3.4.2 Wastewater Collection in Low-Lying Area

Topography in Grand Baie region has lava rocks on surface and scattered small swamps, while having no rivers and streams. Stormwater infiltrates the ground while swamps work as reservoirs. Residential areas are developed on valleys and hills. Therefore, wastewater from houses in low-lying hollow areas, facing beach along the backside of hills, and along with sloping roads are difficult to collect by gravity and require drainage pump.

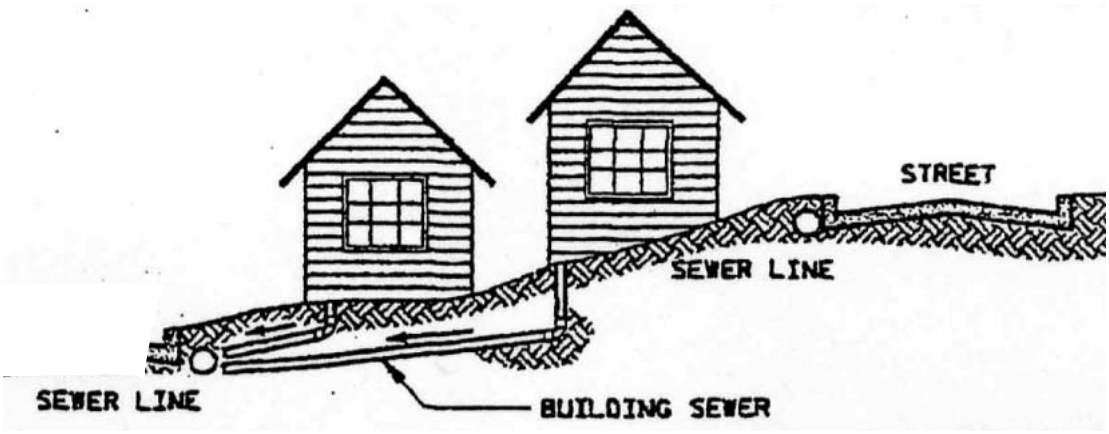
Low-lying areas are shown in Figure 3.4-2 which is developed from contour maps of topographic survey. Examples of wastewater collection in low-lying area are shown in Figures 3.4-2 to 3.4-5 .In Petit Raffray, a condominial sewer is laid in the backyard of a private property, which can be applied to houses in hollow areas. In Cap Malheureux, low-lying houses are located between roads and sugar cane fields. Back yard sewer in private properties is appropriate if land is available. Houses facing beaches along the backside of hills are unsuitable to be laid with sewers, instead, individual drainage pumps or grinder pump units can be applied. Houses along sloping roads are served by communal pumps, which collects wastewater at the lowest point.

Sewers in low-lying areas requires public participation for sewer cleaning and inspection. It is crucial during the detailed design stage to confirm willingness of residents to allow for such options.

Low Lying Housing Lot in Coastal Area

*Sewers installed in backyards, with permission from the land owner, will decrease the total cost as installing individual pump units will be unnecessary.

Low cost sewer

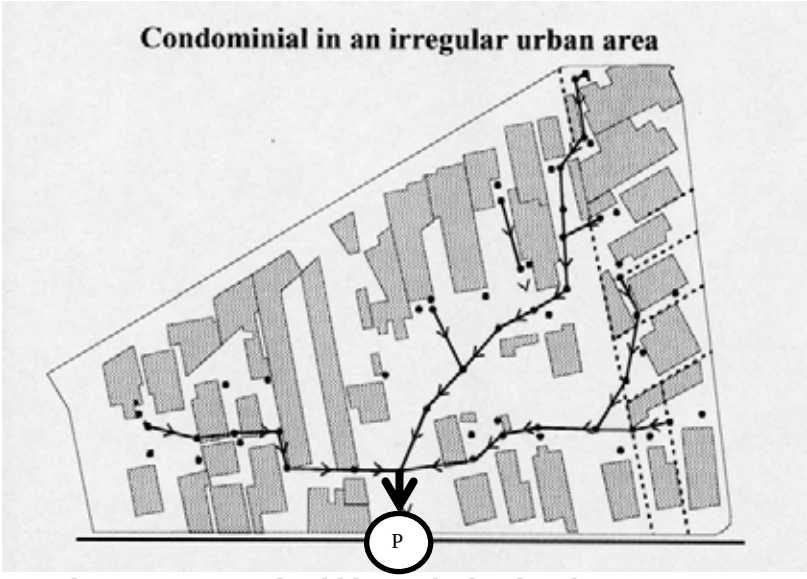


*Sewer in backyard with allowance of private land owner

Figure 3.4-2 Low-Lying Housing Lot in Coastal Area and Backyard Sewerage

Low Lying Housing

Condominial Sewerage and MS (Sewer in Private Lot)



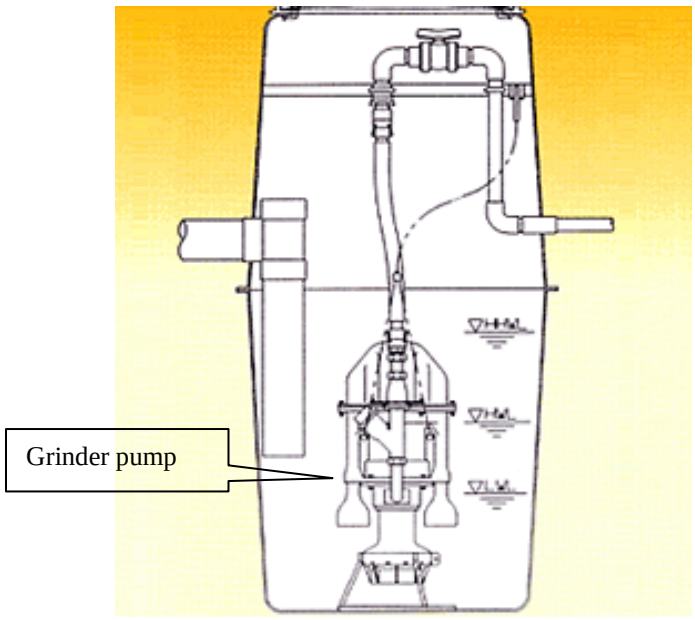
*Condominial Sewer System should be applied in low-lying areas. Citizen participation is necessary in both construction and operation stages.

Figure 3.4-3 Low-Lying Houses in Hollow Areas and Condominial Sewer System

Discharge Pump for Individual House Connection in Beach Side

*Discharge pumps is necessary for individual house along the beach, as it is very difficult to install sewer pipes along the beach. However, individual grinder pump is not recommended due to operational cost and maintenance. Detailed design shall take account how to provide sewerage service to houses in low-lying areas.

Discharge Pump for Individual House Connection



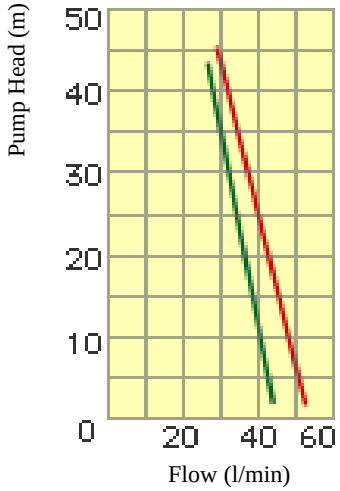


Figure 3.4-4 Houses Facing Beach along the Backside of Hills and the Required Drainage Pump

Low Lying Houses along Sloping Road

*Discharge pump (Grinder Pump Unit) is necessary for low lying houses along sloping road

Discharge Pump for Flat house and Community

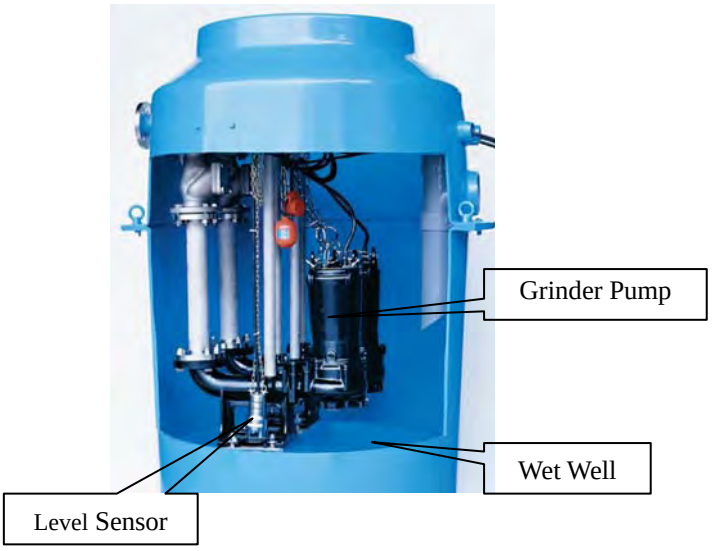


Figure 3.4-5 Low-Lying Houses along Sloping Roads and Communal Discharge Pump

3.4.3 Local Sewer Plan

Detailed design includes sewer design and calculation of wastewater flow, pipe elevation, pipe diameter, and earth cover. The Study provides sewer layout and flow direction using data from street survey, housing lot survey and road maps.

All public roads' sewer facilitates take into account the topographic profile from street survey and housing lot survey. Gravity sewer does not provide house connection but only for public sewerage. Local sewer plan developed in the Study is shown in Appendix 4, "Sewer lay-out plan"..

Local sewer plan is made in consideration of the proposed methodology of sewer plan as shown in Sections 3.4.1 and 3.4.2. Low lying area, where gravity sewer cannot be applied, facilitates mini pumping station and communal pump, involving a grinder pump unit, along public road. Condominial sewer is proposed to houses in low-lying areas where individual drainage pumps is not appropriate. Since the location of sewer is not confirmed due to restrictions by household owners, detailed design shall decide sewer route and pipe elevation through oral interviews.

3.4.4 Conclusions

The Study is to provide sewer layout plan through grasping topographic profile in the project area, deciding on the sewer main route and flow direction of local sewer. The Study also focuses on gravity flow in accordance with road gradient as much as possible for houses in low-lying areas.

However houses in low-lying area and along sloping roads requires drainage pump. In order to save costs, sewer in private property is recommended instead of individual pumps through public participation.

(1) Identification of Sewerage Planning Area

Sewerage system is for wastewater collection, human waste disposal, water pollution control and storm water drainage. Sewerage area shall be planned and decided to maximize the effects of sewerage development.

Individual drainage pumps of individual houses as described in Section 3.4.2 is disadvantageous in terms of costs for construction and O&M, and on inspection and maintenance. Wastewater collection and treatment shall be rational through collaboration

of off-site treatment, or public sewerage, and on-site treatment, or septic tanks.

In the detailed design stage, the sewerage plan must be practical considering technical and administrative aspects. Since individual houses have higher cost for sewerage service, on-site treatment can be regulated. However, on-site treatment has lower level of service due to septic tank management. Administrative service, such as public announcement on sewerage area, shall be provided for fair public service.

Table 3.4-1 Role of Sewerage System

Role of Sewerage System	Requirement Level in Grand Baie	Optional Measures
Wastewater Drainage (Housing Environment Improvement)	Not required (due to high permeability soil)	On-site treatment
Human Waste Treatment	Fairly required	On-site treatment
Water pollution control		
Beach water conservation	Urgently required	On-site treatment
Groundwater inland	Urgently required	
Groundwater in coastal area	Fairly required	On-site treatment
Stormwater drainage	Required	Existing drainage system

(2) Study Result of Project Phase

Housing lot survey aims to provide information of customers and facilities, which are required for O&M stage, through collecting relevant information for project planning, detailed design and construction.

Individual project phase accumulates information on topography, housing, and sewerage facility as shown in Figure3.4-6. Detailed design and construction works consulted with households on house connection, and, as a result, collected detailed information of sewer drawings and households. Since the operation stage requires O&M of facilities, tariff collection and claim shooting, information obtained by the Study is integrated to sewer facility data and customer information.

This Study is prefaced in accumulating information on housing lots, customers, network plans, and facilities in the design and construction stage.

Housing lot survey focuses on low-lying areas as critical information for sewer route planning, since the total connection of 4,400 houses exceeds five times of the studied 900 houses. Total street survey covers 40 km (35 km of street survey and 5 km of housing lot survey), which is equivalent to 43% of the sewer length (estimated to be 92 km).

The Study also provides prototype of house inventory since geological, facilities and customer information have been collected. For the detailed design stage, it is necessary for these information to be accumulated and used practically.

The Study involves primary survey in sewerage project, and public awareness was not fully obtained. Information of housing lot survey is principally provided through interviews. However, for houses whose owners rejected interview, topographic information were supplemented with aerial photographs and visuals, as well as customer information from CWA.

Information on design and construction for house connection was developed to actual sewer planning and construction work complying with the willingness of household owners. Detailed design also collected overall information on household and ground level elevation, and will develop the actual layout for the starting point of the sewer, location of house connections, and drainage pump proposed in this Study.

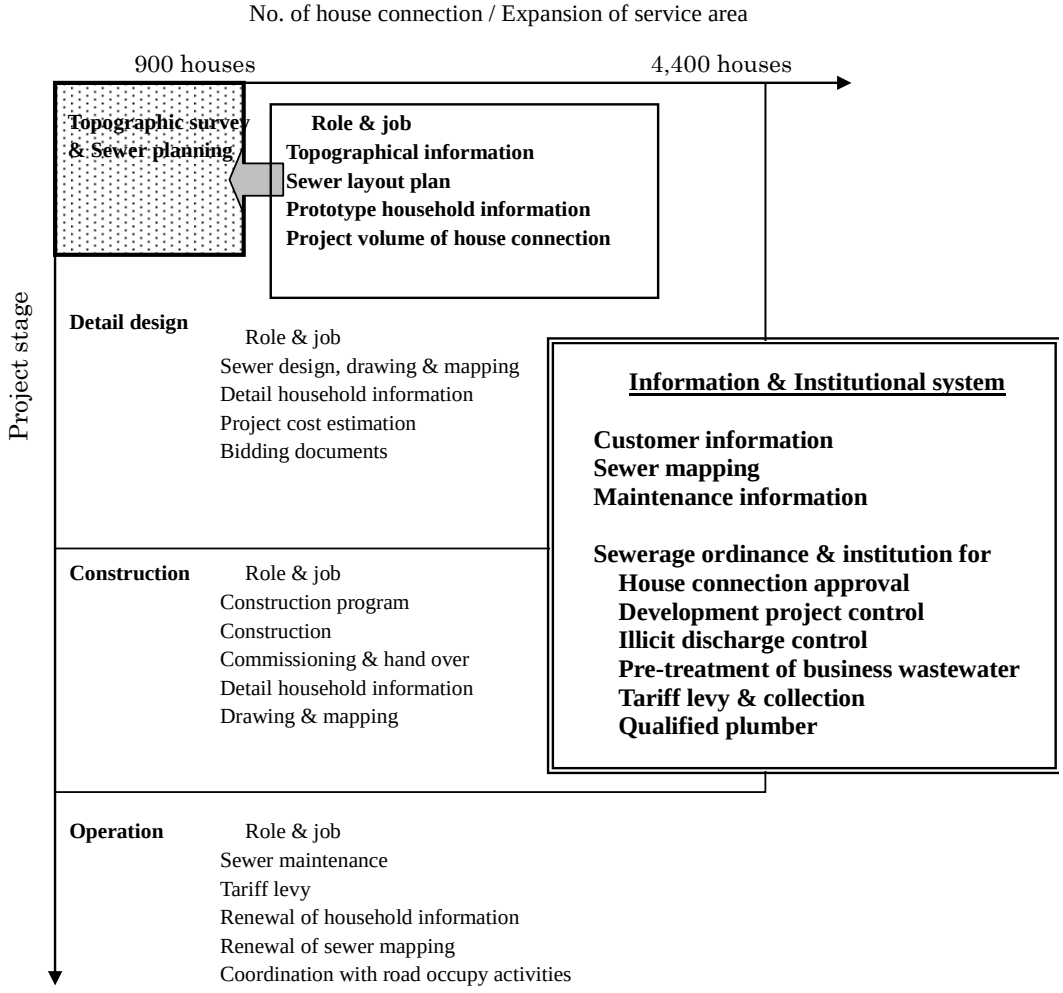


Figure 3.4-6 Job Stage of House Connection on Survey, Design and Construction

CHAPTER 4 GEOLOGICAL SURVEY AND INJECTION WELL SURVEY

4.1 Introduction

4.1.1 Collecting Data for the Injection Well Survey

The studies about the injection wells in the Grand Baie area were carried out in 1999 and 2009 as shown in Table 4.1-1. In 1999, the existing injection wells, BH-1, BH-2 and BH-3, were drilled while in 2009, the permeability tests on the injection wells were conducted.

Table 4.1-1 Past Reports

No.	Title	Date	Studied by
1	Study for the Location of Infiltration Boreholes of the Treated Wastewater of Grand Baie	October 1999	WMA Drilled by Water Research Co. Ltd.
2	Grand Baie Sewerage Project Phase 2	2009	Water Research Co. Ltd.

Source: Study Team

The outline of BH-1, BH-2 and BH-3, which were drilled in 1999, is shown in Table 4.1-2.

Table 4.1-2 Existing Boreholes Drilled in 1999

Borehole No.	Start of Drilling	Depth of Hole	Distance from Sea	Altitude
BH-1	19 March 1999	80 m	1,020 m	16 m
BH-2	12 April 1999	64 m	1,380 m	25 m
BH-3	12 May 1999	72 m	760 m	12 m

Source: Study for the Location of Infiltration Boreholes of the Treated Wastewater of Grand Baie (1999) and Grand Baie Sewerage Project Phase 2

Since the basalt is composed of many xenoliths and scoria, and the lithology of its columnar section was made by observation of small cuttings, it was considered that the agglomerate in Table 4.1-3 shows basalt with xenoliths or scoria. Therefore, the basalt lava on the studied site was distributed to around 70 m deep.

The static water level is almost equivalent to the sea level, thus, it was assumed that the

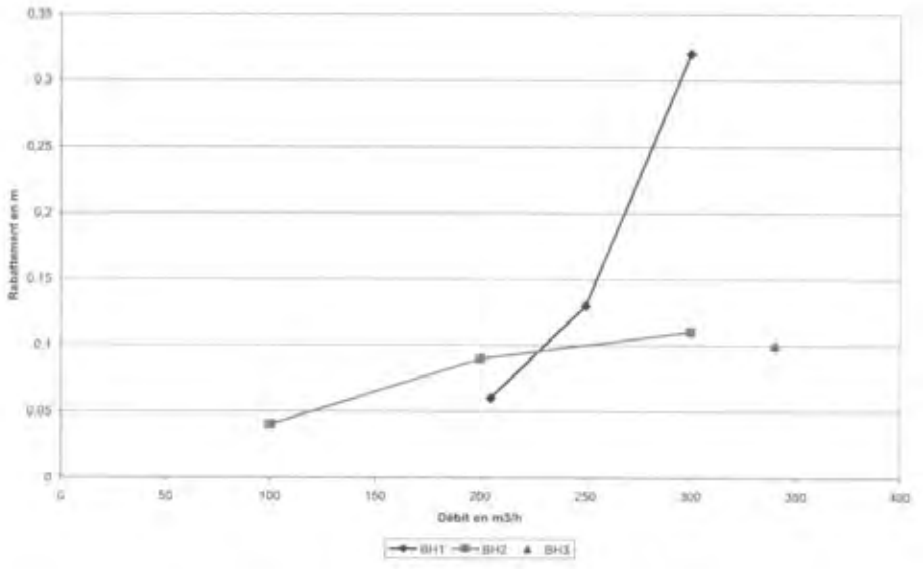
static water level has been affected by the tide level.

In order to determine the permeability of injection wells, the pumping and injection tests were conducted in BH-1, BH-2 and BH-3 as shown in Figure 4.1-1. The report of the survey shows the location of the zones with very high permeability due to fissures – allowing the injection of flow units of more than 400 m^3/h at the border of the freshwater aquifer and saline wedge.

Table 4.1-3 Outline of the Survey for Existing Boreholes

Borehole No.	Lithology		Static Water Level	Permeability	
				Pumping (m^3/h)	Drawdown (m)
BH-1	0~ 1 m 1~18 m 18~46 m 46~80 m	Yellowish brown colluvium Reddish brown to purple agglomerate Grayish blue, porous basalt No circulation at top of hole	16.47 m	300 250 205	0.32 0.13 0.06
BH-2	0~14 m 14~35 m 35~57 m 57~64 m	Purple, porous and altered agglomerate Grayish blue, porous basalt Reddish brown to purple agglomerate Grayish blue, porous basalt	25.52 m	300 200 100	0.11 0.09 0.04
BH-3	0~ 2 m 2~49 m 49~54 m 54~72 m	Grayish brown colluvium Grayish brown to blue porous basalt Purple, porous and altered agglomerate Reddish to grayish blue, porous basalt	12.44 m	340	0.10

Source: Study for the Location of Infiltration Boreholes of the Treated Wastewater of Grand Baie



Source: Grand Baie Sewerage Project Phase 2

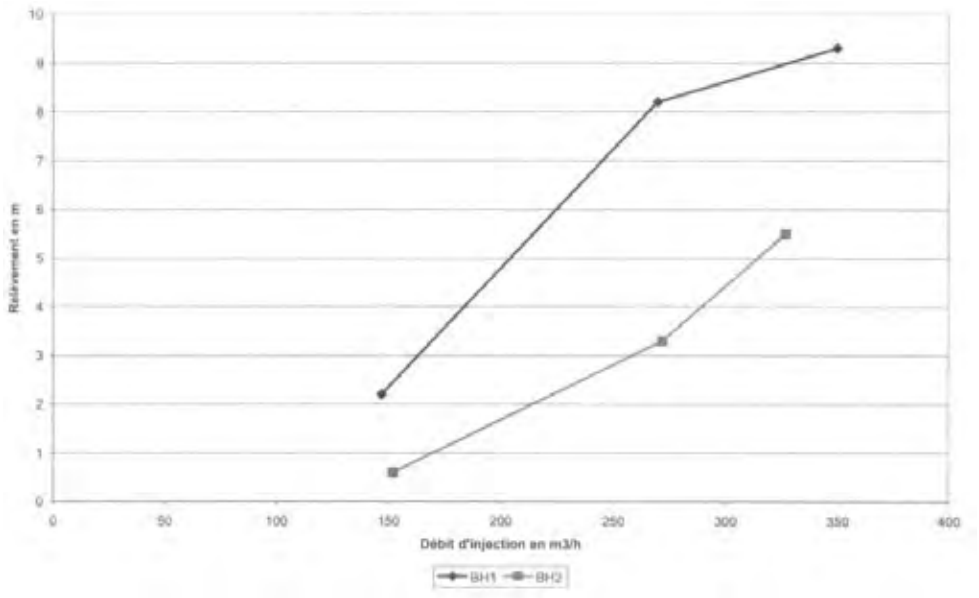
Figure 4.1-1 Result of Step Pumping Test in 1999

The injection tests were conducted for existing boreholes BH-1 and BH-2. The results of the survey in 2009 are shown in Table 4.1-4 and Figure 4.1-2. On the other hand, BH-3 has been abandoned due to clogging. The report of this survey said that the investigations show that the boreholes always have a high capacity of injection and the recommended injection rate of 350 m^3/h can be chosen for the design of the next phase.

Table 4.1-4 Results of the Injection Tests in 2009

Borehole No.	Flow (m^3/h)	Rise (m)	Coefficient of Permeability (m/s) (Length of Strainer: m)	
			Initial Situation	Current Situation
BH-1	147 270 350	2.2 8.2 9.3	0.014 (60)	0.019 (45)
BH-2	152 272 327	0.6 3.3 5.5	0.025 (34)	0.025 (34)
BH-3	-	-	0.014 (62)	0.017 (50)

Source: Grand Baie Sewerage Project Phase 2

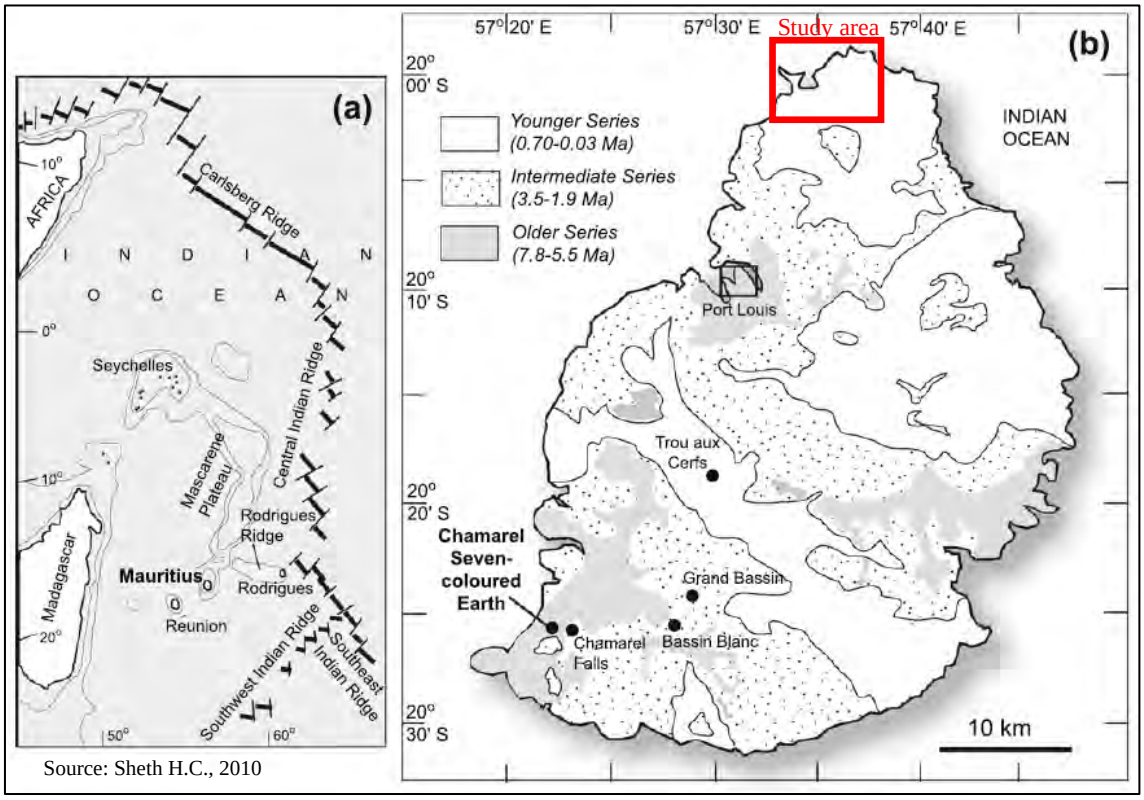


Source: Grand Baie Sewerage Project Phase 2

Figure 4.1-2 Results of the Injection Tests in 2009

4.1.2 Topographic and Geological Conditions

The island of Mauritius is composed of the top of volcanic cones that rise from the ocean floor which is formed over a hot spot caused by a mantle plume upwelling under the African plate. According to Baxter in 1972, Mauritius emerged from the sea 8 Ma (million years ago). The basaltic volcanism of the island of Mauritius is divided into three phases, namely: Older Series (7.8-5.5 Ma), Intermediate Series (3.5-1.9 Ma) and Younger Series (0.7-0.03 Ma), as shown in Figure 4.1-3. These phases roughly correspond respectively to the shield-building, post-shielding and post-erosional stages. The Younger Series lavas, which are mostly olivine basalts with smaller volumes of basanite, cover the bulk of the study area. The basaltic lava exhibits characteristics such as blue grayish color, and porous, and has three directions of fissure: one is horizontal of platy joint, and the other two are almost vertical of columnar joint with trends of NNW-SSE and ENE-WSW (refer to Figure 4.1-4 a, b, and c). According to observations in the rock quarry, the basaltic lava exposes shallow ground under the colluviums with depth of approximately 10-30 cm (refer to Figure 4.1-4 d).



Source: Sheth H.C., 2010

Figure 4.1-3 (a) Geological Location of the Island of Mauritius in the Indian Ocean Region; and (b) Simplified Geological Map of Mauritius

In examining the feasibility for new injection wells, the wastewater treated effluent was assumed to seep into the fissures or cavities such as lava tubes.

Lava tubes form in pahoehoe lava flows when the lava flowing in tubes underneath solidify and then insulate the crust drains out from the tubes. There are many lava tubes known, such as the famous Thurston Lava Tube on the island of Hawaii. In Mauritius, lava tubes are seen in the low sloping areas of Plaine des Roches and Roches Noire in the northeast. The scale of the said lava tubes is not as big as the ones in Hawaii, but wide enough for a person to walk inside. In the study area in Grand Baie, the lava tube has not been confirmed on the ground surface. According to the interview with Dr. Chang, a professor of Mauritius University, it was not mentioned that there were large lava tubes in the Grand Baie area.

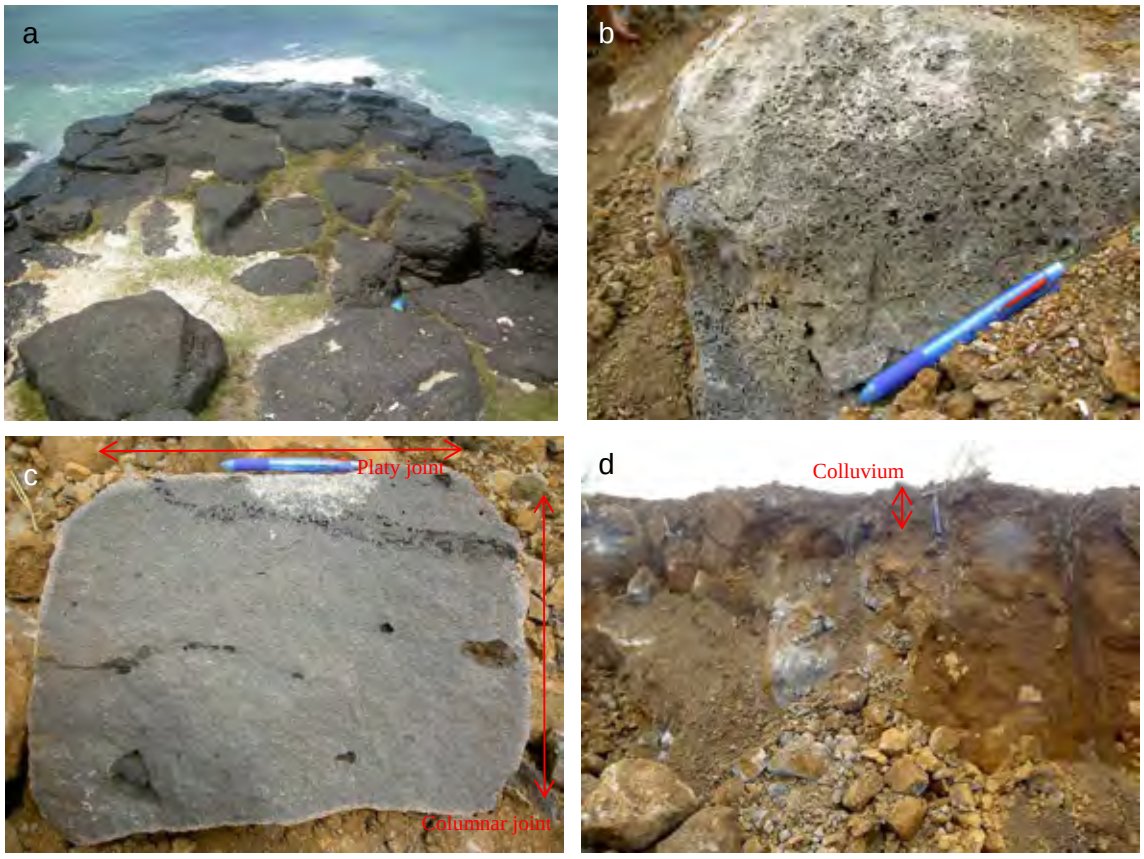


Figure 4.1-4 (a) Columnar Joints Exposed on the Beachside; (b) Ball-like Porous Basalt; (c) Basalt Split along Platy and Columnar Joints; and (d) Thin Colluviums on the Basaltic Rocks

4.2 Core Hole Survey

4.2.1 General

The core hole survey was conducted for the purpose of confirming the foundation for the planned pumping station. The locations and land use of the pumping stations are shown in Table 4.2-1. The core hole survey was composed of the following items.

Table 4.2-1 Location of Core Holes

Core Hole No.	Pumping Station	Location	X	Y	Altitude (m)	Land Use
1	PS-1	Pereybere	19.998667	57.589500	13	Private road
2	PS-3	Chemin vingt pieds	20.002300	57.607883	16	Sugar cane
3	PS-4	Cap Malhereux	19.993033	57.613917	17	Recharge plant
4	PS-5	Petit Raffray	20.013083	57.616083	27	Public land
5	Canceled due to replacement of PS-6 to PS-5					
6	PS-7	The Vale	20.029767	57.609533	39	Sugar cane
7	PS-8	The Vale	20.028650	57.597367	30	Private estate
8	PS-9	Sottise	20.021928	57.581581	36	Farm road

Source: Study Team X, Y and Altitude were measured by portable GPS system.

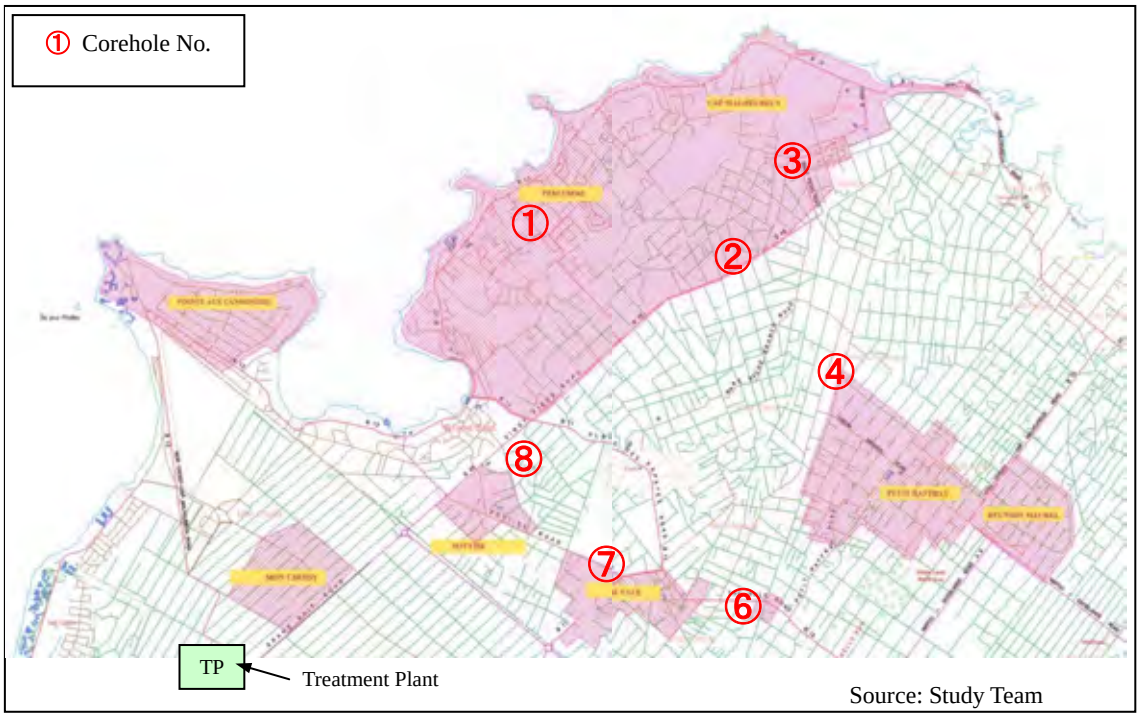


Figure 4.2-1 Location Map of Core Holes

(1) Drilling Survey

In order to determine the lithology and geotechnical characteristics of the soil under the planned pumping station, the drilling survey including all core sampling and standard penetration test (SPT) were carried out. Drilling was implemented using rotary boring machine and NX triple tube core barrel of 76 mm diameter. SPT was conducted at every 1 m.

Finally, PVC pipes with 50 mm diameter, sealing, filter material and protective cover were installed into the core holes in order to collect groundwater samples and measure the groundwater level.

(2) Unconfined Compressive Strength Test

For the purpose of determining the foundation strength for the new pumping station, unconfined compressive strength (UCS) test was conducted using core samples taken at depths as shown in Table 4.2-2. Two samples in each core were collected, and then secured to the required size in order to avoid cracks and weathering. Since all core samples taken from core hole no. 7 were fractured to gravel-size (less than 20 cm) and inadequate for testing, UCS test for core hole no. 7 has not been carried out.

Table 4.2-2 Depth of Samples for UCS Tests

Core Hole No.	Unconfined Compressive Strength	
	Sampling Depth I	Sampling Depth II
1	3.65~3.85	8.64~8.83
2	4.20~4.40	4.70~4.90
3	1.50~1.70	2.50~2.70
4	0.00~0.20	4.00~4.20
6	2.53~2.73	4.05~4.25
7	-	-
8	4.64~4.90	5.32~5.94

Source: Study Team (GL-m)

(3) Water Quality Test

The main purpose of the water quality analysis survey is to identify the present condition of the drilled wells. The parameters to be tested are the following: electrical conductivity, pH, TDS, turbidity, NO_3-N, NO_2-N, COD, Cl^- and SO_4^{2-}.

A sample from each core hole was collected using a small pump. All laboratory analysis works were done in Chemco Ltd. and Cernol Water Solutions Ltd. in Port Louis, as

certificated by the WRU. The chemical parameters and applied analysis techniques are indicated in Table 4.2-3.

Table 4.2-3 Analysis Techniques of Chemical Parameters at the Laboratory

No.	Parameter	Analysis methods
1	Electrical conductivity	APHA 2510B: Conductometry (by use of digital conductivity meter)
2	pH range	APHA 4500 H^+: Electrometry (by means of pH meter with glass electrode)
3	TDS	APHA 2540
4	Turbidity	Nephelometric method
5	NO_3-N	APHA NO_3
6	NO_2-N	APHA NO_2
7	COD	APHA 5220 C
8	Cl^-	APHA 4500 Cl B
9	SO_4^{2-}	AOAC Official Method 973.57

Source: Study Team

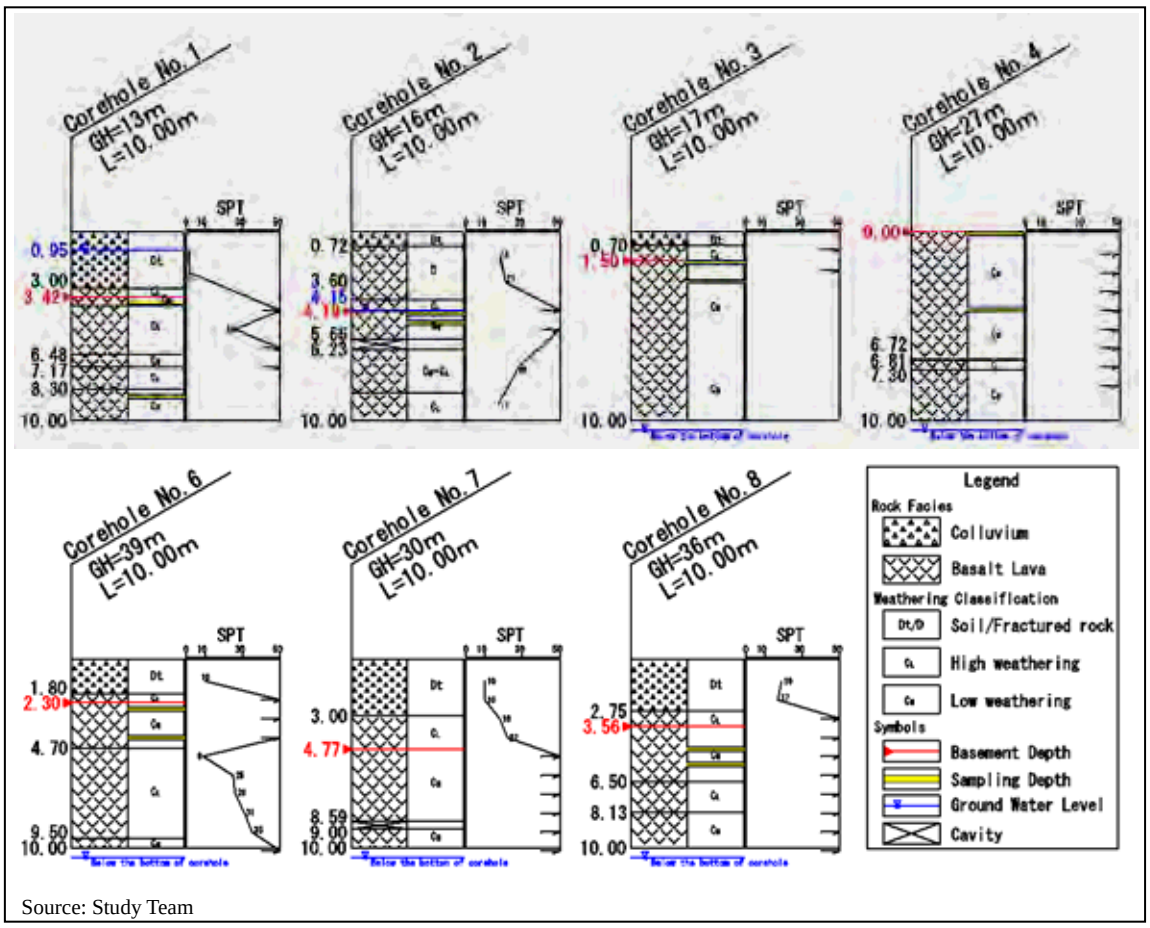
Figure 4.2-2 (a) Drilling the Core Hole by Rotary Boring Machine; (b) Conducting SPT; (c) Installation of Standpipes for Groundwater Level Gauge; and (d) Slotted Tube for Standpipes.

4.2.2 Results of the Cole Hole Survey

(1) Drilling Survey

The results of the drilling survey including core collection, SPT and measurement of groundwater level are summarized in Figure 4.2-3. In the planned sites for the pumping stations, fine-grained basaltic lava are widely distributed, in which many have vesicles and fissures, and some with large cavities and highly fractured interbedded zones. The upper part of basaltic lava below the colluvium was highly weathered and weakened, and the N-value in this zone indicates 10 to 20 blows. The average depth of colluvium layer is approximately 1.00 to 3.00 m. The fresh and intact basalt lava of bedrock indicates an N-value of more than 50 blows.

The static groundwater level is from 0.50 m to 4.15 m below ground level. The closer the core hole is to sea, the lower the static groundwater level is.



Source: Study Team

Figure 4.2-3 Summarized Columnar Section

(2) UCS Test

The results of the UCS test are summarized in Table 4.2-4. The average UCS of the highly vesicular basalt lava samples is approximately 30,775 kN/m^2. On the other hand, the UCS of the dense basalt lava with small isolated vesicles is 64,720 kN/m^2, which is twice as strong as that of the highly vesicular samples. Since both exhibit a very high UCS, it is suitable to build the pumping stations.

Table 4.2-4 UCS Test

Core Hole No.	Pumping Station	Sample Depth	Unconfined Compressive Strength (kN/m^2)	Remarks
1	PS-1	3.65~3.85	30,800	Highly vesicular (~20-25%)
		8.64~8.83	45,900	Slightly vesicular (~5%)
2	PS-3	4.20~4.40	65,500	Isolated vesicles
		4.70~4.90	61,900	Isolated vesicles
3	PS-4	1.50~1.70	29,900	Highly vesicular (~30-40%)
		2.50~2.70	17,900	Failure occurred along the existing crack
4	PS-5	0.00~0.20	37,700	Highly vesicular (~30%)
		4.00~4.20	72,100	Numerous small vesicles
6	PS-7	2.53~2.73	66,700	Some small vesicles
		4.05~4.25	57,400	Numerous small vesicles
7	PS-8	-	-	-
		-	-	-
8	PS-9	4.64~4.90	32,600	Slightly vesicular (~20-25%)
		5.32~5.94	24,700	Highly vesicular (~20-25%)

Source: Study Team

(3) Water Quality Test

The results of the water quality tests are shown in Table 4.2-5.

The groundwater collected in core holes is not clean enough for drinking. Since the groundwater level is shallow at 0.95 m to 4.15 m below ground level, the infiltrated rainwater and drainage water from the road was collected in the boreholes.

Table 4.2-5 Results of Water Quality Tests for the Core Holes

Core Hole No.		1	2	Value	E:Environmental Limit
Pumping Station		PS-1	PS-3		R:Representative value
Electrical Conductivity	µs/cm	825	2,200	200~400	R:Downstream
pH		7.73	7.31	6~8	R: Natural water
TDS	mg/L	422	1190	0 ~1,000 1,000 ~ 20,000	R: Freshwater R: Brackish water
Turbidity	NTU	29.60	4.26	~ 2 1 ~ 10 50 ~ 90	E: Tap water R:Upstream R:Downstream
NO_3-N	mg/L	0.35	5.24	~ 10	E: Groundwater
NO_2-N	mg/L	2	8	~ 10	E: Groundwater
COD	mg/L	221	153	~ 160	E: Sewerage
CL^-	mg/L	110.3	584.0	~ 200	E: Tap water
SO_4^{2-}	mg/L	37.2	168.4	~ 250	E: Tap water

Source: Study Team

4.2.3 Analysis

(1) Method of Analysis

Based on the results of the SPT and UCS test, the allowable bearing capacity was estimated by the following equation:

$$q_a = 1/3(\alpha \cdot c \cdot N_c + \beta \cdot \gamma_1 \cdot B \cdot N_r + \gamma_2 \cdot D_f \cdot N_q)$$

where,

q_a: Allowable bearing capacity (kN/m^2)
c: Cohesion under the bottom of the foundation (kN/m^2)
γ_1: Unit weight of rocks under the bottom of the foundation (kN/m^3)
γ_2: Unit weight of soil on the bottom of the foundation (kN/m^3)
α, β: Shape coefficients
N_c, N_r, N_q: Bearing capacity factors as shown in Table 4.2-8.
D_f: Depth between the bottom of the foundation and the ground surface adjacent to the foundation (m)
B: Minimum width of the bottom of the foundation (m)

The shape coefficients (α, β) were adopted, as shown in Table 4.2-6. The foundation of the planned pumping station was assumed to have a square shape (15 x 15 m), in which the calculation of the shape coefficients was based.

Table 4.2-6 Shape Coefficients

Shape of loading foundation	Square	Rectangle	Circle
α	1.3	1 + 0.3 x B/L	1.3
β	0.4	0.5 - 0.1 x B/L	0.3

L: Long side of the rectangle

Source: The Guideline for Design of Structures, Japan Sewerage Works Agency, Dec. 1999

(2) Result of Analysis

The bearing capacity factors were determined based on the internal frictional angle. The internal frictional angle (φ) was determined by the following equation and then multiplied by the N-value.

$\varphi = 0.888 \times \log(N) + 19.3$

where,

N: N-value of base rock

(Source: Evaluation of Soft Rock, Japan Society of Civil Engineers, 1992)

Table 4.2-7 Internal Frictional Angle (φ)

N-value	φ
20	21.96
50	22.77

Source: Study Team

Table 4.2-8 Bearing Capacity Factors (N_c, N_r, N_q)

φ	N_c	N_r	N_q
0	5.3	0	3.0
5	5.3	0	3.4
10	5.3	0	3.9
15	6.5	1.2	4.7
20	**7.9**	**2.0**	**5.9**
25	9.9	3.3	7.6
28	11.4	4.4	9.1
32	20.9	10.6	16.1
36	42.2	30.5	33.6
More than 40	95.7	114.0	83.2

Source: The Guideline for Design of Structures, Japan Sewerage Works Agency, Dec. 1999

Cohesion (c) can be determined using the following two equations and then multiplied by

the UCS or N-value. The cohesion estimated using the UCS is higher than that by the N-value since the UCS test was generally conducted using a sample without cracks and unweathered sample. The lower value of the two was applied in consideration of safety.

$c = 16.2 \times N^{0.606}$

$c = q_u/2$

where,

q_u: UCS (kN/m^2)
N : N-value

(Source: Evaluation of Soft Rock, Japan Society of Civil Engineers, 1992)

Table 4.2-9 Cohesion (c) Estimated by N-value

N-value of base rock	c (kN/m^2)
20	99.52
50	173.41

Source: Study Team

Table 4.2-10 Cohesion (c) Estimated by UCS

Core Hole No.	Pumping Station	c (kN/m^2)	UCS (kN/m^2)
1	PS-1	15,400	30,800
2	PS-3	32,750	65,500
3	PS-4	14,950	29,900
4	PS-5	18,850	37,700
6	PS-7	33,350	66,700
7	PS-8	-	-
8	PS-9	16,300	32,600

Source: Study Team

The unit weights of base basalt rocks and of soil at the bottom of the foundation were assumed to be 20 kN/m^3 and 18 kN/m^3, respectively.

For example, the allowable bearing capacity (qa) of PS-1 was estimated as follows:

$q_a = 1/3(\alpha \cdot c \cdot N_c + \beta \cdot \gamma_1 \cdot B \cdot N_r + \gamma_2 \cdot D_f \cdot N_q)$

$= 1/3(1.3 \cdot 173.41 \cdot 7.9 + 0.4 \cdot 20 \cdot 15 \cdot 2.0 + 18 \cdot 3.5 \cdot 5.9)$

$= 797.54$ kN/m^2

Table 4.2-11 Allowable Bearing Capacity (q_a)

Core Hole No.	Pumping Station	Depth (m BGL)	N-value	Lithology	q_a (kN/m^2)
1	PS-1	3.5	50	Rock	797.54
2	PS-3	2.5	20	Soil	509.19
		4.2	50	Rock	822.32
3	PS-4	1.5	50	Rock	726.74
4	PS-5	1.0	50	Rock	709.04
6	PS-7	2.3	50	Rock	755.06
7	PS-8	3.5	20	Soil	544.59
		4.8	50	Rock	843.56
8	PS-9	3.6	50	Rock	801.08

Source: Study Team

4.2.4 Conclusion

The basalt rocks in the studied area are exposed on the ground surface or 3.0 m underground. Fresh basalt is very hard having an N-value of more than 50, thus the allowable bearing capacity is 700~800 kN/m^2 which is enough for building the pumping station. The proposed pumping station shall be constructed by removing the loose surface colluvium and then laying spread foundation on hard basalt rock.

The cavities that could be observed in the core hole survey were caused by low-viscosity magma flows or the expansion of gas inside when lava solidifies. It is inferred that its distribution was capillary-like and randomly. Therefore, it is difficult to explain its accurate distribution. Countermeasures against the cavities are not necessary. However in case that cavities are found in the excavation for the foundation, these shall be filled in by cement milk and so on.

4.3 Injection Well Survey

4.3.1 General

Three injection wells were constructed in 1999. Two of the wells are working at present, while one has been stopped due to clogging. However, for the expansion of wastewater treatment, additional injection wells are being required. Hence, an injection well survey

was conducted in order to obtain underground data, and to evaluate whether the conditions can work for the permanent usage of the well or not. Accordingly, the major objectives of this survey are as follows:

- To determine the permeability of the underground aquifer,
- To identify the distribution of saline water wells,
- To understand the hydrogeological conditions, and
- To identify whether the wells are available or not.

The injection well survey includes the following:

- Drilling of two injection wells
  - Holes of 300 mm and 380 mm diameter
  - Installation of casing pipe with 250 mm and 300 mm inside diameter
  - Well development by airlift
- Pumping test
  - Three step test
  - 24-hour pumping test
- Water quality test
  - Conductivity, pH, TDS, turbidity, NO_3-N, NO_2-N, COD, CL^- and SO_4^{2-}

(1) Drilling the Injection Wells

The two wells, BH-4 and BH-5, were drilled for the injection well survey. Their locations are shown in Figure 4.3-1 and Table 4.3-1. The injection wells were located at points where the lava from Mt. Virer erupted towards the WWTP. Land acquisition was agreed upon with the landowners to the extent covered by the Phase 2 project.

BH-4 was drilled to a diameter of 300 mm up to a depth of 52 m using a down-the-hole hammer bit with a rotary–percussion drill. While BH-5 was drilled to a diameter of 380 mm up to a depth of 72 m by the same bit and machine. In order to protect the borehole wall, the casing of the PVC pipes with inside diameter of 250 to 300 mm was installed in the center of the hole. After the drilling, in order to remove the cuttings and mud on the borehole wall and to prevent clogging, the borehole was cleaned using airlift.

Table 4.3-1 Location of the Injection Wells

Injection Well No.	Depth	X	Y	Altitude (m)	Land Use
4	52.0 m	20.036500	57.558817	35	Sugar cane
5	72.0 m	20.035567	57.556983	33	Sugar cane

Source: Study Team

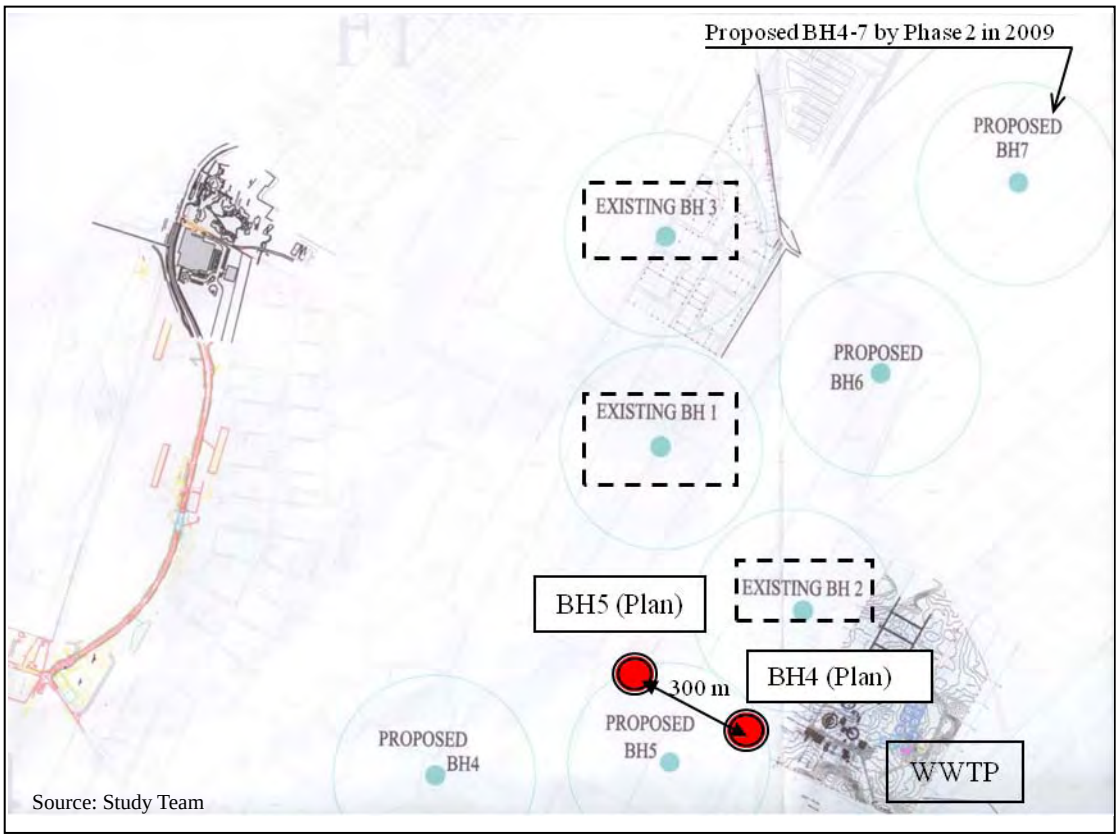


Figure 4.3-1 Location of the Injection Wells and WWTP

Figure 4.3-2 (a) Drilling of BH-4 by Down-the-hole Hammer; (b) Drilling of BH-5 by Down-the-hole Hammer; (c) Down-the-hole Hammer Bit and Rods; (f) Bit with diameter of 300 mm; (e) Drilling with water at BH-4; and (f) Drilling at BH-5

Figure 4.3-3 (a) Casing of PVC Pipe with 300 mm Diameter; (b) Slotted PVC Pipes; (c) Installing the Casing into the Borehole; (d) Installed Casing with Blue Filter; (e) Cleaning by Airlift; (f) Discharge of Airlift

(2) Permeability Test

In order to determine the permeability of aquifer in the site, two types of permeability tests were conducted.

1) Step Test

The step test was carried out in order to evaluate the "permissible yield" in the drilled

wells. The correlation between yield and drawdown was identified by changing the yield in a step-by-step manner. The data plotted on a double logarithmic graph showed that if the yield was under the yield limit, then the incline of the graphed line was less than 45°. However, if the yield exceeded its limit, then the incline was more than 45°. In general, a shifting point on the graph showed the yield limit in which 80% of the yield limit was the permissible yield. The pumping test was then conducted using the permissible yield.

2) Pumping Test

The pumping test consists of the constant rate pumping and recovery tests.

The constant rate pumping test was conducted by pumping the permissible yield for 24 hours and monitoring the drawdown. The recovery test was conducted by monitoring the groundwater level just after the continuous pumping test in order to measure how long it returns to the natural groundwater level. Based on the results, the coefficient of transmissivity was estimated and the proposed amount of effluent infiltration was examined.

The coefficient of transmissivity was calculated according to the following equation:

$$T = \frac{2.3\,q}{4\,\pi} \times \frac{\log t_2 - \log t_1}{H_2 - H_1}$$

where,

T: Coefficient of transmissivity (m^2/s)
H_2, H_1 : Groundwater level after t_1, t_2 from the start of pumping
q: Yield (m^3/s)

Figure 4.3-4 (a) Pump for Step Test; and (b) Measuring the Yield

(3) Water Quality Test

The water quality test was carried out using the same parameters as the injection survey referred to in Section 4.2.1(3). One sample was collected from each borehole. The method of analysis was the same as that of the core hole survey.

Figure 4.3-5 Measuring Groundwater Level

4.3.2 Results of the Injection Well Survey

(1) Drilling Survey

The results of the drilling survey based on the collected cuttings at every 1 m were summarized in Figure 4.3-5. Since the down-the-hole hammer bit cannot produce rock core samples, the lithology of the boreholes was described based on the cuttings which resulted from the drilling by the down-the-hole hammer bit.

The groundwater level was measured upon completion of the drilling and before the start of the pumping test. The location of the saline wedge was shown by result of the conductivity measurement. The static groundwater level is located between 25.0 and 27.0 m below ground level (BGL), and saline water is distributed between 35.0 and 39.0 m BGL, which is equivalent to the sea level.

BH 4	Altitude: 35m
Depth (bgl)	Lithology
0.0m	Basalt
3.0m	Weathered Basalt
5.0m	Basalt
28.0m	SWL 27.50m
	Weathered Basalt
30.0m	Basalt
38.0m	Cavity 31.0 to 31.4m Cavity 33.0 to 33.5m Saline water 35.0m
	Weathered Basalt
44.0m	Basalt
51.0m	Weathered Basalt
52.0m	

BH 5	Altitude: 33m
Depth (bgl)	Lithology
0.0m	Clay
2.0m	Fresh Basalt
4.0m	Moderately Weathered Basalt
8.0m	Moderately Weathered Basalt
32.0m	SWL 26.50m Weathered Basalt
36.0m	Cavity
37.0m	Highly Weathered Basalt
39.0m	Saline water 39.0m Basalt
40.0m	Weathered Basalt
44.0m	Fresh Basalt
48.0m	Highly Weathered Basalt
52.0m	Highly Weathered Basalt
61.0m	Clay
66.0m	Highly Weathered Basalt
72.0m	

Source: Study Team

Figure 4.3-6 Summarized Columnar Section

(2) Permeability Test

1) Step Test

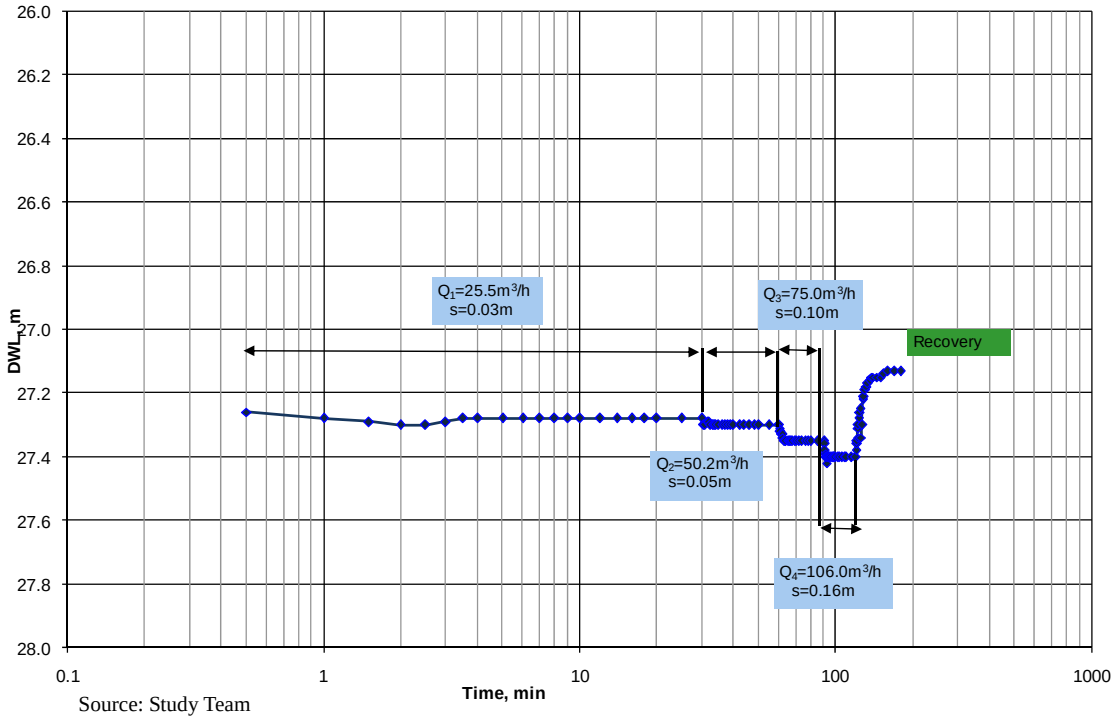
The step test was carried out four times each on BH-4 and BH-5. The yield values and duration of the step test are shown in Table 4.3-2.

According to the results of the step test for BH-4, the ratio of yield and drawdown is from about 600 to 1,000, and a significant shifting point could not be confirmed in the graph. Similarly, the correlation between pumping rate and drawdown on BH-5 shows an almost direct proportion and a significant folding point could not be confirmed in the graph.

Table 4.3-2 Results of the Step Tests for BH-4 and BH-5

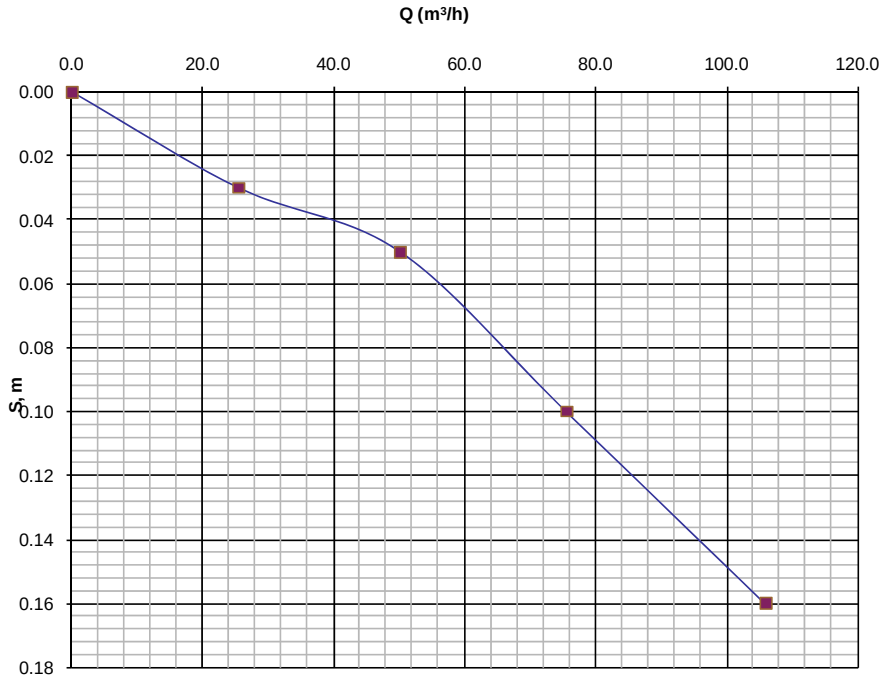
No.	Duration of Test (min)	Yield (Q) (m^3/h)	Drawdown (s) (m)	Q/s (m^2/s)
BH-4	30	25.5	0.03	850.0
	30	50.2	0.05	1,004.0
	30	75.6	0.10	756.0
	30	106.0	0.16	662.5
BH-5	30	69.9	0.03	2,330.0
	30	154.0	0.02	7,700.0
	30	227.7	0.01	22,770.0
	60	363.0	0.09	4,033.3

Source: Study Team



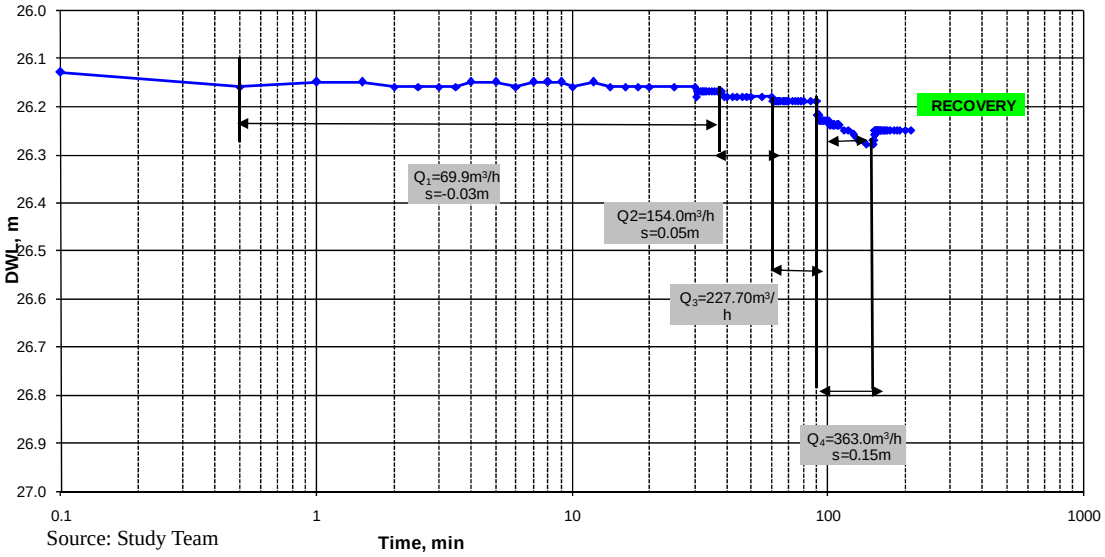
Source: Study Team

Figure 4.3-7 Results of the Step Test for BH-4



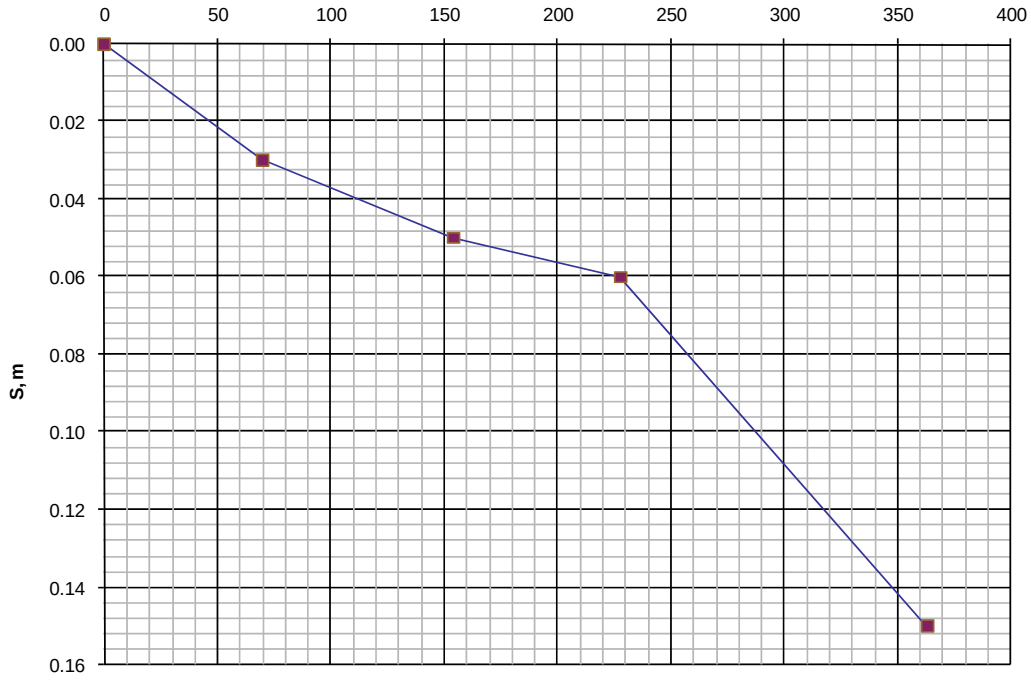
Source: Study Team

Figure 4.3-8 Correlation between Yield (Q) and Drawdown (s) of BH-4



Source: Study Team

Figure 4.3-9 Results of the Step Test for BH-5



Source: Study Team

Figure 4.3-10 Correlation between Yield (Q) and Drawdown (s) of BH-5

Based on the results of the step tests as shown above, it has been evaluated that the permissible yield for the constant rate pumping test for BH-4 and BH-5 were 106.0 m^3/h and 350 m^3/h, respectively, which is the proposed effluent discharge.

2) Pumping Test

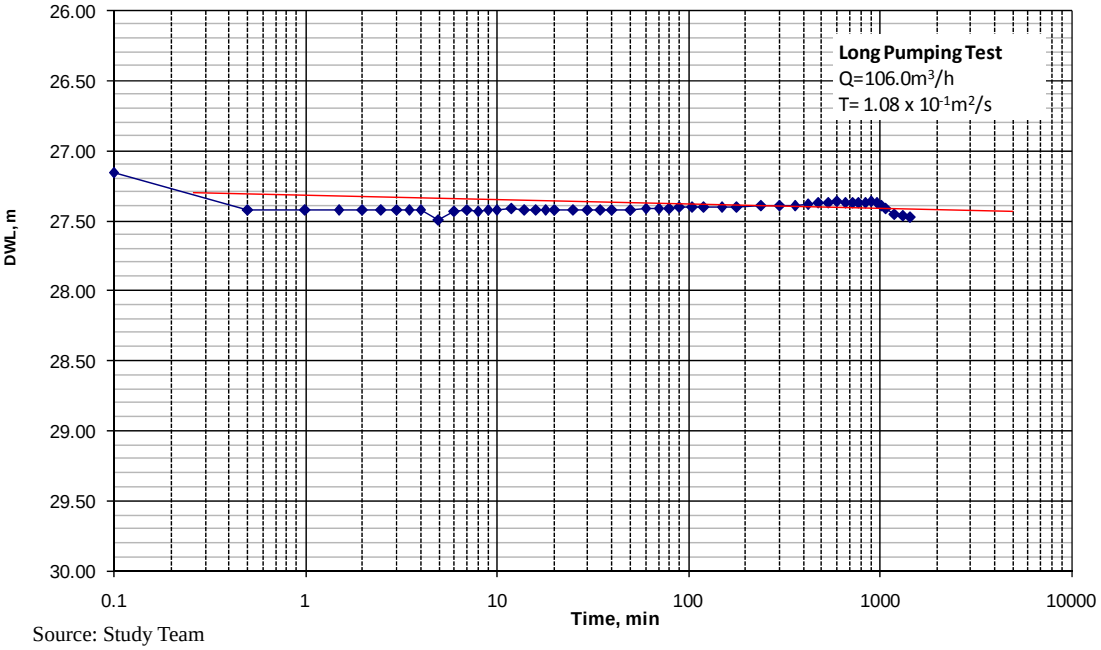
The constant rate pumping tests were carried out for a duration of 24 hours. The drawdown on BH-4 at the end of the pumping test was 0.32 m, while that on BH-5 was 0.03 m.

The coefficients of transmissivity, measured from 100 min (t_1) to 1,000 min (t_2) during the constant rate pumping tests on BH-4 and BH-5, were estimated at $1.08x10^{-1}$ and $1.78x10^{-1}$, respectively. Therefore, the allowable amounts of effluent infiltration were calculated to be 388.8 m^3/h and 640.8 m^3/h, which were much higher than the proposed amount.

Table 4.3-3 Results of the Constant Rate Pumping Tests for BH-4 and BH-5

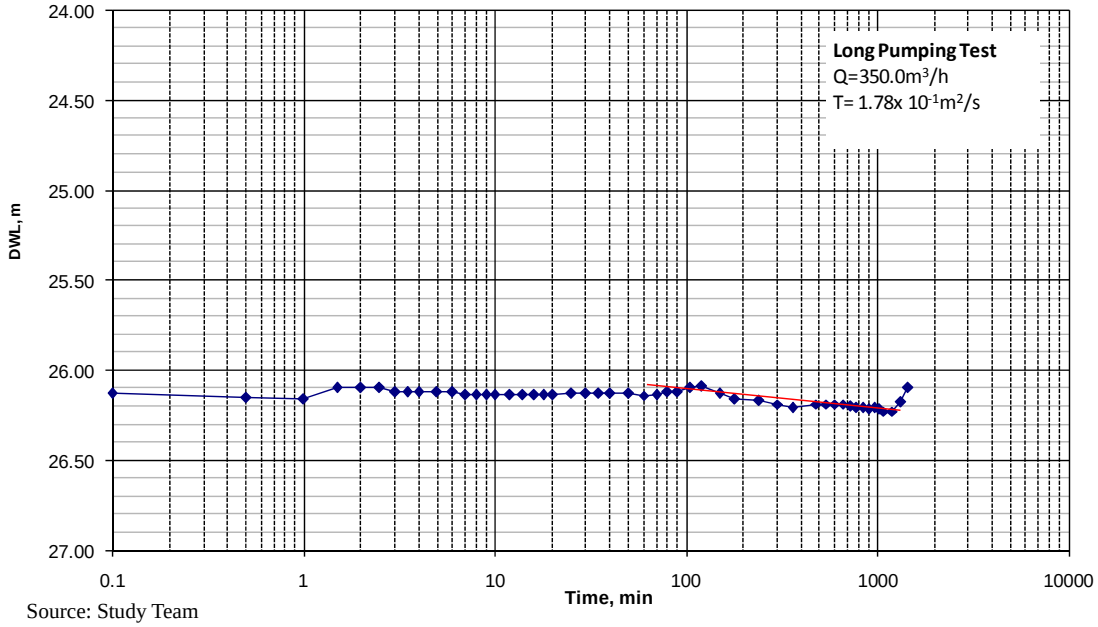
No.	Duration of Test (h)	Yield (Q) (m^3/h)	Drawdown (s) (m)	T (m^2/s)	Allowable Amount of Effluent Infiltration (m^3/h)
BH-4	24	106.0	0.32	1.08×10^{-1}	388.8
BH-5	24	350.0	0.03	1.78×10^{-1}	640.8

Source: Study Team



Source: Study Team

Figure 4.3-11 Results of the Constant Rate Pumping Test for BH-4



Source: Study Team

Figure 4.3-10 Results of the Constant Rate Pumping Test for BH-5

(3) Water Quality Test

The results of water quality tests are shown in Table 4.3-3.

Table 4.3-4 Results of the Water Quality Tests for BH-4 and BH-5

Borehole No.		BH-4	BH-5
Electrical Conductivity	µs/cm	25786	27500
pH		7.88	7.09
TDS	mg/L	18050	19250
Turbidity	NTU	NIL	NIL
NO_3-N	mg/L	45	55
NO_2-N	mg/L	7	4
COD	mg/L	1700	1325
CL^-	mg/L	11457	12462
SO_4^{2-}	mg/L	1350	1750

Source: Study Team

4.3.3 Analysis

(1) Permeability Test

Basalt lava is widely spread out in and around the studied area, and it has accumulated from the ground surface to a depth of approximately 70 m. The presence of lava tubes has not been confirmed, but due to the wide and frequent fissures formed as the basalt lava solidified, the permeability of basalt lava is very high.

Based on the results of the permeability test, the coefficients of transmissivity are $1.08x10^{-1}$ m^3/s and $1.78x10^{-1}$ m^3/s. In case the proposed effluent/influent flow of 350 m^3/h is used, it is inferred that the groundwater level around the boreholes can rise to approximately 0.03 m to 0.32 m based on the results of the pumping test.

(2) Water Quality Test

Based on the results of the conductivity test, it was found that the groundwater contains saline water under freshwater. It is inferred that seawater has intruded in the aquifer at the landside, as shown in Figure 4.3-11. The treated effluents will flow in the permeable basalt lava between the ground surface and groundwater level.

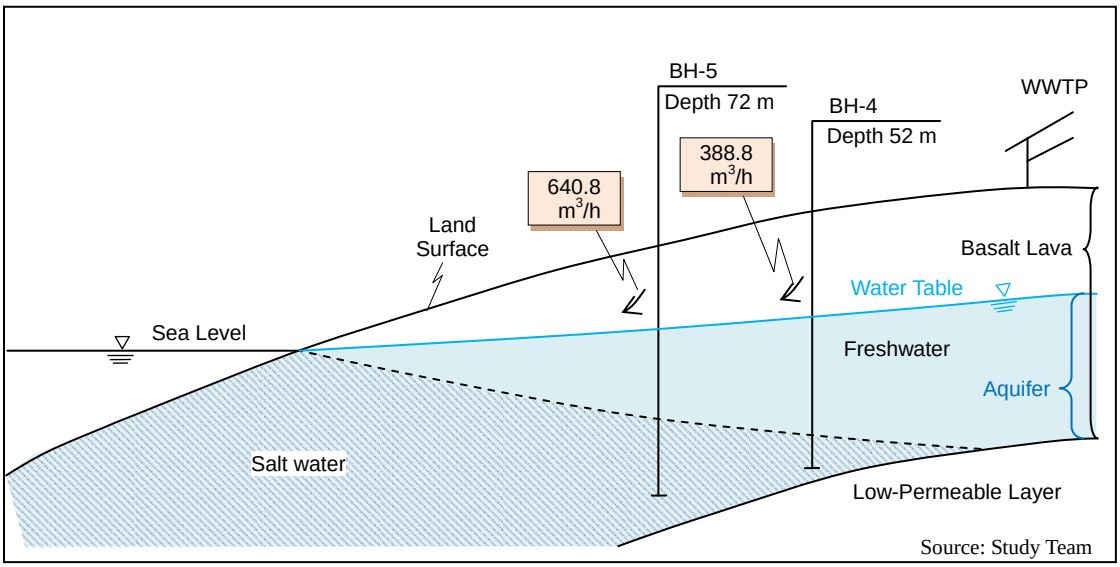


Figure 4.3-11 Schematic Profile of the Site

4.3.4 Conclusion

Since the basalt lava spread around the boreholes has many fissures and cavities which occurred during its formation, it has high permeability which allows the injection of effluent flow up to more than 350 m^3/h according to the results of the pumping test. The treated effluent can flow into the permeable basalt rocks from the ground surface to the upper part of the aquifer.

At present, two injection wells have been operated and groundwater has been monitored at three monitoring wells situated on the seaside. The injection wells drilled in this study are located on the west side of the existing monitoring wells. Therefore, new monitoring wells should be drilled downstream from the new injection well. At the same time, the direction of inflow unit shall be measured (e.g., by calorimetry method or electrical potential technique). Based on these results, the effective operation of the injection well, location of the new monitoring well and the developed plan for the construction of the injection well shall be examined.

CHAPTER 5 INFLOW AND INFILTRATION SURVEY

5.1 Outline of Inflow and Infiltration Mitigation

In the sewerage of Grand Baie, the stormwater inflow leads to flooding in the pumping station and increase of pumping energy. The inflow (stormwater inflow) is principally defined to flow and infiltrate through the storm drain cross connection, cover of manhole, inspection chamber, pipe joint, abandoned pipe, etc.

Inflow and infiltration (I/I) affect flooding of pumping facilities, hygiene of residences, degradation of biological treatment and so on. However, I/I cannot be prevented since fixing the building sewer and pipe joints requires time and costs.

I/I in Japan is equivalent to 1.5 to 2 times of dry weather flow in almost 50% of separate sewerage systems as shown in Figure 1.4-2. Therefore, I/I measures are focused on the typical issues of individual sewerage systems such as preventing sanitary sewer overflow, flooding of pumping station and degradation of biological treatment.

The construction of sewer material for infiltration proofing, and careful construction and inspection of building sewer contribute to I/I mitigation.

5.2 Field Survey

The field survey was conducted consisting of the reconnaissance survey and inflow rate analysis of the existing sewerage in Grand Baie, and the construction site of Plaine Wilhems Sewer Project Lot 2 (Quatre Bornes City).

(1) Sewer Construction

The following I/I measures were carefully applied on sewer construction:

- Flexible joint and rubber sealing
- Prefabricated PE inspection chamber with waterproofing
- Pipe bedding of sand and gravel
- Pressure test of piping during commissioning

The project manager suggested that the registration system was not provided for the building rehabilitation, as follows:

- The stormwater drain was connected to the wastewater drain after starting sewerage services.
- The septic tank and soakaway are still connected to the public sewer, thus, groundwater backflows through the soakaway during a storm.

(2) Existing Sewerage in Grand Baie

The reconnaissance survey of I/I was executed in dry weather and during a storm.

The Grand Baie area is a low-lying tourist spot with a commercial center facing the beach. Stormwater drainage is almost dependent on road surface drainage except for partial street gutter. Stormwater through the building is separated from wastewater and is then drained on to the ground. Manhole covers are located in easily inundated levels due to pavement maintenance works, and consist of large hook holes. The inspection chambers consist of open type for trapping grease and closed type for connections. These are located a little higher than the road surface.

The sewer pipes are PVC pipes with collar connection. The stormwater drain of the building is separated from the wastewater pipe; however, some stormwater drains connect to the gray water pipes.

During heavy rainfall, the habitual flood in low-lying areas is drained into the opened inspection chamber due the to lack of a drainage system. The inflow rate exceeds the

capacity of the sewer and treatment plant. Torrential inflow, which is three to four times of dry weather flow, is due to the intentional draining of inundated water by residents.

Low-lying beach with high groundwater level

Standard stormwater drain (separated)

Wetted manhole cover

Standard manhole cover with large hook hole

Low-lying manhole cover

Ventilation cover in low-lying road

Figure 5.2-1 Existing Sewerage System in Grand Baie (1/3)

Opened gully trap (easily flooded)

Failed hook hole

Roof drain connected to the kitchen sink

PVC pipes without socket and sealing

Habitual flooding

Inundated house

Overflowing manhole

Opened manhole cover

Figure 5.2-1 Existing Sewerage System in Grand Baie (2/3)

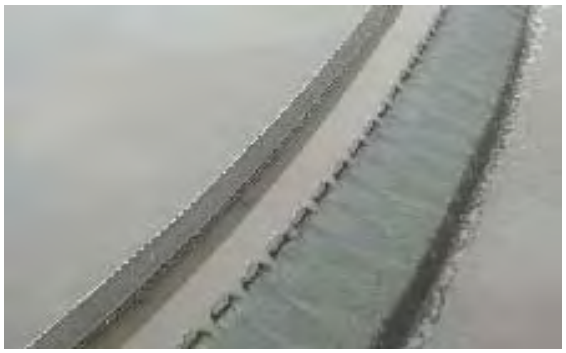
Opened inspection chamber

Cleaning a clogged inspection chamber

Storm drain cross connection

Retained water in manhole

Spill out of activated sludge



Overflow of disk filter（SSO）

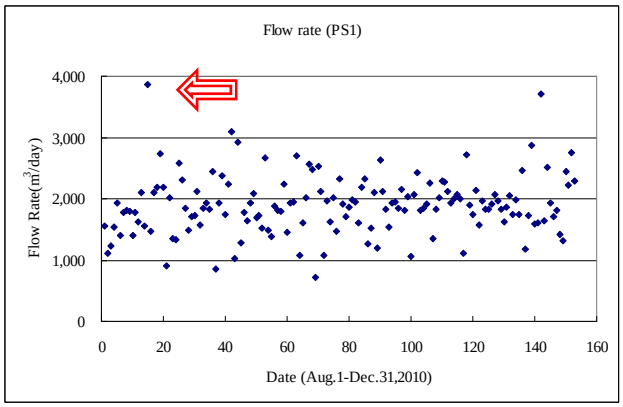
Figure 5.2-1 Existing Sewerage System in Grand Baie (3/3)

(3) Flow Analysis of Pumping Stations

The flow rate of the pumping stations in the Grand Baie sewerage system was analyzed. Flow data of seven of 13 pumping stations were recorded; however, hourly flow was not recorded. The sewerage treatment plant and pumping stations do not have rain gauge facilities. Squall brings downpour in limited rain areas with relatively high precipitation level of 10 mm/hr. As a result, the correlation of precipitation and wastewater flow cannot be determined.

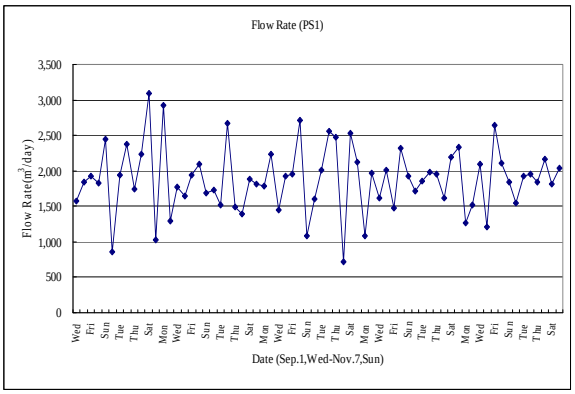
As for service area of each pumping station, the flow rate is the difference of the upper and lower pumping stations. The flow data of individual pumping stations fluctuates and suggests no significant I/I. The flow data also suggests the characteristics of the service area such as for a commercial/tourist spot with regular fluctuation in a week or for a residential area with uniform flow.

PS-1: Aug. 1 – Dec. 31, 2010



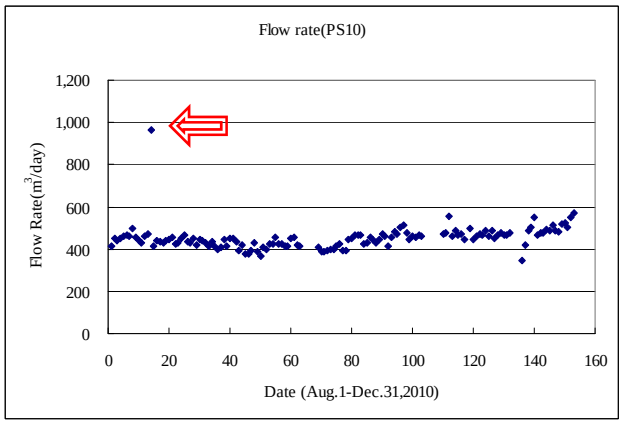
Irregular flow on Aug. 14, 2010

PS-1: Sep. 1 – Nov. 7, 2010



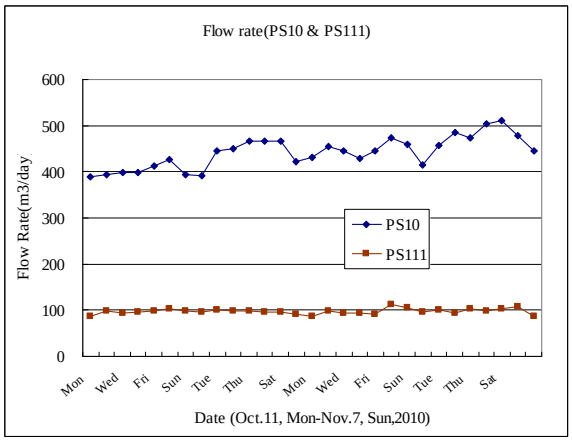
Periodical fluctuation almost in a week.

PS-10: Aug. 1 – Dec. 31, 2010



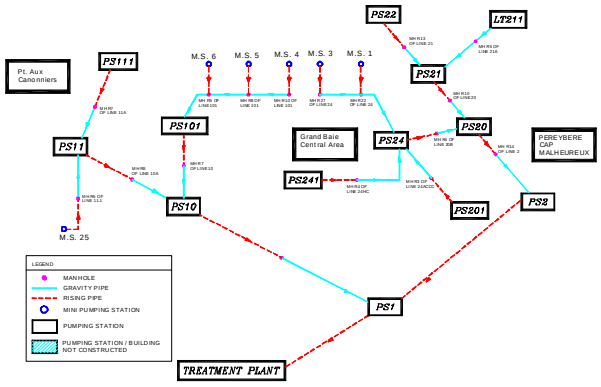
Irregular flow on Aug. 14, 2010.

PS-10 and PS-111: Oct. 11 – Nov. 7, 2010



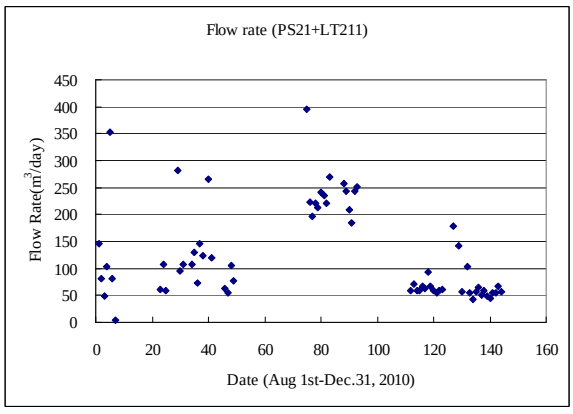
Periodical fluctuation vs. regular flow.

Pump network



Area of PS-21 and LT211

(Flow of PS-21 – Flow of PS-22)



Individual catchments cannot be detected due to the inaccuracy and lack of flow data.

Figure 5.2-2 Flow Rate of Pumping Station

Table 5.2-1 Flow Rate of Pumping Stations (1/3)

Month	Date		PS1	PS10	PS11	PS101	PS111	PS2	PS20	PS21	LT211	PS22	PS24
Individual Area (ha)			219.2	11.7	22.1	12.4	27.6	14.9	11	8.1	4.1	41.2	42
Accumulated Area (ha)			219.2	73.8	49.7			145.4	130.5	53.4			66
2010			Flow(m3/day)										
Aug.	1	Sun	1564	416.50	301.00		246.10					376.20	608.10
	2	Mon	1118	451.80	288.30		241.70					361.60	580.50
	3	Tue	1226	439.00	268.70		346.10					357.70	577.50
	4	Wed	1535	451.10	195.70		295.40					350.30	615.10
	5	Thu	1928	459.80	191.60		284.50						602.40
	6	Fri	1396	465.60	196.50		251.20						659.60
	7	Sat	1777	460.80	186.30		258.20					316.60	694.70
	8	Sun	1818	498.00	272.20		229.40					319.60	740.90
	9	Mon	1797	456.50	218.30		249.80					338.70	684.40
	10	Tue	1399	442.50	263.20		207.00			480.10		333.30	645.20
	11	Wed	1771	429.60	337.80		263.50			415.80		334.00	704.50
	12	Thu	1622	460.50	384.50		221.80			473.50		424.10	638.30
	13	Fri	2102	470.70	213.20		328.20			429.40		326.90	701.50
	14	Sat	1556	965.20	654.80		251.20			910.20		558.10	1814.90
	15	Sun	3864	414.00	388.20		255.50			623.90		542.30	970.20
	16	Mon	1473	442.50	247.90		224.60			536.70		531.70	758.00
	17	Tue	2105	432.80	302.10		226.50			496.00		513.70	901.50
	18	Wed	2190	430.20	252.40		253.20			445.90		482.40	2442.60
	19	Thu	2727	440.00	223.50		246.70			411.00		451.50	
	20	Fri	2192	445.20	455.20		270.20					430.90	
	21	Sat	899	454.80	342.70		282.90					427.90	
	22	Sun	2021	425.30	363.40		237.60					388.10	
	23	Mon	1352	427.40	364.70		223.80					400.00	944.70
	24	Tue	1338	451.30	313.10		104.50					383.00	637.20
	25	Wed	2574	464.50	335.20		107.40					392.50	712.20
	26	Thu	2301	434.30	278.30		104.40					366.70	596.20
	27	Fri	1839	428.00	382.10		104.60					362.30	652.50
	28	Sat	1491	448.90	203.30		115.30					365.10	617.30
	29	Sun	1714	419.50	171.50		109.10					355.70	636.40
	30	Mon	1723	447.10	190.60		109.50					356.70	623.20
	31	Tue	2120	437.60	199.90		111.40					355.80	620.90
Sep..	1	Wed	1575	428.40	256.40		114.00			406.90		347.00	625.50
	2	Thu	1842	415.80	247.50		106.20			428.10		320.50	643.00
	3	Fri	1931	434.60	180.00		107.30			416.90		357.80	707.30
	4	Sat	1832	413.30	184.00		105.20					346.70	684.70
	5	Sun	2452	395.80	181.00		103.90					333.80	676.20
	6	Mon	859	407.90	172.10		106.40					344.80	676.20
	7	Tue	1940	445.40	193.90		108.00			615.10		333.80	660.70
	8	Wed	2373	416.50	182.00		102.40			428.90		334.40	637.50
	9	Thu	1750	451.90			107.10			450.40		343.10	697.00
	10	Fri	2239	449.20			105.90			448.10		914.80	678.50
	11	Sat	3094	434.70			112.10			435.00			654.00
	12	Sun	1025	392.80			103.30			403.50		296.10	638.80
	13	Mon	2924	419.80	190.80		104.20			442.40		312.60	622.70
	14	Tue	1288	379.10	206.90		102.00			389.50		316.60	605.90
	15	Wed	1773	374.80	393.10		104.00			452.00		307.00	609.40
	16	Thu	1638	392.50	174.70		101.00			436.80		312.90	642.00
	17	Fri	1937	427.70	158.20		101.90					309.10	594.20
	18	Sat	2089	388.30	191.10		96.30			575.20		309.00	558.60
	19	Sun	1690	369.30			89.10			408.70		288.70	541.70
	20	Mon	1735	408.00			97.70					294.30	551.20
	21	Tue	1525	400.00			98.50					295.50	569.40
	22	Wed	2672	421.90			106.70					437.00	563.20
	23	Thu	1495	426.70			108.60					308.70	567.70
	24	Fri	1387	458.20			107.50			358.00		295.90	563.80
	25	Sat	1882	424.80			106.50			354.60		300.10	565.70

Table 5.2-1 Flow Rate of Pumping Stations (2/3)

Month	Date		PS1	PS10	PS11	PS101	PS111	PS2	PS20	PS21	LT211	PS22	PS24
	26	Sun	1815	422.30			101.20			399.40		293.60	555.50
	27	Mon	1792	415.90			105.90			374.10		296.80	538.70
	28	Tue	2240	414.50			104.70			737.60			538.20
	29	Wed	1450	450.40			103.10			405.20			589.60
	30	Thu	1926	457.00			104.50			437.80			595.00
Oct.	1	Fri	1956	419.90			95.60			458.30			574.40
	2	Sat	2707	413.50			93.00			480.90			589.20
	3	Sun	1081										
	4	Mon	1605										
	5	Tue	2015										
	6	Wed	2556										
	7	Thu	2479										
	8	Fri	723	410.60			96.40						613.80
	9	Sat	2533	390.20			96.40						585.90
	10	Sun	2124	388.00			86.00						594.30
	11	Mon	1081	392.60			98.40						539.60
	12	Tue	1961	399.10			94.60						578.10
	13	Wed	1616	397.30			97.10						572.70
	14	Thu	2009	412.00			97.80			2359.30			580.10
	15	Fri	1469	426.40			103.70			448.90			601.40
	16	Sat	2321	394.20			99.40			525.40			608.00
	17	Sun	1919	391.90			95.50			488.70			564.50
	18	Mon	1709	445.10			101.80						572.10
	19	Tue	1856	450.30			99.60			608.30			561.50
	20	Wed	1975	467.20			99.10			484.60		287.10	588.20
	21	Thu	1955	465.30			95.30					302.20	587.90
	22	Fri	1613	465.80			95.60					299.50	591.80
	23	Sat	2186	422.90			90.60			719.70		325.10	577.20
	24	Sun	2331	432.20			85.90			499.70		275.80	597.90
	25	Mon	1263	454.40			97.90			466.80		270.30	584.60
	26	Tue	1513	445.80			94.30			501.40		281.20	573.30
	27	Wed	2099	428.30			94.60			487.30		273.90	595.00
	28	Thu	1203	445.80			92.30			514.30		272.80	591.50
	29	Fri	2636	473.80			112.30			503.70		267.70	594.30
	30	Sat	2115	459.50			105.20			502.40		281.80	589.90
	31	Sun	1835	415.40			95.40			533.40		264.30	602.90
Nov.	1	Mon	1542	456.50	98.50		100.50					269.00	567.20
	2	Tue	1929	484.40	144.30		93.40					269.50	611.10
	3	Wed	1949	473.10	190.60		102.40					271.60	589.20
	4	Thu	1844	503.00	170.50		99.10					263.80	608.10
	5	Fri	2162	511.40	211.90		103.10			530.50		272.80	636.50
	6	Sat	1808	478.20	217.70		108.70			521.20		278.50	594.80
	7	Sun	2035	446.30	222.10		85.90			467.30		259.40	575.20
	8	Mon	1064	462.00	212.40		100.00			452.90		268.30	571.40
	9	Tue	2076	457.50	190.30		97.50			508.80		266.40	559.80
	10	Wed	2419	467.70	198.80		99.10			511.90		261.50	521.00
	11	Thu	1804	462.90	193.90		101.20			433.40			
	12	Fri	1851										
	13	Sat	1918										
	14	Sun	2260										
	15	Mon	1354										
	16	Tue	1827										
	17	Wed	2013										
	18	Thu	2297	469.20			111.30						602.70
	19	Fri	2278	478.50			63.30						1011.60
	20	Sat	2120	552.90			100.20						720.50
	21	Sun	1933	462.60			109.70						668.60
	22	Mon	1992	489.90	202.50		110.40						636.10
	23	Tue	2066	466.20	229.60		104.10						604.60
	24	Wed	1997	469.60	218.90		105.80						591.30

Table 5.2-1 Flow Rate of Pumping Stations (3/3)

Month	Date		PS1	PS10	PS11	PS101	PS111	PS2	PS20	PS21	LT211	PS22	PS24
	25	Thu	1116	444.10	206.10		102.30						563.20
	26	Fri	2720		233.80		106.20					245.30	573.30
	27	Sat	1893	498.10	222.90		104.10					265.30	559.10
	28	Sun	1747	444.40	200.20		102.50					263.50	557.60
	29	Mon	2131	462.10	239.50		106.90			355.70		297.30	573.00
	30	Tue	1576	473.60	216.60		99.20			359.10		288.90	598.30
Dec.	1	Wed	1965	467.90	201.30		100.50			357.60		298.10	599.50
	2	Thu	1831	485.10	195.50		102.00			354.00		295.50	572.10
	3	Fri	1834	462.40	241.40		109.20			351.10		283.20	595.70
	4	Sat	1913	487.60	307.20					368.50		306.40	572.70
	5	Sun	2063	449.20	247.60		96.70			348.70		256.00	600.30
	6	Mon	1966	466.80	222.80		109.40			346.50		278.80	563.20
	7	Tue	1830	476.70	213.70		110.30			345.90		286.50	557.80
	8	Wed	1628	468.20	223.60		114.10			349.90		295.00	580.60
	9	Thu	1865	467.20	217.30		106.10			345.30		285.80	564.70
	10	Fri	2052	477.50	204.00		104.80			352.20		291.20	575.90
	11	Sat	1737										
	12	Sun	1982										
	13	Mon	1739										
	14	Tue	2459	344.60			112.20			469.90		291.60	566.70
	15	Wed	1178	419.60			107.90					258.40	566.70
	16	Thu	1728	486.90	223.40		118.40			424.90		282.80	592.00
	17	Fri	2878	505.20	210.00		117.80			348.20		291.80	707.00
	18	Sat	1585	550.00	233.00		127.60					315.90	648.80
	19	Sun	1603	467.90	200.30		100.20			384.10		281.10	608.00
	20	Mon	3710	478.30	250.30		112.20			336.40		282.60	598.60
	21	Tue	1640	476.60	192.00		109.70			351.20		308.10	610.60
	22	Wed	2510	494.30	199.60		109.80			361.70		305.60	636.60
	23	Thu	1928	485.70	188.20		104.40			359.50		293.80	637.10
	24	Fri	1716	516.10	239.60		105.00			347.10		295.80	670.00
	25	Sat	1816	487.20	194.80		103.90			356.10		298.00	
	26	Sun	1411	479.50	191.70		109.90			358.50		310.00	646.00
	27	Mon	1321	519.60	176.00		121.90			349.00		303.80	655.90
	28	Tue	2438	522.90	192.80		122.70			355.10		301.00	663.60
	29	Wed	2228	505.00	192.60		115.70			344.30		288.60	662.40
	30	Thu	2745	550.50	219.40		122.50			359.30		292.80	664.00

5.3 Inflow and Infiltration Mitigation Plan

(1) Overall Inflow and Infiltration Mitigation Plan

The inflow and infiltration mitigation plan is summarized in Table 5.3-1. The plan consists of inflow mitigation and prevention of sewerage facilities and treatment plant.

Mitigation measures were categorized into operation and maintenance (O&M), on-site facilities and off-site facilities. Retention, sewer fixing, expansion of capacity of sewer and pump, stormwater drainage and reuse were applied to individual inflow sources. Bypassing and disinfection were applied for the prevention of treatment degradation.

Since rivers and streams were not developed in the Grand Baie area, stormwater drainage is made of road surface drainage, and infiltration into ground and swamp. Only limited areas have street gutters. Cyclones habitually inundate streets and residences; therefore, residents intentionally drain stormwater into sewers. This is the principal source of inflow in the Grand Baie sewerage system.

The most practical mitigation measure is to build stormwater drainage and facilities for reuse. Locking of manhole covers and separation of building sewers will be practiced after raising the public awareness on stormwater mitigation.

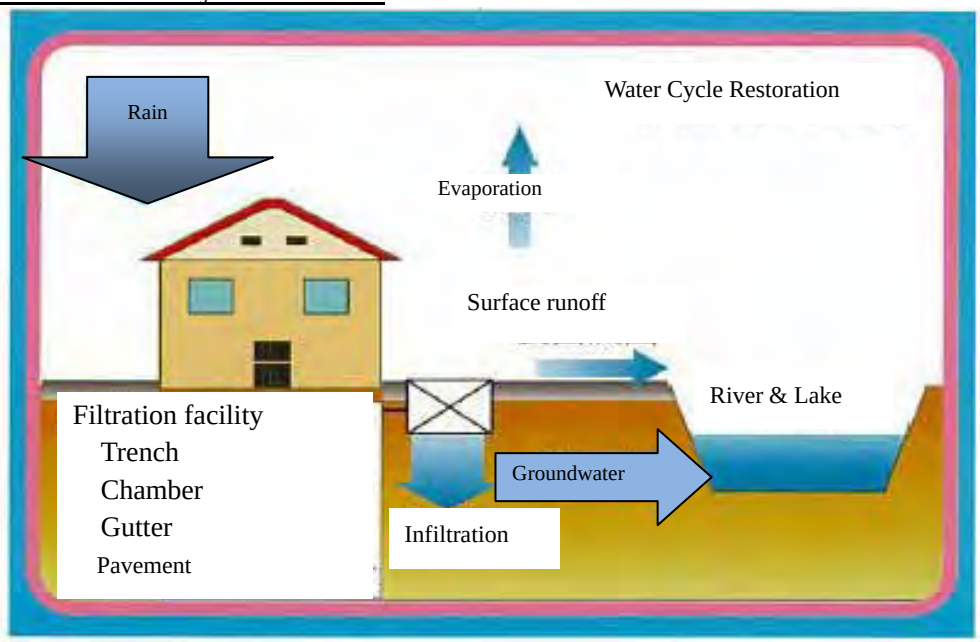
Table 5.3-1 Overall Inflow and Infiltration Mitigation Plan

O&M of facilities	Retaining in sewer Standby pump operation Bypassing aeration tank	
On-site measures	Fixing building sewers	Fixing of pipes and manhole covers, storm drain separation Disconnection of abandoned septic tanks and soakaways
	Fixing sanitary sewers	Fixing of pipes and manhole covers, storm drain separation Disconnection of abandoned sewers
	Stormwater drainage	Drainage, infiltration and reuse, retention
Off-site measures	Sewer and pumping station	Expansion of sewer capacity, standby pump operation Retention reservoir
	Treatment plant	Bypassing aeration tank Sedimentation and coagulation, filtration, etc. Disinfection

(2) Stormwater Drainage and Reuse

Public-private participation is required for the successful implementation of stormwater drainage and reuse facilities. The intensity of infiltration in roads and housing lots has a low efficiency at 2 to 3 mm/h; however, it can be applied to almost all property. Stormwater reuse is acceptable to the public with respect to the environment. Retention and infiltration were applied in order to prevent the contamination of the beach in the village of Triolet. Road surface water is retained in the basin and then released through the weir in case the retaining and infiltration capacity is exceeded. In the Grand Baie area, retention and infiltration (i.e., retaining stormwater before draining into the swamp) is an environmentally friendly measure which can be applied for preventing inundation. A public space for a park and parking area was also developed in the underground retention facility.

Infiltration for water cycle restoration

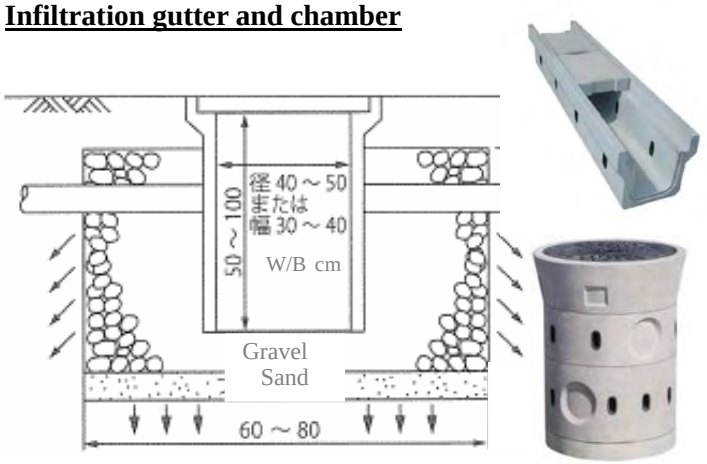


*Stormwater infiltration effects urbanization.

Stormwater retention and reuse

Off-site facilities	Multipurpose retention pond Regulation tank	
On-site facilities	Retention tank	Rain tank for reuse School ground retention Underground retention tank Open retention using building yard, etc.
	Infiltration	Permeable pavement Infiltration gutter and chamber Infiltration trench, etc.

Infiltration gutter and chamber



Rain tank for Stormwater Reuse

Figure 5.3-1 Infiltration and Rainwater Tank

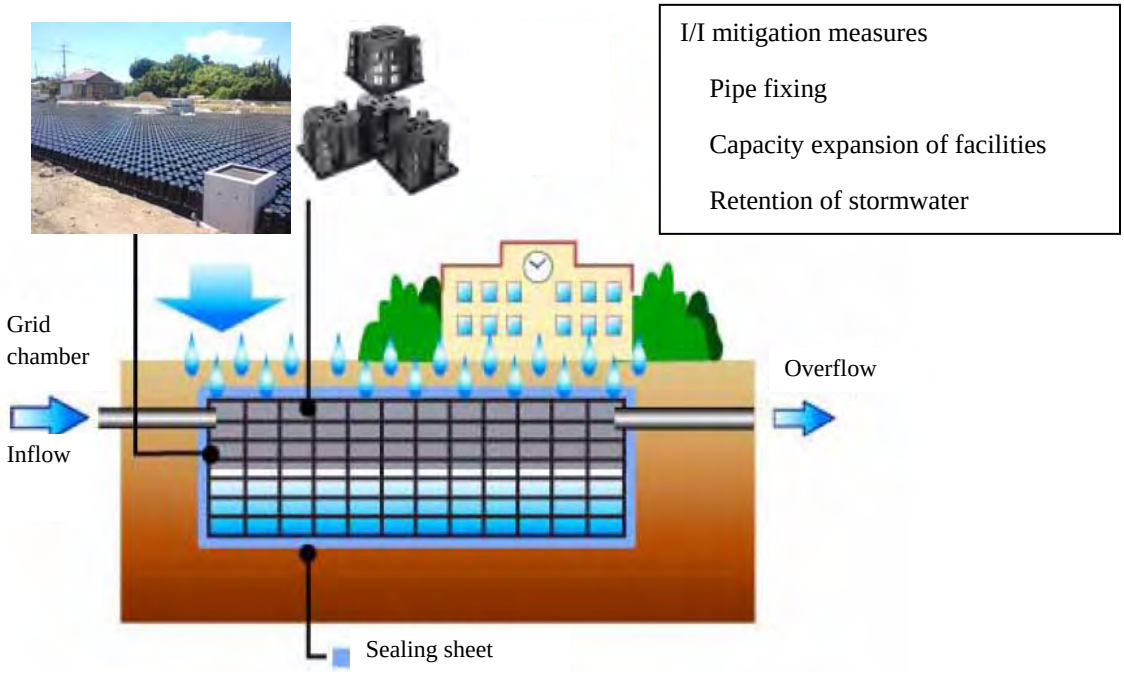


Figure 5.3-2 Stormwater Reservoir in Public Space

Grand Baie Government School

Green space beside swamp

Stromwater outfall with sedimentation and infilitration (Pointe aux Piments)

Figure 5.3-3 Stormwater Reservoir

(3) Design and Construction Measures

Flexible joint, rubber seal and adhering pipe to pipe were significant measures utilized for preventing leakage and deformation of pipe. Backfilling will be executed in accordance with the design drawings as the pipe base is filled and compacted. The insufficient compaction of the pipe base will bring nonuniform load on the pipe causing it to deform and displace and for the road to subside.

In Mauritius, prefabricated PVC manholes and inspection chambers, and rubber seals were utilized for the sewer materials. Pressure tests were also applied. Careful construction supervision in accordance with standard design drawings and construction manual was significantly applied.

Manhole covers, which are locking type with a small hook hole, are recommended. Ventilated manhole covers are not appropriate for the prevention of inflow of street surface water.

Sewer with sand bedding

Pipe with socket and seal ring

Flexible joint and sealing

Adherance and binding

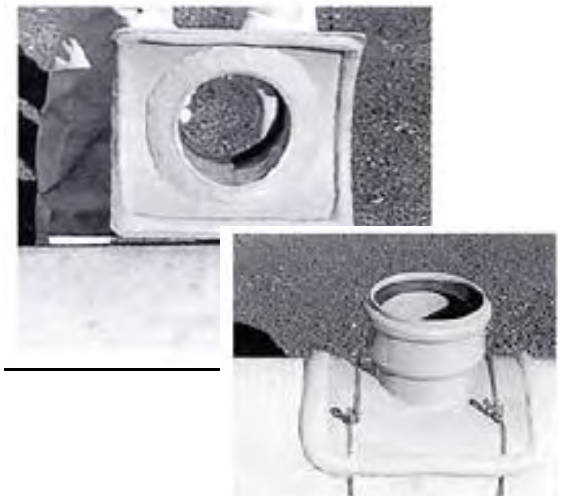
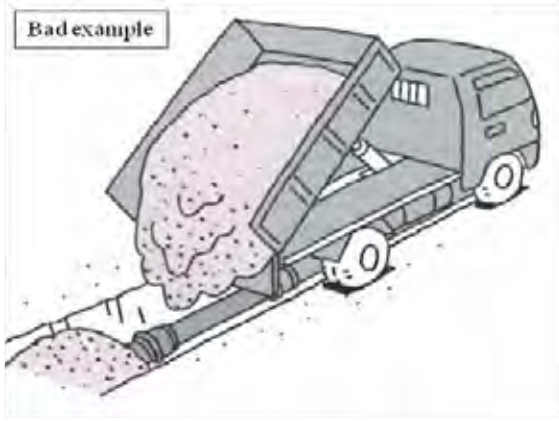


Figure 5.3-4 I/I Mitigation during the Construction Stage (1/2)

Socket pipe with seal ring

Inspection chamber (PVC) with waterproofing

Careful backfilling (bad example)



Careful pipe laying (good example)

Standard manhole cover (Kobe City)

Inflow free cover (Hotaka Town)

Figure 5.3-4 I/I Mitigation during the Construction Stage (2/2)

(4) O&M Measures

1) Rain Gauging

Rain gauges and flow meters will be utilized in order to determine the correlation of wastewater flow and precipitation. Since flow meters were equipped in seven among 13 pumping stations, detecting the inflow of each pumping area is important in order to know the area where to fix the pipes. The rain gauges and flow meters can be operated in the SCADA replacement project.

2) Fixing the Manhole Covers and Inspection Chambers

Manholes with failed hook holes and opened covers shall be fixed in the regularly inundated roads considered. The inflow for hook holes with area of 50 cm^2 and flow rate of 1,000 cm^3/s (velocity: 20 cm/s) is equivalent to 86 m^3/day. Since ventilated manhole covers in low-lying roads are scarce, conventional covers are to be replaced. Inspection chambers and grease traps with closed covers including sewers are not ventilated by ventilated manhole covers but through air ducts connected to houses.

3) Emergency Tank

Emergency storage and storage tanks with volume of 21,000 m^3 each retain increased inflow. The provisional treatment capacity of 2,100 m^3/day for storage, along with 3,430 m^3/day for usual flow treatment (total capacity of 5,530 m^3/day), can treat the retained water.

Manual valves of the diversion facility control the wastewater flow into the biological aeration tank and emergency storage tank. Automatic valves were recommended to replace the manual valves since wastewater flowing into the biological tank can be simultaneously controlled with the pumping flow meter and rain gauge.

The Phase 2 project improves the treatment capacity and diversion chamber equipped controls of the existing treatment and newly constructed facilities. During high inflow in rainy events, the diversion chamber will divert wastewater inflow to the biological treatment and emergency storage tanks.

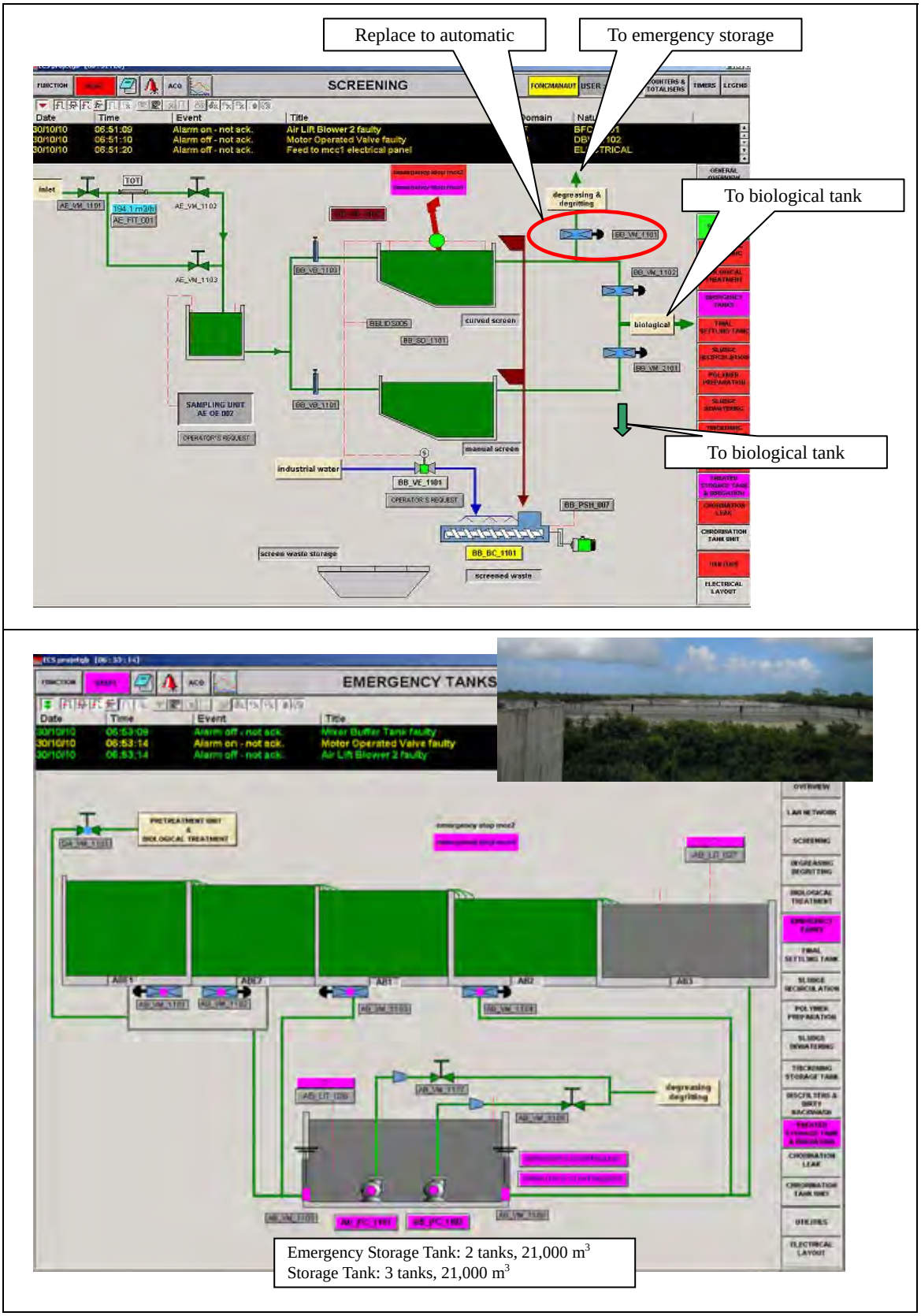


Figure 5.3-5 Diversion Facility

(5) Qualified Plumbers

Since design and construction supervision provide the overall inflow mitigation measures, a new development project will mitigate I/I. The remaining inflow source was assumed from defective plumbing such as cross connection of stormwater drains. The qualification system for plumbers is not provided, and the training and certification were committed on commercial basis. Examining sewerage engineers suggests that inexperienced plumbers bring about I/I issues. The study team discovered displaced connections of water supply and cross connection of stormwater drain to wastewater pipe. Qualified plumbers will be accepted by the public sector since they will provide affordable quality works and prevent defective piping, which can be advantageous to the public sector. With regards to their duties, plumbers can troubleshoot clogging and eliminate offensive odors in the sewer system. The collaboration with plumbers also provides a request center during the night and on weekends.

Figure 5.3-5 Sticker: Authorized Plumber One-Stop Shop of Wastewater-related Matter

The following outlines the plumber registration system and public-private collaboration:

1) Outline of Plumber Registration

- Qualified engineers and facilitated equipment
- Examination and training of qualified plumbers
- Penalty on illegal application and defective piping of house connections
- Registration fee and periodical renewal of plumber certification

2) Public-Private Collaboration on Troubleshooting and Public Relations

- Consultation and public relations on claims regarding building sewer with problems such as clogging and offensive odors
- Announcement on stormwater infiltration and reuse of rainwater
- Report to the community on disaster operations
- Distribution of statements and leaflets

3) Activities of the Association of Plumbers

- Examination for the qualification and certification of plumbers
- Training and seminars for qualified plumbers

4) House Connection Manual under the Ordinance on Sewerage

- Obligation on sewerage services such as building sewer installation and septic tank disconnection
- Application and approval for house connection, and on-site inspection after the completion of plumbing
- Design manual of building sewers such as pipe layout, specifications of plumbing materials, etc.
- Registration of certified plumbers
- Technical guidelines on pretreatment facilities of commercial wastewater discharge such as that from hospitals, gas stations, restaurants, hotels, laundry facilities, etc.
- Penalties or fines

5.4 Technical Assistance Meeting on Inflow and Infiltration Mitigation

(1) Report on Weekly Meeting

The I/I mitigation plan on separated sewerage was discussed in the following meetings:

(i)	January 7, 2011 (Friday)	Introduction of Japanese experience
(ii)	January 31, 2011 (Monday)	Report on field survey (1)
(iii)	February 7, 2011 (Monday)	Report on field survey (2)
(iv)	February 11, 2011 (Friday)	JICA Madagascar Office meeting
(v)	February 18, 2011 (Friday)	Report on field survey (3)
(vi)	February 25, 2011 (Friday)	I/I mitigation plan

(2) Construction Site Meeting

The construction site meeting was held in which information/knowledge were exchanged with the project manager, Mr. Rez. Details of the construction site meeting are as follows:

- Date: January 28, 2011 (Friday)
- Project office: Plaine Wilhems Sewer Project Lot 2 (Quatre Bornes City)
- Project profile:
  - Sewer construction (original plan of 87 km will be extended to 110 km due to urbanization during the ten years after the F/S)
  - Water supply distribution pipe of 50 km will be replaced to DCIP
  - House connections: 13,000 houses
  - Project duration: six years

In the discussion, the project manager informed that the regulation and monitoring system was not provided for the building rehabilitation, as follows:

- Stormwater drain was connected to the wastewater drain after starting sewerage services.
- The septic tank and soakaway are still connected to the public sewer, thus, groundwater backflows through soakaway during a storm.

JICA Study Team

The study team proposed the house connection approval system of Japan's major cities and Singapore, in which the administration regulates building rehabilitation projects through ordinances on sewerage and building approval.

The study team identified in detail the administration system and its operation in Singapore. The WMA, which is under the national government and provides sewerage services, is also similar to the Public Utility Board (PUB) of Singapore. PUB is the responsible organization on the acts and ordinances on sewerage.

(3) DF/R Meeting

The I/I mitigation plan of Grand Baie sewerage, which is attached as Appendix 5 of the Main Report, was provided by means of a PowerPoint presentation tool. The plan is also presented to the O&M staff of the Grand Baie Sewerage Treatment Plant.

CHAPTER 6 CONCLUSION

6.1 Topographical Survey

The topographical survey requires time and manpower since it was executed with the permission and approval of relevant organizations and landowners.

The street survey was executed with sufficient accuracy in order to prevent obstacles as GPS digital terrain model and electro-optical distance measurement are combined. The street survey was efficiently conducted and provided, at the early stage, a contour map which supplied valuable information for the housing lot survey and sewer layout plan. The study is the first to develop a contour map of Grand Baie.

Regarding the housing lot survey, cadastral records and household information were not established, and customer information of the CWA and Energy Services Division of the Ministry of Energy and Public Utilities cannot identify the addresses and house owners. The study aims to survey the addresses, house owners and telephone numbers by interviewing each household. As expected, the housing lot survey was delicate on privacy issues, and the interview was executed with each household by explaining the importance of sewerage. The WMA provided announcements through the radio and the regional office; however, the survey team was forced to visit repeatedly due to the rejection of some residents and noncooperation. As a result, individual information was integrated to the household inventory.

The topographical survey contributed for the reduction to three pumping stations and 11 MSs with 25 m pump head. House connections require drainage pumps for houses in low-lying areas, vacant houses, and houses on the beach at the backside of the hill. Low cost sewers proposed for those such as private properties were condominial sewer system and grinder pump units (individual house type and communal type).

6.2 Land Acquisition and Consultation with Authorities

Rights on land ownership are established and the compulsory acquisition of land shall be delegated to the Board of Assessment, Land Acquisition after preparing the preliminary plan in the detailed design stage. Negotiations on land acquisition starts after Committee monitors and judges. Land is not acquired during the F/S. Facility plan shall be executed in accordance with examining the willingness of landowners.

The study required consultation with relevant authorities and landowners on deciding the location of the pumping station and injection well. For example, core hole and borehole tests require drilling approval from the WRU's groundwater administrator and from CWA's water supply operator. Roadside is regulated as a road reserve, therefore the permission from the road administrator is required (the RDA for classified road and the district council/municipality for nonclassified road). There were also landowners who could not be contacted since they are staying abroad. The study proposed to relocate the candidate site of two pumping stations from private properties to public properties. Land acquisition was considered to be a risk for project delays.

6.3 Geological Survey

The geological survey detected lava rock in five pumping station sites. The groundwater level was also detected to be as deep as the seawater level since only two water samples were obtained.

From the reconnaissance survey and geological survey, lava rocks which affect construction works were detected in the whole project area. Lava rock is jointed, and consists of hard and weathered rocks. Crushers are to be used for construction work and quarry.

The main sewer was planned on the main road with gravity flow and approximately 1 m difference can be excavated. Small roads are difficult to excavate wherein the drainage pump was applied. The proposed sewer layout plan displaces adjacent MS considering the cost of construction and O&M of MS. Sewer pipes were laid in water at ground elevation of 2 m. Construction works were supposed to utilize the drainage pump because of limited groundwater inflow through rock joints.

6.4 Injection Well Survey

The existing two injection wells operate intermittently with each other, and one injection well was abandoned. The study took two additional injection wells and surveyed for their permeability tests. Since lava tubes were not detected in the Grand Baie area, injection was performed through cracks of lava rock. The distribution of injection wells were determined considering the lava flow direction at Mont Virer, the existing well layout and the potential site for wells in future wastewater flow expansion.

The first injection well (BH-4) was stopped at a depth of 52 m because drilling reached a cavity rock layer and debris of 15 cm cannot be exploited. The second well (BH-5) was

changed from 300 mm to 380 mm diameter.

The drilling and injection test detected cavity layers for both wells at a depth of 42 to 52 m.

Transmissivity, measured between 100 and 1,000 min of the 24 hour test, was estimated at 9,311 m^2/day ($1.08x10^{-1}$ m^2/s) for BH-4, and 15,372 m^2/day ($1.78x10^{-1}$ m^2/s) for BH-5.

6.5 Inflow and Infiltration Mitigation

The I/I mitigation plan consists of inflow mitigation and prevention for sewerage and treatment facilities.

In Mauritius, I/I mitigation during the construction stage applies overall measures such as rubber sealing and PE prefabricated inspection chamber, manual excavation, pipe bedding of sand and gravel, pressure test, and separation of stormwater from wastewater drain. The existing sewerage system in Grand Baie facilitates inflow from failed manhole cover and opened inspection chambers for grease trap. However, the most significant inflow is detected from residents' intentional inundated water drainage which amounts to three to four times of dry weather flow.

Therefore, the study proposed stormwater drainage of infiltration, retaining flow in the school grounds and rain reuse, along with comprehensive application of inflow prevention, waterproof sewer material, careful construction and stormwater drainage. As for treatment, the manual valve of the diversion chamber is to be modified to automatic valve in order to prevent overloading of the final sedimentation tank and spilling out of activated sludge. The replacement of SCADA in Phase 1-B and the treatment plant expansion in Phase 2 are essential for upgrading the treatment in the inflow mitigation plan.

As for the soft measures, the study proposed a system for qualified plumbers consisting of certified engineers, plumber registration and penalties in conjunction with public-private relation in order to prevent inferior work, and for troubleshooting of sewer problems, maintenance and public relations.

The study is one of the technical assistance projects which aims to promote a smooth detailed design and construction project under an official development assistance (ODA) loan, and to enhance project results through topographical survey and I/I mitigation survey. The study proposed main sewer routes in accordance with the topographical condition, considering the number of pumping stations and pumping head. Effective wastewater collection in low-lying areas and customer information, which is required during the operation stage, were also proposed. Technical and institutional plans on I/I mitigation were

provided for the management of sewerage facilities.

APPENDIX

1 Land Acquisition Act

LAND ACQUISITION ACT

RL 3/341 – 18 December 1973

ARRANGEMENT OF SECTIONS

PART I – PRELIMINARY

1 Short title

This Act may be cited as the Land Acquisition Act.

2 Interpretation

In this Act –

"acquisition" includes the taking of possession;

"authorised officer" means any person designated as such under section 25;

"Board" means a Board of Assessment appointed under section 25;

"body corporate" means a body corporate of the kind described in section 8 (6) of the Constitution;

"Chairman" means Chairman of the Board;

"divesting order" has the same meaning as in section 2 of the Curatelle Act;

"interested person" –

(a) means a person who owns, possesses, holds a mortgage or charge over, is entitled to or is otherwise interested in, land –
  (i) described in a notice published under section 8 or 9; or
  (ii) affected by the exercise of the powers conferred on the authorised officer under section 6 (4);

(b) does not include –
  (i) a tenant the term of whose lease is less than one month;
  (ii) a person who, otherwise than by the operation of the law relating to testamentary or intestate succession, acquires an interest in land, the acquisition of which is contemplated under this Act, after service of notice on the owner under section 8 or 9;

"land" includes buildings and any right or interest in land;

"Minister" means the Minister to whom responsibility for the subject of lands is assigned;

"owner" means the person capable of alienating any land;

"party" means the authorised officer, an interested person who has made a claim for compensation under this Act or a person on whose behalf the Government is acting under section 5;

"period of public emergency" has the same meaning as in Chapter II of the Constitution;

"vesting order" has the same meaning as in section 2 of the Curatelle Act.

3 Application

This Act shall apply to all cases of compulsory acquisition of land.

PART II – COMPULSORY ACQUISITION OF LAND

4 Land owned by a body corporate

(1) Notwithstanding any other provision of this Act, the Minister may compulsorily acquire any land owned by a body corporate after he has given notice of his intention to do so in the *Gazette*.

(2) The Minister shall cause the notice published under subsection (1) to be transcribed by the Conservator of Mortgages who shall, after the transcription, deliver to the Minister a certificate to the effect that the notice has been transcribed under section 7 of the Transcription and Mortgages Act.

(3) The transcription of the notice under subsection (2) shall constitute in favour of the Government title to the land to which it relates free from all charges and encumbrances.

5 Acquisition other than for Government

(1) Where a person requires any land and has not been able to acquire it by private agreement, he may make a written request to the Minister for the compulsory acquisition of the land.

(2) A request under subsection (1) shall –

(a) set out –

(i) a description of the land which is required;

(ii) the approximate value of the land for compensation purposes;

(iii) the reasons for which the land is required; and

(b) state that it has not been possible to acquire the land by private agreement.

(3) On receipt of a request under subsection (1), the Minister may –

(a) require the person making the request to furnish him with such further information as he requires to enable him to determine whether or not the land may be acquired compulsorily;

(b) acquire the land compulsorily on behalf of the person making the request in accordance with the other provisions of this Act.

(4) Any expenses incurred in connection with the acquisition of land under this section shall be reimbursed to the Government by the person on whose behalf the land has been acquired and shall be paid into the Consolidated Fund.

6 Investigation of land

(1) Subject to section 9, where land is likely to be acquired compulsorily and the Minister is satisfied that –

(a) an investigation of the land is necessary to determine its suitability for the purpose for which it would be acquired;

(b) it is not possible to obtain access to the land by private agreement; and

(c) the conditions of section 8 (1) (a) and (b) of the Constitution are fulfilled,

he shall give notice to that effect in 2 issues of the *Gazette* and in 2 issues of 2 daily newspapers, there being in each case an interval of at least 7 days between the first and second publications.

(2) A notice published under subsection (1) shall –
(a) state the approximate extent of the land;
(b) describe the boundaries of the land;
(c) state the purpose for which the land is likely to be acquired; and
(d) in the case of an acquisition on behalf of a person under section 5, state the name, address and occupation of the person for whom the land may be acquired.

(3) On or about the day of the first publication of the notice specified in subsection (1) a copy of the notice shall be served by the authorised officer on the owner of the land likely to be acquired and on the owner of any other land that may be entered by the authorised officer for the purposes of this section.

(4) Subject to subsection (6), the authorised officer or any person delegated by him may, 14 days after the date of the last publication of a notice under subsection (1), in relation to any land specified in the notice –
(a) enter, survey and take or mark levels;
(b) dig, bore into or take samples of the subsoil;
(c) set out boundaries and the intended line of any work proposed to be done;
(d) place marks and cut trenches;
(e) if necessary, cut down and clear away any standing crop, fence, tree or bush;
(f) with the concurrence of the Central Water Authority, set up and maintain gauges in any stream or watercourse.

(5) For the purpose of exercising any power vested in him under subsection (4), the authorised officer may do any act specified in subsection (4) (a) or (e) in relation to any other land.

(6) The authorised officer shall not enter on any land for the purposes of this section except –
(a) at reasonable hours; and
(b) after having previously given the owner and the occupier at least 48 hours written notice.

7 Abandonment

(1) Where any land in relation to which a notice under section 6 (1) has been published is not to be acquired compulsorily, the Minister may, at any time after the publication of the notice, declare by a fresh notice published in the *Gazette* that the intended acquisition of the land is abandoned.

(2) Where, within 8 months after the date of the second publication of a notice in the *Gazette* under section 6 (1), the land has not been acquired compulsorily or has been abandoned, any interested person may serve a notice on the authorised officer requiring the acquisition of the land to be completed or abandoned.

(3) Where a notice has been served under subsection (2) and the land to which it relates has not been acquired compulsorily within one month of the date of that notice, the intended acquisition shall be deemed to have been abandoned.

8 Compulsory acquisition

(1) Subject to section 9, where the Minister has decided to acquire compulsorily any land either on behalf of the Government or on behalf of another person under section 5 and is satisfied that –
(a) it is neither possible nor expedient to acquire the land by private agreement; and
(b) the conditions of section 8 (1) (a) and (b) of the Constitution are fulfilled,

he shall, whether or not a notice has been served under section 6 (1), give notice to that effect in 2 issues of the *Gazette* and in 2 issues of 2 daily newspapers, there being in each case an interval of at least 7 days between the first and second publications.

(2) A notice published under this section shall –
(a) describe the land with precision, either in words or by reference to a map or

plan which shall be deposited at such place as may be specified in the notice and which shall be open to inspection by the public;

(b) state the purpose for which the land is being acquired;

(c) in the case of an acquisition under section 5, state the name, address and occupation of the person for whom the land is being acquired; and

(d) require every interested person to give the authorised officer, within 14 days of the second publication of the notice in the *Gazette*, a written declaration of the nature of his interest in the land and of the amount and details of his claim for compensation.

(3) On or about the date of the first publication of the notice under subsection (1), a copy of the notice shall be served by the authorised officer on the owner of the land.

9 Emergency

Where land is required by the Government during a period of public emergency for reasons related to that emergency only one notice under section 6 or 8 shall be required to be published.

10 Challenge of legality of acquisition

An interested person who wishes to challenge the legality of the compulsory acquisition of any land may appeal to the Supreme Court within such time and in such manner as may be provided by rules made by the Supreme Court for the purpose.

11 Vesting of land

(1) Where no challenge to the legality of the compulsory acquisition of any land has been made under section 10 or where any such challenge has been overruled, the authorised officer shall cause the notice published in the *Gazette* under section 8 to be transcribed by the Conservator of Mortgages, who shall forthwith deliver to the authorised officer a certificate under section 7 of the Transcription and Mortgages Act.

(2) The transcription of the notice published in the *Gazette* under section 8 shall constitute in favour of the Government, or where the acquisition of the land is made pursuant to a request under section 5 (1), of the person specified in the notice, title to the land to which it relates, free from all charges and encumbrances.

(3) Upon the transcription of the notice published in the *Gazette* under section 8, no proceedings shall be instituted to prevent the transfer of title in the land to which the notice relates, and the rights of any interested person shall be satisfied out of the compensation payable under this Act.

PART III – COMPENSATION, APPORTIONMENT OF RENT AND RESCISSION OF LEASES

12 Right to compensation

An interested person whose land is compulsorily acquired shall be entitled to the payment of compensation under this Act.

13 Determination of persons entitled

The authorised officer shall take such steps as may be necessary to determine to whom compensation is payable under this Act and may, for the purpose, require any interested person in relation to whose land a notice has been published under section 6 or 8 to deliver, within 14 days of the date of the service of the notice, a statement in writing specifying so far as is within that person's knowledge the name of every other interested person and the nature of his own and that of such other interested person's interest in the land.

14 Application for compensation

(1) A claim for compensation, or for the apportionment of compensation, payable under this Act shall be made in writing to the Minister.

(2) Where a claim is made under subsection (1), the Minister shall, unless the claim is sooner settled, refer it, within 28 days of the receipt of the claim, to the Board.

15 Board of Assessment

(1) A Board of Assessment shall be established to determine the right of any interested person and to assess, award and apportion compensation, and to rescind leases and apportion rent.

(2) The Board shall consist of –

(a) a Chairman who shall be a person who holds or has held judicial office in Mauritius, to be designated by the Chief Justice; and

(b) 2 members appointed by the Minister.

(3) No person who –

(a) is a public officer;

(b) is a member of or a candidate for election to the Assembly or a local authority;

(c) has a direct or indirect interest in the land acquired compulsorily; or

(d) is related, by marriage or consanguinity within the fourth degree, to an interested person,

may be appointed as a member of the Board.

16 Report to the Board

(1) Where a claim has been referred to the Board under section 14 (2) the authorised officer shall, within 28 days of the reference of the claim, forward to the Chairman a report and the following documents and particulars relating to the land compulsorily acquired –

(a) a copy of any notice which has been published in the *Gazette*;

(b) a copy of any notice, statement or other communication issued or received by the authorised officer;

(c) the name and address of every person whom the authorised officer knows or has reason to believe is an interested person.

(2) The authorised officer shall, in any report under subsection (1), state his opinion, and the reasons for his opinion, on –

(a) the nature of the land, including particulars of any trees or standing crops;

(b) the value of the land;

(c) the amount of any compensation to be paid;

(d) the description and value of any State land offered by way of payment or part payment of the compensation due;

(e) the apportionment of the compensation among the interested persons.

[Amended 48/91]

17 Inquiry by the Board

(1) Where a claim has been referred to the Board under section 14 (2), it shall hold an inquiry at such place and on such date and time as may be fixed by the Chairman.

(2) At least 14 days' notice of the first meeting of the Board shall be given to the authorised officer and to every interested person.

(3) At any inquiry before the Board, the procedure, the giving and taking of evidence, the summoning and remuneration of witnesses for attendance, and all other questions relating or incidental to the inquiry shall, in the absence of rules made by the Supreme Court, be governed by the laws prescribed for civil proceedings before the Supreme Court.

(4) The parties may appear by counsel before the Board.

(5) The Board, or any person authorised by the Chairman, may at any time before an award is made, enter upon and inspect land for any purpose connected with the inquiry.

(6) Where after the appointment of the Board and before an inquiry is started under subsection (1), or while the inquiry is in progress the parties agree on the amount of compensation to be paid under this Part, the agreement of the parties shall be made the award of the Board.

18 Award of the Board

(1) At the conclusion of an inquiry under section 17, the Board shall make an award on the claim for compensation and the Chairman shall cause that award to be filed in the Registry.