within the pump stations, the potential leachate from the sludge disposal site together with handling of disposal of rubbish within the Kila Kila STP and Morata STP are in order. The trucks transporting the sludge will need to have appropriate signs and awareness carried out to alert the general public about the contents and the potential impacts if there is an accident and spillage. As stated in the EMG, it will need to follow a routine delivery timetable so that it is not caught up in traffic.

Furthermore, monitoring will need to;

- Demonstrate the effectiveness of the proposed sewerage facilities construction and operational procedures so that the consumers are satisfied;
- Collect data which can be used to evaluate whether the assumptions used in the environmental assessments and technical basis are valid estimates;
- Ensure that quality assurance and quality control procedures are followed; and;
- Conduct additional monitoring to investigate any complaints or reports of adverse effects on public health, worker safety and environmental quality related to the construction and operation of the proposed sewerage facilities.

The monitoring plan covers monitoring activities during construction and operation phases since impacts are expected to occur during these stages in project development. The proposed monitoring plan discusses the following elements:

- Activities/parameters to be monitored;
- Specific areas to be monitored;
- Manner of monitoring;
- Frequency of monitoring; and
- Institutional responsibilities for monitoring and data management.

Monitoring is expensive, however with trained manpower, costs for undertaking these will be reduced. A certified laboratory is also required to provide accurate analysis of samples. Here, the parameters

considered are those essential for protecting the environment, managing the system, and safeguarding the personnel and the population.

2.6.1 Construction Phase

2.6.1.1 Water Quality Monitoring

During the construction phase, ambient water quality monitoring at ocean outfall construction site will be conducted by the Contractor. Results of the analysis will be submitted to for control. Validation to confirm the results will be undertaken by IPBC and EDA RANU as the need arises.

Monitoring methods (Items, frequency, number of water sample); monitoring items, frequency, method and implementer are shown in Table 4.

Table 4: Water Quality Parameters for Ocean Outfall during Construction

Item	Unit	Frequency	Method	Implementer
Transparency/ turbidity	-	Everyday	Visible Inspection	Contractor (self monitoring)
SS (Suspended Solid)	mg/l	Weekly	Mass Balance method, Dried 105~110 °C	Contractor IPBC / EDA RANU
Oil/Grease	mg/l	Everyday	n-Hexane extractable material method	Contractor IPBC / EDA RANU

(Source: JICA Study Team)

Locations of ambient water sampling points; monitoring of ambient water quality during construction shall be carried out in at least four sampling stations at the path of the ocean outfall construction sites.

2.6.1.2 Coral Reef Removal

The marine survey estimated that 240 coral boulders will be removed from the pipeline corridor and later transplanted elsewhere. This is a total area of 6,000 square metres that will be disturbed directly requiring removals from the 30m wide pipeline corridor. Table 5 illustrated where the coral will be removed. The zones are explained in Table 10 – Annex 2 referring to the identified marine areas with corresponding depth.

Table 5: Estimated Coral Removal from Pipeline Corridor

Zones covered	Coral Count	Total Boulder Corals
Zones B – C Approx. 6,000 sq. meters of coral area. Depths -1.11 to -1.58 m	10 coral boulders per box (10m x 10 m) x 30 along the western alignment of pipeline.	140
	5 coral boulders per box (10m x 10 m) x 30 along the eastern alignment of pipeline.	70
Zones E – F Coverage along the pipeline route. Depths -1.58 to - 2.78m	Coral counts along 100 m line.	30
	Total	**240**

Source: JICA Study Team

Methods for Coral Removals and Transplantation

Coral removals will be done by digging trenches for the pipeline to dislodge the boulders and lifted out for transplanting elsewhere. For the areas not trenched, this will require digging around the rock base to be dislodged and removed.

Coral transplantation will involve digging up shallow depressions at the new location. It is suggested that replanting occurs only inside the pipeline corridor so as to minimize silt plumes and deposits over a wider area.

Removing corals and transplanting will result in plumes of silt along the corridor and sedimentation. In both instances, silt fence will be necessary to reduce such impacts on the marine environment. Constant daily monitoring during construction will be necessary to ensure silt dispersals and dispositions into other areas are minimized.

2.6.1.3 Coral Reef Monitoring

During the construction phase, transplanted coral and coral reefs along the pipe route will be monitored both by the Contractor and IPBC/EDA RANU. The parameters (Items, frequency, number of water sample); monitoring items, frequency, method and implementer are shown in Table 6.

Table 6: Monitoring Parameters for Coral Reefs during Ocean Outfall Construction
(Source: JICA Study Team)

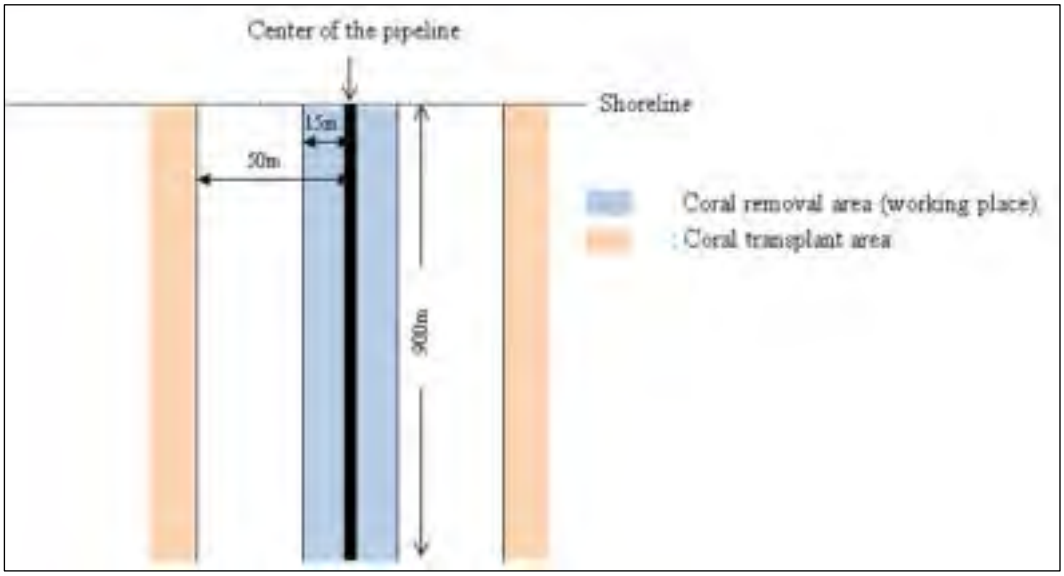
Item	Objective	Procedure	Frequency	Period	Implementer
Recovery rate of transplanted coral reef	Rate of Recovery / Success of transplant	Visual inspection	Once a month for the first three months, every three months for next nine months, thereafter every six months	Three years from transplant	Contractor/IPBC-EDA RANU
Recovery rate of corals along the pipe route	The effect of ocean outfall construction works	Visual inspection by quadrat method	Two times in a year	During construction and one year after construction	Contractor/IPBC-EDA RANU

1) Locations of coral reefs monitoring points

It is essential to indicate where coral reefs will need to be transplanted and Figure 5 illustrates the layout of how the coral will be transplanted

The area of impact was determined to set the limits of coverage severity to the marine life, although this will not be for a longer duration. Any impacts are likely to be confined to the immediate vicinity of the pipeline route, about 15m on each side. Considering the size of the pipe (dia.700mm), the high precision of pipe laying and the needed work space, the area of influence would be no more than a 30m corridor.

Figure 5: Layout for Coral Removal and Transplant (Source: JICA Study Team)



2.6.2 Operational Phase

Water quality monitoring of inlet/outlet sewage and ambient water (sea water) will be conducted during operation of Kila Kila STP. In addition, coral reefs monitoring will be conducted at the transplanted site, discharge point and vicinity of the pipeline route. Both monitoring will be implemented by EDA RANU Environment and Quality Control Department.

2.6.2.1 Water Quality Monitoring

1) Method

Water quality monitoring items are stated in **Table 7**.

Table 7: Water Quality Parameters at Sewage Outfall (Source: JICA Study Team)

Inlet and Outlet Sewage	pH, SS, BOD, COD_{Mn}, T-N, T-P, Total coliform Oil/grease, Temperature
Ambient water (sea water)	pH, SS, COD_{Mn}, T-N, T-P, Total coliform, Oil/grease, Temperature

Monitoring frequency, method and implementation of inlet/outlet sewage and ambient water (sea water) are summarized in Table 8.

2) Locations of water sampling points

Here, water quality samples will need to be collected at the following points to ensure compliance with the monitoring schedule:

- Inlet sewage: at grit chamber
- Outlet sewage: at treated water tank
- Ambient water: at boundary of the Mixing zone[13] (50 m offshore from the discharge point)

Table 8: Water Quality Monitoring during Operations (Source: JICA Study Team)

Items	Frequency		Method
	Inlet/Outlet Sewage at KilaKila STP	Ambient Water (seawater)	
pH	Everyday	Monthly	Glass-electrode method
Suspended Solid (mg/l)	Everyday	Monthly	Mass Balance method, Dried 105~110 ^{o}C
BOD_5 (mg/l)	Every 5days		Dissolved Oxygen Depletion
COD_{Mn} (mg/l)	Everyday	Monthly	Titrimetric manual
Total Nitrogen (mg/l)	Weekly	Monthly	Colorimetric Automated Phenate
Total Phosphorus (mg/l)	Weekly	Monthly	Molybdenum blue absorptiometry method
Total coliform (MPN/100ml)	Weekly	Monthly	Most Probable Number (MPN)
Oils & Grease (mg/l)	Every 5days	Monthly	n-Hexane extractable material method
Temperature (^{o}C)	Everyday	Monthly	Attached with pH/ORP meter

2.6.2.2 Coral Reef Monitoring

During the operational phase, monitoring will need to be on the following parameters; i) recovery rate of transplanted, ii) coral reefs along the pipe route and near outfall point, and iii) recovery of benthic communities. These will be monitored by IPBC/EDA RANU Environment and Quality Control Department.

1) Methods

Monitoring items, frequency, method and implementer are shown in **Table 9**.

[13] Mixing Zone: A discrete body of water into which waste is discharged and where the prescribed water quality criteria are not required to be met and the protection of aquatic life may not be guaranteed (Environment water quality criteria regulation 2002). In case of sewage discharge into sea, the Mixing Zone has been specified within a 50m radius surrounding the discharge point in the permit.

Table 9: Coral Reef Monitoring during Operational Phase (Source: JICA Study Team)

Item	Objective	Procedure	Frequency	Period
Recovery rate of Transplanted coral reef	Rate of / Recovery Success of transplant	Visual inspection	Once a month for the first three months, every three months for next nine months, thereafter every six months	Three years from transplant
Recovery rate of Nearby discharged point	The effect of discharged water	Visual inspection by quadrat method	Two times in a year	Three years from start of operation
Recovery rate of Coral reef around the buried pipe zone	The effect of buried pipe	Visual inspection by quadrat method	Two times in a year	During construction and one year after construction
Recovery of marine biological community	Recovery confirmation of marine biological community	Visual examination	Once a month for the first three months, every three months for next nine months, thereafter every six months	Two years after construction of buried pipe

(a) Locations of coral reefs/benthic communities monitoring points

Coral reefs monitoring points are:

- Transplanted area: refer to Figure 5.
- Nearby discharge point: boundary of the Mixing zone (50 m offshore from the discharge point)
- Corals along the pipeline route: 15 meters line on both sides of the pipeline route
- Recovery of benthic communities: at boundary of the Mixing zone (50 m offshore from the discharge point)

2.7 Public Awareness and Consultation

Public awareness and consultations is essential for the Project to be made aware to the general public in the NCD through appropriate means such as through the NCDC Regular TV Programs and through the print media. It will be also useful for consultation meetings at Hanuabada, Kila Kila and Morata to provide information and also hear possible grievances from the public. Another medium is through the production of one or two page brochures that the general public will be aware of the activities of the POMSSUP. These will need to be in English, Pidgin and Motu. Ongoing consultations will also take place throughout the implementation of the Project.

There is also a need to notify the community and commercial fishers about the Construction and Operation Activities. A community awareness program should be carried out to inform inhabitants of villages situated along the coastline of Joyce Bay about the construction of pipeline landfall including likely timing and the dangers associated with approaching barges and work vessels.

Consultation should include issues such as:

- Project impacts to fishing and resources.
- Access issues and exclusion zones.
- Safety aspects (traffic dangers, approaching traffic too closely, fire/burning etc.).

Annex 1:

EMG 1: LAND ACQUISITION, CLEARING OF RIGHT OF WAY, RESETTLEMENT AND SOCIAL ISSUES

Activities: Acquisition of and clearing of the right-of-way (ROW), road operation

Potential Impacts: Dissatisfaction on the part of affected communities with indemnities offered

Disturbances from construction activities,

Safety problems

Areas of historical or archaeological significance could be discovered and affected

Environmental Mitigation:

Recommended Measures:

Advise the local community of project plans in advance and wherever possible involve them in planning. The road should be designed so as to minimise affected properties. All land acquisition and other activities within EMG1 should be guided by Eda Ranu's community relations policy

Surveys shall be conducted as early as possible during feasibility in order to ensure that all affected people are identified and that negotiations commence.

Surveys shall identify any other infrastructure, such as water supplies, schools, and other infrastructure that will be affected or lost as a result of the project.

Adequate compensation shall be provided to all affected landowners according to standardised procedures and agreed-upon prices, in accordance with the accepted practice of the government and LLG.

If possible, identify suitable land for resettlement if this is necessary.

Identify culturally sensitive areas. If a historical or archaeological site is discovered during construction, all activity shall stop until the appropriate authorities have been notified, in this case the PNG National Museum and Art Gallery.

All required safety measures shall be implemented. This includes occupational health and safety requirements on construction sites and in work camps.

Maximise the opportunities for local people on the project. This could include hiring of day labour for gravel crushing, maintenance of revegetation areas, and any other activities.

Communities and landowners shall always be consulted on the disposal areas, removal of trees and other vegetation, and stockpiles for spoil material.

Inform communities of grievance mechanisms available so that they can voice any concerns that they have. Grievances should be dealt with expediently.

Implementation:

Project Design:

The road shall be designed so as to minimise the need for property acquisition and resettlement. Widening on only one side shall be undertaken where appropriate to minimise affected properties.

The road shall be designed with all required measures to ensure a safe environment. This shall include the appropriate road signs, pull-off bays for buses and pedestrian crossings.

Contract Clause:

The contractor shall comply with the environmental mitigation measures specified in this EMP and the Environmental Impact Assessment Guidelines for Papua New Guinea.

Bill of Quantities:

The cost of compliance with the above requirements shall be at the contractor's own expense and shall be included in the contractor's rate for supplying materials.

Supervision Note:

Monitoring:

The Engineer in liaison with the Public Relations and Community Liaison Officer, NCDC and the Provincial Lands Office shall monitor the following parameters:

Parameters:	Indicators:
The process of land acquisition	Ensure that affected parties are satisfied and receive and compensation payments promptly (before commencement of works)
Legal requirements:	Ensure that legal requirements are being fulfilled.
Grievances	Ensure grievances are dealt with promptly.

EMG 2: EARTH WORKS RELATING TO EXCAVATION AND CUT AND FILL ACTIVITIES

Activities:	Movement and disposal of excavated spoil and surplus construction material, cut material, drainage cleaning debris and landslide mass
Potential Impacts:	Scouring of valley slopes resulting in landslides
	Damage to and removal of trees, vegetation and topsoil
	Increased erosion and slope instability
	Destruction of private property, crops and irrigation systems
	Disruption to natural drainage systems

Surface water pollution and increased sedimentation

Carelessly dumped spoil is aesthetically displeasing

Disruption to pedestrian walkways and local market areas

Environmental Mitigation:

Recommended Measures:

The first priority shall be to use excess material in the construction works as engineered fill material for pipe trenches, site grading, or as embankment, as a base coarse material. The materials could be used for stone masonry works or as drainage outfall retainment wall. Discarded materials that cannot be used in construction and fill may, if suitable, be used for bio-engineering measures. All other excess material shall be disposed of in locations or landfills that will not promote instability and result in destruction of property, vegetation, irrigation and drinking water supply systems. Where possible, spoil should be used to backfill quarries or waste disposal pits before they are revegetated. Spoil can be disposed of in designated areas locally after discussions with landowners or community groups. If so a clear level site must be prepared on which the spoil can be dumped. Close to market areas, discussions must be held with the local community and pedestrian walkways should not be blocked off.

Ground disturbance shall be phased so that it is limited to areas of a workable size.

Construction should be phased so that large areas of soil are not laid bare during the wet season. If the spoil heap or stockpile containing fine sediments is to remain bare for long in a high rainfall area, it should be covered to prevent erosion and sediment runoff. Exposed areas shall be planted with suitable vegetation at the earliest opportunity in order to minimise the time surfaces remain bare.

Spoil material may be discharged to a landfill that is constructed using a series of small spoil benches to prevent slope overloading. If feasible, spoil material shall be disposed of in an abandoned quarry or borrow pit as a means of restoring the natural contour. The stockpile or spoil heap location should be chosen to avoid blocking surface runoff or drainage lines. If this is not a ridge crest or flat plain site, the base should be levelled and contained. Sediment basins may need to be constructed off the creek paths to contain sediment run off and this will be based on the design and scope of the work.

Implementation:

Project Design:

Mass balance techniques shall be employed in designing cut and fill along the road alignment. Safe tipping areas for surplus mass shall be identified in the project design specifications and plan drawings.

Contract Clause:

The Contractor shall comply with the environmental mitigation measures specified in this EMP and the Environmental Impact Assessment Guidelines for Papua New Guinea.

Bill of Quantities:

A separate line item shall be included for excavation and environmentally safe disposal of xx m3 of spoil and excess material resulting from excavation of new earthen drains and filled up existing drains and culverts, cleared landslide debris and other estimates of excess materials. For any revegetation activities, the Bill of Quantities shall include a clause for partial payment of 50% to the contractor when planting is complete. The remaining 50% shall be paid once the seedlings have taken root or for two growing seasons.

Supervision Note:

The Engineer shall identify environmentally sound tipping areas in addition to those specified in the project design specifications. The engineer shall consult with local residents when identifying new tipping areas. The engineer shall also ensure that the contractor and construction work force are aware of and comply with the disposal restrictions.

Monitoring:

The Engineer shall monitor the following parameters:

Parameter	Indicator
Stability of spoil area	Presence of slides, scouring, erosion or destruction of property in valleys, disruption of water supply systems and irrigation systems, complaints from local residents.
Vegetative cover is maintained	Survival rate of plants. Frequent follow up with community

EMG 3: PAVEMENT WORK (SEE EMG 6)

EMG 4: DRAINAGE WORK (SEE EMG 2)

EMG 5: BITUMEN WORK

Activities: Location, preparation and application of bitumen compound to road surfaces

Potential Impacts: Release of bitumen into the environment and runoff of bitumen into surface waters causing water pollution

Deforestation resulting from the use of fuel wood to heat bitumen

Air pollution, smell

Environmental Mitigation:

Recommended Measures:

The contractor shall use bitumen emulsion. Fuel wood shall not be used for heating bitumen. Asphalt batching plants shall be located at least 300-500m downwind of any settlements or inhabited areas and at least 150 m from any water bodies, streams or rivers.

Bitumen shall not be applied during strong winds and rains. No bituminous materials shall be discharged into side drains, nearby trees, vegetation and private property shall be protected during bitumen spraying work.

Oil and bituminous products should be stored at a contained location away from natural drainage areas. Bitumen drums shall be stored in designated locations and not scattered along the road. After construction, the contractor shall ensure that the bitumen preparation area is properly cleaned up and that all wastes are properly disposed (see environmental mitigation requirements for Base Camps relating to wastes). During site clean-up, the contractor shall burn all spilled fuel oils.

Implementation:

Project Design:

Contract Clause:

The Contractor shall comply with the environmental mitigation measures specified in this EMP and the Environmental Impact Assessment Guidelines for Papua New Guinea.

Bill of Quantities:

Bitumen emulsion shall be specified in the materials to be supplied by the contractor.

Supervision Note:

Monitoring:

The Engineer shall monitor the following parameters:

Parameters:	Indicators:
Compliance with requirements:	No usage of fuel wood, proper management of site.

EMG 6: DUST, NOISE AND FUMES CONTROL

Activities: Earth movements, construction of base and sub-base course, re-gravelling, material transport, equipment mobilisation, establishment and operation of construction works and equipments at Kila Kila, Morata and along sewer line routes.

Potential Impacts:

Vibrations, noise and dust generation, traffic and safety problems and damage to roadside vegetation.

Environmental Mitigation:

Recommended Measures:

The Contractor shall ensure that road surfaces and work areas are sprayed with water during construction in dry and windy periods to control dust generation. Wind breaks or fences shall be installed around cement-batching plants and stone-crushing plants as deemed necessary, and quarry loads or load fill loads being carried in open trucks shall be sprayed with water.

Equipment used shall be as modern and well-maintained as possible (with mufflers where appropriate) to control noise pollution. Noise-generating activities shall be carried out during normal working hours. All the construction workers will be provided hearing protection such as earplugs in areas with noise levels not exceeding 75dBA.

Local residents shall be advised of any planned blasting or other unusual noisy activities. Mobilisation of equipment shall be well coordinated during transportation to site and authorities and local residents be advised by way of prior announcement and by using escort vehicles with indicator lights. The generation of smoke, dust, vapors and noxious fumes from construction and other equipment will be only by using equipment, which is in good condition and well-maintained at all times during work. Equipment or vehicles that emit smoke profusely shall be replaced immediately. Regular maintenance of all ventilators and air contaminant control equipment shall be carried out. That should not be any large scale burning of materials that may result in toxic and noxious gases and fumes or other emissions which pose health hazard and nuisance to workers on the construction site and neighboring communities. Construction activities will, as much as possible, be limited to daytime and early evening hours (7:00 AM – 7:00 PM). This is to avoid nuisance, trouble, damage or health problems in the nearby communities.

Implementation:

Project Design:

Contract Clause:

The Contractor shall comply with the environmental mitigation measures specified in this EMP and the Environmental Impact Assessment Guidelines for Papua New Guinea.

Bill of Quantities:

The cost of compliance with the above requirements shall be at the contractor's own expense and shall be included in the contractor's rate for supplying materials.

Supervision Note:

Monitoring:

The Engineer shall monitor the following parameters:

Parameters:	Indicators:
Compliance with requirements:	Noise, dust and fumes control procedures implemented. No visible dust or fumes generation during construction phase and acceptable noise levels

EMG 7: KILA KILA STP AND HOUSING WORKS

Equipment Mobilisation (refer to EMG 6)

Mobilisation of the Labour Force (See Establishment and Operation of Labour Camp)

Establishment and Operation of Labour Camp

Establishment and Operations of Base (Construction) Camps

Material Transport (refer to EMG 6)

Explosives, Combustibles and Toxic Materials Management

ESTABLISHMENT AND OPERATIONS OF LABOUR CAMP

Activities: Location, management, operation and closure of labour camp

Potential Impacts: Introduction of external labour force with different attitudes resulting in social conflicts

Introduced health problems such as HIV/AIDS and STDs

Reforestation, excessive use of fuel wood

Competition for scarce natural resources and food supplies

Pollution of surface and groundwater supplies from unsanitary waste disposal practices

Development of temporary camp into a permanent settlement

Illegal hunting or fishing by camp residents in the vicinity surrounding the camp site

Environmental Mitigation:

Recommended Measures:

Camps shall not be located near settlements or near drinking water supply intakes. They shall not negatively impact local residents' access to drinking water. Camps shall not be located in the vicinity of landslides and floodplains.

The camp shall be operated within a self-sufficient infrastructure. No trees shall be cut for fuel wood, and removal of vegetation shall be minimised. To prevent local inflation and the use of local fuel wood supplies, critical food items and alternate fuel for cooking shall be provided by the contractor. Local people shall be given the option to sell surplus food and fuel wood to the contractor if these items are in surplus and if the extraction of these resources is sustainable during the period of the project. The contractor shall prohibit employees from poaching wildlife and cutting trees. The contractor shall be responsible for the action of their workers.

Water and sanitation facilities shall be provided for the employees. In water deficient areas, the contractor shall haul water from a source outside the area. Solid waste shall be managed according to the following preference hierarchy: recycling, burial or burning. Green or organic wastes shall be composted or used as animal food. Water and pit latrines or septic tanks shall be provided for employees. Use above-water pit latrines or composting toilets or septic tanks at residential construction sites.

Sewage shall be disposed of into hygienic pit latrines or into a septic tank system. In low-lying areas the latrine areas shall be elevated and constructed on a mound of sandy sediment to control seepage into the local groundwater. The contractor shall recruit, to the maximum extent possible, local persons for the labour force, and shall provide appropriate training where necessary. All new employees on site must be informed of the rules and regulations in relation to the camps and the community at large.

Environmental Mitigation:

Recommended Measures:

At the conclusion of work, all wreckage, rubbish, or temporary works shall be removed or donated to local residents. All temporary structures, including sleeping quarters, cooking and food storage structures and latrines shall be removed to prevent encroachment within the right-of-way. The natural contours of the site shall be restored. The engineer shall report in writing that the camp has been vacated and restored to pre-project conditions

Implementation:

Project Design:

Contract Clause:

The Contractor shall comply with the environmental mitigation measures specified in this EMP and the Design Specification requirements in the standard specifications.

Bill of Quantities:

The cost of complying with the above requirements shall be at the contractor's own expense and should be included in the day work rates for labour, or priced in a separate Environmental Management and Restoration (Labour Camp) line item. For this line item, the consultant will prepare technical specifications for which the contractor will include a cost estimate.

Supervision Note:

The Engineer shall ensure that good relations are maintained between workers and local residents, and shall mediate disputes.

Monitoring:

The Engineer shall monitor the following parameters:

Parameters:	Indicators:
Camp is self sufficient in food, water and fuel:	No complaints from residents local prices remain stable
Provision of water and sanitation facilities:	Latrines constructed, no disruption in local water
Waste disposal:	Upon completion, camp site is neat and clean and no rubbish and materials remain.

ESTABLISHMENT AND OPERATIONS OF BASE (CONSTRUCTION) CAMPS

Activities: Location, operation and closure of base camps. Construction at Kila Kila STP

Potential Impacts: Temporary air and noise pollution from machine operation

Water pollution from storage and use of fuel, oils, solvents and lubricants

Solid waste from construction, concrete work, garbage and materials

Disturbances to local residents

Environmental Mitigation:

Recommended Measures:

The Contractor shall consult with the engineer before locating project offices, sheds and construction plants. Camps shall not be located near settlements or near drinking water supply intakes. No trees shall be cut and removal of vegetation shall be minimised. Construction camp sites should be placed on flat ground.

Water and pit latrines shall be provided for employees. Use above-water pit latrines or composting toilets at residential construction sites. Sewage shall be disposed of into hygienic pit latrines or into a septic tank system. In low-lying areas the latrine areas shall be elevated and constructed on a mound of sandy sediment to control seepage into the local groundwater.

Construction plant, workshop and storage areas shall be contained using a bund or trench, or isolated from other surface runoff, and cleaned and rehabilitated when construction is complete.

Used oil and lubricants shall be recovered and reused or removed from the site by the contractor. Explosives, oil, petrol and grease shall be managed according to the Hazardous Materials Management of the EMP. Solid waste should be managed according to the following hierarchy: recycling, reuse, reduce or burial or burned. This includes paper used in bitumen spraying. All stores within the construction site shall be properly contained. When feasible, local residents shall be encouraged to scavenger non-hazardous solid wastes that are no longer useful to the project.

At the conclusion of the project, all wreckage, rubbish or temporary works that are no longer required shall be removed or given to local residents. All temporary structures, including office buildings, shelters and latrines shall be removed to prevent encroachment within the road right-of-way and project area. The natural contours of the site shall be restored. All disabled machinery shall be removed from the project area. Exposed areas around the construction site at Kila Kila and Morata shall be planted with suitable vegetation. The engineer shall report in writing that the camp has been vacated and restored to pre-project conditions before acceptance of the works.

Implementation:

Project Design:

Contract Clause:

The Contractor shall comply with the environmental mitigation measures specified in this EMP and the Environmental Impact Assessment Guidelines for Papua New Guinea.

Bill of Quantities:

The cost of compliance with the above requirements shall be at the contractor's own expense and shall be included in the day work rates for labour, or priced in a separate 'Environmental Management and Restoration (Base Camps) line item. For this line item, the consultant shall prepare technical specifications for which the contractor will include a cost estimate.

Supervision Note:

The Engineer shall ensure that good relations are maintained between workers and local residents and shall mediate disputes. The engineer shall ensure that the contractor removes all installations and surplus materials, leaves the work site in a clean condition and restores areas damaged by asphalt mixing.

Monitoring:

The Engineer shall monitor the following parameters:

Parameters	Indicators
Provision of water and sanitation facilities:	Latrines constructed, no disruptions in local water supplies
Proper site closure:	Natural contours and site appearances restored. Engineer's report testifying to the restoration of the site.

EXPLOSIVES, COMBUSTIBLES AND TOXIC MATERIAL MANAGEMENT

Activities: Storage of explosives, petrol, diesel, oil and lubricants, bitumen and solvents; disposal of used oil, grease, lubricants and solvents, paint, acids for masonry clearing, chemical additives for soil stabiliser (calcium chloride) and concrete curing compound

Potential Impacts: Fire and explosion hazards

Ground and surface water pollution as a result of polluted runoff and infiltration from spills and/or leaks and improperly discarded oils, grease, lubricants and other hazardous material.

Environmental Mitigation:

Recommended Measures:

Hazardous material shall not be stored near surface waters or other drainage areas. All used lubricants, grease and oils, solvents, paint, acid for masonry cleaning, calcium chloride and concrete curing compounds shall be collected and recycled or disposed off site. Plastic sheeting shall be placed under hazardous material storage areas to collect and retain leaks and spills. Contaminated runoff from storage areas shall be captured in ditches and ponds with an oil trap at the outlet. Contaminated and worn plastic sheeting shall be packed into drums and disposed off site. All fuel drums should be contained in an earthen bund which will contain the potential spillages within the bund area for later disposal in designated areas.

Implementation:

Project Design:

Contract Clause:

The Contractor shall comply with the environmental mitigation measures specified in this EMP and the Environmental Impact Assessment Guidelines for Papua New Guinea.

Bill of Quantities:

The cost of compliance with the above requirements shall be at the contractor's own expense and shall be included in the contractor's rate for supplying materials.

Supervision Note:

Monitoring:

The Engineer shall monitor the following parameters:

Parameters:	Indicators:
Compliance with requirements:	Hazardous materials management procedures implemented. No visible puddle of oil or oil contaminated soil.

EMG 8: MARINE WORKS: See Environmental Monitoring (Section 6) together with this EMG

Activities: Dredging and scouring of sea bed to lay sewer outfall pipe

Potential Impacts: Release of sediments in water column causing sea water pollution

Sediments will cover other coral not removed from line of excavation

Oil and grease from operation machinery to be in the water causing sea water pollution

Environmental Mitigation:

Recommended Measures:

The Project Engineer should ensure sedimentation tank, silt curtains or traps and other good industry practice management controls when working in the area, particularly near the seaward extent.

Use gravel core and rock for construction of the cover material over the pipeline. Continue sediment monitoring.

Within dredging activities, the construction of the pipeline should be with procedures to ameliorate impacts that exceed project license conditions. Appropriate awareness should be given to the construction workers on the importance of the marine ecosystem and the importance on this to the surrounding community.

Prohibit works from exceeding the design disturbance width and enforce boundaries through use of markers/tape and worker awareness.

Appropriate daily monitoring is required to ensure contaminants are minimised during construction phase and later regular and periodic monitoring as per Environmental Monitoring (Section 6.6).

EMG 9: TRAFFIC MANAGEMENT PLAN

Activities: Excavation of trenches for sewer line and pump stations along right of way impact traffic flow

Potential Impacts: Temporary increases in traffic flows on the road network leading to potential for delays and congestion

Short-term closures and diversions of existing transport routes eg roads and paths where the sewer lines cross these routes, resulting in disruption to transport users

Visual intrusion, increased roadside litter and traffic-related noise and emissions

Impacts on natural resources where traffic needs to travel `off-road'

Loss of vegetative cover brought about by the construction of new roads

Water pollution from spills or accumulated contaminants on road surfaces and potential modifications to natural drainage patterns brought about by the construction of new access roads

Traffic accident which may result in death, injury or environmental damage.

Environmental Mitigation:

Recommended Measures:

The Contractor shall develop and submit a TMP as the basis for specific measures that will be implemented to mitigate any predicted impacts. The TMP shall include detailed procedures that demonstrate how the impacts of traffic on the city residence and business have been taken into consideration.

This TMP will need to be submitted within 30 days of the start of the construction phase; and this will have detailed project specific procedures that specify how the requirements of their work plan will be implemented to the satisfaction of IPBC and the appropriate traffic authorities prior to the excavation along the ROW.

In addition, the Contractor shall regularly update their TMP as the excavation/construction method is developed and vehicle movement requirements are identified in detail.

The Contractor will also:

- identify those responsible for carrying out and managing the procedures;
- reference the procedures and activities the Contractor will develop and implement;
- identify work to be undertaken on the roads prior to construction activities to excavate sewer line trenches;
- identify the routes that will be used by the contractor in hauling the sewer pipes, estimated numbers of traffic movements, speeds and times of travel;

- justify where a route has to pass through residential areas and the measures that will be used to ensure the safety of the community and minimise the nuisance impact of traffic movements;
- identify how existing road development plans have been taken into account in the identification of routes and road restoration measures;
- identify the programme of road restoration measures that are likely to be required post construction;
- appropriate measures and procedures for mitigating the impacts.

Implementation:

Project Design:

Contract Clause:

The Contractor shall comply with the environmental mitigation measures as specified in the EMP for this project and the Environmental Impact Assessment Guidelines for Papua New Guinea.

Bill of Quantities:

Supervising Note:

Monitoring:

The Project Engineer shall monitor the following parameters.

Parameters	Indicators
Compliance with requirements	Traffic movement properly coordinated with appropriate signage.

EMG 10: OCCUPATIONAL HEALTH AND SAFETY

These notes set out some information on procedures for having Occupational Health and Safety within the project.

All Contractors on all project activities (excavation of sewer lines, pump stations, Kila Kila STP and Housing construction, Morata Disposal Sites must be subject to an Occupational Health and Safety Induction. This would need to be carried out at the beginning of employment and carried out periodically to ensure employees are fully aware of the occupational hazards in the work environment.

During operation, all employees are to be equipped with appropriate clothing, safety boots and glasses (where appropriate) for them to be able to function properly.

An Occupational Health and Safety Plan will be made available to the Project Management and this will be a condition for the consideration of contractors bidding for project related work.

EMG 11: TRANSPORTATION OF SLUDGE

Activity: Transportation of Dewatered Sludge by closed-type dump truck

This set of notes provides guidance to the transportation of dewatered sludge after treated by dewatering machine at Kila Kila STP.

Sewage Composition & Health Concern

Activated sludge contains a range of components such as particulates, readily biodegradable organic materials, nutrients and heavy metals and sundry inorganic ions. The readily biodegradable organic materials include carbohydrates, lipids and amino acids particulates. They may cause acute and chronic toxic effects, bioaccumulation, endocrine disruption and aesthetic problems. Nutrients such as Nitrogen, Phosphorus, and Ammonia may cause Eutrophication, Toxicity and Shifts in population of organisms. Heavy metals and sundry other inorganic ions include cadmium, chromium, cobalt, lead, nickel, mercury, arsenic and cyanide. Toxicity will be severe and that relates to their individual speciation. Their fate in sewage treatment plants could be complexation, sorption, precipitation, methylation and other microbial metabolism.

Transportation

Hence, the sludge needs to be transported in a designated truck that contains the sludge so that there is no possibility of it being exposed to the air or land or water ways during transportation to Morata disposal sites. The frequency of delivery is on a daily basis from Kila Kila STP to Morata.

It is also useful for awareness through the print media and through television highlighting to the city residence of the need for the transportation vehicle (s) so that the vehicle is given priority when transporting this wet sludge. Discussions with Traffic and Road Transport Division are essential to ensure arrangements are fully amicable.

Annex 2: Additional Layout of POMSSUP and Infrastructure

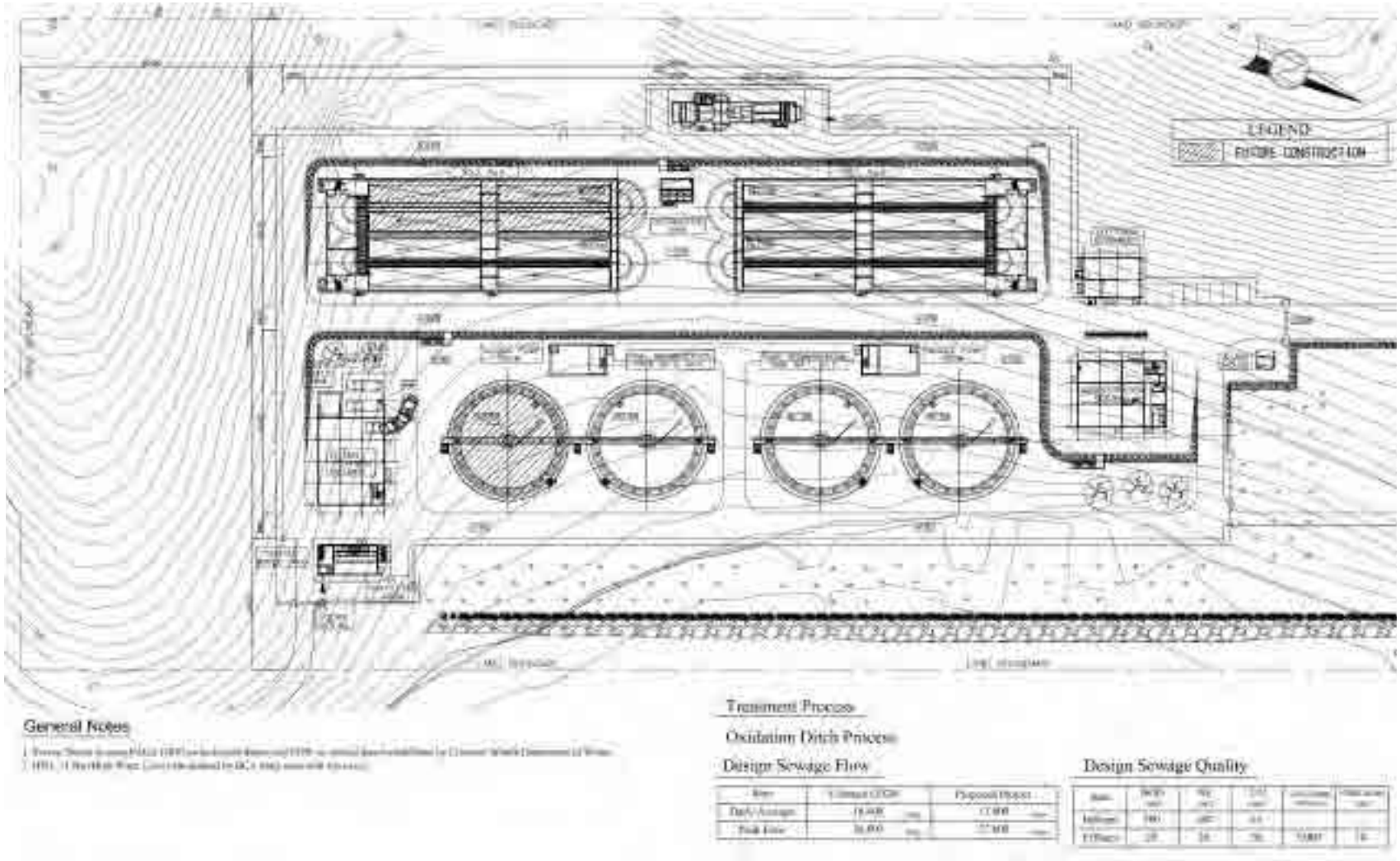
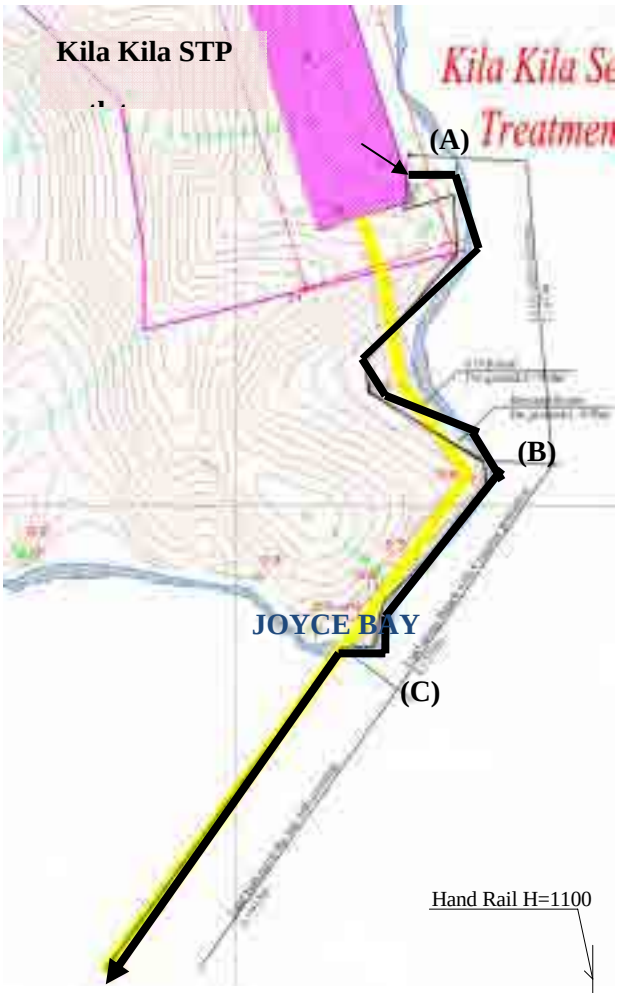
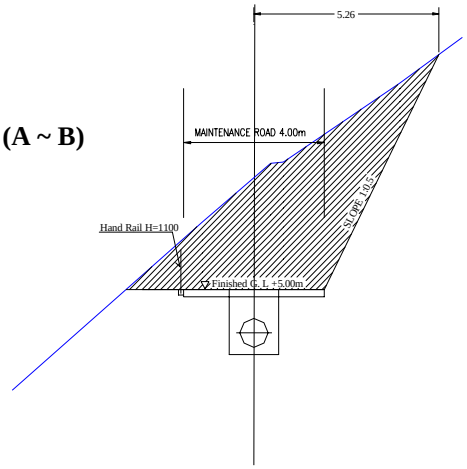


Figure 6: Kila Kila Sewage Treatment Plan: General Layout Plan



(A ~ B)



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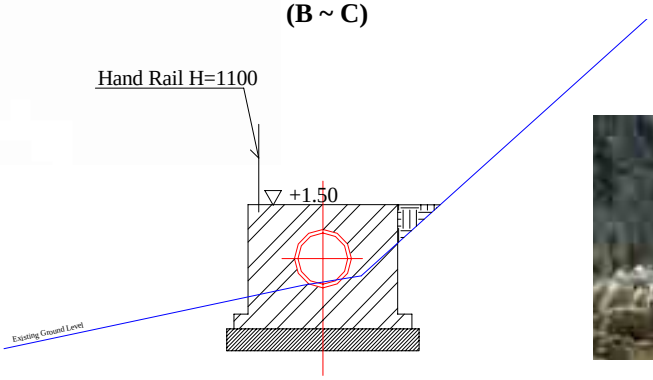


(C ~discharge point, L=900m)

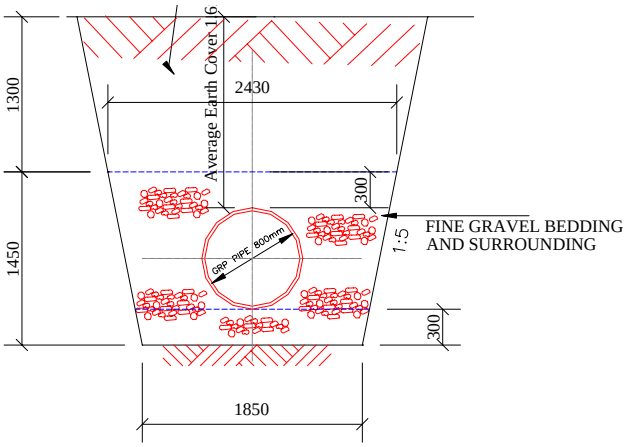


Figure 7: Ocean Outfall (Discharge Pipe) Plan

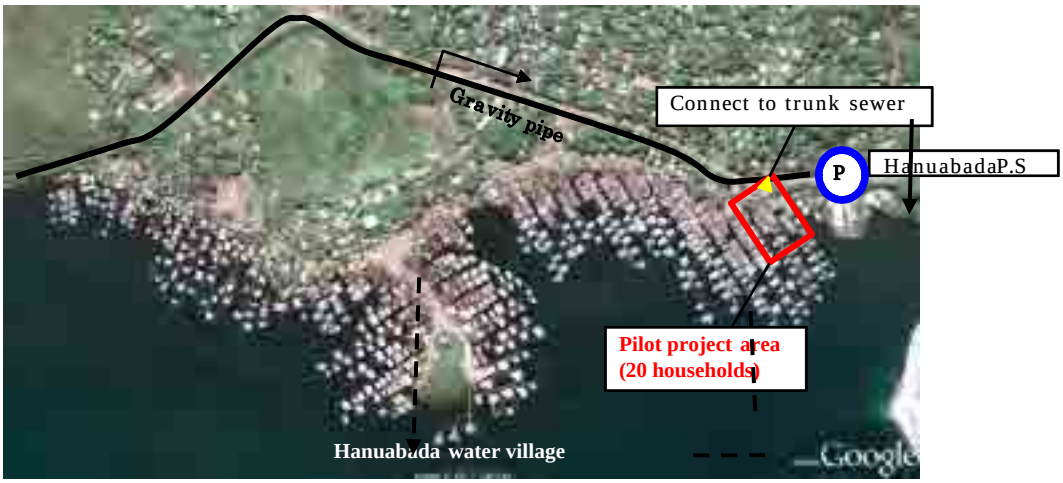
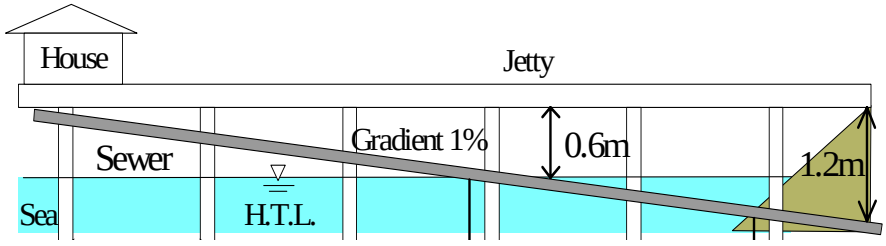
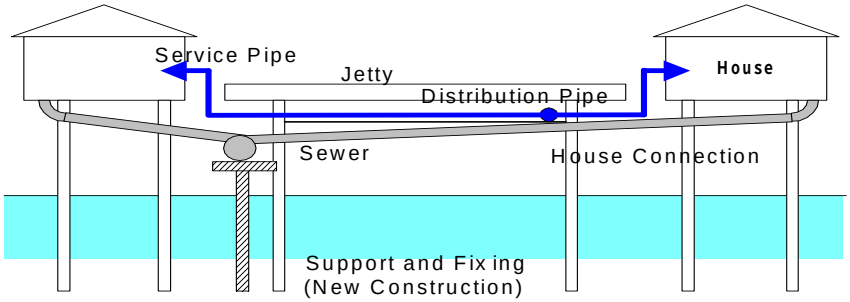


Figure 8: Location of Pilot Project in Hanuabada



Typical long section diagram



Typical cross section diagram

Figure 9: Typical layout for the pilot project in Hanuabada

Figure 10:. POMSSUP Layout Showing Extent of Fringing Reef

Figure 11: Location of The Sewage Effluent Pipeline Route (Blue) and Transect Lines (Yellow) are Approximate

Plate 1. Branching coral *Acropora tenuis*

Plate 2. Brown algae *Sargassum sp*

Plate 3. Boulder coral and leather coral

Plate 4. Boulder coral exposed at low tide

Plate 5. Boulder coral and large carpet shark (*Eucrossorhinus dasypagon*)

Plate 6. Seagrass *Thalassia hemprichii*
Sea star – *Protoreaster nodosus*

Figure 12: Example of Corals, Sea Grass and Fauna in the Joyce Bay

Table 10: Marine Zones surveyed along Pipeline Corridor

Zone	Distance from Shoreline	Habitat, Biological Assemblages and Substrate Type
A	0 - 50 m Depth 0.00 to -1.11m	Headland cliff, loose rocks, pebbles shoreline. Very murky water.
B	50 – 150 m Depth -1.11 to -1.53m	Short seagrass patches, strands of brown algae *Sargassum sp* to the east, barren sandy seabed. Murky water.
C	150 – 350 m Depth -1.53 to -1.58m	Barren sandy seabed, *Sargassum* patches, scattering of table-top boulder *Porites sp* coral both large (> 1 m diameter) and small, *Diadema sp* in small crevices of boulder corals. Water clear.
D	350 – 500 m Depth -1.58 to -1.58m	Coral rubble prominent, remains of dead boulder corals, coarse substrates. Dense short seagrass, some long seagrass mixed in, numerous seastars. Boulder coral (< 1 m diameter) appearing at the seaward fringes.
E	500 – 650 m Depth -1.58 to -1.62m	Reef crest area with dense boulder Porites and Faviid corals appearing as single (< 1 m diameter) or colonies (> I m diameter). Anemones and crinoids present and few types of seastars occurring. Branching corals and soft corals very few. Pockets of coral rubble and dead boulder corals. Several fish species common here.
F	650 – 750 m Depth -1.62 to -2.78m	Reef edge with isolated large bommies of Porites and Faviid corals (2-4 m diameter and standing 3m tall), fish species concentrating over or around the bommies.
G	750 – 950 m Depth -2.78 to -24.38m	Reef slope, coral rubble, little visible coral growths, coarse sand, occasional sponges.
H	950 – 1041 m Depth -24.38 to -26.33m	Pipeline discharge point at 26 m depth. Fine light grey silt and sand. One sponge found growing here. Water murky.

Annex 3: Monitoring Form

1) Construction Phase

Table 11 Water Quality (Ambient Water) Monitoring Form during Ocean Outfall Construction

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Measurement Point	Frequency	Method	Implementer
Transparent	-			Vicinity of ocean outfall construction site	Everyday	Visible check	Construct contractors.
SS (Suspended Solid)	mg/l				Weekly	Mass Balance method, Dried 105~110 ^{o}C	EDA RANU Environment and Quality Control Dept.
Oils/Grease	mg/l				Weekly	n-Hexane extractable material method	"

Table 12 Coral reefs Monitoring Form during Ocean Outfall Construction

Item	Objective	Location	Procedure	Frequency	Period	Results	Implementer
Survival rate of Transplanted coral reef	Rate of Survival/ Success of transplant	Location of transplant	Visual inspection	Once a month for the first three months, every three months for next nine months, thereafter every six months	Three years from transplant		EDA RANU Environment and Quality Control Dept.
Survival rate of Coral zone along the pipe route	The effect of ocean outfall construction works	Several points nearby pipe construction works sites	Visual inspection by quadrat method	Two times in a year	During construction and one year after construction		"

2) Operation phase

Table 13 Water Quality (Inlet and Outlet Sewerage Water) Monitoring in Kila Kila STP, during Operation

Implementer: EDA RANU Environment and Quality Control Dept.

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Design Criteria in Kila Kila STP (Inlet/Outlet)	Measurement Point	Frequency	Method
pH	-			-	Grit chamber	Everyday 1 sample	Glass-elctrode method (JIS K0102)
				-	Treated water tank		
SS (Suspended Solid)	mg/l			180	Grit chamber	Everyday 2 samples	Mass Balance method, Dried 105~110 °C (JIS K0102)
				20	Treated water tank		
BOD_5	mg/l			190	Grit chamber	Every 5days 2 samples	Dissolved Oxygen Depletion (Using pressure censer type BOD_5 analysis set)
				20	Treated water tank		
COD_{Mn}	mg/l			-	Grit chamber	Everyday 2 samples	Titrimetric manual
				-	Treated water tank		
Total Nitrogen	mg/l			45	Grit chamber	Weekly	Colorimetric Automated Phenate (using simple analyzer)
				20	Treated water tank		
Total Phosphorus	mg/l			-	Grit chamber	Weekly	Molybdenum blue absorptiometry method (using simple analyzer)
				-	Treated water tank		
Total coliform	MPN /100 ml			-	Grit chamber	Weekly	Most Probable Number (MPN)
				3,000	Treated water tank		
Oils & Grease	mg/l			-	Grit chamber	Every 5days 2 samples	n-Hexane extractable material method
				10	Treated water tank		
Temperature	°C			-	Grit chamber	Everyday	Attached with pH/ORP meter
				-	Treated water tank		

Table 14 Water Quality (Ambient Water) Monitoring Form during Operation

Implementer: EDA RANU Environment and Quality Control Dept.
Measurement Point: At the boundary of the mixing Zone*
**Mixing Zone has been specified within a 50m radius surrounding the discharge point.*

Item	**Unit**	**Measured Value (Mean)**	**Measured Value (Max.)**	**Country's Standards (PNG Seawater Criteria)**	**Japanese Standards**	**Frequency**	**Method**
pH	-			-	7.8~8.3	Monthly	Glass-elctrode method
COD_{Mn}	mg/l					Monthly	Titrimetric manual
Total Nitrogen	mg/l			-	1: 0.2mg/l 2:0.3mg/l 3: 0.6mg/l 4: 1.0mg/l	Monthly	Colorimetric Automated Phenate (using simple analyzer)
Total Phosphorus	mg/l			-	1: 0.02mg/l 2:0.03mg/l 3: 0.05mg/l 4: 0.09mg/l	Monthly	Colorimetric Automated Phenate (using simple analyzer)
Total coliform	MPN/ 100ml			<=200MPN /100ml (fecal coliform)	<1,000 MPN/1000 ml	Monthly	Most Probable Number (MPN)
Oil/Grease	mg/l			None	None	Monthly	n-Hexane extractable material method (Soxlet extraction unit)
Temperature	^{o}C					Monthly	Attached with pH/ORP meter

Table 15 Coral reefs Monitoring Form during Operation

Implementer: EDA RANU Environment and Quality Control Dept.

Item	Objective	Location	Procedure	Frequency	Period	Results
Survival rate of Transplanted coral reef	Rate of Survival/ Success of transplant	Location of transplant	Visual inspection	Once a month for the first three months, every three months for next nine months, thereafter every six months	Three years from transplant	
Survival rate of Nearby discharged point	The effect of discharged water	Five outfall points and triangulation point as base condition	Visual inspection by quadrat method	Two times in a year	Three years from start of operation	
Survival rate of Coral reef around the buried pipe zone	The effect of buried pipe	Several points around buried pipe zone	Visual inspection by quadrat method	Two times in a year	During construction and one year after construction	
Recovery of marine biological community	Recovery confirmation of marine biological community	Several points around buried pipe zone	Visual examination	Once a month for the first three months, every three months for next nine months, thereafter every six months	Two years after construction of buried pipe	