Annex G

Consideration of Alternatives

Contents

Page :

List of Tables

Page :

List of Figures

Page :

G Consideration of Alternatives

G.1 Consideration of Principal Objective

Principal objective of the Study is to formulate a Master Plan (M/P) of wastewater management (WWM) and solid waste management (SWM) aiming at preserving the coastal aquatic environment in the Study Area. Namely,

Principal objective of the M/P is to preserve the aquatic environment.

Meanwhile, it has been so far understood that pollution load originated from the sectors of WWM and SWM on the groundwater is the most significant environmental impact due to the geological characteristic, then preservation of the groundwater from the pollution load should be focused as the groundwater is closely related to the coastal environment such as cenotes, caves and coral reefs in the Study Area.

Although there are various indicators to grasp pollution load originated from wastewater and solid waste, it is recommendable to focus on BOD in the planning of the Master Plan, as wastewater and solid waste in the Study Area are originated from domestic activities and BOD is the most common indicator to evaluate pollution load cased by domestic activities. BOD amount has close relation with other pollutant such as coliform, nitrogen and phosphorus. Therefore, control of BOD amount leads to controlling other pollutants.

a. BOD Concentration in the Groundwater

As mentioned in Chapter 3, the environmental standard for the public water body defines Class AA for natural environment conservation, of which water quality is BOD concentration of 1 mg/liter and below. It is proposed to refer this standard to preserve the coastal aquatic environment in the Study Area, as such standard does not exist in Mexico. The proposal is as follows.

To set upper limit of BOD discharge amount from the WWM sector and the SWM sector in order to control BOD concentration in the groundwater 1mg/liter and below.

Amount of the groundwater in the Study Area is estimated as 5,237 million m^3/year as shown in Table G-1. In order to control BOD concentration 1 mg/liter and below, BOD inflow to the groundwater should be 5,237 ton/year and below.

$$BOD\_amount = 5{,}237{,}000{,}000(m^3 / year) \times \left(\frac{1(mg / litre)}{1{,}000 \times 1{,}000} \right) = 5{,}237(ton / year)$$

Table G-1: Estimated Groundwater Amount in the Study Area

Unit: million m^3／year

Item	Othón P. Blanco	Felipe C. Puerto	Solidaridad	Total
To sea	927.8	2,428.6	862.6	4219.0
Extraction	124.0	21.2	30.0	175.2
Flow out to anther area	811.8	31.0	0.0	842.8
Total	1,863.6	2,480.8	892.6	5,237.0

b. BOD Generation Amount

It is estimated that BOD generation amount would be 18,719 ton/year in the WWM sector and 12,578 ton/year, 31,297 ton/year in total. This is more than double that in 2003 as shown in Table G-2.

According to Table G-3, 60% of the BOD amount would be from the WWM sector and 40% from the SWM sector. In respective municipalities, BOD generation amount in Felipe C Puerto would be much less than those in other municipalities. Only 8% of the BOD amount would be generated in the municipality. Meanwhile, Othon P Blanco and Solidaridad would generate significant amount of BOD. Both municipalities generate more than 40% each. Furthermore, the BOD amount generated in Solidaridad would increase more rapidly than that in Othon P Blanco.

Table G-2: Forecast of BOD Generation Amount

Unit: ton/year

Item	2003	2005	2010	2015
Wastewater				
OTHON P. BLANCO	4,535.9	5,392.5	7,140.7	8,263.4
FELIPE CARRILLO PUERTO	1,254.5	1,303.6	1,393.0	1,456.6
SOLIDARIDAD	3,408.7	4,711.8	7,019.9	8,999.4
Total	9,199.1	11,407.9	15,553.6	18,719.4
Solid Waste				
OTHON P. BLANCO	3,125.8	3,665.0	4,837.7	5,639.2
FELIPE CARRILLO PUERTO	725.5	754.7	813.0	855.5
SOLIDARIDAD	2,280.0	3,131.0	4,715.3	6,083.3
Total	6,131.3	7,550.7	10,366.0	12,578.0
Overall				
OTHON P. BLANCO	7,661.7	9,057.5	11,978.4	13,902.6
FELIPE CARRILLO PUERTO	1,980.0	2,058.3	2,206.0	2,312.1
SOLIDARIDAD	5,688.7	7,842.8	11,735.2	15,082.7
Total	15,330.4	18,958.6	25,919.6	31,297.4

Table G-3: Share of BOD Generation Amount

	2003	2005	2010	2015
Wastewater				
OTHON P. BLANCO	29.6%	28.4%	27.5%	26.4%
FELIPE CARRILLO PUERTO	8.2%	6.9%	5.4%	4.7%
SOLIDARIDAD	22.2%	24.9%	27.1%	28.8%
Total	60.0%	60.2%	60.0%	59.8%
Solid waste				
OTHON P. BLANCO	20.4%	19.3%	18.7%	18.0%
FELIPE CARRILLO PUERTO	4.7%	4.0%	3.1%	2.7%
SOLIDARIDAD	14.9%	16.5%	18.2%	19.4%
Total	40.0%	39.8%	40.0%	40.2%
TOTAL	100.0%	100.0%	100.0%	100.0%

c. Upper Limit of BOD Discharge Amount

BOD generation amount in 2015 is estimated as 31,297 ton/year, meanwhile discharge limit is 5,237 ton/year in order to control BOD concentration in the groundwater 1 mg/liter and below. Therefore, 26,060 ton/year of BOD amount should be removed.

Consequently, it is proposed to set upper limits of BOD discharge amount below 3,132.3 ton/year in the WWM sector and 2,104.7 ton/year in the SWM sector.

Table G-4: Required BOD Removal Amount in 2015

Item	Required BOD removal amount (ton/year)
Wastewater	15,587.1
Solid waste	10,473.3
Total	26,060.4

Table G-5: Upper Limit (Target Number) of BOD Discharge Amount in 2015

Item	Upper limit of BOD Discharge Amount
Wastewater	3,132.3
Solid waste	2,104.7
Total	5,237.0

G.2 Wastewater Management

G.2.1 Consideration of Objectives and Target Setting

G.2.1.1 Principal Objectives and Target Value

The principal objective of the Wastewater Management (WWM) Master Plan is;

To preserve the groundwater and the coastal aquatic environment in the study area

Target value is;

BOD discharge amount originated from wastewater is to be less than 3,100 ton/year by 2015.

G.2.1.2 Target Values in Various Size of Communities

This section considers how to cope with various sizes of communities dispersed over the Study Area, in order to achieve the target value of the principal objective.

a. BOD Generation Amount by Community Size

In 2015, BOD generation in communities having a population less than 100 is only 0.4%. Communities having a population between 100 and 2,499 occupy 12.8%. Communities having a population of 2,500 and over occupy 86.6% as shown in Table G-6.

Table G-6: BOD Generation Amount by Community Size (2015)

Population size	Total population	Wastewater amount (m3/day)	Pollution load (BOD ton/year)	Contribution of pollution load
Less than 100	3,846	664.8	75.5	0.4%
100 to 499	19,431	3,361.7	383.7	2.0%
500 to 999	39,916	6,905.6	786.5	4.2%
1,000 to 1,499	28,631	4,952.8	564.0	3.0%
1,500 to 2,499	33,914	5,867.1	668.4	3.6%
2,500 to 4,999	37,229	6,440.6	733.8	3.9%
5,000 to 9,999	34,510	5,970.1	680.1	3.6%
10,000 to 19,999	37,428	6,475.0	737.7	3.9%
20,000 to 49,999	114,109	19,740.8	2,249.1	12.0%
50,000 to 99,999	76,088	13,163.3	1,499.7	8.0%
100,000 and over	524,649	90,764.4	10,340.9	55.2%
Total	949,751	164,306.2	18,719.4	100.0%

b. Wastewater Treatment Level by Community Size

Population density is generally low in small communities and pollution load caused by their domestic activities could be assimilated by the surroundings. Meanwhile, large communities are highly populated and economy is active. Then, pollution load of the large communities are much more significant compared to that in rural communities.

It is not strategic approach to take same measures to the various sizes of communities. Therefore, it is recommendable to set targets depending on community size as shown in Table G-7. For example, simple treatment is employed for small communities and advanced treatment is adopted for large communities. If such targets are set, BOD discharge amount originated from the WWM sector to the environment is 3,026 ton/year as shown in Table G-8.

Table G-7: Required Treated Water Quality

Population size of community	Required treated water quality(BOD mg/liter)	Treatment level
Less than 100	312.1	Level 0(No sewer system)
100 to 1,499	150	Level 1
1,500 to 9,999	75	Level 2
10,000 to 49,999	50	Level 3
More than 50,000	30	Level 4

Table G-8: Results of the Required Treated Water Quality Examination in 2015

Population size	Total population	Wastewater amount (m3/day)	Pollution load (BOD ton/year)	Share of pollution load	Required treated water quality (BOD mg/liter)	Discharge pollution load (BOD ton/year)	Reduce amount (BOD ton/year)
Less than 100	3,846	664.8	75.5	0.4%	312.1	75.5	0.0
100 to 499	19,431	3,361.7	383.7	2.0%	150	184.1	199.6
500 to 999	39,916	6,905.6	786.5	4.2%	150	378.1	408.4
1,000 to 1,499	28,631	4,952.8	564.0	3.0%	150	271.2	292.8
1,500 to 2,499	33,914	5,867.1	668.4	3.6%	75	160.6	507.8
2,500 to 4,999	37,229	6,440.6	733.8	3.9%	75	176.3	557.5
5,000 to 9,999	34,510	5,970.1	680.1	3.6%	75	163.4	516.7
10,000 to 19,999	37,428	6,475.0	737.7	3.9%	50	118.2	619.5
20,000 to 49,999	114,109	19,740.8	2,249.1	12.0%	50	360.3	1,888.8
50,000 to 99,999	76,088	13,163.3	1,499.7	8.0%	30	144.1	1,355.6
100,000 and over	524,649	90,764.4	10,340.9	55.2%	30	993.9	9,347.0
Total	949,751	164,306.2	18,719.4	100.0%	50.5	3,025.7	15,693.7

G.2.2 Consideration of Treatment Methods

There exist various treatment methods of domestic wastewater that mainly consists of organic matters such as BOD. Those treatment methods are basically classified into two categories; anaerobic treatment and aerobic treatment.

The anaerobic treatment utilizes digestion process of anaerobic bacteria for decomposition and removal of organic matters.

The aerobic treatment oxidizes, decomposes and removes organic matters with supply of oxygen by, for example, diffused-air aeration. Compared with the anaerobic treatment, the aerobic treatment achieves high quality of treated water. However, it requires power to supply oxygen. It brings higher costs of facilities, construction and operation. The following figure

explains those differences between the aerobic treatment and the anaerobic treatment in BOD removal.

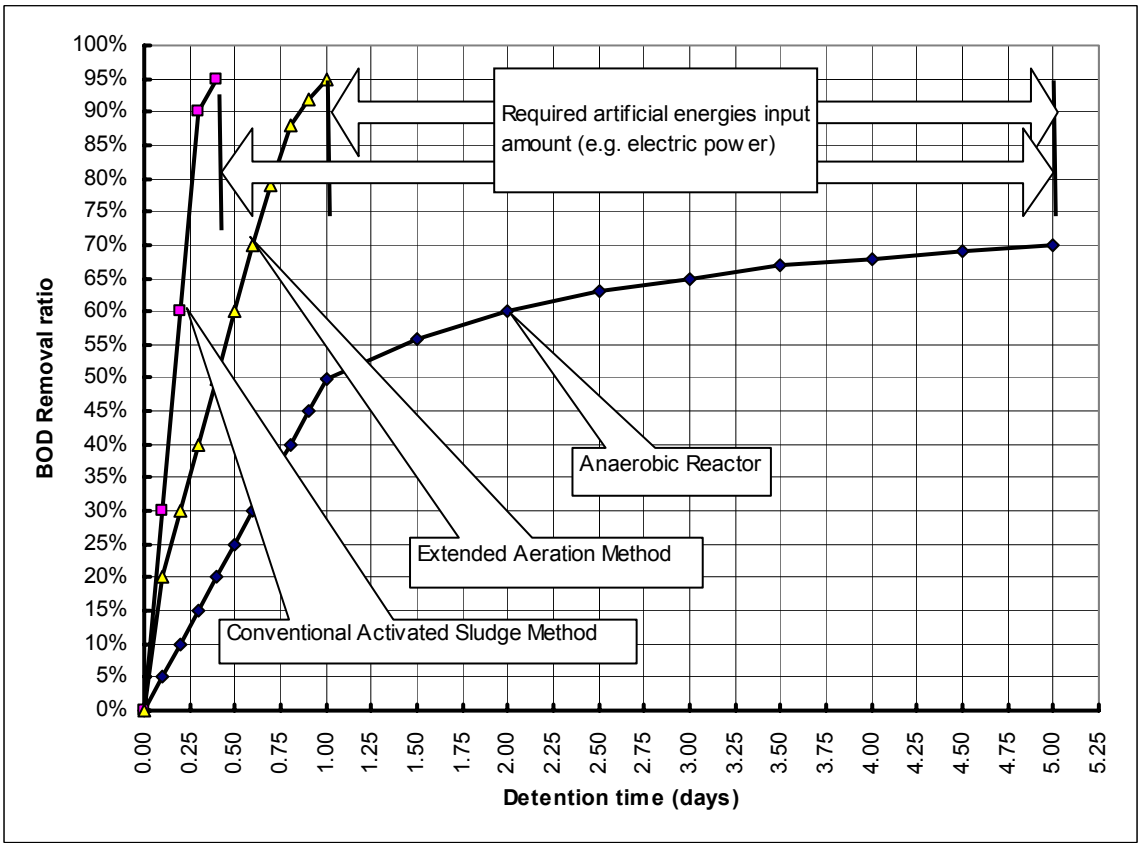


Figure G-1: Concept of BOD Removal and Treatment Method

Required treated water quality is set depending on community size as shown in the following table. This section discusses appropriate treatment methods in different community size with taking into account the relationship among BOD removal rate, treatment methods and required power schematized in the previous figure.

Table G-9: Target Treatment Level by Communities Size

Treatment level	Population size of community	Required target treated water quality and BOD removal Ratio	
		BOD (mg/liter)	BOD remove ratio
Level 1	100 to 1,499	150	52 %
Level 2	1,500 to 9,999	75	76 %
Level 3	10,000 to 49,999	50	84 %
Level 4	More than 50,000	30	90 %

G.2.2.1 Level 1

As the target quality of treated water at Level 1 is 52%, it is recommendable to adopt the anaerobic reactor which does not require energy supply and of which construction cost is

inexpensive. Detention time in a reaction vessel calculated from BOD removal rate is about one day, and 250g/m^3/day and less of BOD volumetric loading is recommendable.

G.2.2.2 Level 2

Target quality of treated water at Level 2 is 76%. This could be achieved by the anaerobic reactor with 7 days detention time. In case of Level 1, the assumed detention time is about one day, meanwhile, about 7 days is required at Level 2. This means that required volume of anaerobic reactor at Level 2 is about seven times at Level 1 per unit wastewater amount. Meanwhile, CAPA carries out sewerage projects in rural areas that adopt a system of anaerobic reactor and aerobic filter. As performance of the system has not yet evaluated, it is estimated that the system could achieve 76% of BOD removal rate according to its design.

In order to select an appropriate treatment method for Level 2, costs of the anaerobic reactor treatment method and the anaerobic reactor and aerobic filter treatment method are compared at a population size of 1,499, where is the boarder between Level 1 and Level 2.

Required volume of anaerobic reactor for a population of 1,499 for obtaining treated water quality of Level 1 is 323.3m^3 and required detention time is 1.25 day. As 7 days detention time is required to achieve the treated water quality of Level 2, required volume of anaerobic reactor will be 5.6 times (7 /1.25) of Level 1. The table below compares costs of facilities and construction of anaerobic reactor for a population of 1,499 at Level 1 and Level 2.

Table G-10: Cost of Anaerobic Reactor Level 2

Population	Pump pit (pesos)	Anaerobic reactor (pesos)	Equipments (pesos)	Total (pesos)	Contingency (pesos)	Total (pesos)
1,499(level 1)	294,000	584,000	132,000	1,010,000	202,000	2,222,000
1,499(level 2)	294,000	3,270,000	132,000	3,696,000	370,000	4,066,000

Meanwhile, facilities and construction costs of anaerobic + aerobic filter can be obtained as follows.

$$Cost = 4.0686Q + 1{,}227.5 \qquad (R^2=0.8874)$$

where:

Cost : treatment facility construction cost (1,000 pesos)
Q : treatment capacity of treatment facility (m^3/day)

In case of a population of 1,499 and 173 liter/person/day of unit discharge amount, required treatment capacity will be 260 m^3/day. Then, costs of facilities and construction will be 2,285,000 pesos that is much inexpensive than the costs of anaerobic reactor of 4,066,000 pesos.

Consequently, if the performance meets with Level 2, the treatment method of anaerobic reactor + aerobic filter is recommendable.

G.2.2.3 Level 3 and Levle4

Activated sludge method and its variations such as trickling filter and rotating biological contactor are potential methods to achieve the BOD removal rates set at Level 3 and Level 4.

a. Activated Sludge Method

The activated sludge method can go back to a long way and has many variations. The following table presents summaries of representative activated sludge methods.

Table G-11: Advantage and Limitation of Activated Sludge Process

Treatment method	Advantages	Limitations
Complete mix	• Common, proven process • Adaptable to many types of wastewater • Large dilution capacity for shock and toxic loads • Uniform oxygen demand • Design is relatively uncomplicated • Suitable for all type of aeration equipment	• Susceptible to filamentous sludge bulking
Conventional plug flow (conventional activated sludge)	• Proven process • May achieve a somewhat higher level of ammonia removal than the complete mix process • Adaptable to many operating schemes include step-feed, selector design, and anoxic/aerobic process	• Design and operation for tapered aeration is more complex • May be difficult to much oxygen supply to oxygen demand in first pass
Extended aeration	• High quality effluent possible • Relatively uncomplicated design and operation • Capable of treating shock/toxic loads • Well stabilized sludge; low bio-solids production	• Aeration energy use is high • Relatively large aeration tanks • Adaptable mostly to small plant
Oxidation ditch	• Highly reliable process; simple operation • Capable of treating shock/toxic loads without affecting effluent quality • Economical process for small plants • Use less energy than extended aeration • Adaptable to nutrient possible • Well stabilized sludge; low bio-solids production	• Large structure, greater space requirement • Low F/M bulking is possible • Some oxidation ditch process modifications are proprietary and license fees may be required • Requires more aeration energy than conventional complete mix and plug flow treatment • Plant capacity expansion is more difficult
Sequencing batch reactor	• Process is simplified; final clarifiers and return activated sludge pumping are not required • Compact facility • Operation is flexible; nutrient removal can be accomplished by operational changes • Can be operated as a selector process to minimize sludge bulking potential • Quiescent settling enhances solid separation (low effluent SS) • Applicable for a variety of plant size	• Process control more complicated • High peak flow can disrupt operation unless accounted for in design • Batch discharge may require equalization prior to filtration and disinfection • Higher maintenance skills required for instruments, monitoring devices, and automatic valves • Some design use less efficient aeration devices

Source: Wastewater Engineering Treatment and Reuse fourth edition, Matcalf & Eddy, McGraw-Hill

Wastewater amount to be treated at Level 3 will not be large; between 1,700 and 8,600 m^3/day. Therefore, oxidation ditch method is recommendable because of small energy consumption and easy operation, although it requires larger area than extended aeration method.

As for Level 4, conventional activated sludge is recommendable as required treatment wastewater amount is large.

b. Trickling Filter and Rotating Biological Contactors

b.1 Tricking Filter

Trickling filters have been used to provide biological wastewater treatment of municipal and industrial wastewaters for nearly 100 years. The trickling filter is a non-submerged fixed-film biological reactor using rock or plastic packing over which wastewater is distributed continuously. Treatment occurs as the liquid flows over the attached bio-film. The depth of the rock packing ranges from 0.9 to 2.5 m and averages 1.8 m. Rock filter beds are usually circular, and the liquid wastewater is distributed over the top of the bed by a rotary distributor. Many conventional trickling filters using rock as the packing material have been converted to plastic packing to increase treatment capacity. Virtually all new trickling filters are now constructed with plastic packing.

Trickling filters that use plastic packing have been built in round, square, and other shapes with depths varying from 4 to 12 m. In addition to the packing, other components of the trickling filter include a wastewater dosing or application system, an under drain, and a structure to contain the packing. The under drain system is important both for collecting the trickling filter effluent liquid and as a porous structure through which air can circulate. The collected liquid is passed to a sedimentation tank where the solids are separated from the treated wastewater.

Trickling filter applications and loadings, based on historical terminology developed originally for rock filter designs, are summarized in below table.

Table G-12: Classification of Tricking Filters

	Low or standard rate	Intermediate rate	High rate	High rate
Type of packing	Rock	Rock	Rock	Plastic
Hydraulic loading (m3/m2/day)	1 to 4	4 to 10	10 to 40	10 to 75
Organic loading (kg BOD/m3/day)	0.07 to 0.22	0.24 to 0.48	0.4 to 2.4	0.6 to 3.2
Recirculation ratio	0	0 to 1	1 to 2	1 to 2
Filter flies	Many	Varies	Few	Few
Sloughing	Intermittent	Intermittent	Continuous	Continuous
BOD removal efficiency (%)	80 to 90	50 to 80	50 to 90	60 to 90

Source: Wastewater Engineering Treatment and Reuse fourth edition, Matcalf & Eddy, McGraw-Hill

Target BOD removal rates are 85% at Level 3 and 90% at Level 4. These targets could be achieved by the high rate method of trickling filter. However, the method could allow outbreak of flies. Consequently, the trickling filter is not recommendable from a viewpoint of nuisance to adjacent areas, although it shows sufficient performance in BOD removal.

b.2 Rotating Biological Contactors (RCB)

There are many similarities between RBC design considerations and those described for trickling filters. Both systems develop a large bio-film surface area and rely on mass transfer of oxygen and substrates from the bulk liquid to the bio-film. The complexity in the physical and hydrodynamic characteristics requires that the design of the RBC process be based on fundamental information from pilot-plant and field installations. As for trickling filters, the organic loading affects BOD removal efficiency and the nitrogen loading after a minimal BOD concentration is reached affects the nitrification efficiency. In contrast to the trickling filter where the wastewater flow approaches a plug flow hydraulic regime, the RBC units are rotated in a basin containing the wastewater, so that separate baffled basins are needed to develop the benefits of a staged biological reactor design.

The history of RBC installations has been troublesome due to inadequate mechanical design and lack of full understanding of the biological process. Structural failure of shafts, disks, and disk support systems has occurred. Development of excessive bio-film growth and sloughing problems has also led to mechanical shaft, bearing, and disk failures. Many of these problems were related to a lack of conservatism in design and scale-up issues from pilot-plant to full-scale units.

BOD removal efficiency of RBC is the almost same as or more than of the trickling filter. However, in Japan it is hardly adopted in a large scale as there are some problems; a larger scale of facility requires larger discs; burden on a shaft becomes in excess; and treated water results in high turbidity. Consequently, RBC is not recommendable to use in a large scale.

G.2.3 Consideration of Wastewater Management Framework

G.2.3.1 Financial Aspect

a. General Considerations

The income from wastewater treatment comprised only around 3% of total CAPA income between 2000 and 2002, while the operation cost alone amounted to around 7%. More specifically, expenditures on wastewater treatment varied from 2.2 times to 3.2 times the income from wastewater treatment service.

The wastewater generation was estimated at 75% of water production, about twice as much as the billed water volume. Treated wastewater was estimated at around 20% of water production and 25% of generated wastewater. Although the tariff for wastewater treatment was set at 20% of water rates, the collected monetary amount was relatively small due possibly to the low degree of household connection to the sewer system. Treated wastewater increased from around 8.5 million m³ in 1999 to 10.9 million m³ in 2002, equivalent to 8.6% yearly growth rate. This growth rate was practically the same as the 8.4% yearly growth rate in water production, from 44.5 million m³ in 1999 to 56.7 million m³ in 2002.

The overhead or administrative expenses of CAPA comprised a large proportion, 55% of total expenditures. The Operation Cost of CAPA comprised around 45% of total expenditures, of which wastewater treatment comprised around 7%. Similarly, Maintenance Cost of wastewater treatment facilities covered electromechanical components for around 0.8%, wastewater pipeline for around 0.4%, and quality control for around 0.5% of total expenditures.

Under these circumstances, the wastewater treatment activity was financially negative in the past three years, as shown in the following Table.

Table G-13: CAPA Wastewater Income & Expenditures (Mill. Pesos)

	2000	2001	2002
Wastewater Income	3.89	4.69	6.74
Wastewater Expenditures	10.86	14.96	14.91
Operation Cost	8.89	12.37	12.57
Maintenance Cost: Electromec.	1.32	1.02	1.33
Maint. Cost: Wastewater Pipe	0.23	0.74	0.33
Quality Control of Wastewater	0.42	0.83	0.68
Income - Expenditures	-6.97	-10.27	-8.17

Source: CAPA

Then, the issue is the financial deficit of the wastewater treatment service, or how to reduce the gap between income and expenditures specific to the service.

b. Charges for Wastewater Treatment

The following are some recommendations provided by the US Environmental Protection Agency.

In resort areas, populations can double or triple during peak months, creating excess demand for wastewater treatment. Seasonal surcharges reflecting demand patterns during this peak period can help send the proper price signals to dischargers to conserve capacity during the peak months. These surcharges should be borne by all dischargers requiring services during the peak months, without excluding year-round residents. Unless dischargers during the peak months know ahead of time that their rates will be substantially higher than normal, they will have little incentive to reduce their discharge levels through increased recycling or water conservation. As charging different wastewater rates depending on months might be an administrative nightmare for CAPA, one alternative is for tourist service providers to shoulder a portion of the cost of wastewater management.

When important differences across customer classes are not recognized, the fee structure may contain behavior-distorting cross-subsidies. Residential users may end up subsidizing industrial dischargers. Although it is the industries that generally discharge most of the difficult or impossible to treat contaminants, cross-subsidies may end up with the ironic result of subsidizing polluters, violating the polluter pays principle.

A common tendency is to want the new dischargers to pay the full costs of extra capacity associated with their discharges. Unless the cost of scarce capacity is charged to all dischargers rather than just to new ones, the proper price signals to reduce consumption of the scarce capacity will not be sent.

G.2.3.2 Legal System

The particular goals intended to be achieved on the Master Plan are considered within the current legal and political framework.

a. Preservation of the aquifer quality

Disposal: The quality of disposal is regulated by the official Mexican Norm NOM-001-SEMARNAT-1996, which establishes the maximum permissible limits of pollutants on wastewater discharge on national water and national assets. Disposal is also regulated by NOM-002-SEMARNAT-1996 that establishes the maximum permissible limits on wastewater discharges on the urban and municipal sewerage systems.

Connections: Landowners of constructed properties, which are obliged to use potable water, are also obliged to connect to the sewer network in places where this service exists, according to the Law of Potable Water and Sewer System on the State of Quintana Roo.

b. Reduction of health risks

Preservation of health: The Political Constitution guarantees the preservation of the environment and the protection of the citizens' health. Through its activities the Master Plan strengthen the actions of the three government levels regarding their efforts to control and to reduce the high incidence of diseases of hydraulic nature.

G.2.3.3 Institutional System

Both CNA and CAPA are actively participating on the achievement of the Study goal, together with the involvement of SEMARNAT and the Marine Department.

On the one hand CNA has shown special interest on the investigations carried out, in order to obtain information that supports the regulations on treated wastewater discharge on injection wells; its interest relies on the fact that they are the main institution regarding national water. On the other hand CAPA, in its role of provider of the service of potable water and sewer, has duplicated its efforts in order to continue with the works that allow the sewer coverage expansion and the promotions to network connections.

G.2.3.4 Management

CAPA is considering establishing a specific administrative unit in order to promote the citizens' connection to the sewer network. For this effect, they are carrying out negotiations in order to obtain a high budgetary appropriation for the next budget.

G.2.3.5 Private Sector Participation

The private sector actively participates on the design and construction contracts of the works; CAPA does not have foreseen the participation of the public sector on the short term. It has been recommended to evaluate the results of the concession of services in Cancun with an economic and social perspective.

G.2.3.6 Citizen Participation

Public participation is crucial in order to achieve the following goals: the protection of the aquifer and the guarantee of citizens' health. Some strategies have been designed in order to accomplish the connection to the sewer system.

G.2.4 Selection of the Treatment Methods

According to the discussions in the above, the following treatment methods for respective levels are recommended.

Table G-14: Proposed Treatment Method

Treatment level	Population size of community	Treatment method
Level 1	100 to 1,499	An-aerobic reactor + disinfection
Level 2	1,500 to 9,999	An-aerobic reactor + aerobic filter + disinfection
Level 3	10,000 to 49,999	Oxidation ditch + disinfection
Level 4	More than 50,000	Activated sludge + disinfection

G.3 Solid Waste Management

G.3.1 Consideration of Objectives and Target Setting

G.3.1.1 Principal Objective and Targeted Value

The principal objective of the Solid Waste Management (SWM) Master Plan is:

To preserve the groundwater and the coastal aquatic environment in the study area

Targeted value is

BOD discharge amount originated from solid waste is to be less than 2,100 ton/year by 2015.

G.3.1.2 Particular Objectives and Targeted Values

The master plan being formulated should aim at achieving the targeted value of the principal objective, in addition, should accomplish the following objectives inherent to solid waste management.

- ***Provision of sanitary living environment:*** by removing waste from houses and communities
- ***Mitigation of environmental impact cased by waste:*** by properly disposing of collected waste
- ***Resource conservation:*** by contributing to establishment of a recycling-oriented society through waste minimization

The particular objectives above should have targeted values with a time frame as follows: i) collection rate is a representative indicator for provision of sanitary living environment; ii) final disposal level can show degree of mitigation of environmental impact caused by waste; and iii) waste minimization rate is one of indicators representing resource conservation. Targeted values in regard to the three points are to be set through discussion below.

a. Issues in Setting Collection Rate

a.1 Demand for Solid Waste Management

Demand for solid waste management vary, e.g., small rural communities may not require waste collection service, meanwhile large communities such as Chetumal and Playa del Carmen require high level of SWM. Figure G-2 presents concept of relation between population size of community and demands to SWM.

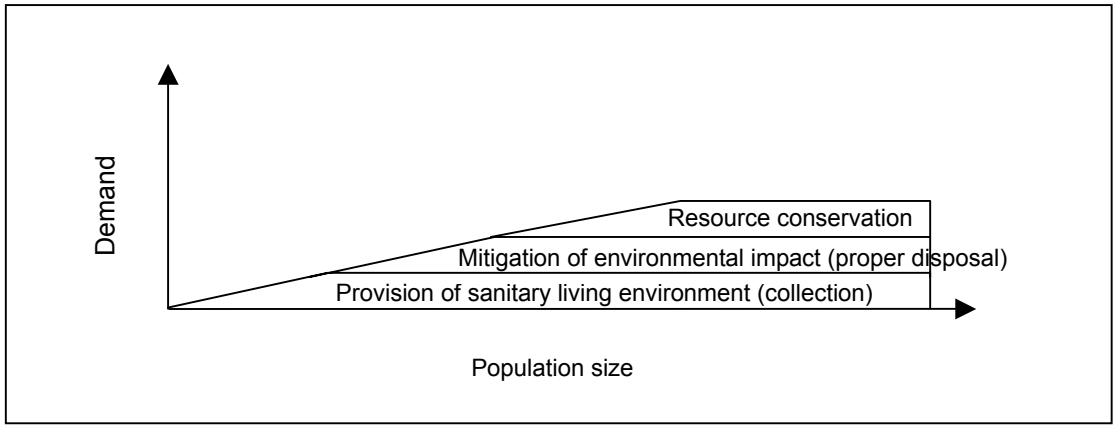


Figure G-2: Solid Waste Demand and Population Size of Community

In addition to the population size, population density is well related to degree of demands for SWM, especially "Provision of sanitary living environment." Even if population size of a community is small, elimination of waste from a living area is important to maintain the area sanitary in case of higher population density. Meanwhile, even if population size is relatively large, community still has a room to dispose waste by means of self-disposal, e.g., burning and/or burying, in case of low population density. Priority of SWM should been basically given in order as follows; i) large population and high population density, ii) small population but high density or large population but low density, iii) small population and low density. The figure below schematizes this concept.

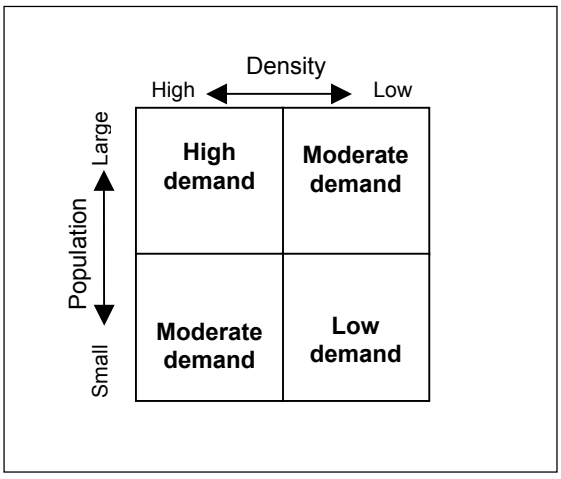


Figure G-3: Relation among Population Size, Density and Demand for SWM

a.2 Various Size of Communities dispersed over the Study Area

The study area has a population of about 500,000 in 2003 over the huge area of 36,000 km^2. The population is distributed to 288 communities. Sizes of communities vary from dozens to over 100,000.

SEDUMA and CAPA consider communities having a population less than 2,500 as rural ones and communities having a population of 2,500 and over as urban ones. Numbers of the rural communities are estimated 273 in 2003 and 264 in 2015 which occupy more than 90% of the total number of communities as shown in Table G-15. However, the population of the rural communities occupies only 25% in 2003 and 15% in 2015 of the total population. Meanwhile, numbers of urban communities are 15 in 2003 and 24 in 2015, which are less than 10% of the total number of communities. However, populations of the communities occupy 75% in 2003 and 85% in 2015 of the total population as shown in Table G-16. Waste amounts generated from those urban communities occupy more than 80% in 2003 and almost 90% in 2015 of the total amount as shown in Table G-17.

As the figures tell, to focus on urban communities to cope with SWM problems will be effective and efficient. Urban communities being having a population 2500 and over in 2015 is shown in Table G-18. PEDU groups communities with taking into account vicinity, economic relation, etc., and calls those groups as urban systems. In this planning, the 24 target communities are gathered up to 10 groups based on the urban systems of PEDU. Table G-19 shows the grouping.

Table G-15: Number of Communities in Urban and Rural Areas

Year	2003		2015	
Community Size	Nos.	%	Nos.	%
Rural (2,499 and below)	273	94.8	264	91.7
Urban (2,500 and over)	15	5.2	24	8.3
Total	288	100.0	288	100.0

Table G-16: Population in Urban and Rural Areas

Year	2003		2015	
Community Size	Nos.	%	Nos.	%
Rural (2,499 and below)	110,571	25.4	130,408	14.6
Urban (2,500 and over)	324,394	74.6	762,386	85.4
Total	434,965	100.0	892,794	100.0

Table G-17: Waste Generation Amount in Urban and Rural Areas

Year	2003		2015	
Community Size	ton/day	%	ton/day	%
Rural (2,499 and below)	94.7	18.2	122.7	11.5
Urban (2,500 and over)	426.1	81.8	945.9	88.5
Total	520.8	100.0	1,068.6	100.0

Table G-18: Target Communities of Master Plan

	Community	Population in 2015
		(nos.)
I. Othon P Blanco		
1	Alvaro Obregon	4,156
2	Bacalar	21,618
3	Calderitas	6,359
4	Chetumal	163,275
5	Ingenio Alvaro Obregon	4,585
6	Limones	18,752
7	Mahahual	73,335
8	Maya Balam	3,048
9	Nicolas Bravo	4,854
10	Punta Pulticub	8,440
11	Sergio Butron Casas	3,733
12	Xahuachol	18,000
13	Xcalak	8,440
14	Xul-ha	2,854
	Sub-total	341,449
II. Felipe C Puerto		
1	Chunhuhub	5,410
2	Felipe Carrillo Puerto	22,069
3	Senor	2,940
4	Tepich	2,627
5	Tihosuco	5,227
	Sub-total	38,273
III. Solidaridad		
1	Ciudad Chemuyil	21,335
2	Coba	3,000
3	Nuevo Akumal	100,000
4	Playa del Carmen	214,664
5	Tulum	43,665
	Sub-total	382,664
	Total	762,386

Table G-19: Grouping of Communities

Urban group	Community	Population (nos.)
I. Othon P Blanco		
1	CALDERITAS	172,488
	CHETUMAL	
	XUL-HA	
2	ALVARO OBREGON	12,474
	INGENIO ALVARO OBREGON	
	SERGIO BUTRON CASAS	
3	NICOLAS BRAVO	4,854
4	BACALAR	43,418
	LIMONES	
	MAYA BALAM	
5	MAHAHUAL	108,215
	PUNTA PULTICUB	
	Xahuachol	
	XCALAK	
II. Felipe C Puerto		
6	FELIPE CARRILLO PUERTO	25,009
	SENOR	
7	CHUNHUHUB	5,410
8	TEPICH	7,854
	TIHOSUCO	
III. Solidaridad		
9	CIUDAD CHEMUYIL	379,664
	NUEVO AKUMAL	
	PLAYA DEL CARMEN	
	TULUM	
10	COBA	3,000
Total		762,386

a.3 Target Values of Collection Rate

Taking into account demand for SWM, such as waste collection and disposal, and efficiency and effectiveness of those implementations, it should prioritize to realize sound solid waste management in cities having large population, i.e. urban communities. However, even in urban communities, fringe areas often do not require regular waste collection service, especially in small urban communities. This could be taken into account when setting a target of collection coverage rate. As for rural communities, special services that comply with their SWM demand should be considered.

Consequently, the discussion above gives two options in regard to setting a target of collection coverage as follows.

1. 100% of collection coverage over the all urban communities
2. 80 to 100% of collection coverage depending on population size of a community

Both cases consider special collection for rural communities corresponding to their demand.

Table G-20: Consideration of Collection Rate (Case 1)

Population (nos.)	Collection Rate
1 – 2,499	0%
2,500 - 7,999	80%
8,000 - 34,999	90%
34,999 - 99,999	95%
100,000 -	100%

Table G-21: Consideration of Collection Rate (Case 2)

Population (nos.)	Collection Rate
1 – 2,499	0%
2,500 -	100%

b. Issues to be considered in Setting Final Disposal Level

b.1 Phased Development of Waste Disposal

BOD amount originated from solid waste can be reduced remarkably by application of appropriate disposal manners. Rain pours on solid waste and water exceeding its retention capacity goes out as leachate. The leachate, which has contacted waste, has been contaminated and contains high concentration of BOD. Then, it pollutes soil and groundwater under and around disposal sites. Therefore, to reduce rainfall amount that gets contact with solid waste is the most effective measure to minimize BOD amount.

Sanitary landfilling is the most effective manner to reduce BOD amount. It compresses solid waste, minimizes areas where rain pours on, control infiltration of rainfall into solid waste with cover soil, then, reduces leachate generation amount remarkably. Furthermore, sanitary landfills having treatment facilities reduce BOD and other pollutants of leachate by a certain level where the effluent does not give serious adverse impact on the environment. This type of sanitary landfill is desirable, however, its construction and operation require a large amount of money and high level of technology. In the study area, there is no this sophisticated type of sanitary landfill yet. Phased development of waste disposal towards the sanitary landfill shown in Table G-22 is recommendable.

Table G-22: Phased Development of Waste Disposal

Disposal level	Contents
0:Open dump	• No control • Waste is scattered all over a dumping site. • No rainwater drainage system • Large amount of leachate is generated • No biogas control (fire, slow decomposition of waste) • Poor quality of leachate due to anaerobic condition
1:Controlled dump	• Inspection on incoming waste: to measure disposal amount, to control hazardous waste, etc. • Approach road, on-site road: to secure access to a dumping area • Landfill equipment: to accumulate waste
2:Enclosed dump	• Fence: to prohibit for unauthorized persons to enter the site • Dike: to avoid waste to be scattered, to prevent water from coming in • Buffer: to keep enough space to adjacent property • Drainage: surrounding and on-site drains
3:Landfill with gas control	• Soil cover: to prohibit vector proliferation, to prevent fire and mal odor, to minimize rainwater infiltration, to improve aesthetics • Gas removal facility: to prevent fire and explosion, to encourage waste decomposition • Weighbridge: important for SWM
4:Landfill with leachate control	• Bottom liner: to prevent leachate to infiltrate into ground (groundwater contamination) • Leachate collection facility: to collect and discharge leachate to the outside • Leachate treatment facility: to treat leachate to a certain quality that does not give serious environment impact

b.2 Comparison of BOD Reduction

Reduction of BOD amount is considered at each level of waste disposal with supposing height of filling, bulk density after compaction, etc. as shown in below.

General Assumption

- BOD concentration of leachate 10,000 mg/litter
- Rainfall 1.29 m/year
- Infiltration rate 0.34
- BOD removal 90%
- Safety factor 2

Calculation

Disposal Level		H (m)	B (ton/m3)	V (m3)	A (m2)	P (m3/year)	Bo (kg/year)	Mo (kg/year)	Ratio (%)
0	Open dump	2	0.2	5.0000	2.5000	3.2250	32.250	32.250	100.00
1	Controlled dump	4	0.4	2.5000	0.6250	0.8063	8.063	16.126	50.00
2	Enclosed dump	8	0.5	2.0000	0.2500	0.3225	3.225	6.450	20.00
3	Landfill with gas control	16	0.6	1.6667	0.1042	0.1344	1.344	2.688	8.33
4	Landfill with leachate control	16	0.6	1.6667	0.1042	0.0457	0.046	0.092	0.29

H: Height of disposed waste m
B: Bulk density ton/m3
V: Volume per ton of waste m3
A: Area per ton of waste m2
P: Percolation amount of rainfall m3/year
Bo: BOD amount per ton of waste kg/year
Mo: Modified BOD by safety factor kg/year

According to the calculation, supposing that BOD amount from open dump as 100%, controlled dump would reduce it by 50%, enclosed dump by 20%, landfill with gas control by 8.33%, and landfill with leachate control by 0.29%.

b.3 Application of Phased Development of Disposal to Urban Groups

This section discusses how apply the phased development of waste disposal to respective urban groups.

Degree of demand to solid waste management generally goes up in proportion to population size. If waste disposal amount is small, it does not give serious adverse impact on the environment. Such impact would be remedied by self-purification capacity of the environment. If waste amount increases, the environment cannot tolerate it. Then, a measure to lower the impact until a certain level, where it would not seriously deteriorate the environment, has to be taken.

Meanwhile, the more sophisticated disposal manner is applied such as sanitary landfill, the more expense piles up. Especially, fix costs for construction and facility procurement becomes large. Even if the same amount of money per person is paid for solid waste management, the aggregated amounts between a small community and a large one are very different. Namely, a small community cannot afford a sophisticated sanitary landfill.

With taking into account the two points mentioned above, or environment aspect and financial aspect, two cases how to apply the phased development of waste disposal are set as shown in Table G-23. L1 applies controlled dump, enclosed dump and landfill gas control depending and sanitary landfill with leachate control according to population size. L2 adopts sanitary landfill with leachate control to all urban groups with disregard to population size.

Table G-23: Application of Phased Development of Disposal

Population	L1	L2
1 - 2,499	0	0
2,500 - 7,999	1	4
8,000 - 34,999	2	4
34,999 - 99,999	3	4
100,000 -	4	4

0: open dump
1: controlled dump
2: enclosed dump
3: landfill with gas control
4: landfill with leachate control

Urban G	Communities	Population (nos.)	L1	L2
1	CALDERITAS, CHETUMAL, XUL-HA	172,488	4	4
2	ALVARO OBREGON, INGENIO ALVARO OBREGON, SERGIO BUTRON CASAS	12,474	2	4
3	NICOLAS BRAVO	4,854	1	4
4	BACALAR, LIMONES, MAYA BALAM	43,418	3	4
5	MAHAHUAL, PUNTA PULTICUB, XAHUACHOL, XCALAK	108,215	4	4
6	FELIPE CARRILLO PUERTO, SENOR	25,009	2	4
7	CHUNHUHUB	5,410	1	4
8	TEPICH, TIHOSUCO	7,854	1	4
9	CIUDAD CHEMUYIL, NUEVO Akumal, PLAYA DEL CARMEN, TULUM	379,664	4	4
10	COBA	3,000	1	4
91	Rural Communities	130,408	0	0

b.4 Environmental Evaluation of the Phased Disposal Site Development

The result of environmental evaluation of the Phased Disposal Site Development is shown in the table on the next page. Environmental items are quoted from the environmental guideline of JICA. The following is description of the result of environmental evaluation.

Level 0: Open dump

Burning waste and its smoke pollute air, and leachate contaminates surface water and groundwater. Offensive odor is spread out of the site. Scattering waste and smoke degrade aesthetics. Public health is threatened due to polluted air and contaminated groundwater.

Level 1: Controlled dump

Since dumping is controlled, problem of waste is improved. Accumulation of waste and reduction of dumping area decrease discharge amount of leachate. However, public health is exposed to adverse influence and fire cannot be stopped.

Level 2: Enclosed dump

Buffer zone can mitigate adverse impact against landscape. As construction of drainage consequently reduces amount of rainwater filtrating into the ground, threatening to public health is improved a little. Waste management is completely controlled by using a weighbridge. Air pollution and water pollution cannot be terminated.

Level 3: Landfill with gas control

Cover soil can reduce production of leachate and discharge of offensive odor. Fire is terminated owing to conduct of gas removal management. Influence of leachate cannot be eliminated enough to solve the problem of public health.

Level 4: Landfill with leachate management

Leachate is prevented from infiltrating into the ground with bottom liner, collected and treated. Therefore, no significant impact is expected.

No.	Concept of phased development of waste disposal site		Social Environment	Resettllement	Economic Activities	Traffic & Public Facilities	Division of Community	Cultural Property	Water Rights /Access Rights	Public Health	Waste	Hazards/Risks	Natural Environment	Topography & Geology	Soil Erosion	Groundwater	Hydrological Situation	Coastal Zone	Fauna and Flora	Meteorology	Landscape /Aestheics	Pollution	Air Pollution	Water Pollution	Soil Contamination	Noise & Vibration	Land Subsidence	Offensive Odor
0	Open dumping site	・No control ・Waste is scattered all over a dumping site ・No rainwater drainage system ・Large amount of leachate ・No biogas control (fire, slow decomposition of ・Poor quality of leachate due to anaerobic								●	●										●		●	●				●
1	Controlled dumping site	・Inspection on incoming waste: to measure disposal amount, to control hazardous waste, etc. ・Approach road, on−site road: to secure access to a dumping area ・Landfill equipment: to accumulate waste								●	○										●		●	●				●
2	Enclosed dumping site	・Fence: to prohibit for unauthrized persons to enter the site ・Dike: to avoid waste to be scattered, to prevent waste from coming in ・Buffer: to keep enough space to adjacent ・Drainage: surrounding and on−site drains ・Weighbridge: important for SWM								○	–										○		●	●				●
3	Landfill with gas management	・Soil cover: to prohibit vector proliferation, to prevent fire and malodor, to minimize rainwater infiltration, to improve aethetics ・Gas removal facility: to prevent fire and explosion, to encourage waste decomposition								○											–		–	○				–
4	Landfill with leachate management	・Bottom liner: to prevent leachate to infiltrate into ground (grondwater contamination) ・Leachate collection facility: to collect and discharge leachate to the outside ・Leachate treatment facility: to treat leachate to acertain quality that gives no serious environmetal impact								–											–		–	–				–

● significant impact ○ impact – no significant impact

Figure G-4: Environmental Evaluation of the Phased Disposal Site Development

c. Issues in Setting Waste Minimization

Waste minimization is currently the central problem of Solid Waste Management. Developed countries have taken the lead in waste minimization so far. However, other countries are also expected to tackle it, as the waste minimization is one of effective measures to preserve natural resources, to prevent the global warming, to reduce hazardous substances and to lower SWM cost.

c.1 Concept of Waste Minimization

Waste minimization has a broad sense, which includes Generation Control, Discharge Control and Resource Recovery as shown in the figure below.

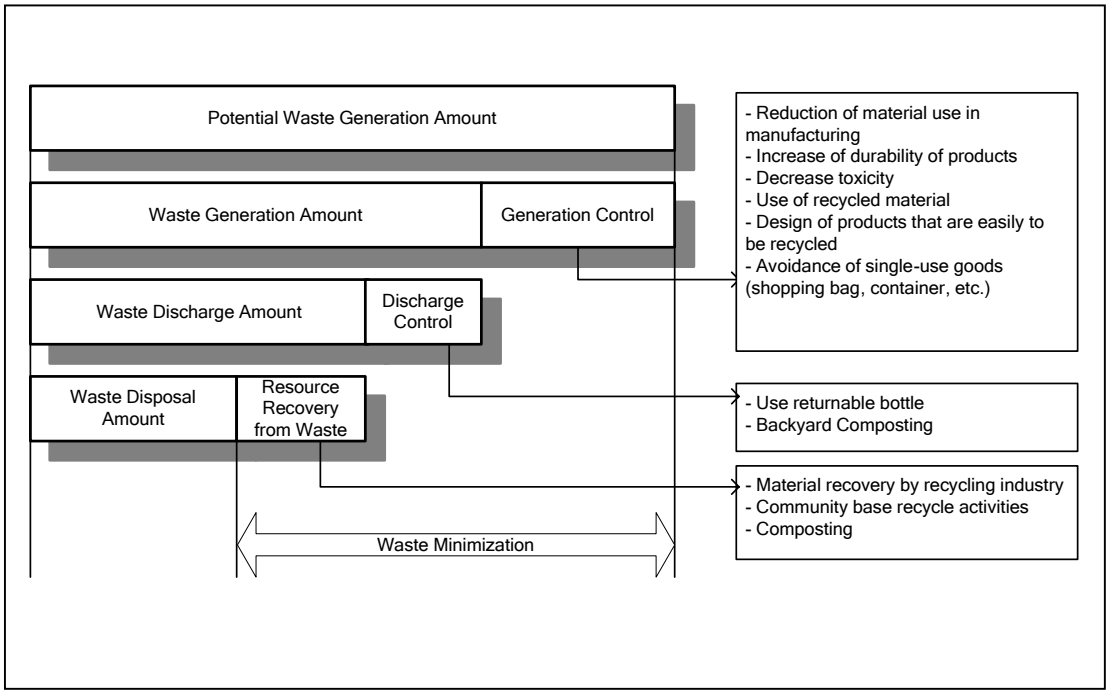


Figure G-5: Concept of Waste Minimization

It is common knowledge around the world that the priority order of SWM policy is 1) to "Reduce," 2) to "Reuse" and 3) "Recycle."

"Generation Control" is the same as reduce. It should be given the first priority. "Discharge Control" practices reuse and/or recycle at waste generation sources. As both measures aims to reduce waste discharged from the generation source, they are called as "Source Reduction."

"Resource Recovery" indicates activities which aim to recover resources from discharged waste. It is generally called as "Recycling." It is often divided into "Material Recovery" and "Energy Recovery."

In this context, "Generation Control" and "Discharge Control" mean as "Source Reduction," and "Resource Recovery" means as "Recycling."

c.2 Towards to Waste Minimization in Mexico

"Ley General para la Prevencion y Gestion Integral de los Residuos" has been promulgated in October 2003. The law puts importance on the following four issues.

- Prevention of waste generation
- Valorization of waste
- Integral management of waste
- Sharing of responsibility

In addition, a SWM campaign "Mexico Limpio" has been carried out ahead of the promulgation of the law, and various measures have been taken at federal, state and municipal levels. Political environment for waste minimization are in place in Mexico.

c.3 Disposal Cost

A major reason why recycling is feasible in developed countries is high cost of waste disposal. That is, waste minimization reduces disposal cost as well as waste disposal amount, and it compensates cost of recycling.

Meanwhile, disposal cost is often not so expensive in developing countries as to compensate recycling cost. In this case, recycling makes bigger financial burden and ceases its operation.

c.4 Waste Composition

Waste composition in the Study Area has about 30% of compostable waste. Backyard composting would be an effective measure to reduce waste at generation source. As for recycling, the waste composition tells that about 30% of waste is recyclable. Tables below show the waste composition in the Study Area.

Table G-24: Waste Composition in Chetumal

Recycle		Composition	Portion (%)
Non-recyclable		Born	0.50
		rubber	4.81
		textile	4.48
		hardening plastic	2.89
		sanitary goods	11.09
		plastic film	0.14
		dust	8.95
		others	9.07
Sub-total			41.93
Recyclable	Recyclable	iron	0.33
		can	2.80
		colored glass	1.23
		clear glass	3.54
		carton	3.77
		paper	9.68
		sub-total	21.35
	Compo-st	garden waste	23.48
		kitchen waste	13.24
		sub-total	36.72
Sub-total			58.07
Total			100.00

Table G-25: Waste Composition in FCP City and Tulum

Recycle		Item	FCP City	Tulum
Non-recyclable		cotton	0.02	0.02
		Wax coating carton	2.21	1.89
		ceramic, tile	0.42	0.14
		leather	0.08	0.25
		born	0.63	0.36
		rubber	6.88	6.73
		Tire	0.00	0.00
		construction waste	1.20	1.09
		sanitary goods	9.81	9.90
		plastic film	0.09	0.01
		hardening plastic	2.66	1.57
		dust	6.89	2.48
		textile	2.63	2.61
		unicel	0.20	0.68
		shoes	0.63	2.56
		others	0.00	0.00
Sub-total			34.35	30.29
Recyclable	Recyclable	aluminum	0.21	0.42
		metals	1.46	0.71
		carton	6.51	5.14
		Can	1.70	3.33
		Iron	0.58	1.02
		paper	8.27	4.76
		PET	5.21	5.21
		colored glass	3.97	2.08
		clear glass	7.01	8.18
		Sub-total	34.92	30.85
	Compost	wood	1.10	0.79
		garden waste	14.89	11.31
		kitchen waste	14.74	26.76
		Sub-total	30.73	38.86
Sub-total			65.65	69.71
Total			100.00	100.00

c.5 Waste Minimization Rate

About 60% of waste is potentially recyclable. However, all of them are not to practically be recycled, because some of materials are contaminated and some of organic materials does not decompose quickly and not suit to composting. Degree of recycling could be encouraged by promotion and/or education. Taking into consideration the mentioned above, the following four options could be conceivable.

- 0% of waste minimization: no measures for waste minimization
- 2.5% of waste minimization: change of consumption behavior by environmental education
- 15% of waste minimization: source reduction by backyard composting, recycling of papers and others, and change of consumption behavior by environmental education
- 25% of waste minimization: 15% of source reduction by backyard composting, recycling of papers and others, and change of consumption behavior by environmental education; 10% of yard trimming composting (garden waste in households and pruning waste in public areas)
- 40% of waste minimization: 15% of source reduction by backyard composting, recycling of papers and others, and change of consumption behavior by environmental education; 10% of yard trimming composting (garden waste in households and pruning waste in public areas); 15% of material recovery

G.3.2 Setting of Alternative Scenarios

This section sets some alternative technical scenarios taking into consideration of characteristics of the Study Area. The minimum requirement is to achieve the principal objective, i.e., less than 2,100 ton/year of BOD discharge amount in 2015.

G.3.2.1 Alternative Scenarios

The following five scenarios are set. Contents of the scenarios explain situations achieved in 2015.

Scenario 1: Conventional System
- 0% of waste minimization: no measures for waste minimization
- 100% of waste collection rate in the urban area
- Sanitary landfills are adopted in all the urban area

Scenario 2: Conservative Recycling-oriented System

- 2.5% of waste minimization: change of consumption behavior by environmental education
- 80 - 100% of waste collection rate depending on population size of community
- Different disposal levels are adopted depending on population size of community

Scenario 3: Semi-progressive Recycling-oriented System

- 15% of waste minimization: source reduction by backyard composting, recycling of papers and others, and change of consumption behavior by environmental education
- 80 - 100% of waste collection rate depending on population size of community
- Different disposal levels are adopted depending on population size of community

Scenario 4: Progressive Recycling-oriented System

- 25% of waste minimization: 15% of source reduction by backyard composting, recycling of papers and others, and change of consumption behavior by environmental education; 10% of yard trimming composting (garden waste in households and pruning waste in public areas)
- 80 - 100% of waste collection rate depending on population size of community
- Different disposal levels are adopted depending on population size of community

Scenario 5: Radical Recycling-oriented System

- 40% of waste minimization: 15% of source reduction by backyard composting, recycling of papers and others, and change of consumption behavior by environmental education; 10% of yard trimming composting (garden waste in households and pruning waste in public areas); 15% of material recovery
- 80 - 100% of waste collection rate depending on population size of community
- Different disposal levels are adopted depending on population size of community

The table below summarizes the five scenarios.

Table G-26: Alternative Scenarios

Scenario	Collection rate	Disposal level	Waste minimization				
			Source reduction		Recycling		Total
			Education	Backyard compost	Compost	MRF	
1	100%	sanitary landfill	0%	0%	0%	0%	0%
2	80-100%	phased development	2.5%	0%	0%	0%	2.5%
3	80-100%	phased development	15%		0%	0%	15%
4	80-100%	phased development	15%		10%	0%	25%
5	80-100%	phased development	15%		10%	15%	40%

Note: ratios of waste minimization mean of waste amount being subject for respective waste minimization measures, not of minimized waste amount.

G.3.2.2 Waste Streams of the Alternative Scenarios

Waste streams of without the Master Plan and the five scenarios are shown below.

Table G-27: Waste Stream of without the M/P

Item	unit	OPB	FCP	SOL	Total
Urban Area					
Population	nos.	341,449	38,273	382,664	762,386
Generation source					
generation	ton/day	406.1	44.0	495.6	945.7
source reduction	ton/day	0.0	0.0	0.0	0.0
self-disposal	ton/day	176.5	35.9	87.2	299.6
discharge	ton/day	229.6	8.1	408.4	646.1
Collection					
mixed	ton/day	229.6	8.1	408.4	646.1
garden	ton/day	0.0	0.0	0.0	0.0
recycle	ton/day	0.0	0.0	0.0	0.0
Intermediate					
composting for product	ton/day	0.0	0.0	0.0	0.0
residue	ton/day	0.0	0.0	0.0	0.0
recycling product	ton/day	0.0	0.0	0.0	0.0
residue	ton/day	0.0	0.0	0.0	0.0
Disposal					
disposal	ton/day	229.6	8.1	408.4	646.1
Rate of minimized waste	%	0.0	0.0	0.0	0.0
Rural Area					
population	nos.	73,740	35,628	21,040	130,408
self-disposal	ton/day	72.9	28.6	21.2	122.7
Collection rate					
urban area	%	57	18	82	68
whole area	%	48	11	79	60

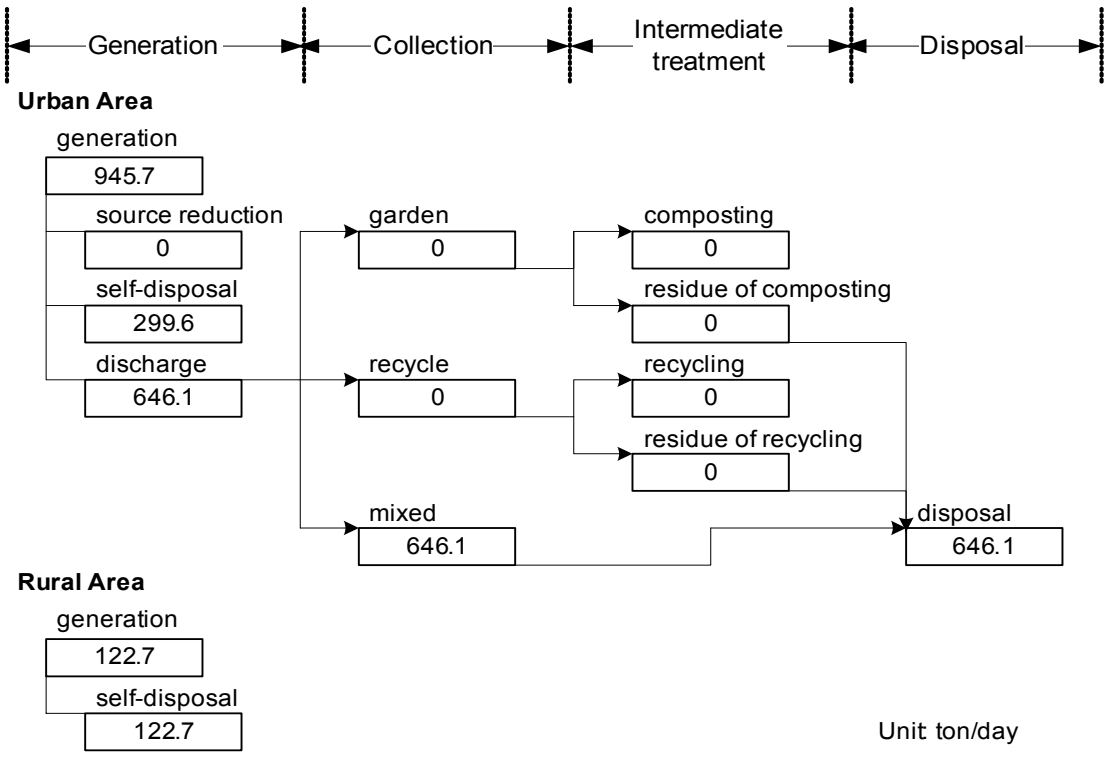


Figure G-6: Waste Stream of without the Master Plan

Table G-28: Waste Stream of Scenario 1

Item	unit	OPB	FCP	SOL	Total
Urban Area					
Population	nos.	341,449	38,273	382,664	762,386
Generation source					
generation	ton/day	406.1	44.0	495.6	945.7
source reduction	ton/day	0.0	0.0	0.0	0.0
self-disposal	ton/day	0.0	0.0	0.0	0.0
discharge	ton/day	406.1	44.0	495.6	945.7
Collection					
mixed	ton/day	406.1	44.0	495.6	945.7
garden	ton/day	0.0	0.0	0.0	0.0
recycle	ton/day	0.0	0.0	0.0	0.0
Intermediate					
composting for product	ton/day	0.0	0.0	0.0	0.0
residue	ton/day	0.0	0.0	0.0	0.0
recycling product	ton/day	0.0	0.0	0.0	0.0
residue	ton/day	0.0	0.0	0.0	0.0
Disposal					
disposal	ton/day	406.1	44.0	495.6	945.7
Rate of minimized waste	%	0.0	0.0	0.0	0.0
Rural Area					
population	nos.	73,740	35,628	21,040	130,408
self-disposal	ton/day	72.9	28.6	21.2	122.7
Collection rate					
urban area	%	100	100	100	100
whole area	%	85	61	96	89

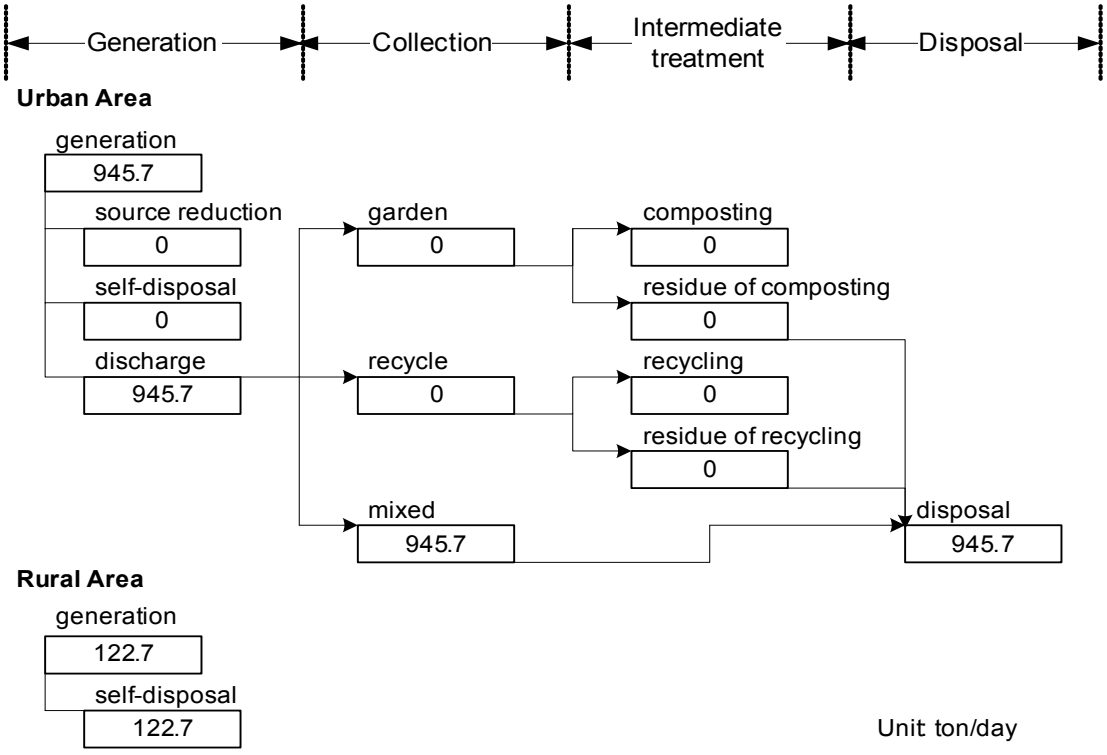


Figure G-7: Waste Stream of Scenario 1

Table G-29: Waste Stream of Scenario 2

Item	unit	OPB	FCP	SOL	Total
Urban Area					
Population	nos.	341,449	38,273	382,664	762,386
Generation source					
generation	ton/day	406.1	44.0	495.6	945.7
source reduction	ton/day	10.2	1.1	12.4	23.7
self-disposal	ton/day	5.0	5.8	0.7	11.5
discharge	ton/day	390.9	37.1	482.5	910.5
Collection					
mixed	ton/day	390.9	37.1	482.5	910.5
garden	ton/day	0.0	0.0	0.0	0.0
recycle	ton/day	0.0	0.0	0.0	0.0
Intermediate					
composting for product	ton/day	0.0	0.0	0.0	0.0
residue	ton/day	0.0	0.0	0.0	0.0
recycling product	ton/day	0.0	0.0	0.0	0.0
residue	ton/day	0.0	0.0	0.0	0.0
Disposal					
disposal	ton/day	390.9	37.1	482.5	910.5
Rate of minimized waste	%	2.5	2.5	2.5	2.5
Rural Area					
population	nos.	73,740	35,628	21,040	130,408
self-disposal	ton/day	72.9	28.6	21.2	122.7
Collection rate					
urban area	%	99	86	100	99
whole area	%	83	52	96	87

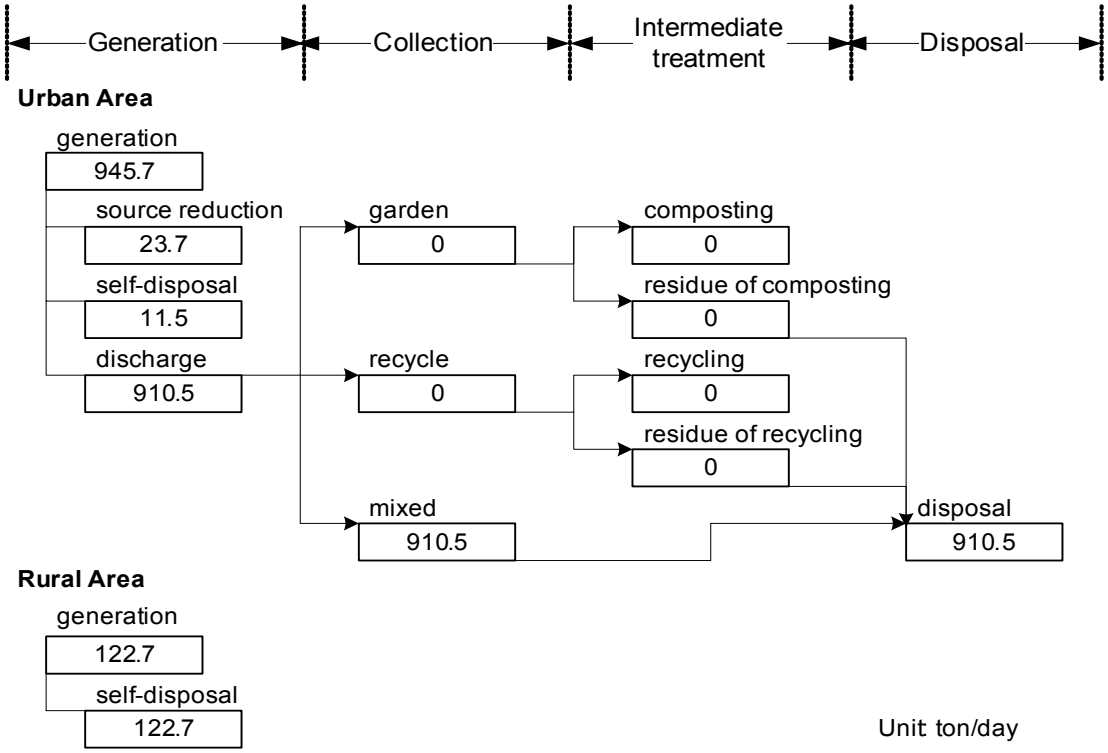


Figure G-8: Waste Stream of Scenario 2

Table G-30: Waste Stream of Scenario 3

Item	unit	OPB	FCP	SOL	Total
Urban Area					
Population	nos.	341,449	38,273	382,664	762,386
Generation source					
generation	ton/day	406.1	44.0	495.6	945.7
source reduction	ton/day	61.0	6.6	74.3	141.9
self-disposal	ton/day	4.4	5.0	0.6	10.0
discharge	ton/day	340.7	32.4	420.7	793.8
Collection					
mixed	ton/day	340.7	32.4	420.7	793.8
garden	ton/day	0.0	0.0	0.0	0.0
recycle	ton/day	0.0	0.0	0.0	0.0
Intermediate					
composting for product	ton/day	0.0	0.0	0.0	0.0
residue	ton/day	0.0	0.0	0.0	0.0
recycling product	ton/day	0.0	0.0	0.0	0.0
residue	ton/day	0.0	0.0	0.0	0.0
Disposal					
disposal	ton/day	340.7	32.4	420.7	793.8
Rate of minimized waste	%	15.0	15.0	15.0	15.0
Rural Area					
population	nos.	73,740	35,628	21,040	130,408
self-disposal	ton/day	72.9	28.6	21.2	122.7
Collection rate					
urban area	%	99	87	100	99
whole area	%	82	49	95	86

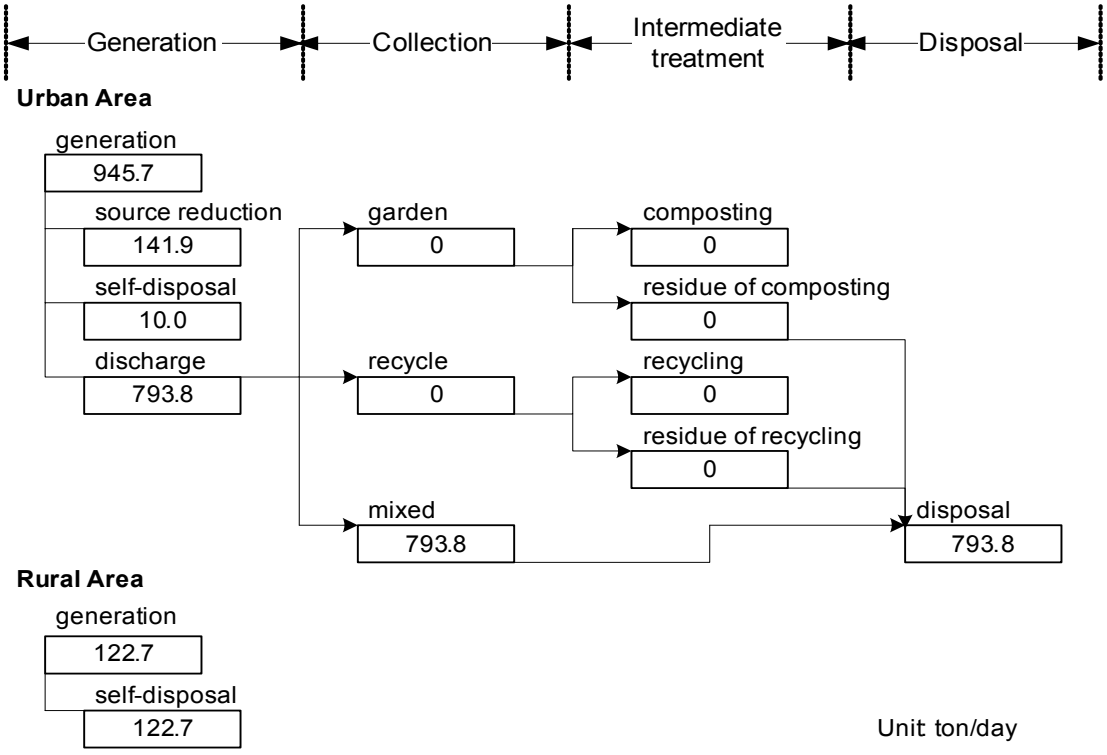


Figure G-9: Waste Stream of Scenario 3

Table G-31: Waste Stream of Scenario 4

Item	unit	OPB	FCP	SOL	Total
Urban Area					
Population	nos.	341,449	38,273	382,664	762,386
Generation source					
generation	ton/day	406.1	44.0	495.6	945.7
source reduction	ton/day	61.0	6.6	74.3	141.9
self-disposal	ton/day	4.4	5.0	0.6	10.0
discharge	ton/day	340.7	32.4	420.7	793.8
Collection					
mixed	ton/day	300.0	28.0	371.1	699.1
garden	ton/day	40.7	4.4	49.6	94.7
recycle	ton/day	0.0	0.0	0.0	0.0
Intermediate					
composting for product	ton/day	36.5	4.0	44.6	85.1
residue	ton/day	4.2	0.4	5.0	9.6
recycling product	ton/day	0.0	0.0	0.0	0.0
residue	ton/day	0.0	0.0	0.0	0.0
Disposal					
disposal	ton/day	304.2	28.4	376.1	708.7
Rate of minimized waste	%	24.0	24.1	24.0	24.0
Rural Area					
population	nos.	73,740	35,628	21,040	130,408
self-disposal	ton/day	72.9	28.6	21.2	122.7
Collection rate					
urban area	%	99	87	100	99
whole area	%	82	49	95	86

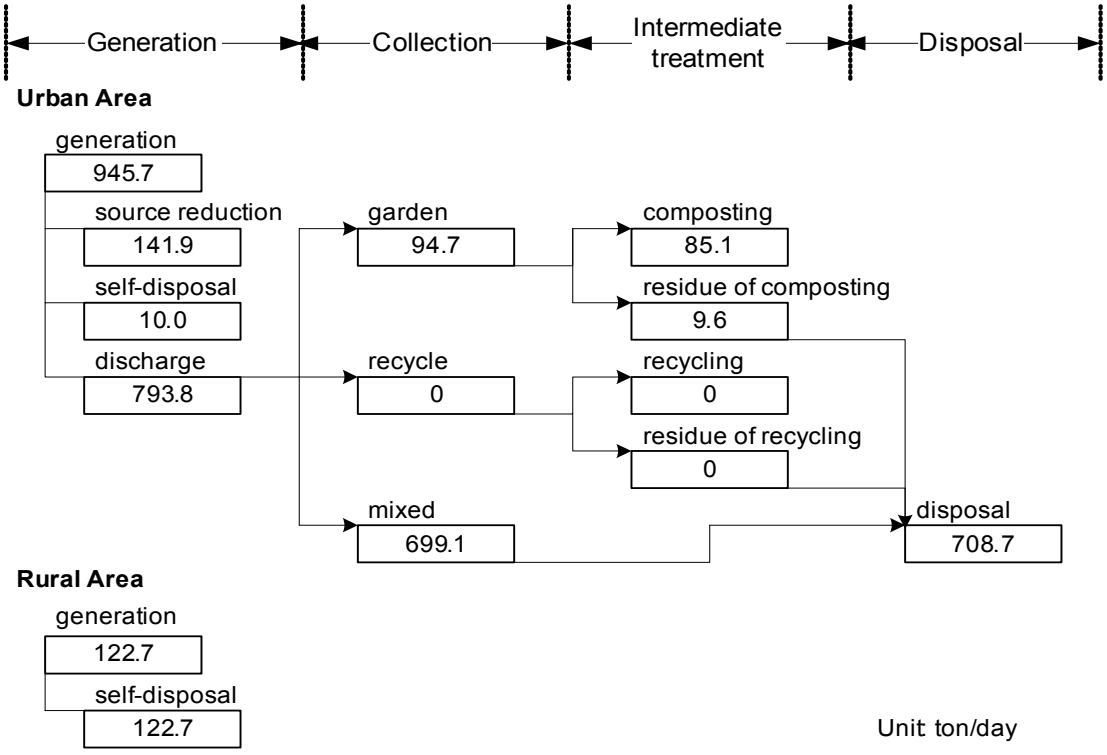


Figure G-10: Waste Stream of Scenario 4

Table G-32: Waste Stream of Scenario 5

Item	unit	OPB	FCP	SOL	Total
Urban Area					
Population	nos.	341,449	38,273	382,664	762,386
Generation source					
generation	ton/day	406.1	44.0	495.6	945.7
source reduction	ton/day	61.0	6.6	74.3	141.9
self-disposal	ton/day	4.4	5.0	0.6	10.0
discharge	ton/day	340.7	32.4	420.7	793.8
Collection					
mixed	ton/day	239.0	21.4	296.8	557.2
garden	ton/day	40.7	4.4	49.6	94.7
recycle	ton/day	61.0	6.6	74.3	141.9
Intermediate					
composting for product	ton/day	36.5	4.0	44.6	85.1
residue	ton/day	4.2	0.4	5.0	9.6
recycling product	ton/day	36.5	4.0	44.6	85.1
residue	ton/day	24.5	2.6	29.7	56.8
Disposal					
disposal	ton/day	267.7	24.4	331.5	623.6
Rate of minimized waste	%	33.0	33.2	33.0	33.0
Rural Area					
population	nos.	73,740	35,628	21,040	130,408
self-disposal	ton/day	72.9	28.6	21.2	122.7
Collection rate					
urban area	%	99	87	100	99
whole area	%	82	49	95	86

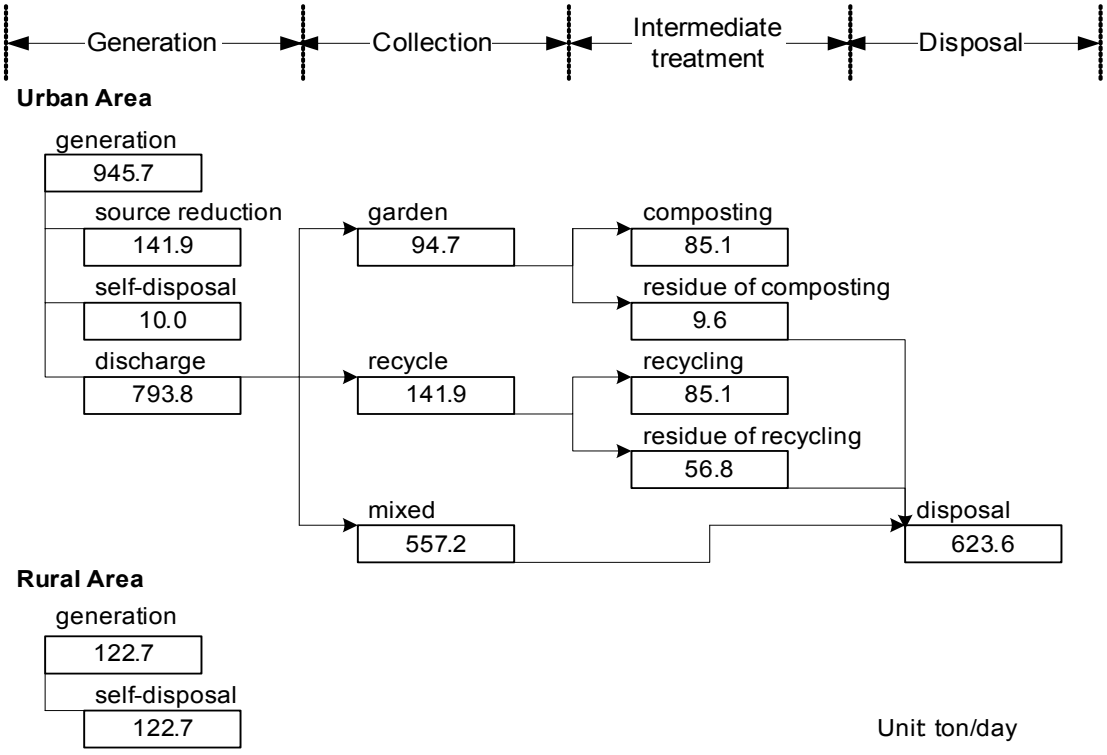


Figure G-11: Waste Stream of Scenario 5

G.3.2.3 BOD Discharge Amount of the Alternative Scenarios

This section describes results of calculation of BOD discharge amount of respective scenarios. As Table G-33 shows, every scenario achieves the principal objective, less than 2,100 ton/year of BOD discharge amount. Scenario 1 discharges the least amount, then, Scenario 5, 4, 3 and 2 in order.

Table G-33: BOD Discharge Amount of the Alternative Scenarios

Scenario	BOD (ton/year)
w/o M/P	7,090
1	1,475
2	1,854
3	1,803
4	1,772
5	1,744

Table G-34: BOD Discharge Amount of without the Master Plan

Munici.	Urban G	Population	Daily waste amount		Yearly waste amount		Disposal level		Unit BOD discharge		BOD discharge
			Self-disposal	Disposal	Self-disposal	Disposal	Self-disposal	Disposal	Self-disposal	Disposal	total
	No	nos.	ton/day	ton/day	ton/year	ton/year	level	level	kg/year/ton of waste		ton/year
Urban area											
OPB	1	172,488	20.4	183.4	7,446	66,941	0	1	32.250	16.126	1,320
OPB	2	12,474	4.4	10.3	1,606	3,760	0	0	32.250	32.250	173
OPB	3	4,854	5.7	0.0	2,081	0	0	0	32.250	32.250	67
OPB	4	43,418	15.4	35.9	5,621	13,104	0	0	32.250	32.250	604
OPB	5	108,215	130.6	0.0	47,669	0	0	0	32.250	32.250	1,537
FCP	6	25,009	20.7	8.1	7,556	2,957	0	0	32.250	32.250	339
FCP	7	5,410	6.2	0.0	2,263	0	0	0	32.250	32.250	73
FCP	8	7,854	9.0	0.0	3,285	0	0	0	32.250	32.250	106
SOL	9	379,664	83.7	408.4	30,551	149,066	0	3	32.250	2.688	1,386
SOL	10	3,000	3.5	0.0	1,278	0	0	0	32.250	32.250	41
	sub-t	762,386	299.6	646.1	109,356	235,828					5,646
Rural		130,408	122.7	0	44,786	0	0	0	32.250	32.250	1,444
Total		892,794	422.3	646.1	154,142	235,828					7,090

Table G-35: BOD Discharge Amount of Scenario 1

Munici.	Urban G	Population	Daily waste amount		Yearly waste amount		Disposal level		Unit BOD discharge		BOD discharge
			Self-disposal	Disposal	Self-disposal	Disposal	Self-disposal	Disposal	Self-disposal	Disposal	total
	No	nos.	ton/day	ton/day	ton/year	ton/year	level	level	kg/year/ton of waste		ton/year
Urban area											
OPB	1	172,488	0.0	203.8	0	74,387	0	4	32.250	0.092	7
OPB	2	12,474	0.0	14.7	0	5,366	0	4	32.250	0.092	0
OPB	3	4,854	0.0	5.7	0	2,081	0	4	32.250	0.092	0
OPB	4	43,418	0.0	51.3	0	18,725	0	4	32.250	0.092	2
OPB	5	108,215	0.0	130.6	0	47,669	0	4	32.250	0.092	4
FCP	6	25,009	0.0	28.8	0	10,512	0	4	32.250	0.092	1
FCP	7	5,410	0.0	6.2	0	2,263	0	4	32.250	0.092	0
FCP	8	7,854	0.0	9.0	0	3,285	0	4	32.250	0.092	0
SOL	9	379,664	0.0	492.1	0	179,617	0	4	32.250	0.092	17
SOL	10	3,000	0.0	3.5	0	1,278	0	4	32.250	0.092	0
	sub-t	762,386	0.0	945.7	0	345,183					31
Rural		130,408	122.7	0	44,786	0	0	0	32.250	32.250	1,444
Total		892,794	122.7	945.7	44,786	345,183					1,475

Table G-36: BOD Discharge Amount of Scenario 2

Munici.	Urban G	Population	Daily waste amount		Yearly waste amount		Disposal level		Unit BOD discharge		BOD discharge
			Self-disposal	Disposal	Self-disposal	Disposal	Self-disposal	Disposal	Self-disposal	Disposal	total
	No	nos.	Ton/day	ton/day	ton/year	ton/year	level	level	kg/year/ton of waste		ton/year
Urban area											
OPB	1	172,488	0.0	198.7	0	72,526	0	4	32.250	0.092	7
OPB	2	12,474	1.4	12.9	511	4,709	0	2	32.250	6.450	47
OPB	3	4,854	1.1	4.5	402	1,643	0	1	32.250	16.126	39
OPB	4	43,418	2.5	47.5	913	17,338	0	3	32.250	2.688	76
OPB	5	108,215	0.0	127.3	0	46,465	0	4	32.250	0.092	4
FCP	6	25,009	2.8	25.3	1,022	9,235	0	2	32.250	6.450	93
FCP	7	5,410	1.2	4.8	438	1,752	0	1	32.250	16.126	42
FCP	8	7,854	1.8	7.0	657	2,555	0	1	32.250	16.126	62
SOL	9	379,664	0.0	479.8	0	175,127	0	4	32.250	0.092	16
SOL	10	3,000	0.7	2.7	256	986	0	1	32.250	16.126	24
	sub-t	762,386	11.5	910.5	4,199	332,336					410
Rural		130,408	122.7	0	44,786	0	0	0	32.250	32.250	1,444
Total		892,794	134.2	910.5	48,985	332,336					1,854

Table G-37: BOD Discharge Amount of Scenario 3

Munici.	Urban G	Population	Daily waste amount		Yearly waste amount		Disposal level		Unit BOD discharge		BOD discharge
			Self-disposal	Disposal	Self-disposal	Disposal	Self-disposal	Disposal	Self-disposal	Disposal	total
	No	nos.	Ton/day	ton/day	ton/year	ton/year	level	level	kg/year/ton of waste		ton/year
Urban area											
OPB	1	172,488	0.0	173.2	0	63,218	0	4	32.250	0.092	6
OPB	2	12,474	1.2	11.3	438	4,125	0	2	32.250	6.450	41
OPB	3	4,854	1.0	3.8	365	1,387	0	1	32.250	16.126	34
OPB	4	43,418	2.2	41.4	803	15,111	0	3	32.250	2.688	67
OPB	5	108,215	0.0	111.0	0	40,515	0	4	32.250	0.092	4
FCP	6	25,009	2.4	22.1	876	8,067	0	2	32.250	6.450	80
FCP	7	5,410	1.1	4.2	402	1,533	0	1	32.250	16.126	38
FCP	8	7,854	1.5	6.1	548	2,227	0	1	32.250	16.126	54
SOL	9	379,664	0.0	418.3	0	152,680	0	4	32.250	0.092	14
SOL	10	3,000	0.6	2.4	219	876	0	1	32.250	16.126	21
	sub-t	762,386	10.0	793.8	3,651	289,739					359
Rural		130,408	122.7	0	44,786	0	0	0	32.250	32.250	1,444
Total		892,794	132.7	793.8	48,437	289,739					1,803

Table G-38: BOD Discharge Amount of Scenario 4

Munici.	Urban G	Population	Daily waste amount		Yearly waste amount		Disposal level		Unit BOD discharge		BOD discharge
			Self-disposal	Disposal	Self-disposal	Disposal	Self-disposal	Disposal	Self-disposal	Disposal	total
	No	nos.	ton/day	ton/day	ton/year	ton/year	level	level	kg/year/ton of waste		ton/year
Urban area											
OPB	1	172,488	0.0	154.9	0	56,539	0	4	32.250	0.092	5
OPB	2	12,474	1.2	10.0	438	3,650	0	2	32.250	6.450	38
OPB	3	4,854	1.0	3.3	365	1,205	0	1	32.250	16.126	31
OPB	4	43,418	2.2	36.8	803	13,432	0	3	32.250	2.688	62
OPB	5	108,215	0.0	99.2	0	36,208	0	4	32.250	0.092	3
FCP	6	25,009	2.4	19.5	876	7,118	0	2	32.250	6.450	74
FCP	7	5,410	1.1	3.6	402	1,314	0	1	32.250	16.126	34
FCP	8	7,854	1.5	5.3	548	1,935	0	1	32.250	16.126	49
SOL	9	379,664	0.0	374.0	0	136,510	0	4	32.250	0.092	13
SOL	10	3,000	0.6	2.1	219	767	0	1	32.250	16.126	19
	sub-t	762,386	10.0	708.7	3,651	258,678					328
Rural		130,408	122.7	0	44,786	0	0	0	32.250	32.250	1,444
Total		892,794	132.7	708.7	48,437	258,678					1,772

Table G-39: BOD Discharge Amount of Scenario 5

Munici.	Urban G	Population	Daily waste amount		Yearly waste amount		Disposal level		Unit BOD discharge		BOD discharge
			Self-disposal	Disposal	Self-disposal	Disposal	Self-disposal	Disposal	Self-disposal	Disposal	total
	No	nos.	ton/day	ton/day	ton/year	ton/year	level	level	kg/year/ton of waste		ton/year
Urban area											
OPB	1	172,488	0.0	136.6	0	49,859	0	4	32.250	0.092	5
OPB	2	12,474	1.2	8.7	438	3,176	0	2	32.250	6.450	35
OPB	3	4,854	1.0	2.8	365	1,022	0	1	32.250	16.126	28
OPB	4	43,418	2.2	32.2	803	11,753	0	3	32.250	2.688	57
OPB	5	108,215	0.0	87.4	0	31,901	0	4	32.250	0.092	3
FCP	6	25,009	2.4	16.9	876	6,169	0	2	32.250	6.450	68
FCP	7	5,410	1.1	3.0	402	1,095	0	1	32.250	16.126	31
FCP	8	7,854	1.5	4.5	548	1,643	0	1	32.250	16.126	44
SOL	9	379,664	0.0	329.7	0	120,341	0	4	32.250	0.092	11
SOL	10	3,000	0.6	1.8	219	657	0	1	32.250	16.126	18
	sub-t	762,386	10.0	623.6	3,651	227,616					300
Rural		130,408	122.7	0	44,786	0	0	0	32.250	32.250	1,444
Total		892,794	132.7	623.6	48,437	227,616					1,744

G.3.2.4 Cost Comparison of the Alternative Scenarios

a. Unit Cost used for the Cost Comparison

Typical solid waste management costs are known from various studies, investigations, and projects. Table G-40 presents costs which CEPIS recommends as appropriate in Latin American countries. Solid waste management costs are generally defined in a range where governmental bodies and/or residents can cover. Table G-41 shows typical costs by income level. Phenomena of economies of scale are found in solid waste management costs, i.e., the lager amount of waste is dealt with, the smaller expense is required per ton of waste up to a certain amount. Figure G-12 shows the economies of scale in collection. Table G-42 shows actual solid waste management costs in the study area. Most costs of Othon P Blanco and Felipe C Puerto are collection costs including street sweeping, as the municipalities hardly expense for final disposal. In Solidaridad, landfill with gas control is working at present. Thus, the difference of about 10 USD from Othon P Blanco and Solidaridad could be considered as final disposal cost.

Table G-40: Acceptable Solid Waste Management Costs in Latin American Countries by CEPIS

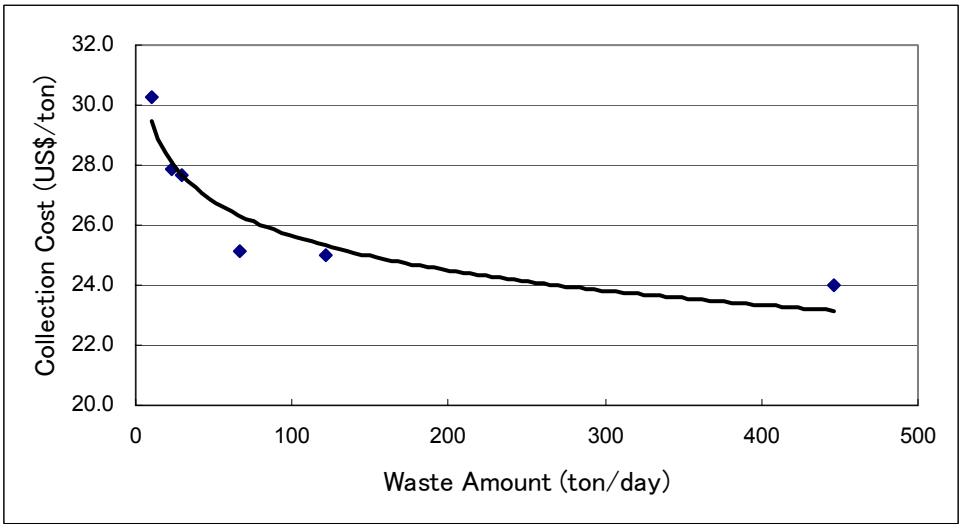
Item	Unit	Cost		
Collection	USD/ton	25.0	-	40.0
Street sweeping	USD/km	15.0	-	20.0
Transfer	USD/ton	8.0	-	12.0
Disposal	USD/ton	4.0	-	10.0
Maintenance	USD/ton	3.0	-	5.0

Source: Fernando A. Paraguassú de Sá and Carmen Rosío Rojas Rodríguez, (2002), Indicadores para el Gerenciamiento del Servicio de Limpieza Pública, Centro Panamericano de Ingenieria Sanitaria y Ciencias del Ambiente (CEPIS)

Table G-41: Typical Solid Waste Management Costs by Income Level

Income level	Low-income	Middle-income	High-income
Average waste generation (ton/capita/year)	0.2	0.3	0.6
Average income from GNP ($US/capita/year)	370	2,400	22,000
Collection cost ($US/ton)	10 - 30	30 - 70	70 - 120
Transfer cost ($US/ton)	3 - 8	5 - 15	15 - 20
Sanitary landfill cost ($US/ton)	3 - 10	8 - 15	20 - 50
Total cost without transfer ($US/ton)	13 - 40	38 - 85	90 - 170
Total cost with transfer ($US/ton)	16 - 48	43 - 100	105 - 190
Cost as percent of income (%)	0.7 - 2.6	0.5 - 1.3	0.2 - 0.5

Source: Cointreau-Levine, Sandra and Adrian Coad, (2000), from Guidance Pack, Private Sector Participation in Municipal Solid Waste Management, SKAT, Switzerland



Source: Prepared by the Study Team, data obtained from JICA Study in El Salvador in 2000 was adjusted to the study area

Figure G-12: Correlation between Collection Cost and Collection Waste Amount

Table G-42: Solid Waste Management Costs of the Municipalities in the Study Area

Municipality	Estimated Cost	Activities	Remarks
Othon P Blanco	27 USD/ton	Collection and street sweeping	In 2001, 62,000 ton/year of estimated waste collection amount, 16.91 Million Pesos of a total SWM cost
Felipe C Puerto	26 USD/ton	Collection and street sweeping	In 2002, 4,380 ton/year of estimated waste collection amount, 1.16 Million Pesos of a total SWM cost
Solidaridad	34 USD/ton	Collection, street sweeping and disposal	In 2001, 48,000 ton/year of estimated disposal amount, 1.47 Million Pesos of a concession fee

Source: Data obtained from respective municipalities in 2003

Taking into account the solid waste management costs mentioned above, unit costs are estimated for cost comparison of the alternative scenarios as shown in Table G-43, Table G-44 and Table G-45.

Table G-43: Unit Cost of Collection

Population	Cost (US$/ton)
2,500 - 7,999	31
8,000 - 34,999	28
34,999 - 99,999	26
100,000 -	25

Urban Group	Municipality	Population (nos.)	Cost (US$/ton)
1	OPB	172,488	25
2	OPB	12,474	28
3	OPB	4,854	31
4	OPB	43,418	26
5	OPB	108,215	25
6	FCP	25,009	28
7	FCP	5,410	31
8	FCP	7,854	31
9	SOL	379,664	25
10	SOL	3,000	31
Total	-	762,386	-

Table G-44: Unit Cost of Intermediate Treatment

Item	US$/ton
Composting	30
Material Recovery	28

Table G-45: Unit Cost of Disposal

Disposal level	US$/ton
Open dump	1
Controlled dump	3
Enclosed dump	5
Landfill with gas control	10
Landfill with leachate control	15

Urban Group	Municipality	Population (nos.)	Disposal Type	Cost (US$/ton)
1	OPB	172,488	Landfill with leachate	15
2	OPB	12,474	Enclosed	5
3	OPB	4,854	Controlled	3
4	OPB	43,418	Landfill with gas	10
5	OPB	108,215	Landfill with leachate	15
6	FCP	25,009	Enclosed	5
7	FCP	5,410	Controlled	3
8	FCP	7,854	Controlled	3
9	SOL	379,664	Landfill with leachate	15
10	SOL	3,000	Controlled	3
Total	-	762,386	-	-

b. Cost Comparison of the Alternative Scenarios

The table below shows costs of the alternative scenarios. The cheapest one is Scenario 3, then, Scenario 4, 2, 1 and 5 in order.

Table G-46: Cost Comparison of the Alternative Scenarios

unit: 1000USD/year

Municipality	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
OPB	5,977	5,596	5,100	5,403	6,023
FCP	707	451	419	466	546
SOL	7,243	7,039	6,408	6,763	7,496
Total	13,927	13,086	11,927	12,632	14,065

G.3.3 Consideration of Solid Waste Management Framework

Solid Waste Management consist of various components which are related each other. Thus, SWM should be integrated as a system having balance among the components. In order the SWM to play its roles appropriately, first, a firm legal system is required and an institutional system where responsibilities and interrelationships of organizations concerned has to be established. Second, an executing agency of SWM should have management capability to provide sound services to citizens. Third, appropriate technology shall be adopted with taking into account natural and social conditions. Forth, cooperation of the citizens and participation of the private sector are indispensable. Figure G-13 shows concept of the above mentioned.

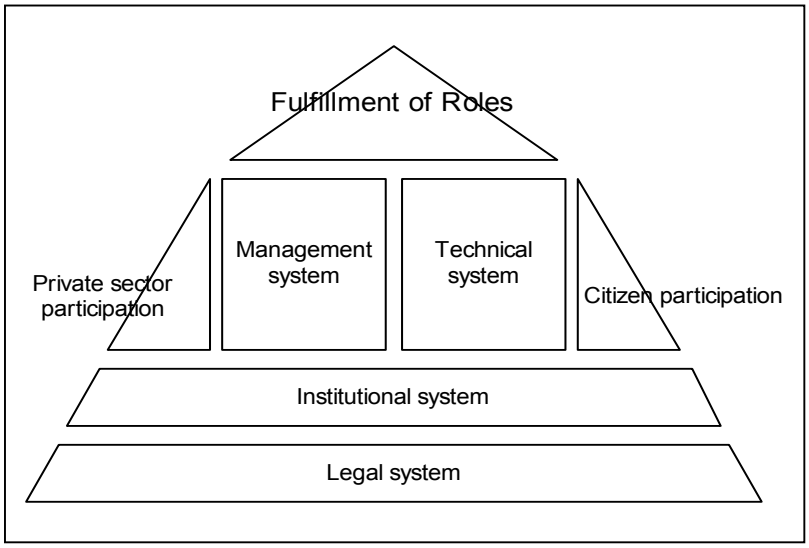


Figure G-13: Framework of Integral Solid Waste Management

This section considers financial aspect first and other aspects of the framework subsequently in order to select an optimum scenario.

G.3.3.1 Financial Aspect

a. General Considerations

In the financing of solid waste service, the trend in the Study Area has been not to depend totally on income from service charges. Rather, municipal services have been financed mainly by general funds of the municipal budget. It is worth remembering that federal funds in the past few years have comprised a large proportion of municipal budgets, over 90% in Felipe Carrillo Puerto, more than 70% in Othon P. Blanco, and around 40% in Solidaridad

When the solid waste service is financed with general funds of the municipal budget, it is natural to suppose that there is weakness in the practice of analyzing cost and income specific to the service, as basis of decision making in operation and financial management. Under these circumstances, cost of the service usually needs to be estimated by tracking down the relevant budget accounts, which are designed for budget control, rather than for cost control.

The financial system for the solid waste management should aim at financial self-sufficiency of measures proposed in the Master Plan. However, this objective can be reached only when the issues raised in the following section are satisfactorily addressed.

a.1 Issues on Financial Aspects of Solid Waste Management

The issues pertaining to a sound financial management of solid waste service can be described as follows.

a.1.1 General application of service charges

All users of solid waste service should pay service charges. Presently, however, solid waste service is provided without charges in Felipe Carrillo Puerto, while Othon P. Blanco applies service charges solely on commercial firms. Only Solidaridad applies service charges to all users of the solid waste service. It is presumed that the practice of not charging fees on solid waste service is based on good reasons for the community, but from the financial viewpoint it is an unfair aberration, because of the obvious costs entailed in the solid waste service. All generators of solid waste who use the collection and disposal service should actively participate in the cost recovery effort by paying their share of service costs. According to the proposed regulation on solid waste management, households are expected to pay fixed monthly charges, while commercial-industrial firms and institutions are expected to pay volume-based tariff.

a.1.2 Realistic service charges and income improvement

The prevailing custom of setting service charges on yearly basis eliminates the all too common trouble of rigidity of service charges. The charges for solid waste service should

seek to recover the service costs as much as possible. This implies the need to keep accurate record of the cost of the service, to serve as a basis of setting the service charges. Then, justification of changes in service fees can be more convincing. Increasing SW service charges as a means to improve income should be only one of the options, and other measures should be explored, such as expansion of customer base and improvement in the bill collection efficiency.

a.1.3 Timely billing and payment facility

Billing periodicity set in the proposed regulation on solid waste management should be strictly respected, bimonthly for households, and monthly for commercial and industrial firms, as well as for institutional clients. It is important to keep the option open for SW service users to make payments not only in the main city government offices, but also in more convenient places like supermarkets. It is of crucial importance to ensure that payments made by the users of SW service end up in municipal coffers.

a.1.4 Control of bill collection

Bill collection should be carefully conducted in order to keep late accounts under control. This implies an analysis on the reasons why payment of a service user becomes late, and the application of fines and penalties when payments by service users are not done in a timely fashion. The period of two months after due date to initiate collection processes should be strictly enforced, in addition to the application of fines and penalties when deemed necessary.

a.1.5 Specific use of income

The income obtained as solid waste service charges should ideally be earmarked for use in the improvement of the service. However, time will be required for the solid waste service to be able to operate exclusively with its own income. This will presuppose improvement in the service, as basis for expansion of customer base and setting higher service charges. A transition period may be required, during which general government funds may have to be applied to solid waste management, hopefully in declining proportions, until self-sufficiency is reached.

a.1.6 Constant monitoring

Service performance should be constantly monitored through selected quantified indicators, so as to promptly introduce corrective measures where and when the monitored indicators stray away from the acceptable range of values.

a.2 Summary of Issues on Financial Aspects

The important issues are summarized as follows.

1) Municipal services are financed with general funds of the municipal budget, where the main sources are federal funds.

2) Income from solid waste service charges at present covers only a minimal portion of the service cost.

3) Solid waste service is provided without charges in Felipe Carrillo Puerto.

4) Households do not pay for solid waste service in Othon P. Blanco.

5) Data on the cost of solid waste service are not readily available, and estimation of service cost depends on the proper identification of relevant budget accounts.

6) Decision making on solid waste service is not based on the analysis of income and cost specific to the service.

7) Indicators on service performance are not available.

b. The Solid Waste Master Plan and Financial Viability

The financial viability of the solid waste Master Plan depends on its cost and its capacity to generate income from service charges over the entire period encompassing the Master Plan. This analysis is usually done discounting the flow of income and cost over the period of the Master Plan. However, the analysis that follows is not a financial evaluation in the strict sense of the phrase. Rather, it is a brief discussion on financial aspects concerning the capacity to pay of users of the solid waste service.

b.1 Analysis of Solid Waste Management Cost

Mexico was classified as an upper middle income country. The last item in Table G-41 referred to solid waste management cost as percent of household income, while the second item indicated income in terms of GNP per capita per year. Table G-41 also indicated that middle-income countries were those with more than USD2,400 and less than USD22,000 in GDP per capita per year, and for this group of countries the benchmark for solid waste management cost ranged from 0.5% to 1.3% of household income.

The basic data for this financial analysis are shown in the following tables.

Table G-47: Basic Data for Financial Analysis

Municipalities	Urban Population 2015	Family Size	Hhold. Number 2015
Othon P. Blanco	341,449	4.23	80,733
Felipe Carrillo Puerto	38,273	4.96	7,718
Solidaridad	382,664	3.77	101,578
Total 3 Municipalities	762,386	4.24	190,030

Table G-48: Costs of the Alternative Scenarios

unit: 1000USD/year

Municipality	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
OPB	5,977	5,596	5,100	5,403	6,023
FCP	707	451	419	466	546
SOL	7,243	7,039	6,408	6,763	7,496
Total	13,927	13,086	11,927	12,632	14,065

Gross domestic product per capita in Quintana Roo State was estimated as approximately USD8,300. This number multiplied by the population in the 3 Municipalities would result in the gross production of the 3 Municipalities, and the ratio between the estimated costs of the alternative scenarios and the estimated gross production turned out to be 0.22% at Scenario 1, 0.21% at Scenario 2, 0.19% at Scenario 3, 0.20% at Scenario 4 and 0.22% at Scenario 5 way below the benchmark of 0.5% to 1.3%, as shown in the following table.

Table G-49: Solid Waste Management Cost as Ratio to Gross Production

Item	Value
GDP/capita Q.Roo (USD)	8,300
GDP 3 Munic (Million USD)	6,328
Total Cost/GDP (%)	
scenario 1	0.22
scenario 2	0.21
scenario 3	0.19
scenario 4	0.20
scenario 5	0.22

Repeating the same calculation using the household income reported in the biennial National Survey on Household Income and Expenditures, the ratio between the estimated cost of the alternative scenarios and the urban household income turned out to be 0.69% at Scenario 1, 0.65% at Scenario 2, 0.59% at Scenario 3, 0.63% at Scenario 4 and 0.70% at Scenario 5, well within the benchmark ranging from 0.5% to 1.3%, as shown in the following table.

Table G-50: Solid Waste Management Cost as Ratio to Household Income

Item	Value
National Urban Household Income 2002 (peso)	29,000
Mexican Pesos per 1 USD	11
Hhold Income in USD	2,636
Hhold Income 3 Munic (Mill. USD)	2,010
Total Cost/Hhold. Income (%)	
scenario 1	0.69
scenario 2	0.65
scenario 3	0.59
scenario 4	0.63
scenario 5	0.70

b.2 Analysis of Income from Solid Waste Service

b.2.1 Income Potential from Commercial Firms

In Othon P. Blanco in October 2003, commercial firms paying solid waste service charges numbered 8,279. Taking the population in Othon P. Blanco in 2003 to be 228,683 and a family size of 4.23, the number of households would be 54,071. Then, the number of commercial firms (8,279) would be equivalent to around 15% of the number of households. Likewise, taking only communities of 2,500 or more residents in 2003, the population would be 182,073 and the number of households would be 43,050, resulting in around 19% of commercial firms with respect to the number of households. These results were 50% to 90% higher than the CEPIS benchmark for estimating the number of commercial firms as 10% of the number of households. Yet, those 8,279 firms paying for solid waste service probably did not include all commercial firms in the formal sector, and many more in the informal sector would be generating solid waste.

The income potential of commercial firms was explored by setting three scenarios based on variable number of commercial firms as percentages of the number of households, and variable solid waste fee ranging between 50 Pesos, the predominant tariff charged in Othon P. Blanco, and 150 Pesos, slightly more than the 132.50 Pesos set for commercial firms in Solidaridad.

Starting with the number of commercial firms as 10% of the number of households in 2015, income sources of solid waste service would be around 19,000 commercial firms. Assumed solid waste service charges were 50 Pesos, 100 Pesos and 150 Pesos, and a bill collection efficiency of 80% was assumed, as shown in the following table.

Table G-51: Income Potential from Commercial Firms as 10% of Households

Item	Value	Value	Value
Number of commercial firms: 10% of households	19,000	19,000	19,000
Service charges per month (Pesos)	50	100	150
Annual income (Pesos)	11,400,000	22,800,000	34,200,000
Bill collection efficiency: 80% (Pesos)	9,120,000	18,240,000	27,360,000
Pesos per 1 USD	11	11	11
Annual income in USD	829,091	1,658,182	2,487,273

The above table shows that even with a service charge of 150 Pesos per month, the income potential from commercial firms would be only around USD2.5 Million per year, if the number of commercial firms was assumed to be 10% of households.

Then, the number of commercial firms was assumed to be 15% of the number of households, while service charges and collection efficiency were assumed to be the same as in the previous scenario. Results are shown in the following table.

Table G-52: Income Potential from Commercial Firms as 15% of Households

Item	Value	Value	Value
Number of commercial firms: 15% of households	28,500	28,500	28,500
Service charges per month (Pesos)	50	100	150
Annual income (Pesos)	17,100,000	34,200,000	51,300,000
Bill collection efficiency: 80% (Pesos)	13,680,000	27,360,000	41,040,000
Pesos per 1 USD	11	11	11
Annual income in USD	1,243,636	2,487,273	3,730,909

The above table shows that the income potential from commercial firms would be around USD3.7 Million per year, if the number of commercial firms was assumed to be 15% of households, and service charges were assumed to be 150 Pesos per month.

Finally, the number of commercial firms was assumed to be 20% of the number of households, while service charges and collection efficiency were assumed to be the same as in the previous scenarios. Results are shown in the following table.

Table G-53: Income Potential from Commercial Firms as 20% of Households

Item	Value	Value	Value
Number of commercial firms: 20% of Hhold	38,000	38,000	38,000
Service charges per month (Pesos)	50	100	150
Annual income (Pesos)	22,800,000	45,600,000	68,400,000
Bill collection efficiency: 80% (Pesos)	18,240,000	36,480,000	54,720,000
Pesos per 1 USD	11	11	11
Annual income in USD	1,658,182	3,316,364	4,974,545

The above table shows that the income potential from commercial firms would be around USD5.0 Million per year, if the number of commercial firms was assumed to be 20% of households, and service charges were assumed to be 150 Pesos per month.

The preceding analysis showed that income from commercial firms could be significantly increased only if the customer base was greatly expanded and the service charges were raised to around 150 Pesos per month. It is worth remembering that the proposed regulation on solid waste foresees setting the solid waste service fee for commercial firms on the basis of the volume of generated waste, that is, volumetric tariff.

b.2.2 Income Potential from Households

In 2003, only households in Solidaridad had the obligation to pay for solid waste service, 31.80 Pesos per month in the case of those living in a house, and 23.80 Pesos per month in the case of those living in a rental apartment.

On the other hand, international aid agencies usually estimate the capacity of households to pay for solid waste service as 0.75% to 1.7% of household income. The National Survey on Household Income and Expenditures of 2000 and 2002 gave similar results on household income, around 29,000 Pesos in communities with 2,500 or more residents. Using this household income and the percentages mentioned before, 0.75% and 1.7%, the capacity to pay for solid waste service turned out to be between 18 Pesos and 41 Pesos per month. Accordingly, the income potential from households was estimated by assuming solid waste service charges of 20 Pesos, 30 Pesos and 40 Pesos per month, as shown in the following table.

Table G-54: Income Potential from Households

Item	Value	Value	Value
Number of households	190,030	190,030	190,030
Service charges per month (Pesos)	20	30	40
Annual income (Pesos)	45,607,200	68,410,800	91,214,400
Bill collection efficiency: 80% (Pesos)	36,485,760	54,728,640	72,971,520
Pesos per USD	11	11	11
Annual income in USD	3,316,887	4,975,331	6,633,775

The above table shows that the income potential from households appears to be good. Even with solid waste service charges of 30 Pesos per month, the potential income would be around USD5.0 Million, practically identical with the potential income from commercial firms under the most favorable scenario, that is, assuming the number of commercial firms as 20% of the number of households and service fee of 150 Pesos per month. In the case of the service fee of 40 Pesos per month, potential income from households would be around USD6.6 Million, slightly over 50% of the estimated cost. If the proposed volumetric tariff is

set at the right level and applied on commercial and industrial firms as well as on institutions, this group of service users can contribute the other half of the cost of the service, even though this group is normally expected to contribute more than the share of households. Alternatively, the preceding analysis on cost and income potential of solid waste service seems to indicate that the cost of around USD13 Million could be financed equitably by the municipal governments, commercial firms and households, each contributing about USD5.0 Million.

c. Concluding Remarks

To achieve improvements in the financial aspect of solid waste management, possible measures fall necessarily under either cost reduction or income improvement. A better income can result from an expansion in the customer base, a change in the fee system, and improved bill collection efficiency. Cost reduction can be derived from a more efficient operation of the solid waste service.

However, full advantage could be taken from improved efficiency in the operation of solid waste service only if cost data were properly registered to reflect the improved operation. Therefore, introduction of COSEPRE (Costs of Services Provided) software was proposed, aiming at the systematic record keeping of the costs of solid waste service. The purpose of introducing COSEPRE was two-fold, to facilitate record keeping of real costs by activity (collection, transport, final disposal), and to facilitate data generation for calculating the performance indicators. These indicators are indispensable when a service is to be improved, because without quantified indicators it is difficult to conduct monitoring as a means for improvement. Calculation of performance indicators depends on the existence of appropriate data on operation and finance, which implies the need for a record keeping system, especially those pertaining to specific cost of the service. Performance indicators would become the tool for constant monitoring aimed at service improvement.

Another measure would be periodic updating of the database on users of the solid waste service. The purpose is expansion of the customer base of service users on a permanent basis. Double checking with other data sources may increase accuracy. Also, a better knowledge of types of service users can permit the design and implementation of measures to provide improved service tailored to the needs of diverse customer groups. This can increase the number of satisfied service users and improve their willingness to pay for the service.

G.3.3.2 Legal System

a. General Law for the Prevention and Integral Management of Wastes

The General Law for the Prevention and Integral Management of Wastes was published in the Official Newspaper of the Federation on the 8th of October of 2003. This law regulates the dispositions of the Political Constitution of the Mexican United States which are related to the protection of the environment regarding prevention and integral management of wastes in the Mexican territory; additionally, it complements matters related to solid wastes which are included in the General Law of Ecological Equilibrium and Environmental Protection.

The dispositions in this law are public and of social interest and they have as objective to guarantee the right of every person to enjoy/live in an adequate environment and encourage a sustainable development through the prevention of the generation, the valorization, and integral management of hazardous, urban, and special wastes; additionally, the dispositions are aimed to prevent the pollution of locations as the result of the disposal of these wastes and the remediation of the sites which have already been polluted.

The regulation of this law should be enacted in a term no longer of one hundred eighty calendar days beginning from the date when the law is published, in other words, around the 8th of June of 2004.

b. Regulation for the Provision of Urban Public Services of Non-hazardous Solid Wastes

A draft for the Regulation for the Provision of Urban Public Services of Non-hazardous Solid Wastes regarding the dispositions for the provision of services related to SWM was prepared and reviewed by the municipalities and SEDUMA.

This regulation has the objective to regulate the relationships between the Municipality, the clients, and the private providers of the service and the provision of cleansing services with the purpose to preserve and recover the quality of the environment and the protection of the health.

A summary of the main regulations contained in the new law and the draft proposal of the Regulation about the Provision of Service is shown in the following table. *It can be stated that now there is available an adequate legal framework for the integral management of urban solid wastes.*

Table G-55: Roles of Solid Waste Management and Legal System

Provision of a healthy environment
• Every person has the right to the protection of his/her health • Every person has the right to an adequate environment for his/her development and well-being • It is the responsibility of the wastes generator to bear the costs derived of the integral management of them; if it is required, remediation costs should also be born by the generators. • There should be a shared responsibility between the producers, importers, exporters, consumers, companies which manage solid waste services with objective to establish a SWM which is environmentally efficient, technologically viable, and economically feasible.
Mitigation of environmental impacts caused by solid wastes
• NOM-001-SEMARNAT-1996 which establishes the maximum permissible limits of pollutants which can be discharged as wastewaters in national waters and properties. • PROY-NOM-083-SEMRNAT-2003 Specifications of environmental protection to select the site, design, construction, operation, monitoring, closure and complementary works for the final disposal site of municipal solid wastes. • Wastes disposal will be limited to those which valorization or treatment is not economically viable, technologically feasible and environmentally adequate. • It is considered a public utility the measures needed to prevent the deterioration or destruction that the natural elements might endure in detriment of the community as the result of discharging the wastes to the environment • It is considered of public utility the implementation of works which have the purpose to prevent, conserve, and protect the environment and the remediation of polluted sites whenever these works are deemed indispensable to reduce health risks
Conservation of resources
• To establish a society oriented to the conservation of resources through the minimization of solid wastes by practicing reuse, reduction, and recycling • To prevent and minimize the generation of wastes and encourage its valorization in order to use them as raw material for other productive activities • Access to general public to information, environmental education and training in order to achieve the prevention of generation and the sustainable management of wastes

G.3.3.3 Institutional System

a. Roles and Responsibilities of the Three Governmental Levels

Under the concurrence principle which is established in the political constitution in the article 73 fraction XXIX-G, the new General Law for the Prevention and Integral Management of Wastes establishes the coordination procedures between three government levels and defines their responsibilities regarding the prevention of generation, valorization, and integral management of wastes.

The next table shows the roles and responsibilities which correspond to each one of the three levels of government according to the new Law.

Table G-56: Roles and Responsibilities of the Three Governmental Levels established in General Law for the Prevention and Integral Management of Wastes

Provision of a healthy environment
• The Federation -To formulate, direct and evaluate the national policy -To issue the official Mexican standards on the matter -To regulate and control the hazardous wastes • The State -To formulate a State Program for the Prevention and Integral Management of Wastes -To formulate, direct, and evaluate the state policy and to elaborate programs on matters related to wastes of special management

-To authorize and undertake the control of hazardous wastes which are generated and managed by micro-generators and impose penalties • The Municipalities -To formulate in coordination with the State and the participation of different social sectors the Municipal Programs for the Prevention and Integral Management of Urban Solid Wastes -To issue regulations and other legal administrative dispositions -To provide by itself or other manager/provider the public service for the integral management of urban solid wastes -To grant the authorizations or concessions of one or more activities which include the provision of services -To conduct the billing for the payment of services related to the integral management of urban solid wastes and direct this income for the operation and strengthening of these services
Mitigation of environmental impacts caused by solid wastes
• The Federation -To issue the official Mexican standards on the matter -To control the discharge quality on national waters (CNA) • The State -To design and encourage the establishment and application of economic, fiscal, financial, and market incentives which should have the objective to prevent the generation of wastes; their valorization; their integral and sustainable management, as well as to prevent the pollution of sites by wastes and their remediation if necessary. -To provide technical assistance to the municipalities • The Municipalities -To operate the final disposal and remediate those sites polluted by solid wastes
Resource Conservation
• The Federation -To manage the National System of Environmental Information and Natural Resources • The State -To integrate the Information System for the Integral Management of Wastes -To promote the continuous education and training of persons, groups or organizations with the purpose to contribute to the change of negative habits toward the environment during production and consumption of goods • The Municipalities -To integrate the Information System about the Integral Management of Wastes -To encourage solid waste minimization through resource conservation campaigns: reuse, reduction, and recycling

b. Information System for the Integral Waste Management

The new law establishes the creation of the Information System for the Integral Management of Wastes with the purpose to build a coordination and information methodology between three levels of government in issues related to prevention of generation, valorization, and integral management of wastes.

Concurrent government organizations can be linked through this Information System with the Implementation of the Master Plan, as well as, organizations which constitute the social capital at the level of the State of Quintana Roo.

Similarly, the Information System can be used as an information methodology for the implementation of the Master Plan. The following shows different activities which can strengthen this System.

- Coordination mechanism between the organizations at the three government levels
- To inform the general public about the Master Plan and its benefits
- Broadcast mean for sanitary and environmental education

- To encourage the participation of the public in the provision of the services
- To strengthen the management capacity of the provider of the service
- To know the opinion of the public through surveys

G.3.3.4 Management

The new law has established the roles and responsibilities that corresponds to each one of the government levels. Now, the mechanism and instruments should be created for an effective solid waste management which can protect the health and preserve the environment.

At the State level, it is convenient to reinforce its management of solid wastes through the creation of a specialized administrative unit in the organizational structure of SEDUMA.

In each municipality, administrative units which are responsible to provide the service should be re-structured under the concepts and actions which are shown in the following table.

Table G-57: Restructuring of the administrative units of the municipalities

Concepts	Actions
Higher hierarchy due to its responsibility in managing a vital public service which makes use of an important part of the municipal treasury resources	• An administrative unit with the Directive level and with direct relationship with the Municipal President
To improve the efficiency of operations	• Definition of goals to be attained in accordance to the recommendations of the Master Plan • New organizational structure • Establishment of management indicators • Training of human resources • Equipping
To attain the service quality levels which can ensure the protection of health and the preservation of the environment	• To attain quality levels which are established in the Draft of the Regulation for the Provision of Services
To ensure a continuous flow and sufficient funds through the establishment of the corresponding rights	• To establish the rights which correspond to the provision of the service taking into account the right to a fix charge for the household units and for a charge which depends on the volume for the institutionals, commercials, and industrial clients • The new General Law for the Prevention and Integral Management of Wastes authorize to the municipalities to collect charges for the services related to the integral management of solid wastes and destine this income for the operation and strengthening of them (Article 10 fraction X)
To achieve the participation of the public in the provision of services	• To integrate an information system for the Integral Management of Wastes • To distribute periodically reports about the relevant issues related to the provision of the service

G.3.3.5 Participation of the Private Sector

Solidaridad Municipality has delegated the solid waste management to the private sector.

In Othon P. Blanco Municipality, Mahahual has a private operator. The other localities are serviced by the Municipality and Delegations. In Felipe Carrillo Puerto, the operation is conducted by the municipality.

a. Chetumal

The participation of the private sector can be beneficial as long as it is decided previously that it is necessary such participation and a legal framework is established for the contraction and provision of services by the private sector.

The model project for the improvement of the collection system for Chetumal city will provide information about the investment needs taking into account a defined quality of service and costs. Subsequently, the possibility of the participation of the private sector can be evaluated; an important limitation could be the deficient charge derived from the service.

After the implementation of the model project for the improvement of the final disposal site in Calderitas, it could be considered the participation of the private sector which can ensure the continuous quality of the service and achieve the protection of the aquifer in view of the leachate generated.

b. Felipe Carrillo Puerto

The results of the model project for the improvement of collection will establish the investment needs; however, a small community with low income such as FCP could represent a low profitability for the private sector.

The dump site will be repaired and it has been proposed that is should work as a manual sanitary landfill.

G.3.3.6 Citizen Participation

The new Law establishes that the three government levels will encourage the participation of all sectors of the society in the prevention of generation, the valorization and integral management of wastes. The following shows in detail the main activities which are the responsibility of the different government levels.

- Encouraging and supporting the conformation, consolidation, and operation of intersectorial groups which are interested in the design and implementation of policies and programs, to prevent pollution of sites and undertake remediation.
- To convoke the organized social groups to participate in projects aimed at generating the required information to sustain programs for the integral management of wastes

- Holding agreements with the massive media to promote activities for the prevention and integral management of wastes
- Encouraging ecological conciousness and the application of the Law
- Coordinating actions and investments with the social and private sectors, academic institutions, groups and social organizations, and other interested physical and moral persons.
- Integrating consultation organism in which the social capital takes part with consultanships, evaluation and follow up in matters related to prevention policy and integral management of wastes
- Ensuring that the law is satisfied and it is also satisfied what the Regulation for the Provision of the Service establishes.

G.3.4 Selection of an Optimum System

a. Evaluation of the Alternative Scenarios

The table below shows evaluation of the Alternative Scenarios.

Table G-58: Evaluation of the Alternative Scenarios

Evaluation items	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
1. Principal objective	All of the scenarios comply with the target value; less than 2,100 ton/year of BOD discharge amount.				
BOD (ton/year)	1,475	1,854	1,803	1,772	1,744
2. Particular objectives					
1) Provision of sanitary living environment	100% of collection rate is assumed. It provides high level of sanitary living environment, but it would be excessive service.	Collection rate from 80 to 100% is supposed to be adopted depending on population size of communities. The lager population of a community, the higher collection rate is employed. Although lower level of sanitary living environment is achieved compared with Scenario 1, it will be sufficient to keep the living environment.			
Collection rate (urban area)	100%	99%	99%	99%	99%
Collection rate (whole area)	89%	87%	86%	86%	86%
2) Mitigation of environmental impact caused by waste	All of disposal sites are supposed to be sanitary landfill, even for small communities. It would be excessive measures.	Different disposal levels are supposed to be adopted depending on population size of communities, i.e., from controlled dumping to sanitary landfilling. Although lower level of mitigation of environmental impact is achieved compared with Scenario 1, it will be sufficient not to give serious impact on the environment.			
3) Resource conservation	No measure of waste minimization is to be adopted.	Only environmental education is to be adopted	Backyard compost is to be adopted in addition to the environmental education.	Compost of pruning waste is introduced in addition to measures of Scenario 3.	Material Recovery is to be introduced in addition to measures of Scenario 4.
Waste minimization rate	0%a (0%)b	2.5% a (2.5%) b	15% a (15%) b	25% a (24%) b	40% a (33%) b
3. Financial aspect	Ratios between estimated costs of all scenarios and household income are well within the benchmark ranging from 0.5% to 1.3% for middle income countries.				
1000 USD/year	13,927	13,086	11,927	12,632	14,065
Cost/Hhold. Income	0.69%	0.65%	0.59%	0.63%	0.70%
4. Legal system	The new federal law, “General Law for the Prevention and Integral Management of Waste,” aims to prevent generation of waste and recycle materials. Therefore, higher target value of waste minimization meets the objective of the law.				
5. Institutional system	Close relationship among institutions such as federal, state and municipal governments are required to achieve a certain level of final disposal and to encourage waste minimization.				
6. Management system	High capability of executing agencies (municipalities) is required for appropriately managing final disposal and waste minimization. Especially, sanitary landfills for small communities are difficult to operate in views of engineering and finance.				
7. Private sector participation	There would be opportunities where public and private sectors could cooperate in SWM. In order to introduce the private sector, the pubic sector should have enough capability to control them to provide adequate services to the citizens.				
8. Citizen participation	Waste minimization requires citizen’s positive participation in SWM, such as adequate discharge of waste, backyard composting, separation and recycling of waste.				

a: ratios of waste amount being subject for minimization measures.
b: ratios of waste amount minimized.

b. Selection of an Optimum Scenario

Every scenario complies with the principal objective, i.e., less than 2,100 ton/year of BOD discharge amount. And, costs of them range between 0.5 and 1.3% of household income,

which is assumed as a benchmark of middle income countries such as Mexico. Therefore, it could be said that the all scenarios meet the minimum requirement.

Scenario 1 takes 100% collection rate and sanitary landfilling in the urban area, then, discharge the least BOD amount. However, it costs the highest. It is practically difficult to achieve 100% collection rate in small communities and its cost-effectiveness is low. Likewise, construction and operation of landfills in small communities are not viable.

Other scenarios consider population size of community, then, try to adopt different level of waste collection and disposal depending on the population size. In this regard, the other scenarios are realistic compared with Scenario 1.

Those scenarios have different target values in respect to waste minimization. Scenario 2 employs lower waste minimization rate, then, collection amount and its cost will not lower so much.

Scenario 3 is supposed to encourage citizens to practice backyard composting. This could reduce collection amount and cost. This scenario would be the cheapest one. However, no waste minimization measure is not taken by municipalities and other public institutions. This might discourage citizens to practice waste minimization.

Scenario 4 is supposed to carry out composting of pruning waste, in addition to measures of Scenario 3. Then, this scenario costs more than Scenario 3. However, this scenario imposes burden of waste minimization on the public sector not only on the citizens. This may encourage citizens to take actions of waste minimization.

Scenario 5 is supposed to adopt Material Recovery Facility. Although it will reduce waste to be disposed, cost of construction and operation of MRF could not compensate with reduction of disposal cost. This scenario costs the highest.

The Mexican counterpart and the Study Team had discussions for selecting an optimum scenario with taking into account the considerations above. Consequently, Scenario 4 was selected as the optimum scenario.

Table G-59: Selected SWM Technical System

Technical System	Scenario 4
1. Source Reduction	Source reduction; by backyard composting, recycling of papers and others, and change of consumption behavior by environmental education
2. Collection and Transport	80 - 100% of collection rate depending on population size of community
3. Intermediate Treatment	Pruning waste composting
4. Final Disposal	Different disposal levels depending on population size of community

Annex H

The Master Plan

Contents

Page :

List of Tables

Page :

List of Figures

Page :

H The Master Plan

H.1 Basic Concept

H.1.1 Guiding Principle, Principal Objective and Basic Approach

The Master plan intends to integrate all efforts of the public sector, the private sector, residents and visitors under the following shared values.

a. Guiding Principle

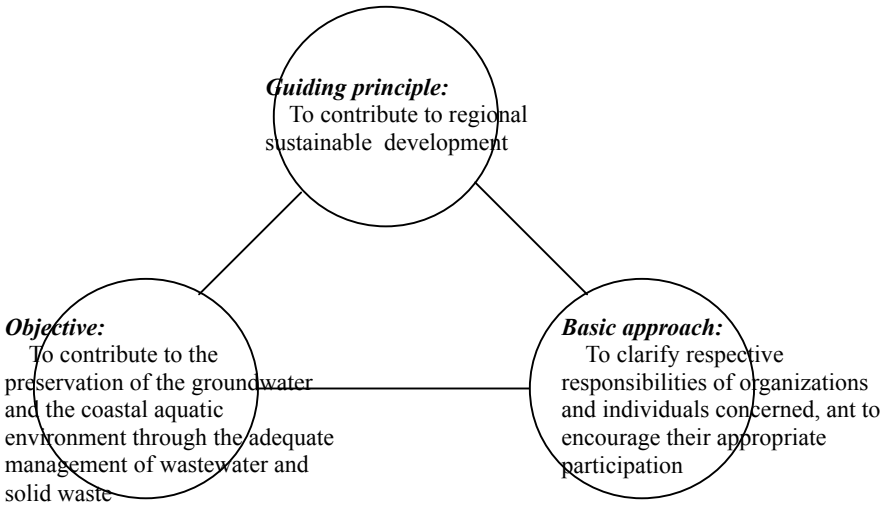
To contribute to regional sustainable development

b. Principal Objective

To preserve the groundwater and the coastal aquatic environment in the southern Quintana Roo State, or municipalities of Othon P Blanco, Felipe C Puerto and Solidaridad, through the adequate management of wastewater and solid waste

c. Basic Approach

To clarify respective responsibilities of the public sector, the private sector, the residents and the tourists, and to encourage their appropriate participation in the Environmental Sanitation Management



H.1.2 Targeted Value of the Master Plan

The principal goal of the Master Plan is:

BOD discharge amount originated from wastewater and solid waste is to be less than 5,200 ton/year by 2015,

Less than 3,100 ton/year from wastewater, and

Less than 2,100 ton/year from solid waste.

Aiming at preservation of the groundwater and the coastal aquatic environment in the study area, BOD amount originated from wastewater and solid waste discharged to the environment shall be controlled less than 5,200 ton/year by 2015; less than 3,100 ton/year from wastewater and less than 2,100 ton/year from solid waste.

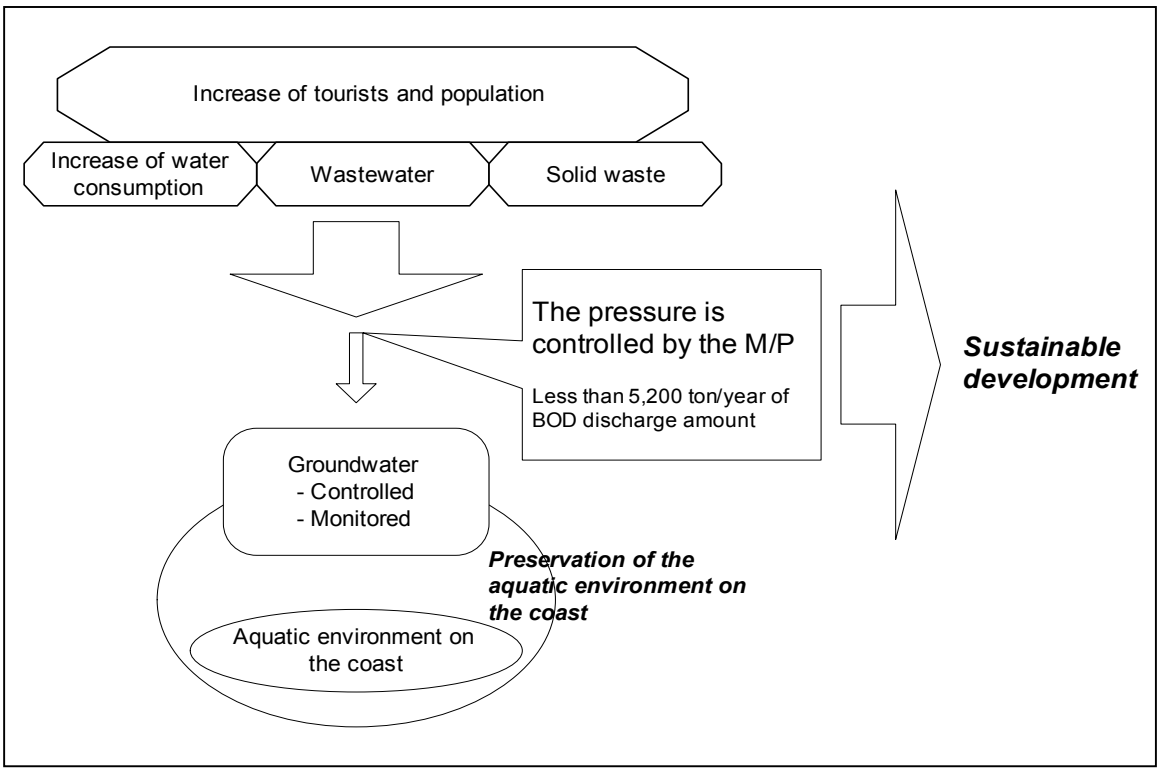


Figure H-1: Targeted Value of the Master Plan

H.2 Wastewater Management Master Plan

H.2.1 Objectives, Targeted Values and Targeted Year

a. Principal Objective and Targeted Value

The principal objective of the Wastewater Management (WWM) Master Plan is;

To preserve the groundwater and the coastal aquatic environment in the study area

Targeted value is;

BOD discharge amount originated from wastewater is to be around 3,100 ton/year by 2015.

b. Particular Objectives and Targeted Values

A master plan formulated should aim at achieving the principal objective, in addition, should play the following objective inherent to wastewater management.

- Reduction of health risks of the residents through employment of appropriate technology

In order to play the roles, particular goals regarding treated water quality and sewer service coverage as shown in Table H-1 and Table H-2.

At present, there is a problem, where the residents hesitate to connect to the sewer system as they have septic tanks that contaminate the groundwater. Therefore, measures to bring importance of preservation of the groundwater to their attention and to encourage them to connect to the sewer system must be a key to achieve the objectives.

Table H-1: Targeted Values of the Wastewater Management Master Plan

Items	*Municipalities*	*Present*	*Goals in 2015*
Number of connection	*Othón P. Blanco*	*10,288*	*98,330*
	Felipe Carrillo Puerto	*114*	*14,562*
	Solidaridad	*1,770*	*107,059*
Sewer system served population (permanent population basis)	*Othón P. Blanco*	*37,044*	*413,971*
	Felipe Carrillo Puerto	*567*	*72,429*
	Solidaridad	*6,655*	*402,529*
Sewer system service coverage ratio (sewer line& treatment, population basis)	*Othón P. Blanco*	*16.2%*	*99.7%*
	Felipe Carrillo Puerto	*0.9%*	*98.0%*
	Solidaridad	*4.7%*	*99.7%*

Table H-2: Target Treatment Level by Community Size

Treatment level	Population size of community	Target treated water quality	
		BOD (mg/liter)	SS (mg/liter)
Level 1	100 to 1,499	150	125
Level 2	1,500 to 9,999	75	75
Level 3	10,000 to 49,999	50	50
Level 4	More than 50,000	30	40

c. Target Year

The target year for master plan is set up as follows:

Master Plan: Year 2015

H.2.2 Proposed Measures

H.2.2.1 Wastewater Treatment Method

Treatment methods shown in Table H-3 are proposed to achieve the treatment levels set as shown in Table H-4. The treatment methods will be reviewed based on discussion with the Counterparts and results to be obtained by the Model Projects.

Table H-3: Proposed Treatment Method

Treatment level	Population size of community	Treatment method
Level 1	100 to 1,499	An-aerobic reactor + disinfection
Level 2	1,500 to 9,999	An-aerobic reactor + aerobic filter + disinfection
Level 3	10,000 to 49,999	Oxidation ditch + disinfection
Level 4	More than 50,000	Activated sludge + disinfection

Table H-4: Target Treatment Level by Communities Size

Treatment level	Population size of community	Target treated water quality	
		BOD (mg/liter)	SS (mg/liter)
Level 1	100 to 1,499	150	125
Level 2	1,500 to 9,999	75	75
Level 3	10,000 to 49,999	50	50
Level 4	More than 50,000	30	40

H.2.2.2 Sludge Management Plan

Excess sludge will be generated in large quantity in the future along with expansion of wastewater treatment. And measures to cope with the excess sludge need to be taken.

a. Forecast of Excess Sludge Generation Amount

Excess sludge is derived from SS and BOD in wastewater. Amount of the excess sludge can be obtained by the formula below based on experience in Japan. Table H-5 shows results of the calculation at dry base. Actually the excess sludge has water content. Table H-6 shows excess sludge amount at disposal, which has water content at 85%.

$$Sa = BODrem \times 50\% + SSrem \times 95\%$$

Where:

Sa	:	Excess sludge generation amount (dry solid)
BODrem	:	BOD remove amount in the treatment system
SSrem	:	SS remove amount in the treatment system

Table H-5: Forecast of Excess Sludge Generation Amount

Unit : DS-ton/year

Year	OTHON P. BLANCO				FELIPE CARRILLO PUERTO			SOLIDARIDAD			
	Level 1	Level 2	Level 3	Level 4	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3	Level 4
2003	0	0	0	1,042	0	0	16	0	0	0	2,960
2004	0	0	0	1,042	0	0	16	0	0	0	2,960
2005	0	0	0	1,825	0	0	59	0	0	0	3,373
2006	20	73	205	2,490	0	0	105	0	0	242	4,131
2007	39	145	410	3,155	0	0	151	0	0	485	4,890
2008	59	218	615	3,820	0	0	197	0	0	727	5,648
2009	78	291	820	4,485	0	0	243	0	0	969	6,329
2010	176	363	1,024	5,151	49	66	289	26	0	1,211	7,165
2011	273	581	1,098	5,307	130	132	335	52	52	1,301	7,523
2012	371	799	1,171	5,463	212	197	382	78	104	1,390	7,882
2013	468	1,017	1,244	5,620	293	263	428	104	156	1,480	8,240
2014	566	1,235	1,317	5,776	375	329	474	142	208	1,569	8,598
2015	761	1,525	1,391	5,932	456	461	520	181	261	1,659	8,956
Total	2,811	6,247	9,295	51,108	1,515	1,448	3,215	583	781	11,033	78,655

Table H-6: Required Excess Sludge Disposal Amount

Unit: m^3/year

Year	OTHON P. BLANCO				FELIPE CARRILLO PUERTO			SOLIDARIDAD			
	Level 1	Level 2	Level 3	Level 4	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3	Level 4
2003	0	0	0	6,947	0	0	107	0	0	0	19,733
2004	0	0	0	6,947	0	0	107	0	0	0	19,733
2005	0	0	0	12,167	0	0	393	0	0	0	22,487
2006	133	487	1,367	16,600	0	0	700	0	0	1,613	27,540
2007	260	967	2,733	21,033	0	0	1,007	0	0	3,233	32,600
2008	393	1,453	4,100	25,467	0	0	1,313	0	0	4,847	37,653
2009	520	1,940	5,467	29,900	0	0	1,620	0	0	6,460	42,193
2010	1,173	2,420	6,827	34,340	327	440	1,927	173	0	8,073	47,767
2011	1,820	3,873	7,320	35,380	867	880	2,233	347	347	8,673	50,153
2012	2,473	5,327	7,807	36,420	1,413	1,313	2,547	520	693	9,267	52,547
2013	3,120	6,780	8,293	37,467	1,953	1,753	2,853	693	1,040	9,867	54,933
2014	3,773	8,233	8,780	38,507	2,500	2,193	3,160	947	1,387	10,460	57,320
2015	5,073	10,167	9,273	39,547	3,040	3,073	3,467	1,207	1,740	11,060	59,707
Total	18,740	41,647	61,967	340,720	10,100	9,653	21,433	3,887	5,207	73,553	524,367

b. Sludge Management Plan

Disposal measures of excess sludge are landfilling, desiccation and incineration. Desiccation and incineration requires large investment and sophisticated technology. Such measures are considered not suitable for the Study Area. Therefore, it is recommendable to landfill the excess sludge after dewatering.

H.2.3 Treatment Process Design

H.2.3.1 Level 1

a. Design Conditions and Treatment Flow Sheet

Recommended treatment method at Level 1 is the anaerobic reactor. Design conditions and treatment process flow sheet are shown below.

Table H-7: Design Conditions of Level 1

Item	Number
Treatment method	Anaerobic reactor
Applicable population size (nos. of population)	100 to1,499
Wastewater generation rate (liter/person/day)	173
Intake BOD concentration (mg/liter)	312
BOD-Anaerobic reactor Load (g/m^3/day)	250
Detention time of disinfection tank (minute)	15
Sludge generation rate (m^3/person/year)	0.04
Sludge detention period (year)	3
Treated water quality (mg/liter)	BOD:150, SS:125

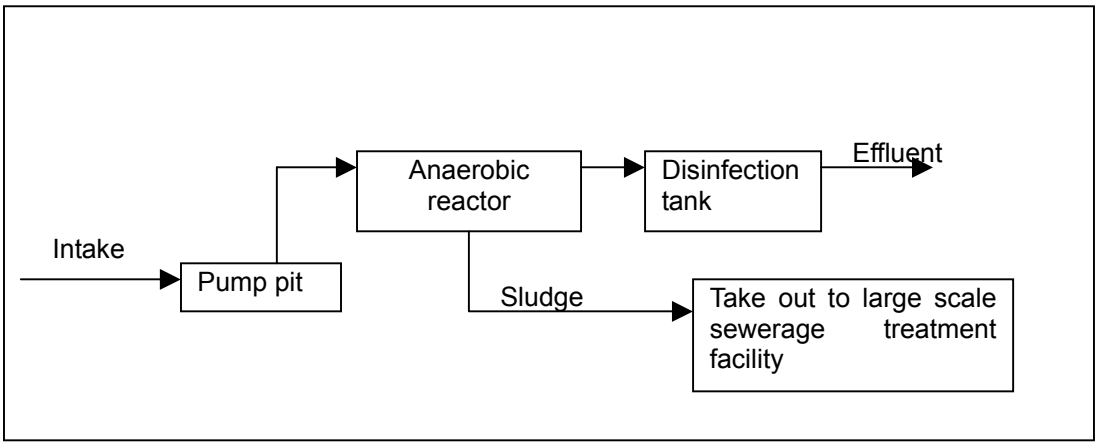


Figure H-2: Treatment Process Flow Sheet (Level 1)

b. Design

The table below shows required volume of reactor, based on the above conditions.

Table H-8: Outline of Design Calculation

Population size	Wastewater amount (m^3/day)	Anaerobic reactor			
		Intake BOD amount (g/day)	Volume for treatment (m^3)	Volume for sludge storage (3 year sludge volume(m^3)	Total required (m^3)
100	17	5,305.7	21.2	12	33.2
250	43	13,420.3	53.7	30	83.7
500	87	27,152.7	108.6	60	168.6
750	130	40,573.0	162.3	90	252.3
1,499	259	80,833.9	323.3	180	503.3

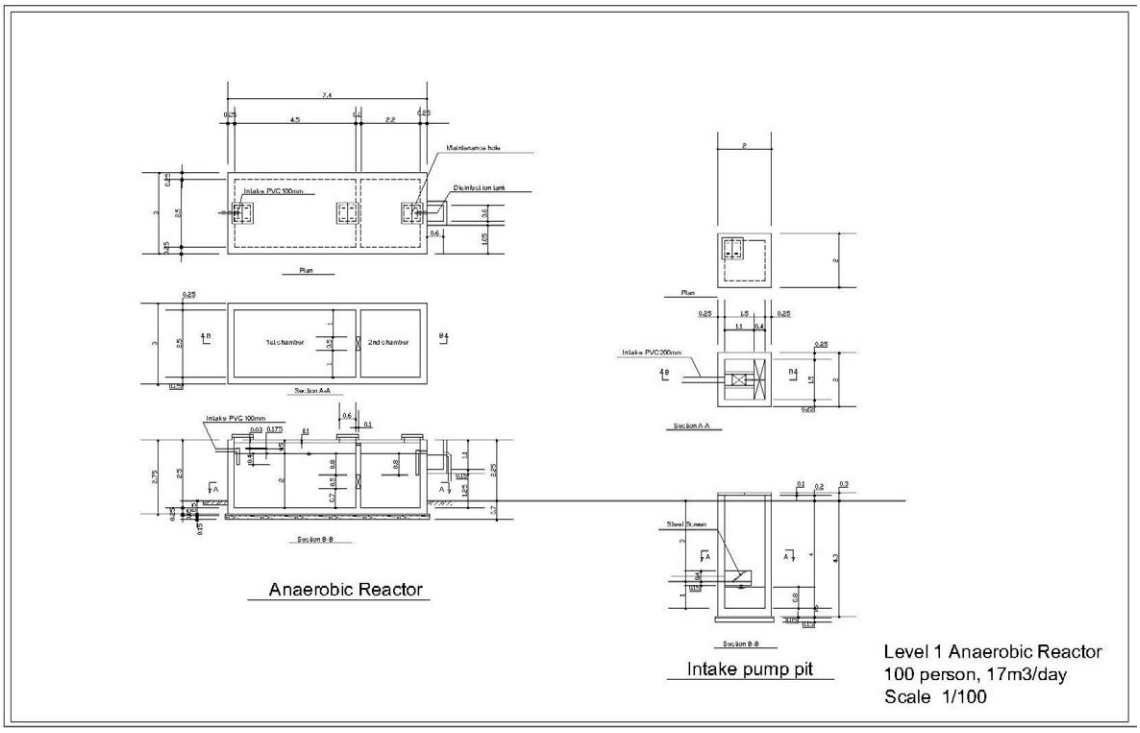


Figure H-3: Anaerobic Reactor for 100 Persons

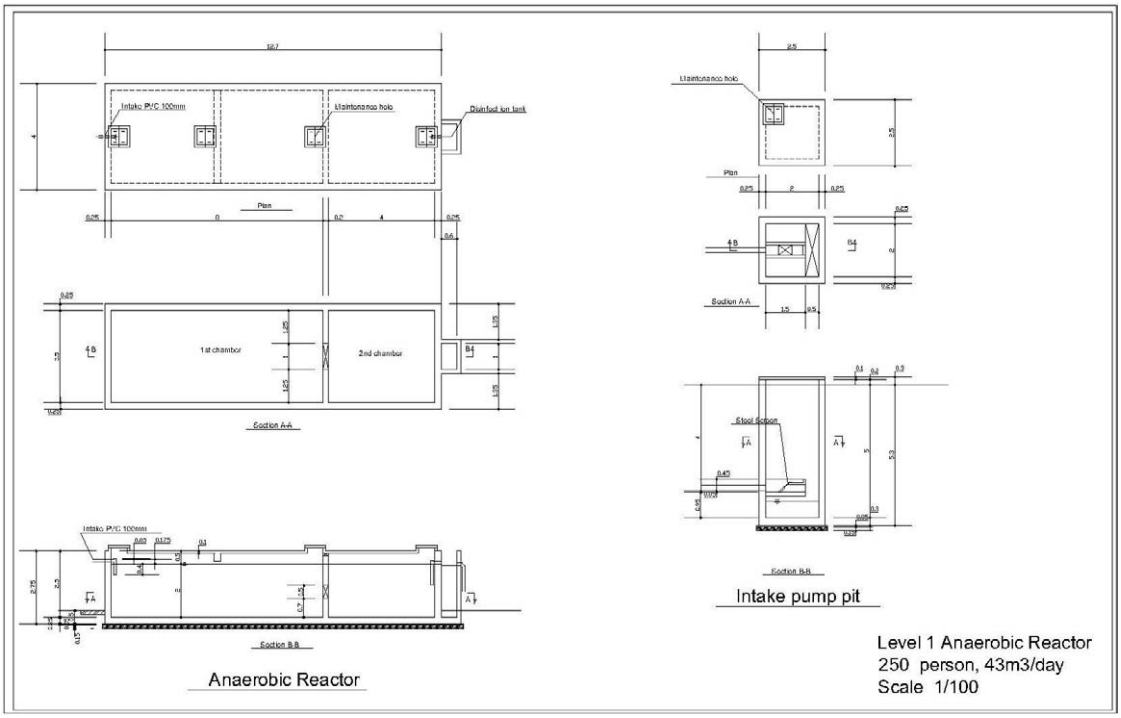


Figure H-4: Anaerobic Reactor for 250 Persons (1 set), for 500 persons (2 sets), for 750 persons (3 sets)

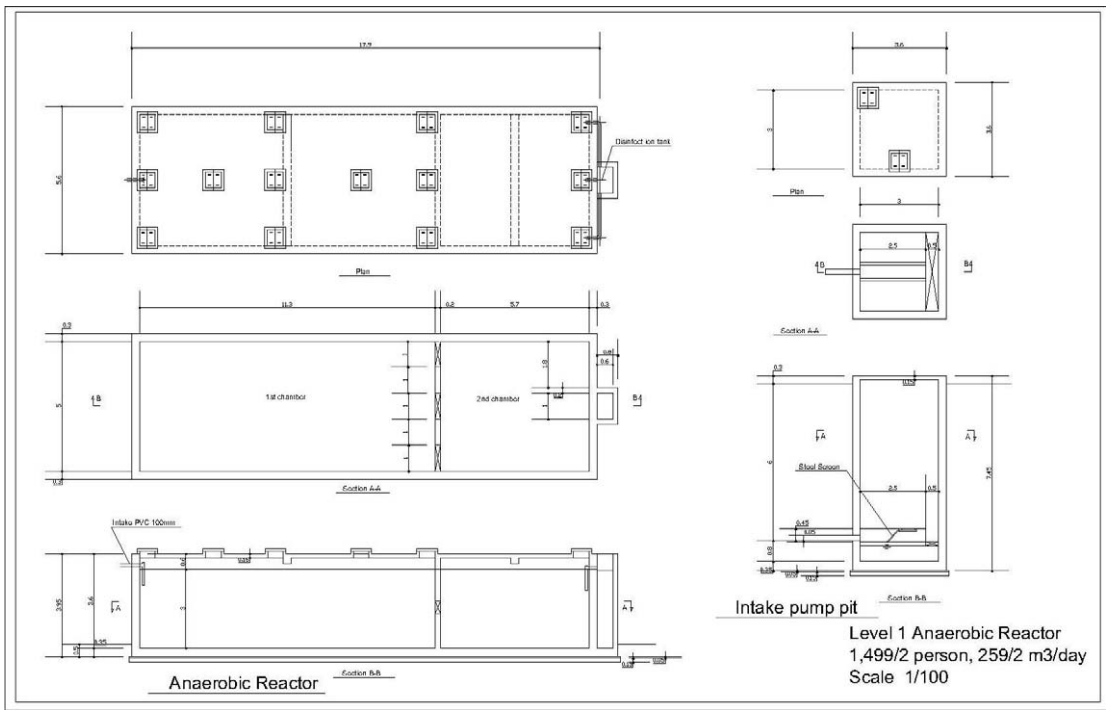


Figure H-5: Anaerobic Reactor for 1,499 Persons (2 sets)

H.2.3.2 Level 2

a. Design Conditions and Treatment Flow Sheet

Recommended treatment method at Level 2 is anaerobic reactor and aerobic filter. Design conditions and treatment process flow sheet are shown below.

Table H-9: Design Conditions of Level 2

Item	Number
General	
Treatment method	Anaerobic rector and aerobic filter
Applicable population size (nos. of population)	1,500 to9,999
Wastewater generation rate (liter/person/day)	173
Intake BOD concentration (mg/liter)	312
Intake SS concentration (mg/liter)	300
Treated water BOD concentration (mg/liter)	75
Treated water SS concentration (mg/liter)	75
Bio-reactor	
BOD-Anaerobic reactor Load ($g/m^3/day$)	250
BOD-Aerobic filter Load ($kg/m^3/day$)	0.8
Filter media filling rate	More than 80%
Sedimentation tank	
Hydraulic surface load ($m^3/m^2/day$)	25
Hydraulic over flow weir load ($m^3/m/day$)	30
Detention time (hr)	4.5
Disinfection tank	
Detention time (minute)	15
Sludge management	
Sludge generation amount kg/day)	50% of BOD removal amount plus 95% of SS removal amount
Moisture contents of raw sludge	99%
Moisture contents of thickened sludge	98%
Thickener	
Sludge (dry solid) surface load ($kg/m^2/day$)	90
Detention time (hr)	12
Thickened sludge storage tank	
Detention time (day)	7
Detention time of disinfection tank (minute)	15

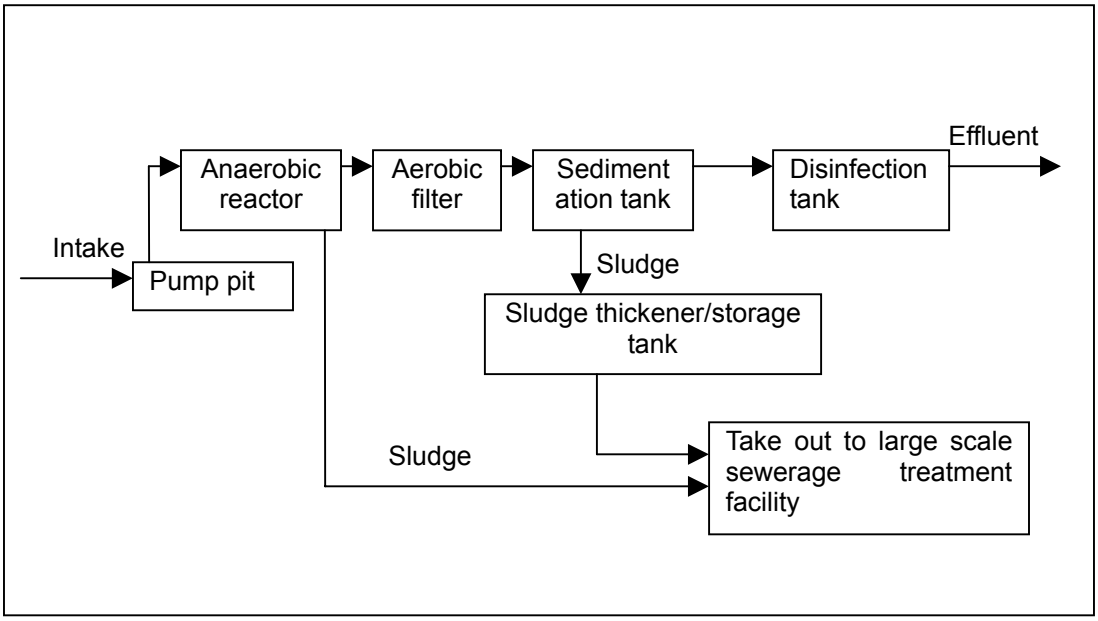


Figure H-6: Treatment Process Flow Sheet (Level 2)

b. Design

The table below shows required volume of reactors based on the above conditions.

Table H-10: Outline of Design Calculation

Population size	1,500	2,500	5,000	7,500	9,999
Intake amount (m^3/day)	260.0	433.0	865.0	1,298.0	1,730.0
BOD intake amount (g/day)	81,146.0	135,139.3	269,966.5	405,105.8	539,933.0
Anaerobic reactor					
Volume 1 treatment(m^3)	324.6	540.6	1,079.9	1,620.4	2,159.7
Volume2 sludge 3 year (m^3)	60.0	100.0	200.0	300.0	400.0
Total volume (m^3)	384.6	640.6	1,279.9	1,920.4	2,559.7
Detention time(day)	1.2	1.2	1.2	1.2	1.2
Aerobic filter					
BOD conc.(mg/liter)	150.0	150.0	150.0	150.0	150.0
BOD in (kg/day)	39.0	65.0	129.8	194.7	259.5
Required volume (m^3)	48.8	81.3	162.3	243.4	324.4
Detention time (hr)	4.5	4.5	4.5	4.5	4.5
Sedimentation					
Surface load (m^3/m^2/day)	25.0	25.0	25.0	25.0	25.0
Required area (m^2)	10.4	17.3	34.6	51.9	69.2
Detention time (hr)	3.0	3.0	3.0	3.0	3.0
Volume (m^3)	32.5	54.1	108.1	162.3	216.3
Depth (m)	3.1	3.1	3.1	3.1	3.1
Weir length (m)	8.7	14.4	28.8	43.3	57.7
Sludge					
Inflow aerobic BOD (mg/liter)	150	150	150	150	150
Inflow aerobic SS (mg/liter)	125	125	125	125	125
Effluent BOD (mg/liter)	75	75	75	75	75
Effluent SS(mg/liter)	75	75	75	75	75
BOD removal amount (kg/day)	19.5	32.5	64.9	97.4	129.8
SS removal amount (kg/day)	13.0	21.7	43.3	64.9	86.5
From BOD (kg/day)	9.8	16.3	32.5	48.7	64.9
From SS (kg/day)	12.4	20.6	41.1	61.7	82.2
Total (kg/day)	22.2	36.9	73.6	110.4	147.1
Sludge volume of (water contents 99%) (m^3)	2.2	3.7	7.4	11.0	14.7
Sludge volume of (water contents 98%) (m^3)	1.1	1.8	3.7	5.5	7.4
Thickener/storage thank					
Detention time (day)	7.0	7.0	7.0	7.0	7.0
Required volume (m^3)	7.7	12.6	25.9	38.5	51.8

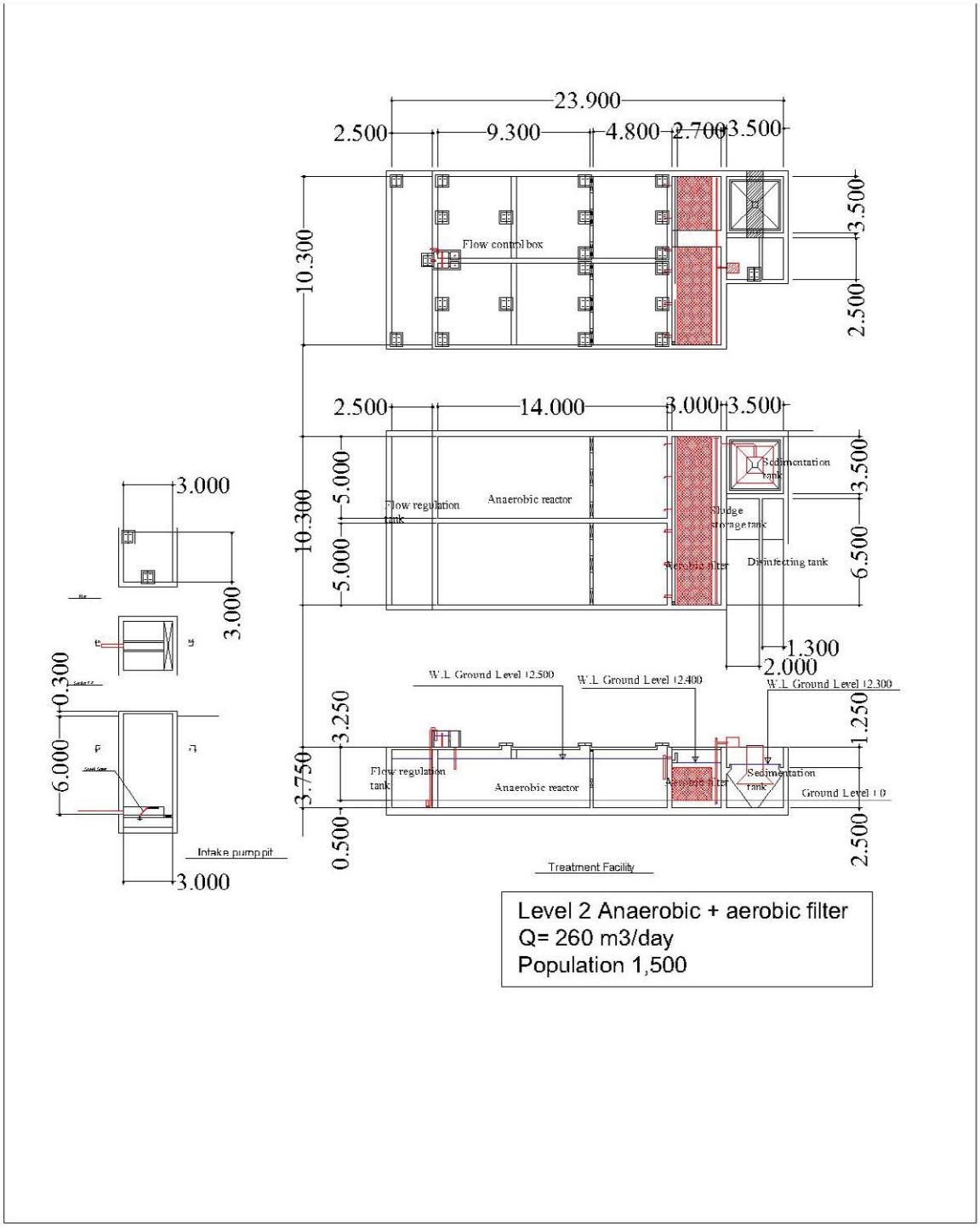


Figure H-7: Level 2 Treatment Process for 1,500 persons

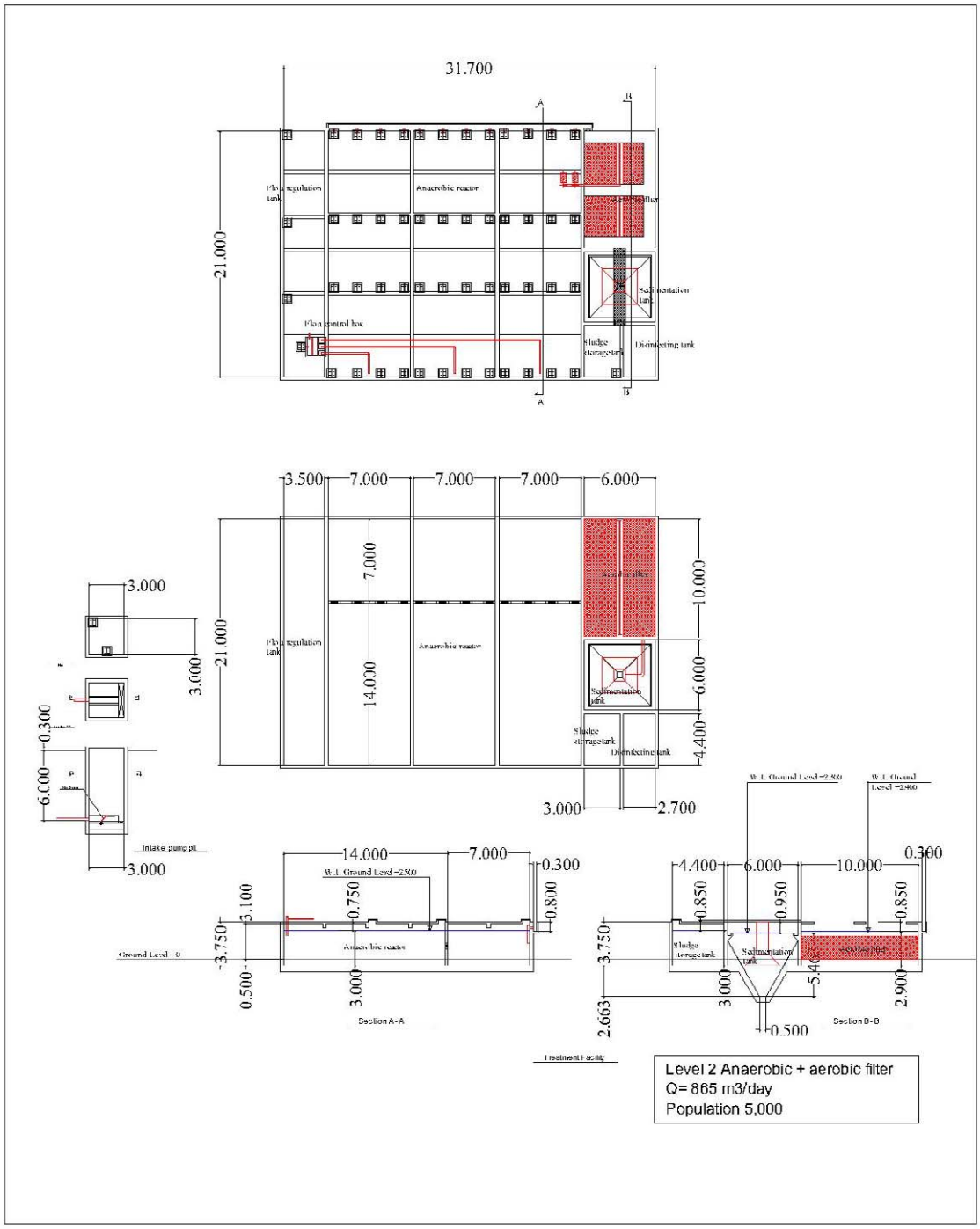


Figure H-8: Level 2 Treatment Process for 5,000 persons

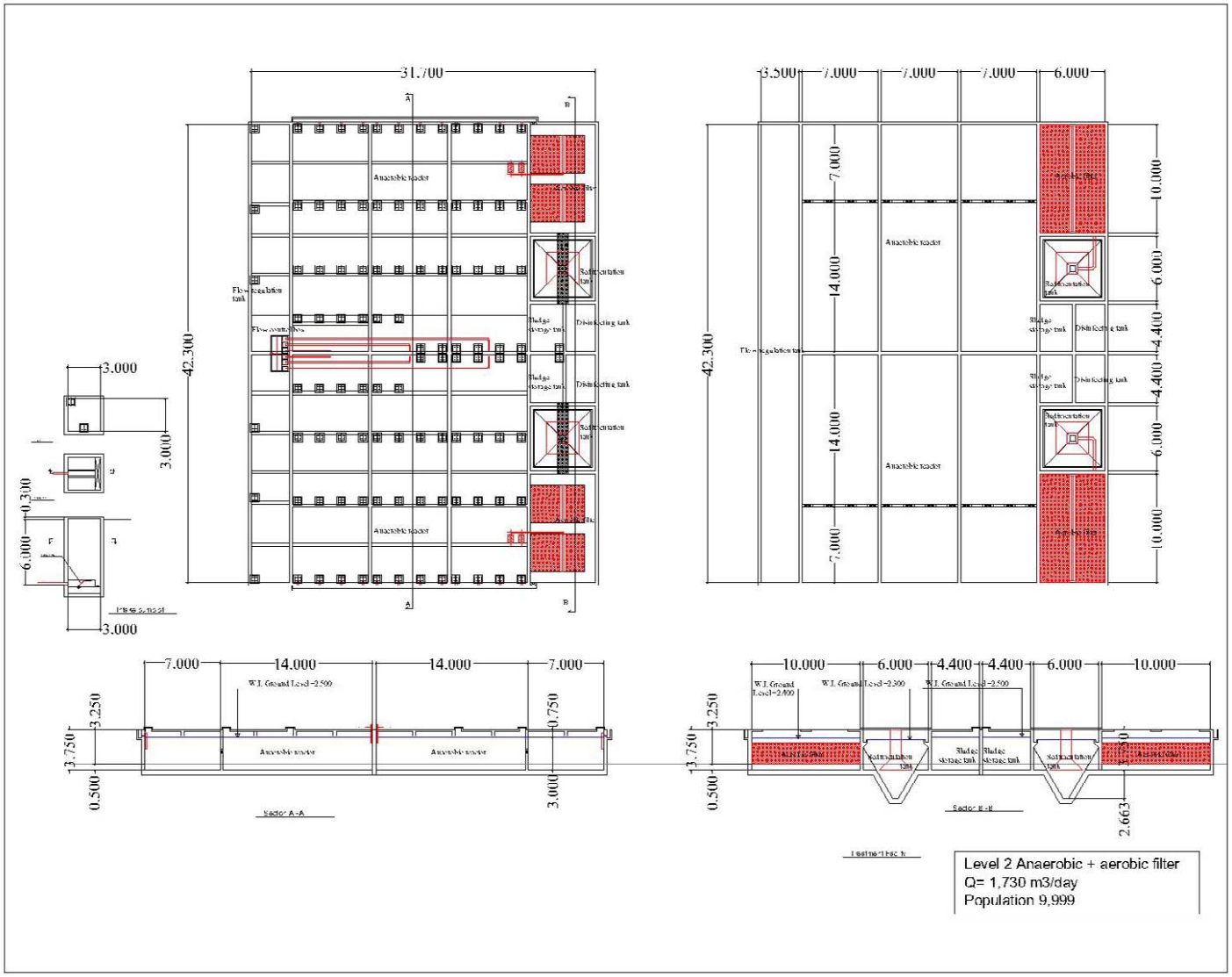


Figure H-9: Level 2 Treatment Process for 9,999 persons

H.2.3.3 Level 3

a. Design Conditions and Treatment Flow Sheet

Recommended treatment method at Level 3 is oxidation ditch. Design conditions and treatment process flow sheet are shown below.

Table H-11: Design Conditions of Level 3

Item	Number
General	
Treatment method	Oxidation ditch
Applicable population size (nos. of population)	10,000 to 49,999
Wastewater generation rate (liter/person/day)	173
Intake BOD concentration (mg/liter)	312
Intake SS concentration (mg/liter)	300
Treated water BOD concentration (mg/liter)	50
Treated water SS concentration (mg/liter)	50
Grit Chamber & pump pit	
Coefficient of hydraulic design	$M=1+(14/(4+P^{0.5})$
Hydraulic surface load (m^3/m^2/day)	1,800
Pump pit detention time (min.)	10
Oxidation ditch	
MLSS concentration (mg/liter)	4,000
BOD-MLSS Load (BOD-kg/MLSS-kg/day)	0.05
Sedimentation tank	
Hydraulic surface load (m^3/m^2/day)	25
Hydraulic over flow weir load (m^3/m/day)	30
Detention time (hr)	6.0
Disinfection tank	
Detention time (minute)	15
Sludge management	
Sludge generation amount (kg/day)	50% of BOD removal amount plus 95% of SS removal amount
Moisture contents of raw sludge	99%
Moisture contents of thickened sludge	98%
Thickener	
Sludge (dry solid) surface load (kg/m^2/day)	90
Detention time (hr)	12
Thickened sludge storage tank	
Detention time (day)	3
Detention time of disinfection tank (minute)	15
Sludge dehydration	
Type of sludge dehydrator	Belt filter press
Filtration rate (kg-SS/m)	120

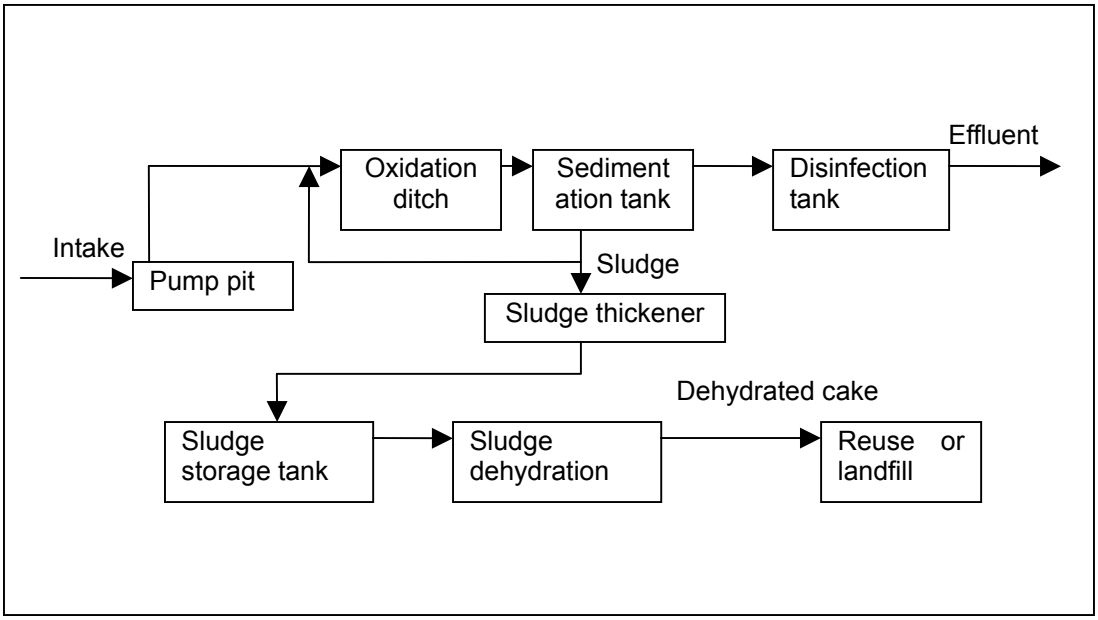


Figure H-10: Treatment Process Flow Sheet (Level 3)

b. Design

The table below shows required volume of reactors based on above conditions.

Table H-12: Outline of Design Calculation

Population size	10,000	20,000	30,000	40,000	49,999
Intake amount (m^3/day)	1,730.0	3,460.0	5,190.0	6,920.0	8,650.0
BOD intake (g/day)	539,933	1,079,866	1,619,799	2,159,732	2,699,665
Grit Chamber					
Coefficient (M)	3.0	2.7	2.5	2.4	2.3
Design flow amount (m^3/day)	5,104.0	9,169.0	12,871.0	16,331.0	19,549.0
Required surface area (m^2)	2.8	5.1	7.2	9.1	10.9
Required pump pit volume (m^3)	35.4	63.7	89.4	113.4	135.8
Oxidation ditch					
BOD-SS load (kg/kg/day)	0.1	0.1	0.1	0.1	0.1
MLSS (mg/liter)	4,000.0	4,000.0	4,000.0	4,000.0	4,000.0
Required volume (m^3)	2,699.7	5,399.3	8,099.0	10,798.7	13,498.3
Detention time	37.5	37.5	37.5	37.5	37.5
Sedimentation tank					
Surface load (m^3/m^2/day)	12.0	12.0	12.0	12.0	12.0
Required area (m^2)	144.2	288.3	432.5	576.7	720.8
Detention time (hr)	6.0	6.0	6.0	6.0	6.0
Required volume (m^3)	432.5	865.0	1,297.5	1,730.0	2,162.5
Depth (m)	3.0	3.0	3.0	3.0	3.0
Disinfection tank					
Detention time (min)	15.0	15.0	15.0	15.0	15.0
Required volume (m^3)	18.0	36.0	54.1	72.1	90.1
Sludge management					
Effluent BOD conc. (mg/liter)	50.0	50.0	50.0	50.0	50.0
Effluent SS conc.(mg/liter)	50.0	50.0	50.0	50.0	50.0
BOD remove amount(kg/day)	453.3	906.5	1,359.8	1,813.0	2,266.3
SS remove amount(kg/day)	432.5	865.0	1,297.5	1,730.0	2,162.5
Dry solid from SS (kg/day)	226.7	453.3	679.9	906.5	1,133.2
Dry solid from BOD (kg/day)	410.9	821.8	1,232.6	1,643.5	2,054.4
Sludge amount (DS-kg/day)	637.6	1,275.1	1,912.5	2,550.0	3,187.6
Sludge volume of (water contents 99%) (m^3)	63.8	127.5	191.3	255.0	318.8
Sludge volume of (water contents 98%) (m^3)	31.9	63.8	95.6	127.5	159.4
Thickener					
Solid load (kg/m^2/day)	90.0	90.0	90.0	90.0	90.0
Required area (m^2)	7.1	14.2	21.3	28.3	35.4
Detention time (hr)	12.0	12.0	12.0	12.0	12.0
Required volume (m^3)	31.9	63.8	95.7	127.5	159.4
Sludge storage thank					
Detention time (days)	3.0	3.0	3.0	3.0	3.0
Required volume (m3)	95.7	191.4	286.8	382.5	478.2

Population size	10,000	20,000	30,000	40,000	49,999
Sludge dehydration					
Filtration rate (kg/m/h)	120.0	120.0	120.0	120.0	120.0
Operation time (hr)	8.0	8.0	8.0	8.0	8.0
Treatment amount (kg/hr)	79.7	159.4	239.1	318.8	398.5
Required belt wide (m)	0.7	1.3	2.0	2.7	3.3
Nos. of equipment	1.0	1.0	2.0	2.0	2.0
Use belt filter press wide (m/equipment)	0.7	1.3	1.0	1.4	1.7

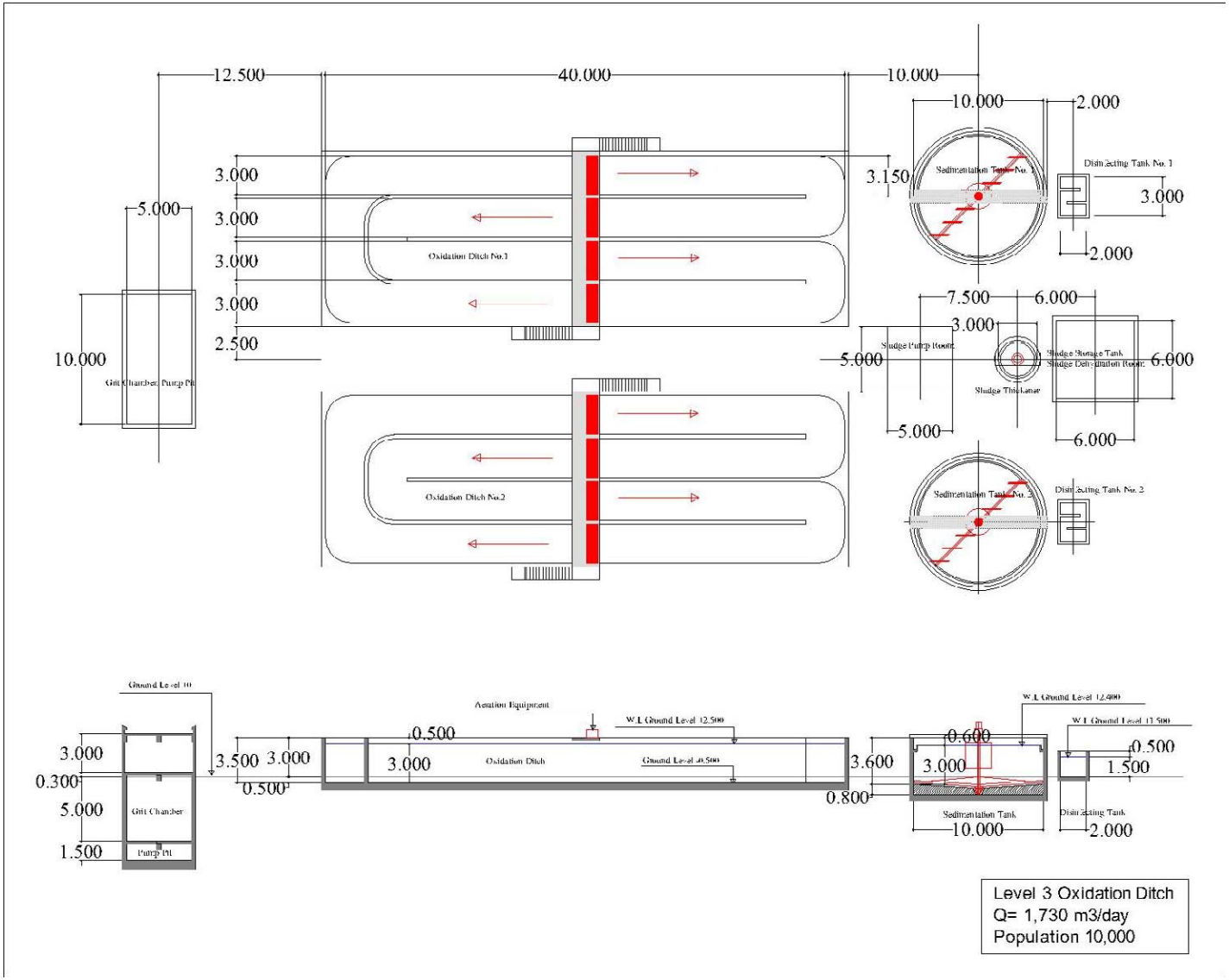


Figure H-11: Level 3 Treatment Process for 10,000 persons

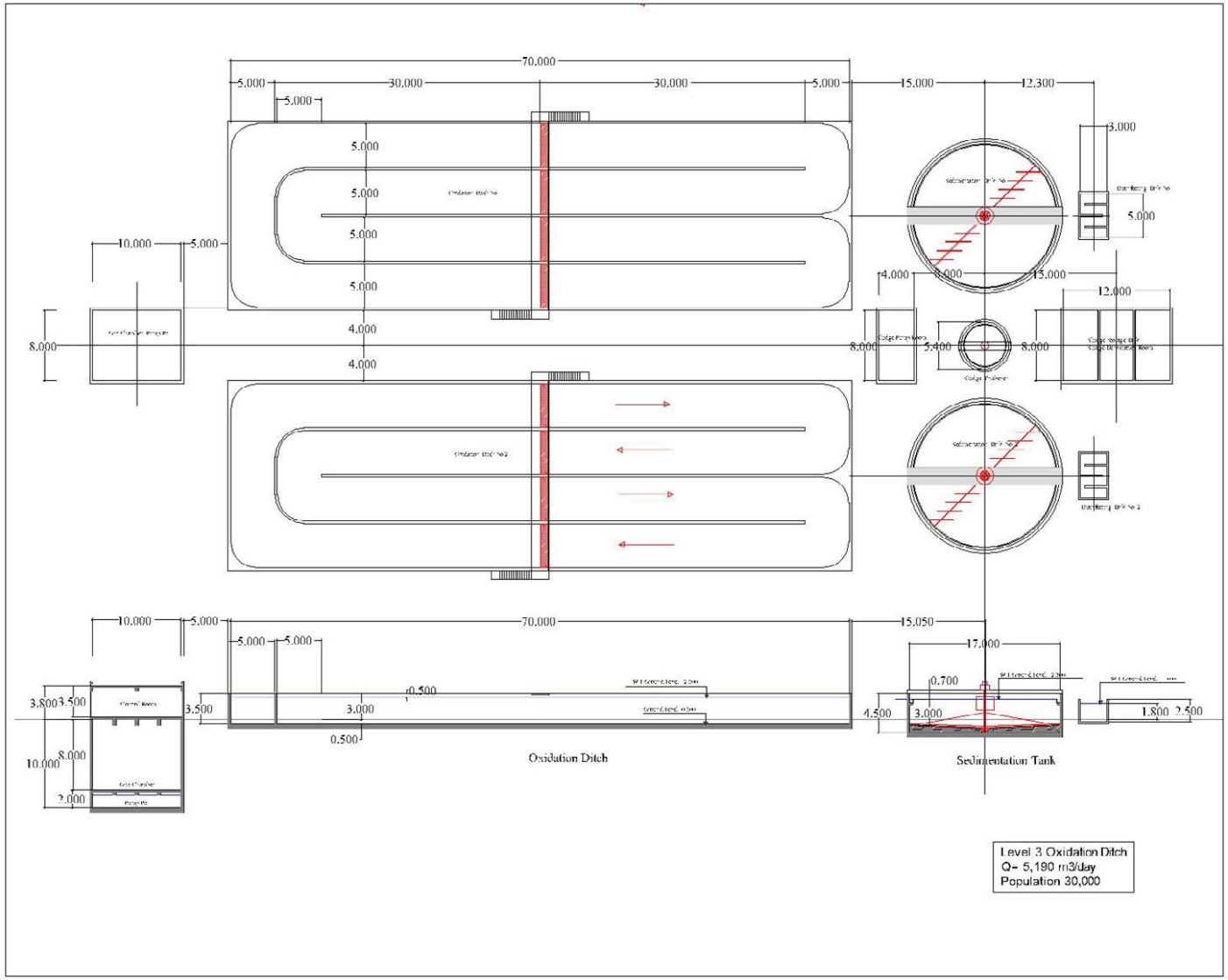


Figure H-12: Level 3 Treatment Process for 30,000 persons

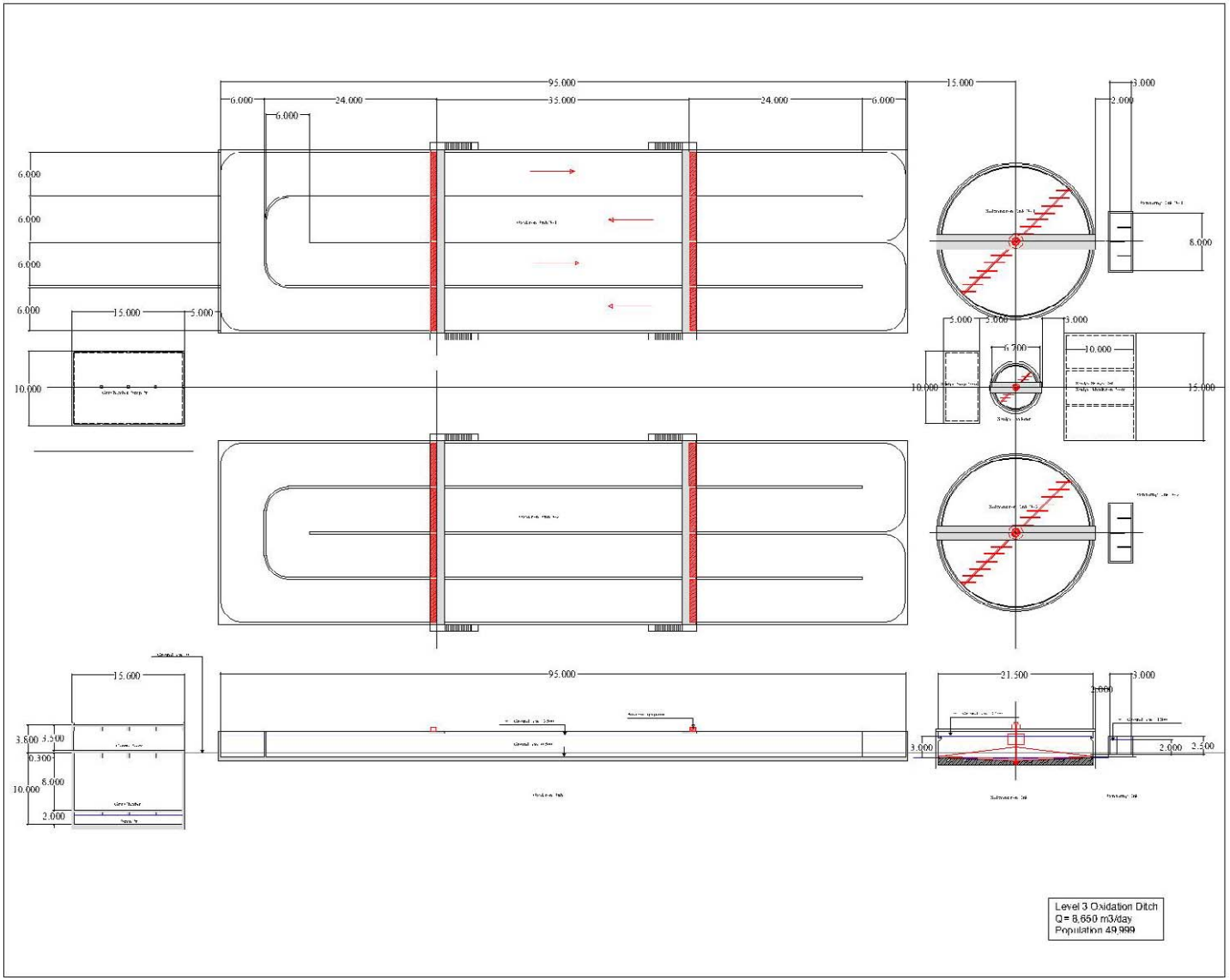


Figure H-13: Level 3 Treatment Process for 49,999 persons

H.2.3.4 Level 4

a. Design Conditions and Treatment Flow Sheet

Recommended treatment method at Level 4 is activated sludge. Design conditions and treatment process flow sheet are shown below.

Table H-13: Design Conditions of Level 4

Item	Number
General	
Treatment method	Conventional activated sludge method
Applicable population size (nos. of population)	50,000 to 200,000
Wastewater generation rate (liter/person/day)	173
Intake BOD concentration (mg/liter)	312
Intake SS concentration (mg/liter)	300
Treated water BOD concentration (mg/liter)	30
Treated water SS concentration (mg/liter)	40
Grit Chamber & pump pit	
Coefficient of hydraulic design	$M=1+(14/(4+P^{0.5})$
Hydraulic surface load (m^3/m^2/day)	1,800
Pump pit detention time (min.)	10
Premiere sedimentation tank	
Hydraulic surface load (m^3/m^2/day)	35
Hydraulic over flow weir load (m^3/m/day)	250
Detention time (hr)	3.0
Aeration tank	
MLSS concentration (mg/liter)	2,000
BOD-MLSS Load (BOD-kg/MLSS-kg/day)	0.3
Final sedimentation tank	
Hydraulic surface load (m^3/m^2/day)	20
Hydraulic over flow weir load (m^3/m/day)	150
Detention time (hr)	4.0
Disinfection tank	
Detention time (minute)	15
Sludge management	
Sludge generation amount (kg/day)	50% of BOD removal amount plus 95% of SS removal amount
Moisture contents of raw sludge	99%
Moisture contents of thickened sludge	98%
Thickener	
Sludge (dry solid) surface load (kg/m^2/day)	90
Detention time (hr)	12
Thickened sludge storage tank	
Detention time (day)	3

Item	Number
Detention time of disinfection tank (minute)	15
Sludge dehydration	
Type of sludge dehydrator	Belt filter press
Filtration rate (kg-SS/m)	120

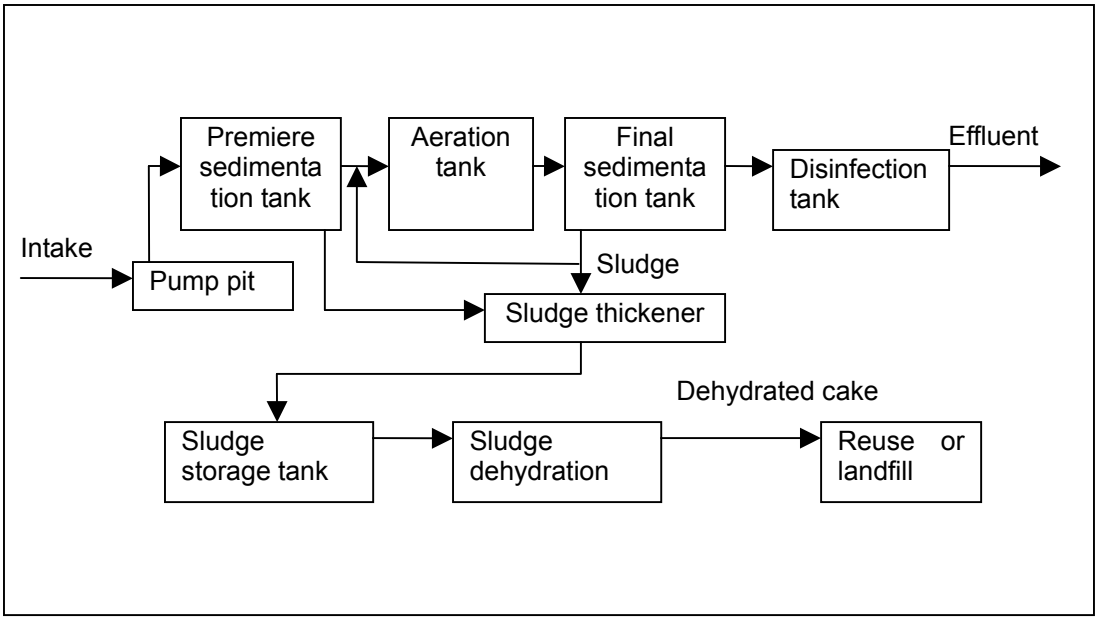


Figure H-14: Treatment Process Flow Sheet (Level 4)

b. Design

Below table shows required volume of reactors based on above conditions.

Table H-14: Outline of Design Calculation

Population size	50,000	75,000	100,000	150,000	200,000
Intake amount (m^3/day)	8,650.0	12,975.0	17,300.0	25,950.0	34,600.0
BOD intake (g/day)	2,699,665	4,049,498	5,399,330	8,098,995	10,798,660
Grit Chamber					
Coefficient (M)	2.3	2.1	2.0	1.9	1.8
Design flow amount (m^3/day)	19,549.0	27,377.0	34,600.0	48,267.0	61,242.0
Required surface area (m^2)	10.9	15.2	19.2	26.8	34.0
Required pump pit volume (m^3)	135.8	190.1	240.3	335.2	425.3
Premiere sedimentation tank					
BOD removal ratio (%)	30	30	30	30	30
Surface load (m^3/m^2/day)	35.0	35.0	35.0	35.0	35.0
Required area (m^2)	247.1	370.7	494.3	741.4	988.6
Detention time (hr)	3.0	3.0	3.0	3.0	3.0
Required volume (m^3)	1,081.3	1,621.9	2,162.5	3,243.8	4,325.0
Depth (m)	4.4	4.4	4.4	4.4	4.4
Outflow BOD amount (kg/day)	1,889.2	2,833.7	3,778.3	5,667.5	7,556.6
Aeration tank					
BOD-MLSS load (kg/kg/day)	0.3	0.3	0.3	0.3	0.3
MLSS (mg/liter)	2,000.0	2,000.0	2,000.0	2,000.0	2,000.0
Required volume (m^3)	3,148.7	4,722.8	6,297.2	9,445.8	12,594.3
Detention time (hr)	8.7	8.7	8.7	8.7	8.7
Depth (m)	4.0	4.0	4.0	4.0	4.0
Final sedimentation tank					
Surface load (m^3/m^2/day)	20.0	20.0	20.0	20.0	20.0
Required area (m^2)	432.5	648.8	865.0	1,297.5	1,730.0
Detention time (hr)	4.0	4.0	4.0	4.0	4.0
Required volume (m^3)	1,441.7	2,162.5	2,883.3	4,325.0	5,766.7
Depth (m)	3.3	3.3	3.3	3.3	3.3
Disinfection					
Detention time (min)	15.0	15.0	15.0	15.0	15.0
Required volume (m^3)	90.1	135.2	180.2	270.3	360.4
Sludge management					
Effluent BOD conc. (mg/liter)	30.0	30.0	30.0	30.0	30.0
Effluent SS conc.(mg/liter)	40.0	40.0	40.0	40.0	40.0
BOD remove amount(kg/day)	2,439.3	3,659.0	4,878.6	7,317.9	9,757.2
SS remove amount(kg/day)	2,249.0	3,373.5	4,498.0	6,747.0	8,996.0
Dry solid from SS (kg/day)	1,219.7	1,829.5	2,439.3	3,659.0	4,878.6
Dry solid from BOD (kg/day)	2,136.6	3,204.8	4,273.1	6,409.7	8,546.2
Sludge amount (DS-kg/day)	3,356.3	5,034.3	6,712.4	10,068.7	13,424.8
Sludge volume of (water contents 99%) (m^3)	335.6	503.4	671.2	1,006.9	1,342.5

Population size	50,000	75,000	100,000	150,000	200,000
Sludge volume of (water contents 98%) (m^3)	167.8	251.7	335.6	503.4	671.2
Thickener					
Solid load (kg/m^2/day)	90.0	90.0	90.0	90.0	90.0
Required area (m^2)	37.3	55.9	74.6	111.9	149.2
Detention time (hr)	12.0	12.0	12.0	12.0	12.0
Required volume (m^3)	167.8	251.7	335.6	503.5	671.3
Sludge storage thank					
Detention time (days)	3.0	3.0	3.0	3.0	3.0
Required volume (m3)	503.4	755.1	1,006.8	1,510.2	2,013.6
Sludge dehydration					
Filtration rate (kg/m/h)	120.0	120.0	120.0	120.0	120.0
Operation time (hr)	8.0	8.0	8.0	8.0	8.0
Treatment amount (kg/hr)	419.5	629.3	839.1	1,258.6	1,678.1
Required belt wide (m)	3.5	5.2	7.0	10.5	14.0
Nos. of equipment	2.0	2.0	3.0	4.0	5.0
Use belt filter press wide (m/equipment)	1.8	2.6	2.3	2.6	2.8

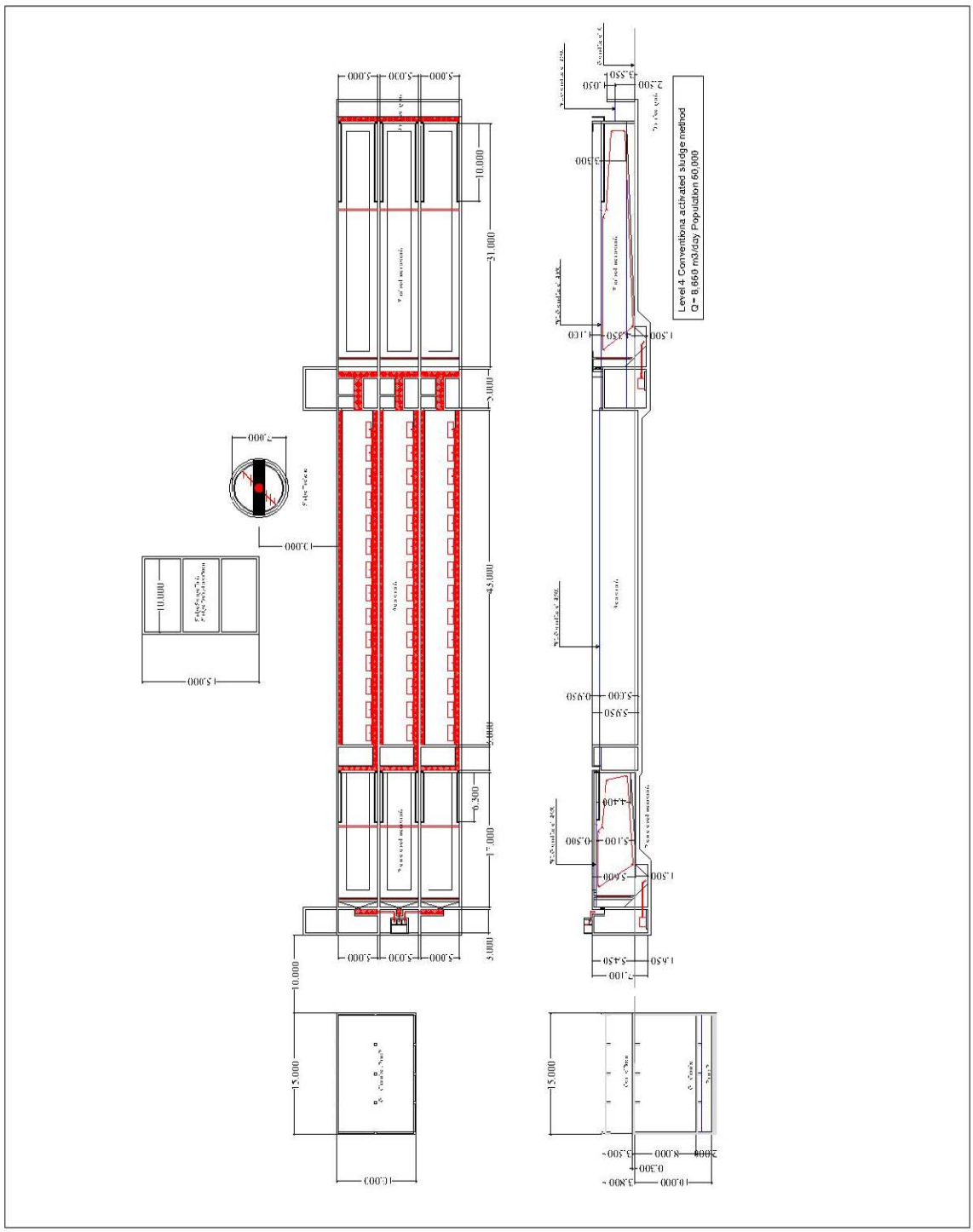


Figure H-15: Level 4 Treatment Process for 50,000 persons

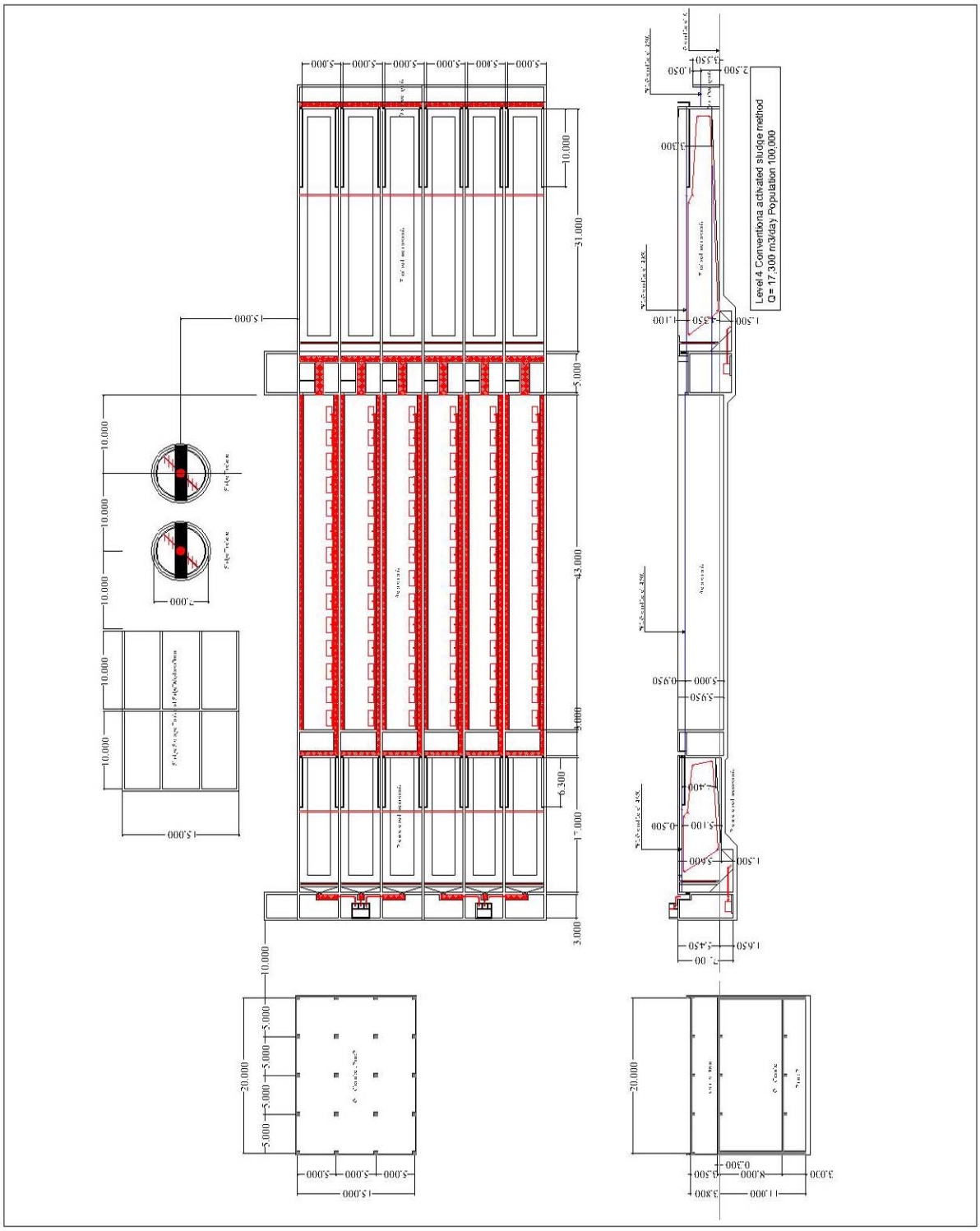


Figure H-16: Level 4 Treatment Process for 100,000 persons

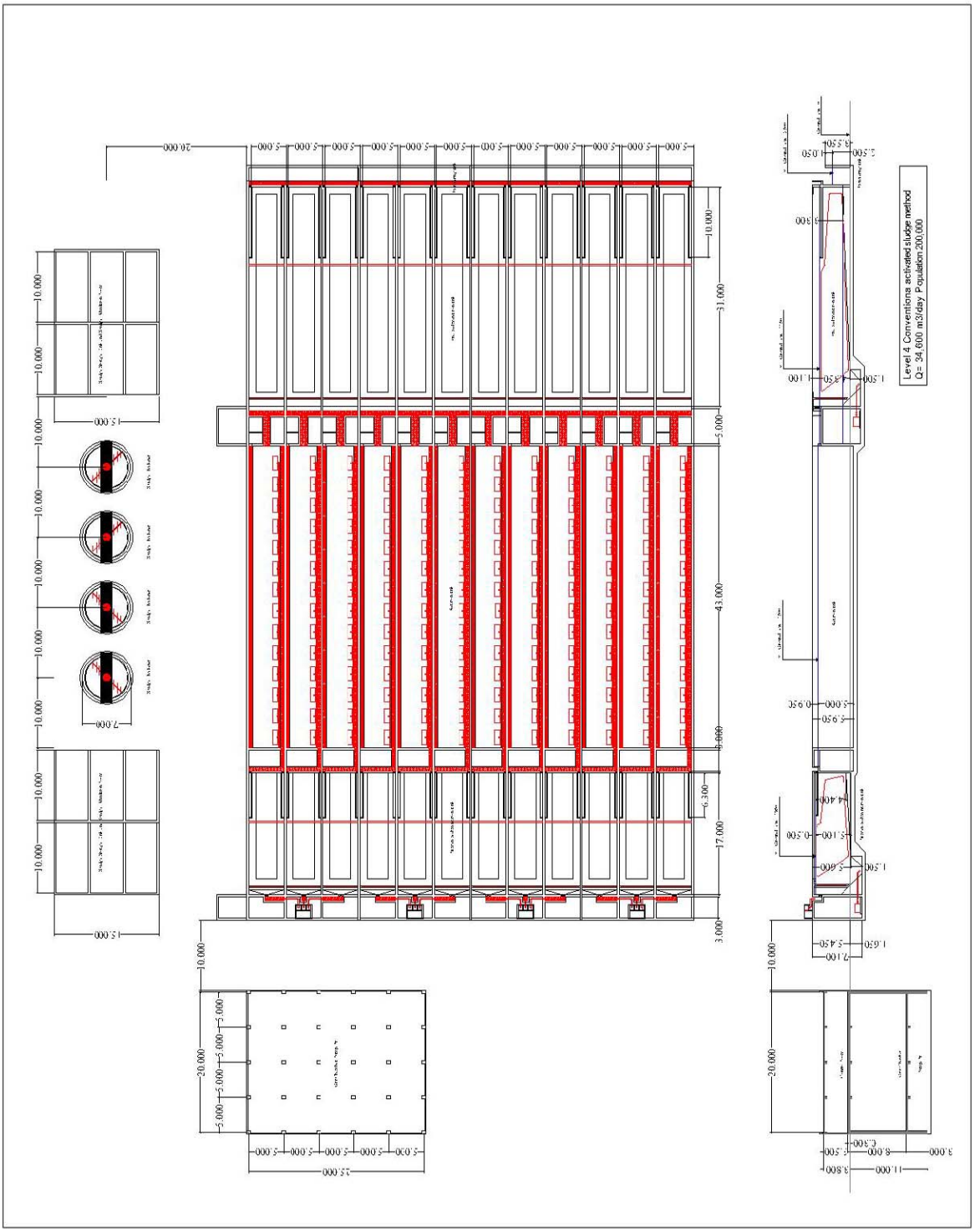


Figure H-17: Level 4 Treatment Process for 200,000 persons

H.2.4 Cost Estimation of Wastewater Management

H.2.4.1 Unit prices and Cost Functions

Required Cost of the Master Plan is estimated based on model designs, cost functions used in sewerage planning in Japan, cost functions derived from various projects of CAPA and unit cost per person. The following table summarizes cost estimation method adopted for respective levels.

Table H-15: Outline of Cost Estimation Method

Level	Sewer line	Treatment facility
Level 1	Estimated unit cost (pesos/population) based on CAPA rural system (Akumal and Subteniente Lopez)	Setup cost function based on model designs (population size 100,250,500,750 and 1,499).
Level 2	Estimated unit cost (pesos/population) based on CAPA rural system (Akumal and Subteniente Lopez)	Set up cost function based on design of rural sewer systems (Hol-Box, Akumal, Puerto Aventuras and Subteninte Lopez) which CAPA prepared.
Level 3	Set up cost function based on CAPA's Strategic Plan.	Set up cost function based on guideline of river basin sewerage system planning in Japan (oxidation ditch method) taking in to account Mexican conditions such as price level and required specifications.
Level 4	Set up cost function based on CAPA's Strategic Plan.	Set up cost function based on guideline of river basin sewerage system planning in Japan (standard activated sludge method) taking in to account Mexican conditions such as price level and required specifications.

a. Level 1

a.1 Sewer Line

Unit cost of sewer line construction shown in the following table is set up based on data of CAPA. Meanwhile, 5% of the construction cost is assumed as operation cost during the period of the Master Plan, between 2004 and 2015.

Table H-16: Unit Cost of Rural Sewer Line Construction

	Investment cost[(a)] (peso)	Number of population	Unit cost (pesos/person)
Akumal	3,560,912	2,078	1,714
Sub-Lopez	4,515,131	2,320	1,946
Average	-	-	1,830

[(a)] PROYECTO EJECUTIVO PARA EL ALCANTARILLADO SANITARIO Y TRATAMIENTO DE AGUAS RESIDUALES DE LAS LOCALIDADES DE CHIQUILÁ Y HOL-BOX EN EL MUNICIPIO DE LÁZARO CÁRDENAS; AKUMAL, COBÁ Y PUERTO AVENTURAS EN EL MUNICIPIO DE SOLIDARIDAD, QUINTANA ROO, INFORME FINAL, OCTUBRE DE 2002,CAPA, PROYECTO EJECUTIVO PARA EL ALCANTARILLADO SANITARIO Y TRATAMIENTO DE AGUAS RESIDUALES DE LAS LOCALIDADES DE XCALAK, HUAY-PIX, XUL-HÁ Y SUBTENIENTE LÓPEZ EN EL MUNICIPIO DE OTHÓN P. BLANCO, QUINTANA ROO, INFORME FINAL, OCTUBRE DE 2002,CAPA

a.2 Sewerage Treatment Facility

The following table summarizes costs of sewerage treatment facilities in population sizes based on the designs mentioned above.

Table H-17: Cost of Anaerobic Reactor Process

Population	Pump pit (pesos)	Anaerobic reactor (pesos)	Equipments (pesos)	Total (pesos)	Contingency (pesos)	Total (pesos)
100	85,000	125,000	32,000	242,000	24,200	266,200
250	133,000	236,000	55,000	424,000	42,400	466,400
500	133,000	472,000	91,000	696,000	69,600	765,600
750	133,000	708,000	126,000	967,000	96,700	1,063,700
1499	294,000	584,000	132,000	1,010,000	202,000	2,222,000

a.3 Cost Function

Function of facilities and construction costs is derived from relation between treated water amount and costs mentioned in the previous table as follows.

$$Cost = 8{,}063.5Q + 92{,}367 \qquad (R^2=0.9956)$$

where:

Cost : treatment facility construction cost (pesos)

Q : treatment capacity of treatment facility (m^3/day)

In addition, 5% of facilities and construction costs are assumed as operation cost in the period from 2004 to 2015.

b. Level 2

Cost function at Level 2 is obtained based on cost estimation of rural system by CAPA.

Table H-18: Construction Cost of CAPA Rural System

Location	Treatment capacity (m3/day)	Cost (1,000 pesos)
Akumal	206	1,972
Hol-Box	162	1,854
Puerto-Aventuras	104	1,686
Sub-Lopez	230	2,254

Source: CAPA

Function of facilities and construction costs are derived from regression analysis of relation between costs and treatment capacities in the table above. The function is shown below.

$$Cost = 4.0686Q + 1{,}227.5 \qquad (R^2=0.8874)$$

where:

Cost : treatment facility construction cost (1,000 pesos)

Q : treatment capacity of treatment facility (m^3/day)

In addition, 5% of facilities and construction costs are assumed as operation cost in the period from 2004 to 2015.

c. Level 3

c.1 Sewer Line

Function of sewer line construction cost is obtained based on relation between costs and wastewater amounts estimated in the strategic plan of CAPA[1].

[1] PLAN ESTRATEGICO DE LOS SERVICEO DE AGUA POTABLE, ALCANTARILLADO Y SANEAMIENTO 2001-2025, Mayo de 2001(v.1.1), CAPA

Table H-19: Relation Between Wastewater Amount and Sewer Line Construction Cost

Wastewater amount (liter/sec)	Sewer line construction cost (million pesos)
313	77
265	79
752	216
60	22
495	134
34	23
34	16
101	49
114	85
8	6
17	14
519	468
128	93
384	278
43	58
3	2
6	4
21	38
5	2
543	191
339	134
911	383

Function of facilities and construction costs are derived from regression analysis of relation between costs and wastewater amounts in the table above. The function is shown below.

$$Cost = 0.9744Q^{0.8693} \qquad (R^2=0.916)$$

where:

Cost : sewer line installation cost (million pesos)

Q : planed wastewater amount (liter / sec.)

In addition, 5% of facilities and construction costs are assumed as operation cost in the period from 2004 to 2015.

c.2 Wastewater Treatment Facility

Cost function of treatment facility at Level 3 is obtained based on cost function of oxidation ditch method described in a planning guidance in Japan[2] with taking into account price level and facility level in Mexico.

Original formulas of construction cost function for Oxidation Ditch Method: $Cost = 230.90Q + 145.98$

Where:

Cost : construction cost (million yen)

Q : treatment capacity (1,000 m^3/day)

Original formulas of operation and maintenance cost function for Oxidation Ditch Method: $O\&M = 21.107Q^{0.4692}$

Where:

O & M : annual operation and maintenance cost (million yen/year)

Q : treatment amount (1,000 m^3/day)

Table H-20: Assumption of Cost Function Modification

Item	Number
Price level	0.45
Facility specification factor	0.7
Currency exchange rate	1 pesos = 10yen

Construction cost function for the master plan

$$Cost = \frac{(230.90Q + 145.98) \times 0.45 \times 0.7}{10} = 7.27335Q + 4.9837$$

Where:

Cost : construction cost (million pesos)

Q : treatment capacity (1,000 m^3/day)

Operation and maintenance cost function for the master plan

[2] Planning guideline for river basin sewer system in Japan, Ministry of Construction in Japan, year 2000 version

$$O\&M = \frac{0.45 \times 0.7 \times (21.107Q^{0.4692})}{10} = 0.66487Q^{0.4692}$$

Where:

O & M : annual operation and maintenance cost (million pesos/year)

Q : treatment amount (1,000 m^3/day)

d. Level 4

As for function of sewer line construction cost at Level 4, the same function as at Level 3 is adopted. As for function of treatment facility cost at Level 4, it is obtained based on function of activated sludge method in Japan in the same way of Level 3.

Original formulas of construction cost function for Standard Activated Sludge Method: $Cost = 932.18Q^{0.7229}$

Where:

Cost : construction cost (million yen)

Q : treatment capacity (1,000 m^3/day)

Original formulas of operation and maintenance cost function for Standard Activated Sludge Method: $O\&M = 19.824Q^{0.8102}$

Where:

O & M : annual operation and maintenance cost (million yen/year)

Q : treatment amount (1,000 m^3/day)

Construction cost function for the master plan

$$Cost = \frac{(932.18Q^{0.7229}) \times 0.45 \times 0.7}{10} = 29.3637Q^{0.7229}$$

Where:

Cost : construction cost (million pesos)

Q : treatment capacity (1,000 m^3/day)

Operation and maintenance cost function for the master plan

$$O\&M = \frac{0.45 \times 0.7 \times (19.824Q^{0.4692})}{10} = 0.62446Q^{0.4692}$$

Where:

O & M : annual operation and maintenance cost (million pesos/year)

Q : treatment amount (1,000 m^3/day)

H.2.4.2 Cost Estimation

Table H-21: Master Plan Cost of Sewer Line in Othón P. Blanco Municipality

Item	Level	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Sewer line													unit: million pesos	
Construction	Level 1	0	0	2.546	2.452	2.388	2.344	11.419	12.651	10.447	10.296	11.734	21.356	87.633
	Level 2	0	0	10.61	8.912	2.026	12.523	2.266	18.467	21.638	12.345	19.323	23.171	131.281
	Level 3	0	10.491	10.491	10.491	10.491	10.491	3.76	3.76	3.76	3.76	3.76	0	71.255
	Level 4	0	0	14.169	14.241	14.241	14.241	3.647	3.647	3.647	3.647	3.647	0	75.127
	total	0	10.491	37.816	36.096	29.146	39.599	21.092	38.525	39.492	30.048	38.464	44.527	365.296
Design & supervision	Level 1	0	0.076	0.074	0.072	0.07	0.343	0.38	0.313	0.309	0.352	0.641	0	2.63
	Level 2	0	0.318	0.267	0.061	0.376	0.068	0.554	0.649	0.37	0.58	0.695	0	3.938
	Level 3	0.315	0.315	0.315	0.315	0.315	0.113	0.113	0.113	0.113	0.113	0	0	2.14
	Level 4	0	0.425	0.427	0.427	0.427	0.109	0.109	0.109	0.109	0.109	0	0	2.251
	total	0.315	1.134	1.083	0.875	1.188	0.633	1.156	1.184	0.901	1.154	1.336	0	10.959
Operation & maintenance	Level 1	0	0	0.127	0.25	0.368	0.486	1.056	1.691	2.213	2.725	3.313	4.382	16.611
	Level 2	0	0	0.532	0.978	1.077	1.707	1.818	2.737	3.82	4.437	5.402	6.564	29.072
	Level 3	0	0	0.524	1.049	1.574	2.099	2.623	2.812	2.999	3.187	3.375	3.563	23.805
	Level 4	0.662	1.021	1.734	2.442	3.154	3.866	4.578	4.761	4.943	5.126	5.308	5.49	43.085
	total	0.662	1.021	2.917	4.719	6.173	8.158	10.075	12.001	13.975	15.475	17.398	19.999	112.573
Sewer line total		0.977	12.646	41.816	41.69	36.507	48.39	32.323	51.71	54.368	46.677	57.198	64.526	488.828

Table H-22: Master Plan Cost of Sewerage Treatment Facilities in Othón P. Blanco Municipality

Item	Level	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Treatment facilities														unit: million pesos
Construction	Level 1	0	0	2.15	2.071	2.019	1.98	9.645	10.687	8.825	8.698	9.912	18.042	74.029
	Level 2	0	0	4.071	5.178	1.177	7.276	1.316	10.728	12.571	7.172	11.226	13.462	74.177
	Level 3	0	38.561	0	38.561	0	38.561	0	0	0	0	0	0	115.683
	Level 4	0	215.679	0	81.431	134.248	81.431	0	0	0	0	0	0	512.789
	total	0	254.24	6.221	127.241	137.444	129.248	10.961	21.415	21.396	15.87	21.138	31.504	776.678
Design & supervision	Level 1	0	0.065	0.062	0.061	0.059	0.289	0.321	0.265	0.261	0.297	0.541	0	2.221
	Level 2	0	0.122	0.155	0.035	0.218	0.039	0.322	0.377	0.215	0.337	0.404	0	2.224
	Level 3	0.578	0.578	0.578	0.578	0.578	0.578	0	0	0	0	0	0	3.468
	Level 4	3.235	3.235	1.221	3.235	2.014	1.221	0	0	0	0	0	0	14.161
	total	3.813	4	2.016	3.909	2.869	2.127	0.643	0.642	0.476	0.634	0.945	0	22.074
Operation & maintenanc e	Level 1	0	0	0.107	0.211	0.311	0.411	0.892	1.429	1.869	2.302	2.798	3.701	14.031
	Level 2	0	0	0.3	0.553	0.608	0.964	1.027	1.547	2.159	2.507	3.052	3.709	16.426
	Level 3	0	0	1.44	1.993	2.411	2.759	3.064	3.166	3.265	3.361	3.453	3.543	28.455
	Level 4	1.799	4.338	6.338	8.267	9.977	11.409	12.796	13.12	13.442	13.762	14.08	14.396	123.724
	total	1.799	4.338	8.185	11.024	13.307	15.543	17.779	19.262	20.735	21.932	23.383	25.349	182.636
Treatment facilities total		5.612	262.578	16.422	142.174	153.62	146.918	29.383	41.319	42.607	38.436	45.466	56.853	981.388

Table H-23: Master Plan Cost of Sludge Management in Othón P. Blanco Municipality

Item	Level	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Sludge management													unit: million pesos	
Disposal cost	Level 1	0	0	0.016	0.032	0.047	0.062	0.135	0.216	0.282	0.348	0.422	0.558	2.118
	Level 2	0.029	0.031	0.09	0.166	0.183	0.29	0.309	0.467	0.651	0.757	0.921	1.118	5.012
	Level 3	0	0	0.15	0.301	0.451	0.601	0.751	0.805	0.859	0.912	0.966	1.02	6.816
	Level 4	0.764	1.338	1.826	2.314	2.801	3.289	3.777	3.892	4.006	4.121	4.236	4.35	36.714
	total	0.793	1.369	2.082	2.813	3.482	4.242	4.972	5.38	5.798	6.138	6.545	7.046	50.66

Table H-24: Overall Cost of the Master Plan in Othón P. Blanco Municipality

Item	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
												unit: million pesos	
Sewer line	0.977	12.646	41.816	41.690	36.507	48.390	32.323	51.710	54.368	46.677	57.198	64.526	488.828
Treatment facilities	5.612	262.578	16.422	142.174	153.620	146.918	29.383	41.319	42.607	38.436	45.466	56.853	981.388
Sludge management	0.793	1.369	2.082	2.813	3.482	4.242	4.972	5.380	5.798	6.138	6.545	7.046	50.660
Overall total	7.382	276.593	60.320	186.677	193.609	199.550	66.678	98.409	102.773	91.251	109.209	128.425	1,520.876

Table H-25: Master Plan Cost of Sewer Line in Felipe Carrillo Puerto Municipality

Item	Level	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Sewer line														unit: million pesos
Construction	Level 1	0.000	0.000	0.000	0.000	0.000	0.000	5.444	11.974	7.827	9.188	9.476	8.605	52.514
	Level 2	0.000	0.000	0.000	0.000	0.000	0.000	1.637	0.015	1.625	0.944	0.863	1.774	6.858
	Level 3	1.584	3.219	2.274	2.248	2.274	2.274	2.248	2.274	2.274	2.248	2.274	0.000	25.191
	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	total	1.584	3.219	2.274	2.248	2.274	2.274	9.329	14.263	11.726	12.380	12.613	10.379	84.563
Design & supervision	Level 1	0.000	0.000	0.000	0.000	0.000	0.163	0.359	0.235	0.276	0.284	0.258	0.000	1.575
	Level 2	0.000	0.000	0.000	0.000	0.000	0.049	0.000	0.049	0.028	0.026	0.053	0.000	0.205
	Level 3	0.097	0.068	0.067	0.068	0.068	0.067	0.068	0.068	0.067	0.068	0.000	0.000	0.706
	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	total	0.097	0.068	0.067	0.068	0.068	0.279	0.427	0.352	0.371	0.378	0.311	0.000	2.486
Operation & maintenance	Level 1	0.000	0.000	0.000	0.000	0.000	0.000	0.273	0.872	1.263	1.722	2.195	2.626	8.951
	Level 2	0.000	0.000	0.000	0.000	0.000	0.000	0.082	0.083	0.164	0.211	0.254	0.343	1.137
	Level 3	0.018	0.097	0.258	0.372	0.484	0.598	0.712	0.824	0.938	1.052	1.164	1.278	7.795
	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	total	0.018	0.097	0.258	0.372	0.484	0.598	1.067	1.779	2.365	2.985	3.613	4.247	17.883
Sewer line total		1.699	3.384	2.599	2.688	2.826	3.151	10.823	16.394	14.462	15.743	16.537	14.626	104.932

Table H-26: Master Plan Cost of Sewerage Treatment Facilities in Felipe Carrillo Puerto Municipality

Item	Level	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Treatment facilities														unit: million pesos
Construction	Level 1	0.000	0.000	0.000	0.000	0.000	0.000	4.689	10.311	6.740	7.913	8.160	7.410	45.223
	Level 2	0.000	0.000	0.000	0.000	0.000	0.000	5.690	0.053	5.650	3.283	2.999	6.168	23.843
	Level 3	0.000	13.574	0.000	0.000	13.574	0.000	0.000	13.574	0.000	0.000	0.000	0.000	40.722
	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	total	0.000	13.574	0.000	0.000	13.574	0.000	10.379	23.938	12.390	11.196	11.159	13.578	109.788
Design & supervision	Level 1	0.000	0.000	0.000	0.000	0.000	0.141	0.309	0.202	0.237	0.245	0.222	0.000	1.356
	Level 2	0.000	0.000	0.000	0.000	0.000	0.171	0.002	0.170	0.098	0.090	0.185	0.000	0.716
	Level 3	0.204	0.204	0.000	0.204	0.204	0.000	0.204	0.204	0.000	0.000	0.000	0.000	1.224
	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	total	0.204	0.204	0.000	0.204	0.204	0.312	0.515	0.576	0.335	0.335	0.407	0.000	3.296
Operation & maintenance	Level 1	0.000	0.000	0.000	0.000	0.000	0.000	0.235	0.751	1.088	1.483	1.890	2.261	7.708
	Level 2	0.000	0.000	0.000	0.000	0.000	0.000	0.285	0.287	0.570	0.734	0.883	1.192	3.951
	Level 3	0.113	0.300	0.588	0.698	0.791	0.873	0.947	1.015	1.078	1.137	1.193	1.246	9.979
	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	total	0.113	0.300	0.588	0.698	0.791	0.873	1.467	2.053	2.736	3.354	3.966	4.699	21.638
Treatment facilities total		0.317	14.078	0.588	0.902	14.569	1.185	12.361	26.567	15.461	14.885	15.532	18.277	134.722

Table H-27: Master Plan Cost of Sludge Managements in Felipe Carrillo Puerto Municipality

Item	Level	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Sludge management													unit: million pesos	
Disposal cost	Level 1	0.000	0.000	0.000	0.000	0.000	0.000	0.034	0.111	0.161	0.219	0.279	0.334	1.138
	Level 2	0.000	0.000	0.000	0.000	0.000	0.000	0.081	0.081	0.161	0.208	0.250	0.338	1.119
	Level 3	0.012	0.043	0.077	0.111	0.144	0.178	0.212	0.246	0.280	0.314	0.348	0.381	2.346
	Level 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	total	0.012	0.043	0.077	0.111	0.144	0.178	0.327	0.438	0.602	0.741	0.877	1.053	4.603

Table H-28: Overall Cost of the Master Plan in Felipe Carrillo Puerto Municipality

Item	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
												unit: million pesos	
Sewer line	1.699	3.384	2.599	2.688	2.826	3.151	10.823	16.394	14.462	15.743	16.537	14.626	104.932
Treatment facilities	0.317	14.078	0.588	0.902	14.569	1.185	12.361	26.567	15.461	14.885	15.532	18.277	134.722
Sludge management	0.012	0.043	0.077	0.111	0.144	0.178	0.327	0.438	0.602	0.741	0.877	1.053	4.603
Overall total	2.028	17.505	3.264	3.701	17.539	4.514	23.511	43.399	30.525	31.369	32.946	33.956	244.257

Table H-29: Master Plan Cost of Sewer Line in Solidaridad Municipality

Item	Level	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Sewer line													unit: million pesos	
Construction	Level 1	0.000	0.000	0.000	0.000	0.000	0.000	3.395	3.358	3.016	3.085	2.954	3.878	19.686
	Level 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.867	0.045	0.045	0.708	0.594	2.259
	Level 3	0.000	11.438	11.438	11.438	11.438	11.438	4.174	4.174	4.174	4.174	4.174	0.000	78.060
	Level 4	9.380	20.291	20.383	20.383	18.498	22.176	9.186	9.186	9.186	9.186	9.186	0.000	157.041
	total	9.380	31.729	31.821	31.821	29.936	33.614	16.755	17.585	16.421	16.490	17.022	4.472	257.046
Design & supervision	Level 1	0.000	0.000	0.000	0.000	0.000	0.102	0.101	0.090	0.093	0.089	0.116	0.000	0.591
	Level 2	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.001	0.001	0.021	0.018	0.000	0.067
	Level 3	0.343	0.343	0.343	0.343	0.343	0.126	0.126	0.126	0.126	0.126	0.000	0.000	2.345
	Level 4	0.608	0.611	0.611	0.555	0.665	0.276	0.276	0.276	0.276	0.276	0.000	0.000	4.430
	total	0.951	0.954	0.954	0.898	1.008	0.504	0.529	0.493	0.496	0.512	0.134	0.000	7.433
Operation & maintenance	Level 1	0.000	0.000	0.050	0.052	0.053	0.055	0.216	0.374	0.516	0.661	0.801	0.984	3.762
	Level 2	0.000	0.000	0.019	0.021	0.024	0.026	0.028	0.061	0.062	0.064	0.091	0.113	0.509
	Level 3	0.000	0.000	0.572	1.144	1.716	2.287	2.859	3.068	3.277	3.486	3.694	3.903	26.006
	Level 4	3.630	4.099	5.114	6.133	7.152	8.077	9.186	9.644	10.104	10.563	11.023	11.482	96.207
	total	3.630	4.099	5.755	7.350	8.945	10.445	12.289	13.147	13.959	14.774	15.609	16.482	126.484
Sewer line total		13.961	36.782	38.530	40.069	39.889	44.563	29.573	31.225	30.876	31.776	32.765	20.954	390.963

Table H-30: Master Plan Cost of Sewerage Treatment Facilities in Solidaridad Municipality

Item	Level	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Treatment facilities														unit: million pesos
Construction	Level 1	0.000	0.000	0.000	0.000	0.000	0.000	2.800	2.767	2.487	2.543	2.435	3.198	16.230
	Level 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.301	0.172	0.171	2.696	2.262	8.602
	Level 3	0.000	38.734	0.000	38.734	0.000	38.734	0.000	0.000	0.000	0.000	0.000	0.000	116.202
	Level 4	138.935	98.931	0.000	237.866	0.000	98.931	138.935	0.000	0.000	0.000	0.000	0.000	713.598
	total	138.935	137.665	0.000	276.600	0.000	137.665	141.735	6.068	2.659	2.714	5.131	5.460	854.632
Design & supervision	Level 1	0.000	0.000	0.000	0.000	0.000	0.084	0.083	0.075	0.076	0.073	0.096	0.000	0.487
	Level 2	0.000	0.000	0.000	0.000	0.000	0.000	0.099	0.005	0.005	0.081	0.068	0.000	0.258
	Level 3	0.581	0.581	0.581	0.581	0.581	0.581	0.000	0.000	0.000	0.000	0.000	0.000	3.486
	Level 4	3.568	1.484	3.568	3.568	1.484	3.568	2.084	0.000	0.000	0.000	0.000	0.000	19.324
	total	4.149	2.065	4.149	4.149	2.065	4.233	2.266	0.080	0.081	0.154	0.164	0.000	23.555
Operation & maintenanc e	Level 1	0.000	0.000	0.041	0.043	0.044	0.045	0.178	0.308	0.425	0.545	0.661	0.812	3.102
	Level 2	0.000	0.000	0.071	0.080	0.090	0.098	0.108	0.231	0.238	0.244	0.345	0.430	1.935
	Level 3	0.000	0.000	1.240	1.717	2.077	2.377	2.639	2.726	2.809	2.888	2.966	3.041	24.480
	Level 4	6.470	7.506	9.443	11.841	13.777	15.157	16.783	17.461	18.132	18.796	19.455	20.110	174.931
	total	6.470	7.506	10.795	13.681	15.988	17.677	19.708	20.726	21.604	22.473	23.427	24.393	204.448
Treatment facilities total		149.554	147.236	14.944	294.430	18.053	159.575	163.709	26.874	24.344	25.341	28.722	29.853	1,082.635

Table H-31: Master Plan Cost of Sludge Management in Solidaridad Municipality

Item	Level	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Sludge management													unit: million pesos	
Disposal cost	Level 1	0.007	0.007	0.007	0.007	0.007	0.007	0.029	0.051	0.070	0.089	0.108	0.133	0.522
	Level 2	0.018	0.021	0.024	0.028	0.031	0.034	0.037	0.080	0.082	0.084	0.120	0.149	0.708
	Level 3	0.000	0.000	0.177	0.356	0.533	0.711	0.888	0.954	1.019	1.085	1.151	1.217	8.091
	Level 4	2.171	2.474	3.029	3.586	4.142	4.641	5.254	5.517	5.780	6.043	6.305	6.568	55.510
	total	2.196	2.502	3.237	3.977	4.713	5.393	6.208	6.602	6.951	7.301	7.684	8.067	64.831

Table H-32: Overall Cost of the Master Plan in Solidaridad Municipality

Item	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
												unit: million pesos	
Sewer line	13.961	36.782	38.530	40.069	39.889	44.563	29.573	31.225	30.876	31.776	32.765	20.954	390.963
Treatment facilities	149.554	147.236	14.944	294.430	18.053	159.575	163.709	26.874	24.344	25.341	28.722	29.853	1,082.635
Sludge management	2.196	2.502	3.237	3.977	4.713	5.393	6.208	6.602	6.951	7.301	7.684	8.067	64.831
Overall total	165.711	186.520	56.711	338.476	62.655	209.531	199.490	64.701	62.171	64.418	69.171	58.874	1,538.429

Table H-33: Overall Cost of the Master Plan

Item	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
													unit: million pesos
Othón P. Blanco	7.382	276.593	60.320	186.677	193.609	199.550	66.678	98.409	102.773	91.251	109.209	128.425	1,520.876
Felipe Carrillo Puerto	2.028	17.505	3.264	3.701	17.539	4.514	23.511	43.399	30.525	31.369	32.946	33.956	244.257
Solidaridad	165.711	186.520	56.711	338.476	62.655	209.531	199.490	64.701	62.171	64.418	69.171	58.874	1,538.429
Total	175.121	480.618	120.295	528.854	273.803	413.595	289.679	206.509	195.469	187.038	211.326	221.255	3,303.562

H.2.5 Financial Analysis

H.2.5.1 Considerations on Income Sources

Possible income sources considered for wastewater treatment were (1) service charges from wastewater treatment, (2) surplus of water supply income, and (3) contribution of the tour industry. Income was estimated based on the number of residents plus the number of tourists and their period of stay or visit ("tourist/day"), their water consumption and their wastewater generation.

The data on income per cubic meter was obtained from the CAPA financial results during the first nine months of 2003, which indicated 7.11 Pesos per cubic meter of drinking water, and 1.42 Pesos per cubic meter of wastewater treatment. The income per cubic meter of wastewater treatment was equivalent to 20% of the income per cubic meter of water supply, probably based on the wastewater treated at present as a proportion of water consumption. Then, the income per cubic meter of wastewater treatment should increase in the same way as the increasing treatment of wastewater as a proportion of water consumption up to 75% in 2011 and thereafter, as indicated in the following Table.

Table H-34: Wastewater Treatment Achievement Ratio and Assumed Treatment

Year	Wastewater Treatment Achievement Ratio (%)	Assumed treated wastewater / water consumed (%)
2003	17.5	20
2004	17.6	20
2005	22.9	25
2006	31.8	35
2007	40.8	45
2008	49.4	50
2009	58.2	60
2010	68.8	70
2011	74.9	75
2012	81.1	75
2013	86.6	75
2014	92.8	75
2015	100.0	75

The upper bound of treated wastewater was assumed to be 75% of water consumed.

In order to estimate the surplus of water supply income as the second source of income for the Wastewater Master Plan, the cost of production of drinking water was estimated to be 90% of gross income of water supply according to the analysis of CAPA Income Statement of 2002, and 95% according to the Income Statements of 2000 and 2001.

Water consumption was assumed to be 230 l/c/d, as per CNA directives for hot climate.

As the third income source for the implementation of the Wastewater Master Plan, the tour industry was assumed to share in the cost of the Wastewater Master Plan according to the percentage of water consumption by tourists.

H.2.5.2 Financial Analysis

a. Income and Cost of Wastewater Master Plan

Estimation of income from the three sources considered in this analysis resulted in the following Table showing possible income levels in relation to the cost of Wastewater Master Plan.

Table H-35: Income by Source and Wastewater Master Plan Cost by Municipality

Unit: Million Pesos

Income Source	OPB	FCP	Solidaridad	Study Area
Wastewater Income Only	1,170.07	130.75	2,847.86	4,148.67
Water Supply Income Surplus (WS expenses = 90% of gross income)	176.93	18.23	439.16	634.31
Water Supply Income Surplus (WS expenses = 95% of gross income)	88.46	9.11	219.58	317.16
Tour Industry Share in the Cost of Wastewater Treatment Master Plan	34.41	0	142.37	176.78
Cost of the Wastewater Master Plan	1,521.00	244.20	1,538.50	3,303.70

The income from user charges of wastewater treatment in the Study Area was estimated to be around 4,149 Million Pesos over the Master Plan period, while the cost of the Wastewater Master Plan was estimated at about 3,304 Million Pesos.

The surplus of income from water supply as another income source for the Wastewater Master Plan in the Study Area could add around 634 Million Pesos over the Master Plan period if the cost of water production was assumed to be 90% of gross water supply income, and at about 317 Million Pesos over the Master Plan period when the cost of water production was assumed to be 95% of gross water supply income.

The contribution of the tour industry operators as the third income source of the Wastewater Master Plan was estimated on the basis of water consumption by tourists as percentage of total water consumption, which turned out to be around 5.3% in the Study Area (7.1% in Solidaridad), and the corresponding cumulative amount resulted in around 177 Million Pesos for the whole Study Area over the Master Plan period.

b. Financial Balance of Wastewater Master Plan

Financial balance resulting from the difference between income and cost of the Wastewater Master Plan differed depending on the Municipality in the Study Area, which was equivalent to say that the projected number of tourists differed greatly among the municipalities. The large inflow of tourists in Solidaridad Municipality made the financial balance positive not only in the Municipality, but the resulting surplus was sufficient to cover the financial deficits that were estimated to occur in Othon P. Blanco and Felipe Carrillo Puerto, thereby turning a financial surplus for the Wastewater Master Plan in the whole Study Area, as shown in the following Table.

Table H-36: Financial Balance of Wastewater Master Plan

Unit: Million Pesos

Financial Balance	OPB	FCP	Solidaridad	Study Area
Financial Balance with Wastewater Income Only	-350.93	-113.45	1,309.36	844.97
Financial Balance with All Income Sources (WS expenses = 90% of gross income)	-139.59	-95.23	1,890.88	1,656.07
Financial Balance with All Income Sources (WS expenses = 95% of gross income)	-228.05	-104.34	1,671.30	1,389.77

The above Table shows that the financial balance was estimated to be grossly negative in Othon P. Blanco and Felipe Carrillo Puerto under the three sets of assumptions for income estimation: wastewater charges only, and all income sources including wastewater charges, income surplus of water supply (assuming costs to comprise 90% and 95% of gross income), and the share of the tour industry in the cost of Wastewater Master Plan.

c. Indices of Financial Viability of Wastewater Master Plan

The flow of income and costs of the Wastewater Master Plan over the Master Plan period was examined as regards its financial viability using the following indices: financial internal rate of return (FIRR), net present value (NPV) calculated with a 10% discount rate, and the benefit cost ratio (B/C) calculated with a 10% discount rate, as indicated in the following Table.

Table H-37: Indices of Financial Viability of Wastewater Master Plan

Income Sources & Indices	OPB	FCP	Solidaridad	Study Area
Wastewater Income Only				
FIRR (%)	Not applicable	Not applicable	20.18	8.35
NPV10% (Million Pesos)			331.45	-84.84
B/C Ratio 10%			1.34	0.96
All Income Sources (WS expenses = 90% of gross income)				
FIRR (%)	Not applicable	Not applicable	32.76	17.12
NPV10% (Million Pesos)			644.72	343.79
B/C Ratio 10%			1.67	1.18
All Income Sources (WS expenses = 95% of gross income)				
FIRR (%)	Not applicable	Not applicable	28.66	14.62
NPV10% (Million Pesos)			537.06	220.13
B/C Ratio 10%			1.56	1.11

c.1 Financial Viability with Wastewater Treatment Service Charges

Even when the only income source was considered to be the service charges for wastewater treatment, FIRR turned out to be 20.18% in Solidaridad and 8.35% for the Study Area as a whole. On the other hand, in Othon P. Blanco and Felipe Carrillo Puerto, as the financial balance turned out to be grossly negative, the calculation of FIRR was considered to be meaningless.

As for the other indices, Solidaridad was estimated to produce NPV of 331.45 Million Pesos and a B/C ratio of 1.34, while in the Study Area as a whole NPV was estimated to be negative and the B/C ratio was estimated at 0.96 when discounted at 10%. These indices were also regarded as meaningless to compute in the case of Othon P. Blanco and Felipe Carrillo Puerto, as the financial balance turned out to be grossly negative in these two Municipalities.

c.2 Financial Viability with All Income Sources (WS expenses = 90% of gross income)

When all three income sources were included, and water supply income surplus was estimated as 10% of gross income, FIRR turned out to be 32.76% in Solidaridad and 17.12% in the Study Area. Also, NPV was estimated to be 644.72 Million Pesos in Solidaridad and 343.79 Million Pesos in the Study Area, while the B/C ratio was estimated to be 1.67 in Solidaridad and 1.18 in the Study Area, when discounted at 10%.

Even including all three income sources, the relevant financial viability indices were considered as meaningless to be caulculated in Othon P. Blanco and Felipe Carrillo Puerto, as the financial balance was still negative.

c.3 Financial Viability with All Income Sources (WS expenses = 95% of gross income)

When all three income sources were included, but the expenditures on water supply were estimated to comprise 95% of gross income, then logically the financial viability indices decreased slightly. FIRR was estimated to be 28.66% in Solidaridad and 14.62% in the Study Area, while NPV was estimated to be 537.06 Million Pesos in Solidaridad and 220.13 Million Pesos in the Study Area, while the B/C ratio was estimated to be 1.56 in Solidaridad and 1.11 in the Study Area, when discounted at 10%.

Again in this case, it was considered as meaningless to calculate these financial viability indices in Othon P. Blanco and Felipe Carrillo Puerto due to the large financial deficits.

H.2.5.3 Sensitivity Analysis

Sensitivity analysis was conducted assuming the usual three cases:

Case 1: 10% decrease in income

Case 2: 10% increase in cost

Case 3: 10% decrease in income and 10% increase in cost

The income sources considered were wastewater user charges only, and all income sources with water supply income surplus considering the costs of water supply to be 90% of gross water supply income. It was considered meaningless to conduct sensitivity analysis when water supply income surplus was calculated assuming the costs of water supply to be 95% of gross water supply income, as it would be a mere repetition of the previous case and the financial viability indices would simply be lower.

Table H-38: Sensitivity Analysis of Wastewater Master Plan

Income Sources & Indices	OPB	FCP	Solidaridad	Study Area
Base Case Wastewater Income Only FIRR (%) NPV10% (Million Pesos) B/C Ratio 10%	Not applicable	Not applicable	20.18 331.45 1.34	8.35 -84.84 0.96
Case 1: income -10% Wastewater Income Only FIRR (%) NPV10% (Million Pesos) B/C Ratio 10%	Not applicable	Not applicable	16.41 202.05 1.21	4.48 -271.96 0.86
Case 2: cost +10% Wastewater Income Only FIRR (%) NPV10% (Million Pesos) B/C Ratio 10%	Not applicable	Not applicable	16.76 235.20 1.22	4.85 -280.45 0.87
Case 3: income -10% & cost +10% Wastewater Income Only FIRR (%) NPV10% (Million Pesos) B/C Ratio 10%	Not applicable	Not applicable	13.15 105.80 1.1	0.99 -467.57 0.78
Base Case All Income Sources (WS expenses = 90% of gross income) FIRR (%) NPV10% (Million Pesos) B/C Ratio 10%	Not applicable	Not applicable	32.76 644.72 1.67	17.12 343.79 1.18
Case 1: income -10% All Income Sources (WS expenses = 90% of gross income) FIRR (%) NPV10% (Million Pesos) B/C Ratio 10%	Not applicable	Not applicable	27.19 484.00 1.54	12.42 113.80 1.06
Case 2: cost +10% All Income Sources (WS expenses = 90% of gross income) FIRR (%) NPV10% (Million Pesos) B/C Ratio 10%	Not applicable	Not applicable	28.22 558.26 1.53	12.85 148.18 1.07
Case 3: income -10% & cost +10% All Income Sources (WS expenses = 90% of gross income) FIRR (%) NPV10% (Million Pesos) B/C Ratio 10%	Not applicable	Not applicable	23.07 396.56 1.37	8.37 -81.81 0.96

In Solidaridad, the sensitivity analysis showed that the estimated income, even from wastewater service charges alone, would result in a stable financial situation, responding in similar ways to a decrease in income or an increase in cost. Even in the worst case scenario of a 10% increase in cost and a 10% reduction in income, the resulting financial viability indices were estimated as FIRR of 13.15%, NPV of 105.80 Million Pesos and B/C ratio of 1.1 when discounted at 10%. Needless to say, these indices improved notably when all income sources were considered.

For the Wastewater Master Plan in the Study Area, income from wastewater charges alone in the base case resulted in FIRR of 8.35%, which meant that the NPV was negative and the B/C ratio was below one when discounted at 10%. Under either case of a 10% decrease in income or a 10% increase in cost, the resulting FIRR was slightly lower than 5%. And the worst case of a simultaneous increase in cost and a decrease in income would result in FIRR of less than 1%.

When all income sources were considered in Wastewater Master Plan in the Study Area, the base case resulted in FIRR of 17.12%, NPV of 343.79 Million Pesos and B/C ratio of 1.18 when discounted at 10%. The case of 10% decrease in cost or a 10% increase in cost would result in FIRR of around 13%. And even the worst case of a simultaneous 10% reduction in income and a 10% increase in cost would result in FIRR of 8.37%, a negative NPV and B/C ratio of 0.96 when discounted at 10%.

H.2.5.4 Financial Plan

As the previous discussions indicated, Solidaridad and the Study Area would have sufficient income to cover the cost of the Wastewater Master Plan. On the other hand, Othon P. Blanco would need around 614 Million Pesos and Felipe Carrillo Puerto around 98 Million Pesos in additional funds in order to cover the cost of the Wastewater Master Plan in their respective Municipalities. Othon P. Blanco would need the additional funds up to 2009 while surplus is estimated between 2010 and 2015. Felipe Carrillo Puerto, on the other hand, would need these funds up to 2014.

As already mentioned, these additional funds required in OPB and FCP could be covered with the surplus estimated to occur in Solidaridad, which despite income deficits in 2004, 2005 and 2007, the surplus estimated over the Master Plan period would amount to around 1,890 Million Pesos.

Details on costs and income sources per Municipality and per year are shown in the corresponding Tables:

Othon P Blanco: Financial Plan of Wastewater Master Plan,

Felipe C Puerto: Financial Plan of Wastewater Master Plan,

Solidaridad: Financial Plan of Wastewater Master Plan, and

Study Area: Financial Plan of Wastewater Master Plan.

Table H-39: Othon P Blanco: Financial Plan of Wastewater Master Plan

Unit: Million Pesos

Item	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Costs	7.4	276.6	60.3	186.7	193.6	199.6	66.7	98.4	102.8	91.3	109.2	128.4	1,521.0
Income	8.7	276.6	60.3	186.7	193.6	199.6	137.8	160.1	173.8	184.6	198.2	215.4	1,381.4
User charges	5.5	11.9	25.1	43.5	59.7	87.3	119.8	140.2	152.3	162.0	173.8	189.0	1,170.1
Water supply	2.8	4.8	7.2	9.7	11.9	14.6	17.1	18.7	20.3	21.6	23.2	25.2	176.9
Tour industry	0.4	13.6	2.0	4.6	3.8	3.3	0.9	1.3	1.2	1.0	1.1	1.2	34.4
Other sources	0.0	246.4	26.0	129.0	118.1	94.5	0.0	0.0	0.0	0.0	0.0	0.0	614.0
Balance	1.3	0.0	0.0	0.0	0.0	0.0	71.1	61.7	71.0	93.3	89.0	87.0	474.5

Table H-40: Felipe C Puerto: Financial Plan of Wastewater Master Plan

Unit: Million Pesos

Item	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Costs	2.0	17.5	3.3	3.7	17.5	4.5	23.5	43.4	30.5	31.4	32.9	34.0	244.2
Income	2.0	17.5	3.3	3.7	17.5	4.5	23.5	43.4	30.5	31.4	32.9	36.7	149.0
User charges	0.1	0.4	0.9	1.7	2.5	3.7	8.5	13.0	18.1	22.5	26.9	32.4	130.7
Water supply	0.0	0.2	0.3	0.4	0.5	0.6	1.2	1.7	2.4	3.0	3.6	4.3	18.2
Tour industry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other sources	1.9	17.0	2.1	1.6	14.5	0.2	13.7	28.7	10.0	5.9	2.4	0.0	98.0
Balance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	2.9

Table H-41: Solidaridad: Financial Plan of Wastewater Master Plan

Unit: Million Pesos

Item	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Costs	165.7	186.5	56.7	338.5	62.7	209.5	199.5	64.7	62.2	64.4	69.2	58.9	1,538.5
Income	62.9	78.5	96.8	170.4	186.6	262.7	343.9	386.0	416.1	443.2	473.8	508.5	3,429.4
User charges	23.7	37.5	70.4	113.9	151.3	212.1	289.7	337.0	363.9	387.8	414.7	445.9	2,847.9
Water supply	11.9	15.0	20.1	25.3	30.3	35.4	41.4	44.9	48.5	51.7	55.3	59.5	439.2
Tour industry	27.3	26.0	6.3	31.3	5.1	15.2	12.9	4.0	3.7	3.7	3.8	3.1	142.4
Other sources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Balance	-102.8	-108.0	40.1	-168.1	123.9	53.2	144.4	321.3	353.9	378.8	404.6	449.6	1,890.9

Table H-42: Study Area: Financial Plan of Wastewater Master Plan

Unit: Million Pesos

Item	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Costs	175.1	480.6	120.3	528.9	273.8	413.6	289.7	206.5	195.5	187.1	211.3	221.3	3,303.7
Income	73.6	372.6	160.4	360.9	397.7	466.8	505.2	589.5	620.3	659.3	704.9	760.6	4,959.8
User charges	29.3	49.7	96.5	159.1	213.5	303.1	418.0	490.2	534.2	572.4	615.4	667.3	4,148.7
Water supply	14.7	19.9	27.6	35.4	42.7	50.5	59.7	65.4	71.2	76.3	82.1	89.0	634.3
Tour industry	27.7	39.6	8.2	35.8	8.9	18.5	13.8	5.3	4.9	4.7	5.0	4.4	176.8
Other sources	1.9	263.4	28.1	130.6	132.6	94.7	13.7	28.7	10.0	5.9	2.4	0.0	712.0
Balance	-101.5	-108.0	40.1	-168.0	123.9	53.2	215.5	383.0	424.8	472.2	493.6	539.3	2,368.1

H.2.6 Implementation Plan

Order of implementation of works should be decided with taking into account cost-effectiveness. Table H-43 shows cost per ton of BOD removal amount. According to the table, it is found that the implementation of the works in Solidaridad is the most cost-effective, subsequently, Othon P Blanco and Felipe C Puerto, from the aspect of treatment level, Level 4 is the most cost-effective, subsequently, Level 3, Level 2 and Level 1. Table H-44, Table H-45, Table H-46 and Table H-47 shows achievement ratio of the works in respective municipalities and in treatment levels that are set based on the order of cost-effectiveness.

Table H-43: Unit Investment Cost of BOD Remove (2004 to 2015)

Level	Total investment (million pesos)	BOD remove al amount (ton)	BOD removal unit investment cost(pesos/ton)
OTHON P. BLANCO			
Level 1	166.513	1,960.8	84,921
Level 2	211.62	4,996.0	42,358
Level 3	192.546	6,752.6	28,514
Level 4	604.328	37,119.5	16,281
Total	1,175.007	50,828.9	23,117
FELIPE CARRILLO PUERTO			
Level 1	100.668	1,056.0	95,330
Level 2	31.622	1,115.3	28,353
Level 3	67.843	2,323.6	29,197
Total	200.133	4,494.9	44,524
SOLIDARIDAD			
Level 1	36.994	482.4	76,687
Level 2	11.186	705.5	15,855
Level 3	200.093	8,015.6	24,963
Level 4	894.393	56,121.2	15,937
Total	1,142.666	65,324.7	17,492

Table H-44: Achievement Ratio in the Whole Study Area

	Target treatment amount (m3/day)					Achievement Ratio				
Year	Level 1	Level 2	Level 3	Level 4	Total	Level 1	Level 2	Level 3	Level 4	Total
2003	91.0	472.3	115.7	27,934.1	28,613.1	0.6%	2.7%	0.4%	26.9%	17.5%
2004	94.3	524.2	115.7	27,934.1	28,668.3	0.6%	2.9%	0.4%	26.9%	17.6%
2005	97.7	575.3	432.0	36,279.4	37,384.4	0.6%	3.2%	1.6%	34.9%	22.9%
2006	341.5	1,273.1	4,055.0	46,216.9	51,886.5	2.2%	7.1%	15.5%	44.5%	31.8%
2007	576.4	2,152.7	7,678.0	56,154.4	66,561.5	3.8%	12.1%	29.3%	54.0%	40.8%
2008	805.4	2,381.0	11,301.0	66,091.9	80,579.3	5.3%	13.4%	43.1%	63.6%	49.4%
2009	1,030.1	3,598.8	14,924.0	75,489.9	95,042.8	6.8%	20.2%	56.9%	72.6%	58.2%
2010	2,945.2	4,743.7	18,546.6	85,966.7	112,202.2	19.4%	26.6%	70.7%	82.7%	68.8%
2011	5,590.4	6,971.7	20,080.4	89,558.8	122,201.3	36.7%	39.1%	76.6%	86.2%	74.9%
2012	7,603.1	9,930.2	21,614.2	93,150.9	132,298.4	50.0%	55.8%	82.4%	89.6%	81.1%
2013	9,736.8	11,637.8	23,148.0	96,743.0	141,265.6	64.0%	65.4%	88.3%	93.1%	86.6%
2014	12,021.0	14,323.0	24,681.8	100,335.1	151,360.9	79.0%	80.4%	94.1%	96.5%	92.8%
2015	15,220.1	17,807.9	26,215.8	103,927.7	163,171.5	100.0%	100.0%	100.0%	100.0%	100.0%

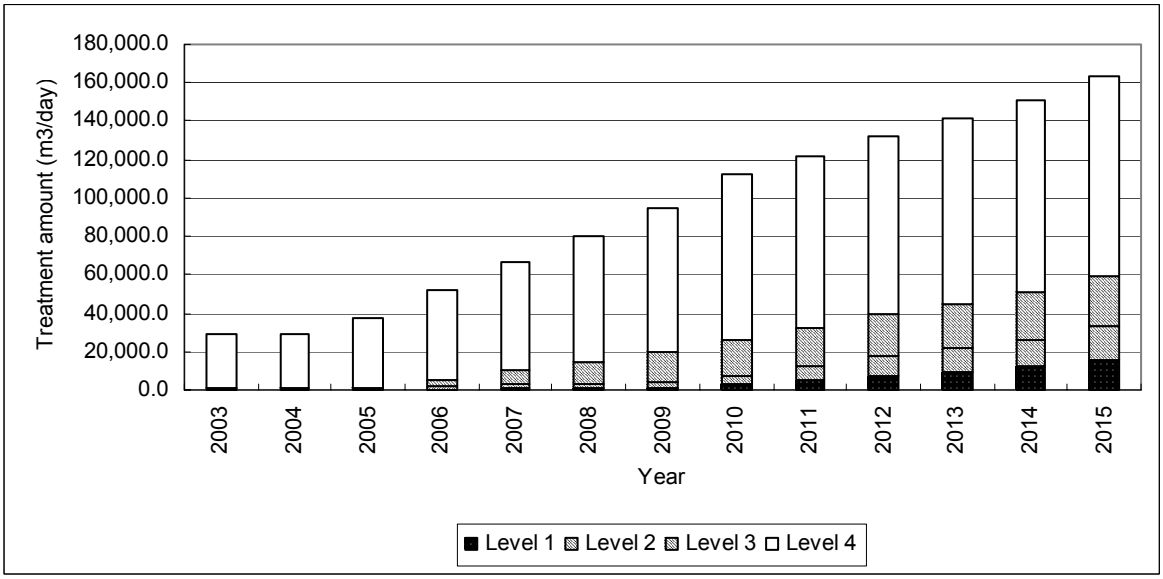


Figure H-18: Target treatment Amount in Whole Study Area

Table H-45: Achievement Ratio in Othón P. Blanco

	Target treatment amount (m3/day)					Achievement Ratio				
Year	Level 1	Level 2	Level 3	Level 4	Total	Level 1	Level 2	Level 3	Level 4	Total
2003	0	314.7	0	7,273	7,587	0.0%	2.5%	0.0%	17.6%	10.5%
2004	0	327.7	0	7,273	7,600	0.0%	2.6%	0.0%	17.6%	10.5%
2005	0	340.5	0	12,737	13,078	0.0%	2.7%	0.0%	30.8%	18.1%
2006	240.6	1,003.0	1504.9	17,380	20,129	2.9%	8.1%	14.7%	42.0%	27.8%
2007	472.4	1,845.6	3009.8	22,023	27,351	5.7%	14.9%	29.5%	53.2%	37.8%
2008	698.3	2,037.1	4514.7	26,666	33,916	8.4%	16.4%	44.2%	64.4%	46.9%
2009	919.9	3,221.0	6019.6	31,309	41,470	11.1%	26.0%	58.9%	75.6%	57.3%
2010	1,999.3	3,435.1	7524.4	35,953	48,911	24.1%	27.7%	73.7%	86.8%	67.6%
2011	3,195.3	5,180.8	8062.5	37,044	53,483	38.6%	41.7%	78.9%	89.5%	74.0%
2012	4,182.9	7,226.4	8600.6	38,135	58,145	50.5%	58.2%	84.2%	92.1%	80.4%
2013	5,156.3	8,393.4	9138.7	39,227	61,915	62.2%	67.6%	89.5%	94.7%	85.6%
2014	6,265.5	10,220.1	9676.8	40,318	66,481	75.6%	82.3%	94.7%	97.4%	91.9%
2015	8,284.5	12,410.6	10214.9	41,410	72,320	100.0%	100.0%	100.0%	100.0%	100.0%

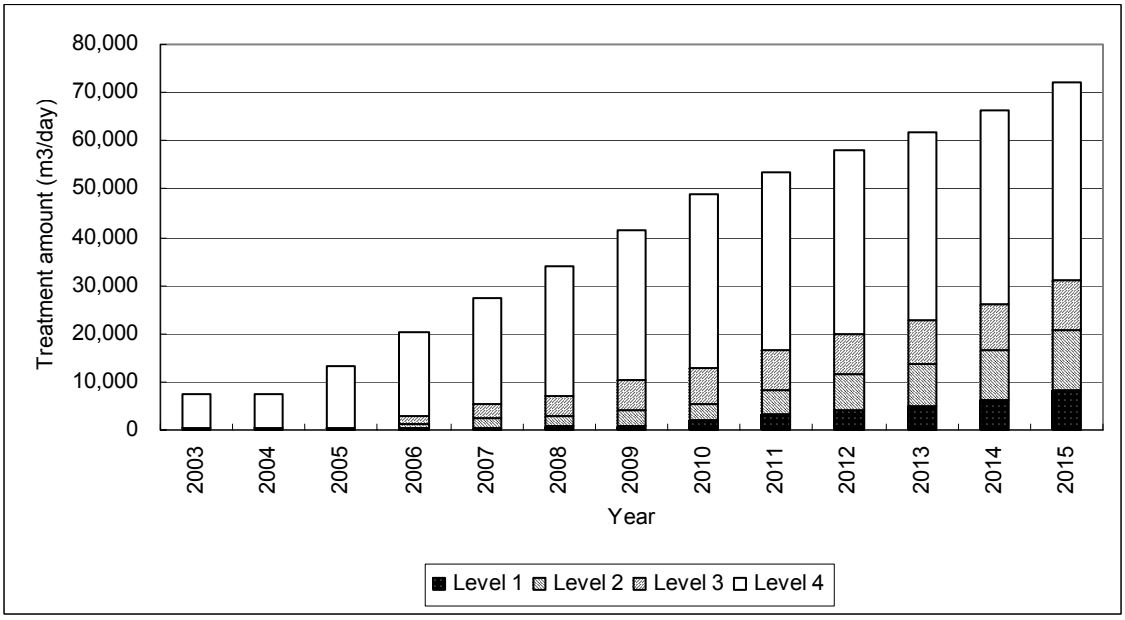


Figure H-19: Target treatment Amount in Othón P. Blanco

Table H-46: Achievement Ratio in Felipe Carrillo Puerto

	Target treatment amount (m3/day)				Achievement Ratio			
Year	Level 1	Level 2	Level 3	Total	Level 1	Level 2	Level 3	Total
2003	0.0	0.0	115.7	115.7	0.0%	0.0%	3.0%	0.9%
2004	0.0	0.0	115.7	115.7	0.0%	0.0%	3.0%	0.9%
2005	0.0	0.0	432.0	432.0	0.0%	0.0%	11.3%	3.4%
2006	0.0	0.0	770.6	770.6	0.0%	0.0%	20.2%	6.1%
2007	0.0	0.0	1,109.2	1,109.2	0.0%	0.0%	29.1%	8.9%
2008	0.0	0.0	1,447.8	1,447.8	0.0%	0.0%	37.9%	11.6%
2009	0.0	0.0	1,786.4	1,786.4	0.0%	0.0%	46.8%	14.3%
2010	514.7	894.4	2,125.0	3,534.1	10.4%	23.9%	55.7%	28.2%
2011	1,646.6	902.7	2,463.6	5,012.9	33.2%	24.1%	64.5%	40.0%
2012	2,386.5	1,790.9	2,802.2	6,979.6	48.1%	47.8%	73.4%	55.7%
2013	3,255.2	2,306.9	3,140.8	8,702.9	65.6%	61.6%	82.3%	69.5%
2014	4,151.0	2,778.3	3,479.4	10,408.7	83.6%	74.1%	91.1%	83.1%
2015	4,964.4	3,747.9	3,817.9	12,530.2	100.0%	100.0%	100.0%	100.0%

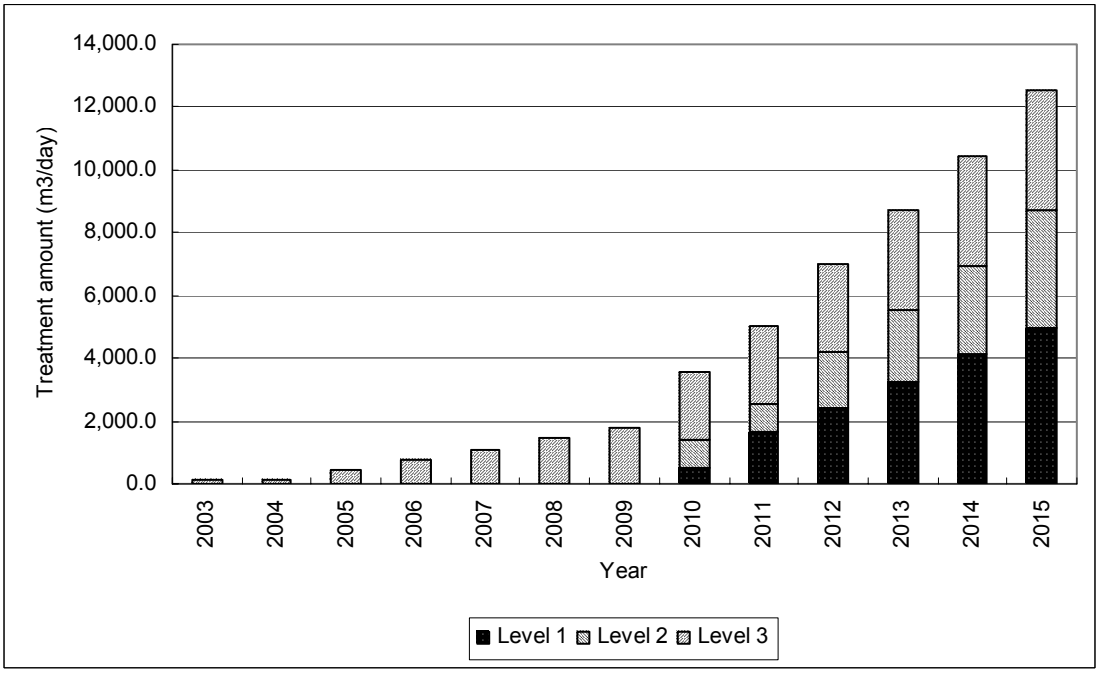


Figure H-20: Target treatment Amount in Felipe Carrillo Puerto

Table H-47: Achievement Ratio in Solidaridad

	Target treatment amount (m3/day)					Achievement Ratio				
Year	Level 1	Level 2	Level 3	Level 4	Total	Level 1	Level 2	Level 3	Level 4	Total
2003	91.0	157.6	0.0	20,661.5	20,910.1	4.6%	9.6%	0.0%	33.0%	26.7%
2004	94.3	196.5	0.0	20,661.5	20,952.3	4.8%	11.9%	0.0%	33.0%	26.8%
2005	97.7	234.8	0.0	23,542.4	23,874.9	5.0%	14.2%	0.0%	37.7%	30.5%
2006	100.9	270.1	1,779.5	28,836.8	30,987.3	5.1%	16.4%	14.6%	46.1%	39.6%
2007	104.0	307.1	3,559.0	34,131.2	38,101.3	5.3%	18.6%	29.2%	54.6%	48.6%
2008	107.1	343.9	5,338.5	39,425.6	45,215.1	5.4%	20.9%	43.8%	63.1%	57.7%
2009	110.2	377.8	7,118.0	44,180.5	51,786.5	5.6%	22.9%	58.4%	70.7%	66.1%
2010	431.2	414.2	8,897.2	50,014.2	59,756.8	21.9%	25.1%	73.0%	80.0%	76.3%
2011	748.5	888.2	9,554.3	52,514.9	63,705.9	38.0%	53.8%	78.4%	84.0%	81.3%
2012	1,033.7	912.9	10,211.4	55,015.6	67,173.6	52.4%	55.3%	83.8%	88.0%	85.8%
2013	1,325.3	937.5	10,868.5	57,516.3	70,647.6	67.2%	56.8%	89.2%	92.0%	90.2%
2014	1,604.5	1,324.6	11,525.6	60,017.0	74,471.7	81.4%	80.3%	94.6%	96.0%	95.1%
2015	1,971.2	1,649.4	12,183.0	62,517.8	78,321.4	100.0%	100.0%	100.0%	100.0%	100.0%

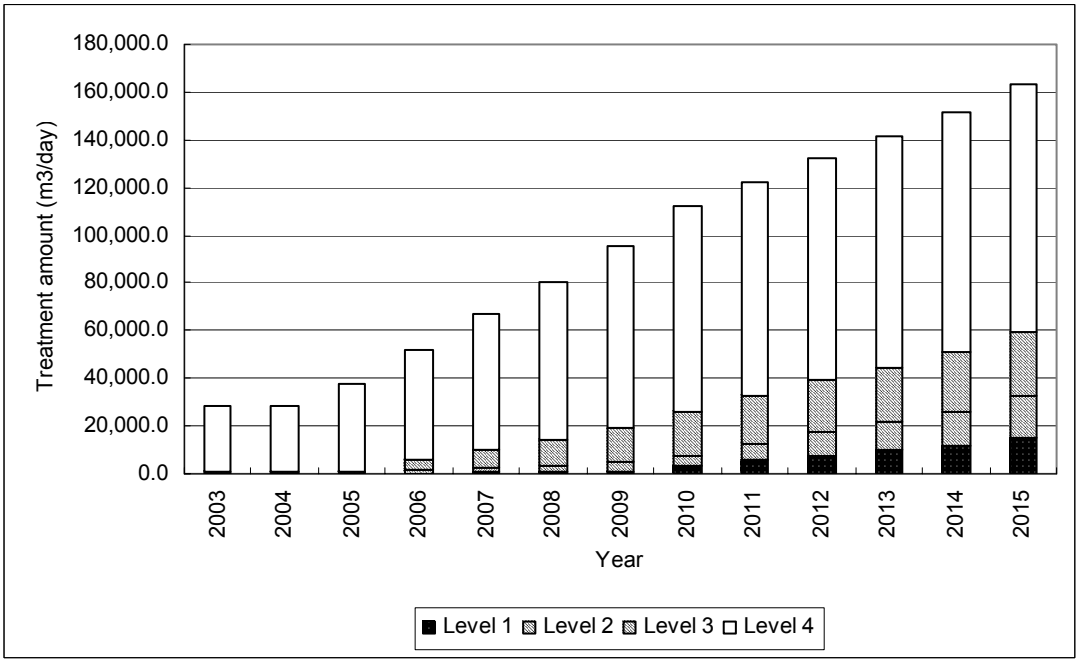


Figure H-21: Target treatment Amount in Solidaridad

Table H-48: Summary of Service Projected Communities in Othón P. Blanco

Year	Level 1	Level 2	Level 3	Level 4
2003		SUBTENIENTE LOPEZ		
2004				
2005				
2006	COCOYOL	PUNTA PULTICUB	BACALAR 1 / LIMONES 1 / Xahuachol 1	CHETUMAL new 1 / MAHAHUAL new 1
2007	PEDRO JOAQUIN COLDWELL	XCALAK		
2008	DIVORCIADOS, LOS		BACALAR 2 / LIMONES 2 / Xahuachol 2	MAHAHUAL new 2
2009	SAN PEDRO PERALTA	CALDERITAS		CHETUMAL new 2
2010	LAZARO CARDENAS DEL RIO / PALMAR / REFORMA / FRANCISCO VILLA / MANUEL AVILA CAMACHO		BACALAR 3 / LIMONES 3 / Xahuachol 3	MAHAHUAL new 3
2011	TRES GARANTIAS / JUAN SARABIA / RAMONAL / CHACCHOBEN / ALLENDE / LUIS ECHEVERRIA ALVAREZ	NICOLAS BRAVO / INGENIO ALVARO OBREGON		
2012	MIGUEL ALEMAN / PANTERA, LA / LAZARO CARDENAS SEGUNDO / NUEVO BECAR / LAZARO CARDENAS / BLANCA FLOR	ALVARO OBREGON / SERGIO BUTRON CASAS / MAYA BALAM		
2013	LAGUNA GUERRERO / NACHI COCOM / SACXAN / VALLEHERMOSO / HUATUSCO / SAN FRANCISCO BOTES / JESUS GONZALEZ ORTEGA	XUL-HA / CACAO		
2014	ZAMORA / SAN ROMAN / LIBERTAD, LA / RIO VERDE / SAN ISIDRO LA LAGUNA / ALTOS DE SEVILLA / OTILIO MONTANO / BUENA ESPERANZA / NUEVO JERUSALEN / DAVID GUSTAVO GUTIERREZ RUIZ	MOROCOY / PUCTE / CARLOS A. MADRAZO / KUCHUMATAN		
2015	DIECIOCHO DE MARZO / MARGARITA MAZA DE JUAREZ / RIO ESCONDIDO / TOMAS GARRIDO CANABAL / GUADALUPE VICTORIA / PACTO OBRERO-CAMPESINO / MELCHOR OCAMPO / PEDRO ANTONIO SANTOS / CEDRAL, EL / MIGUEL HIDALGO Y COSTILLA / DOS AGUADAS / ESTEBAN BACA CALDERON / BUENA FE / RAUDALES / TIERRAS NEGRAS / LAZARO CARDENAS DEL RIO TERCERO / PROGRESO, EL / FRANCISCO J. MUJICA / NUEVO TABASCO / ANDRES QUINTANA ROO / SANTA ROSA / SAN FERNANDO / ALVARO OBREGON VIEJO / LAZARO CARDENAS I / LIMONAR / SAN JOSE DE LA MONTANA / CAAN LUMIL / CEDRALITO, EL / VERACRUZ / CINCO DE MAYO / PARAISO, EL / NUEVO ICAICHE / CAANAN / PAYO OBISPO / REVOLUCION / NUEVO CAANAN / CEIBA, LA / JESUS MARTINEZ ROSS / ITURBIDE / GALLITO, EL	SABIDOS / UNION, LA / CAOBAS / HUAY-PIX / JOSE NARCISO ROVIROSA / UCUM		

Table H-49: Level1 Service Projected Population in Othón P. Blanco

Year / Name of community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Service population total	0	0	0	1,183	2,369	3,568	4,789	10,603	17,248	22,975	28,816	35,616	47,889
COCOYOL	1,101	1,131	1,160	1,183	1,206	1,229	1,252	1,276	1,299	1,322	1,345	1,368	1,391
PEDRO JOAQUIN COLDWELL	1,061	1,090	1,117	1,140	1,163	1,186	1,209	1,230	1,252	1,274	1,296	1,318	1,340
DIVORCIADOS, LOS	1,031	1,059	1,087	1,109	1,131	1,153	1,175	1,196	1,218	1,240	1,262	1,284	1,306
SAN PEDRO PERALTA	1,013	1,040	1,069	1,090	1,111	1,132	1,153	1,176	1,197	1,218	1,239	1,260	1,281
LAZARO CARDENAS DEL RIO	1,009	1,036	1,064	1,085	1,106	1,127	1,148	1,171	1,192	1,213	1,234	1,255	1,276
PALMAR	1,009	1,036	1,064	1,085	1,106	1,127	1,148	1,171	1,192	1,213	1,234	1,255	1,276
REFORMA	992	1,019	1,045	1,066	1,087	1,108	1,129	1,150	1,171	1,192	1,213	1,234	1,255
FRANCISCO VILLA	965	991	1,018	1,038	1,058	1,078	1,098	1,120	1,140	1,160	1,180	1,200	1,220
MANUEL AVILA CAMACHO	959	985	1,011	1,031	1,051	1,071	1,091	1,113	1,133	1,153	1,173	1,193	1,213
TRES GARANTIAS	959	985	1,011	1,031	1,051	1,071	1,091	1,113	1,133	1,153	1,173	1,193	1,213
JUAN SARABIA	949	975	999	1,019	1,039	1,059	1,079	1,100	1,120	1,140	1,160	1,180	1,200
RAMONAL	904	928	954	973	992	1,011	1,030	1,050	1,069	1,088	1,107	1,126	1,145
CHACCHOBEN	901	925	951	970	989	1,008	1,027	1,046	1,065	1,084	1,103	1,122	1,141
ALLENDE	899	923	949	968	987	1,006	1,025	1,044	1,063	1,082	1,101	1,120	1,139
LUIS ECHEVERRIA ALVAREZ	850	873	897	915	933	951	969	986	1,004	1,022	1,040	1,058	1,076
MIGUEL ALEMAN	787	808	830	847	864	881	898	914	931	948	965	982	999
PANTERA, LA	764	785	804	820	836	852	868	885	901	917	933	949	965
LAZARO CARDENAS SEGUNDO	754	774	796	812	828	844	860	876	892	908	924	940	956
NUEVO BECAR	744	764	784	800	816	832	848	863	879	895	911	927	943
LAZARO CARDENAS	736	756	776	792	808	824	840	854	870	886	902	918	934
BLANCA FLOR	723	743	761	776	791	806	821	837	852	867	882	897	912
LAGUNA GUERRERO	696	715	734	749	764	779	794	807	822	837	852	867	882
NACHI COCOM	667	685	703	717	731	745	759	773	787	801	815	829	843
SACXAN	636	653	671	684	697	710	723	738	751	764	777	790	803
VALLEHERMOSO	619	636	652	665	678	691	704	717	730	743	756	769	782
HUATUSCO	614	631	646	659	672	685	698	711	724	737	750	763	776
SAN FRANCISCO BOTES	611	628	643	656	669	682	695	707	720	733	746	759	772
JESUS GONZALEZ ORTEGA	606	622	640	653	666	679	692	704	717	730	743	756	769
ZAMORA	582	598	613	625	637	649	661	675	687	699	711	723	735
SAN ROMAN	581	597	612	624	636	648	660	673	685	697	709	721	733

Name of community / Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LIBERTAD, LA	574	590	604	616	628	640	652	664	676	688	700	712	724
RIO VERDE	549	564	579	591	603	615	627	637	649	661	673	685	697
SAN ISIDRO LA LAGUNA	510	524	537	548	559	570	581	591	602	613	624	635	646
ALTOS DE SEVILLA	489	502	516	526	536	546	556	568	578	588	598	608	618
OTILIO MONTANO	462	475	486	496	506	516	526	534	544	554	564	574	584
BUENA ESPERANZA	458	470	484	494	504	514	524	533	543	553	563	573	583
NUEVO JERUSALEN	434	446	457	466	475	484	493	503	512	521	530	539	548
DAVID GUSTAVO GUTIERREZ RUIZ	430	442	452	461	470	479	488	498	507	516	525	534	543
DIECIOCHO DE MARZO	398	409	419	427	435	443	451	461	469	477	485	493	501
MARGARITA MAZA DE JUAREZ	394	405	415	423	431	439	447	456	464	472	480	488	496
RIO ESCONDIDO	377	387	398	406	414	422	430	438	446	454	462	470	478
TOMAS GARRIDO CANABAL	364	374	383	391	399	407	415	421	429	437	445	453	461
GUADALUPE VICTORIA	356	366	374	382	390	398	406	412	419	426	433	440	447
PACTO OBRERO-CAMPESINO	355	365	373	381	389	397	405	411	418	425	432	439	446
MELCHOR OCAMPO	341	350	360	367	374	381	388	396	403	410	417	424	431
PEDRO ANTONIO SANTOS	339	348	358	365	372	379	386	394	401	408	415	422	429
CEDRAL, EL	332	341	350	357	364	371	378	385	392	399	406	413	420
MIGUEL HIDALGO Y COSTILLA	317	326	333	340	347	354	361	367	374	381	388	395	402
DOS AGUADAS	308	316	326	333	340	347	354	359	366	373	380	387	394
ESTEBAN BACA CALDERON	294	302	309	315	321	327	333	341	347	353	359	365	371
BUENA FE	292	300	307	313	319	325	331	338	344	350	356	362	368
RAUDALES	245	252	258	263	268	273	278	283	288	293	298	303	308
TIERRAS NEGRAS	244	251	256	261	266	271	276	282	287	292	297	302	307
LAZARO CARDENAS DEL RIO TERCERO	234	240	248	253	258	263	268	273	278	283	288	293	298
PROGRESO, EL	209	215	220	224	228	232	236	242	246	250	254	258	262
FRANCISCO J. MUJICA	208	214	219	223	227	231	235	240	244	248	252	256	260
NUEVO TABASCO	205	211	215	219	223	227	231	237	241	245	249	253	257
ANDRES QUINTANA ROO	204	210	214	218	222	226	230	235	239	243	247	251	255
SANTA ROSA	199	204	211	215	219	223	227	233	237	241	245	249	253

Name of community \ Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
SAN FERNANDO	198	203	210	214	218	222	226	231	235	239	243	247	251
ALVARO OBREGON VIEJO	191	196	202	206	210	214	218	222	226	230	234	238	242
LAZARO CARDENAS I	190	195	201	205	209	213	217	221	225	229	233	237	241
LIMONAR	189	194	200	204	208	212	216	220	224	228	232	236	240
SAN JOSE DE LA MONTANA	189	194	200	204	208	212	216	220	224	228	232	236	240
CAAN LUMIL	183	188	193	197	201	205	209	212	216	220	224	228	232
CEDRALITO, EL	181	186	190	194	198	202	206	209	213	217	221	225	229
VERACRUZ	180	185	189	193	197	201	205	208	212	216	220	224	228
CINCO DE MAYO	160	164	170	173	176	179	182	187	190	193	196	199	202
PARAISO, EL	160	164	170	173	176	179	182	187	190	193	196	199	202
NUEVO ICAICHE	149	153	157	160	163	166	169	173	176	179	182	185	188
CAANAN	148	152	156	159	162	165	168	172	175	178	181	184	187
PAYO OBISPO	144	148	151	154	157	160	163	166	169	172	175	178	181
REVOLUCION	142	146	149	152	155	158	161	164	167	170	173	176	179
NUEVO CAANAN	140	144	146	149	152	155	158	161	164	167	170	173	176
CEIBA, LA	131	135	137	140	143	146	149	151	154	157	160	163	166
JESUS MARTINEZ ROSS	130	134	136	139	142	145	148	149	152	155	158	161	164
ITURBIDE	124	127	132	135	138	141	144	146	149	152	155	158	161
GALLITO, EL	93	96	97	99	101	103	105	107	109	111	113	115	117
Population total	37,865	38,894	39,908	40,706	41,504	42,302	43,100	43,914	44,709	45,504	46,299	47,094	47,889

Table H-50: Level 1 Projected Treatment Amount in Othón P. Blanco

Year / Name of community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Projected treatment amount (m3/day)	0.0	0.0	0.0	204.7	409.8	617.3	828.6	1,834.3	2,983.8	3,974.5	4,985.0	6,161.6	8,284.5
COCOYOL	190.5	195.7	200.7	204.7	208.6	212.6	216.6	220.7	224.7	228.7	232.7	236.7	240.6
PEDRO JOAQUIN COLDWELL	183.6	188.6	193.2	197.2	201.2	205.2	209.2	212.8	216.6	220.4	224.2	228.0	231.8
DIVORCIADOS, LOS	178.4	183.2	188.1	191.9	195.7	199.5	203.3	206.9	210.7	214.5	218.3	222.1	225.9
SAN PEDRO PERALTA	175.2	179.9	184.9	188.6	192.2	195.8	199.5	203.4	207.1	210.7	214.3	218.0	221.6
LAZARO CARDENAS DEL RIO	174.6	179.2	184.1	187.7	191.3	195.0	198.6	202.6	206.2	209.8	213.5	217.1	220.7
PALMAR	174.6	179.2	184.1	187.7	191.3	195.0	198.6	202.6	206.2	209.8	213.5	217.1	220.7
REFORMA	171.6	176.3	180.8	184.4	188.1	191.7	195.3	199.0	202.6	206.2	209.8	213.5	217.1
FRANCISCO VILLA	166.9	171.4	176.1	179.6	183.0	186.5	190.0	193.8	197.2	200.7	204.1	207.6	211.1
MANUEL AVILA CAMACHO	165.9	170.4	174.9	178.4	181.8	185.3	188.7	192.5	196.0	199.5	202.9	206.4	209.8
TRES GARANTIAS	165.9	170.4	174.9	178.4	181.8	185.3	188.7	192.5	196.0	199.5	202.9	206.4	209.8
JUAN SARABIA	164.2	168.7	172.8	176.3	179.7	183.2	186.7	190.3	193.8	197.2	200.7	204.1	207.6
RAMONAL	156.4	160.5	165.0	168.3	171.6	174.9	178.2	181.7	184.9	188.2	191.5	194.8	198.1
CHACCHOBEN	155.9	160.0	164.5	167.8	171.1	174.4	177.7	181.0	184.2	187.5	190.8	194.1	197.4
ALLENDE	155.5	159.7	164.2	167.5	170.8	174.0	177.3	180.6	183.9	187.2	190.5	193.8	197.0
LUIS ECHEVERRIA ALVAREZ	147.1	151.0	155.2	158.3	161.4	164.5	167.6	170.6	173.7	176.8	179.9	183.0	186.1
MIGUEL ALEMAN	136.2	139.8	143.6	146.5	149.5	152.4	155.4	158.1	161.1	164.0	166.9	169.9	172.8
PANTERA, LA	132.2	135.8	139.1	141.9	144.6	147.4	150.2	153.1	155.9	158.6	161.4	164.2	166.9
LAZARO CARDENAS SEGUNDO	130.4	133.9	137.7	140.5	143.2	146.0	148.8	151.5	154.3	157.1	159.9	162.6	165.4
NUEVO BECAR	128.7	132.2	135.6	138.4	141.2	143.9	146.7	149.3	152.1	154.8	157.6	160.4	163.1
LAZARO CARDENAS	127.3	130.8	134.2	137.0	139.8	142.6	145.3	147.7	150.5	153.3	156.0	158.8	161.6
BLANCA FLOR	125.1	128.5	131.7	134.2	136.8	139.4	142.0	144.8	147.4	150.0	152.6	155.2	157.8
LAGUNA GUERRERO	120.4	123.7	127.0	129.6	132.2	134.8	137.4	139.6	142.2	144.8	147.4	150.0	152.6
NACHI COCOM	115.4	118.5	121.6	124.0	126.5	128.9	131.3	133.7	136.2	138.6	141.0	143.4	145.8
SACXAN	110.0	113.0	116.1	118.3	120.6	122.8	125.1	127.7	129.9	132.2	134.4	136.7	138.9
VALLEHERMOSO	107.1	110.0	112.8	115.0	117.3	119.5	121.8	124.0	126.3	128.5	130.8	133.0	135.3
HUATUSCO	106.2	109.2	111.8	114.0	116.3	118.5	120.8	123.0	125.3	127.5	129.8	132.0	134.2
SAN FRANCISCO BOTES	105.7	108.6	111.2	113.5	115.7	118.0	120.2	122.3	124.6	126.8	129.1	131.3	133.6
JESUS GONZALEZ ORTEGA	104.8	107.6	110.7	113.0	115.2	117.5	119.7	121.8	124.0	126.3	128.5	130.8	133.0

Name of community / Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
ZAMORA	100.7	103.5	106.0	108.1	110.2	112.3	114.4	116.8	118.9	120.9	123.0	125.1	127.2
SAN ROMAN	100.5	103.3	105.9	108.0	110.0	112.1	114.2	116.4	118.5	120.6	122.7	124.7	126.8
LIBERTAD, LA	99.3	102.1	104.5	106.6	108.6	110.7	112.8	114.9	116.9	119.0	121.1	123.2	125.3
RIO VERDE	95.0	97.6	100.2	102.2	104.3	106.4	108.5	110.2	112.3	114.4	116.4	118.5	120.6
SAN ISIDRO LA LAGUNA	88.2	90.7	92.9	94.8	96.7	98.6	100.5	102.2	104.1	106.0	108.0	109.9	111.8
ALTOS DE SEVILLA	84.6	86.8	89.3	91.0	92.7	94.5	96.2	98.3	100.0	101.7	103.5	105.2	106.9
OTILIO MONTANO	79.9	82.2	84.1	85.8	87.5	89.3	91.0	92.4	94.1	95.8	97.6	99.3	101.0
BUENA ESPERANZA	79.2	81.3	83.7	85.5	87.2	88.9	90.7	92.2	93.9	95.7	97.4	99.1	100.9
NUEVO JERUSALEN	75.1	77.2	79.1	80.6	82.2	83.7	85.3	87.0	88.6	90.1	91.7	93.2	94.8
DAVID GUSTAVO GUTIERREZ RUIZ	74.4	76.5	78.2	79.8	81.3	82.9	84.4	86.2	87.7	89.3	90.8	92.4	93.9
DIECIOCHO DE MARZO	68.9	70.8	72.5	73.9	75.3	76.6	78.0	79.8	81.1	82.5	83.9	85.3	86.7
MARGARITA MAZA DE JUAREZ	68.2	70.1	71.8	73.2	74.6	75.9	77.3	78.9	80.3	81.7	83.0	84.4	85.8
RIO ESCONDIDO	65.2	67.0	68.9	70.2	71.6	73.0	74.4	75.8	77.2	78.5	79.9	81.3	82.7
TOMAS GARRIDO CANABAL	63.0	64.7	66.3	67.6	69.0	70.4	71.8	72.8	74.2	75.6	77.0	78.4	79.8
GUADALUPE VICTORIA	61.6	63.3	64.7	66.1	67.5	68.9	70.2	71.3	72.5	73.7	74.9	76.1	77.3
PACTO OBRERO-CAMPESINO	61.4	63.1	64.5	65.9	67.3	68.7	70.1	71.1	72.3	73.5	74.7	75.9	77.2
MELCHOR OCAMPO	59.0	60.6	62.3	63.5	64.7	65.9	67.1	68.5	69.7	70.9	72.1	73.4	74.6
PEDRO ANTONIO SANTOS	58.6	60.2	61.9	63.1	64.4	65.6	66.8	68.2	69.4	70.6	71.8	73.0	74.2
CEDRAL, EL	57.4	59.0	60.6	61.8	63.0	64.2	65.4	66.6	67.8	69.0	70.2	71.4	72.7
MIGUEL HIDALGO Y COSTILLA	54.8	56.4	57.6	58.8	60.0	61.2	62.5	63.5	64.7	65.9	67.1	68.3	69.5
DOS AGUADAS	53.3	54.7	56.4	57.6	58.8	60.0	61.2	62.1	63.3	64.5	65.7	67.0	68.2
ESTEBAN BACA CALDERON	50.9	52.2	53.5	54.5	55.5	56.6	57.6	59.0	60.0	61.1	62.1	63.1	64.2
BUENA FE	50.5	51.9	53.1	54.1	55.2	56.2	57.3	58.5	59.5	60.6	61.6	62.6	63.7
RAUDALES	42.4	43.6	44.6	45.5	46.4	47.2	48.1	49.0	49.8	50.7	51.6	52.4	53.3
TIERRAS NEGRAS	42.2	43.4	44.3	45.2	46.0	46.9	47.7	48.8	49.7	50.5	51.4	52.2	53.1
LAZARO CARDENAS DEL RIO TERCERO	40.5	41.5	42.9	43.8	44.6	45.5	46.4	47.2	48.1	49.0	49.8	50.7	51.6
PROGRESO, EL	36.2	37.2	38.1	38.8	39.4	40.1	40.8	41.9	42.6	43.3	43.9	44.6	45.3
FRANCISCO J. MUJICA	36.0	37.0	37.9	38.6	39.3	40.0	40.7	41.5	42.2	42.9	43.6	44.3	45.0
NUEVO TABASCO	35.5	36.5	37.2	37.9	38.6	39.3	40.0	41.0	41.7	42.4	43.1	43.8	44.5

Year / Name of community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
ANDRES QUINTANA ROO	35.3	36.3	37.0	37.7	38.4	39.1	39.8	40.7	41.3	42.0	42.7	43.4	44.1
SANTA ROSA	34.4	35.3	36.5	37.2	37.9	38.6	39.3	40.3	41.0	41.7	42.4	43.1	43.8
SAN FERNANDO	34.3	35.1	36.3	37.0	37.7	38.4	39.1	40.0	40.7	41.3	42.0	42.7	43.4
ALVARO OBREGON VIEJO	33.0	33.9	34.9	35.6	36.3	37.0	37.7	38.4	39.1	39.8	40.5	41.2	41.9
LAZARO CARDENAS I	32.9	33.7	34.8	35.5	36.2	36.8	37.5	38.2	38.9	39.6	40.3	41.0	41.7
LIMONAR	32.7	33.6	34.6	35.3	36.0	36.7	37.4	38.1	38.8	39.4	40.1	40.8	41.5
SAN JOSE DE LA MONTANA	32.7	33.6	34.6	35.3	36.0	36.7	37.4	38.1	38.8	39.4	40.1	40.8	41.5
CAAN LUMIL	31.7	32.5	33.4	34.1	34.8	35.5	36.2	36.7	37.4	38.1	38.8	39.4	40.1
CEDRALITO, EL	31.3	32.2	32.9	33.6	34.3	34.9	35.6	36.2	36.8	37.5	38.2	38.9	39.6
VERACRUZ	31.1	32.0	32.7	33.4	34.1	34.8	35.5	36.0	36.7	37.4	38.1	38.8	39.4
CINCO DE MAYO	27.7	28.4	29.4	29.9	30.4	31.0	31.5	32.4	32.9	33.4	33.9	34.4	34.9
PARAISO, EL	27.7	28.4	29.4	29.9	30.4	31.0	31.5	32.4	32.9	33.4	33.9	34.4	34.9
NUEVO ICAICHE	25.8	26.5	27.2	27.7	28.2	28.7	29.2	29.9	30.4	31.0	31.5	32.0	32.5
CAANAN	25.6	26.3	27.0	27.5	28.0	28.5	29.1	29.8	30.3	30.8	31.3	31.8	32.4
PAYO OBISPO	24.9	25.6	26.1	26.6	27.2	27.7	28.2	28.7	29.2	29.8	30.3	30.8	31.3
REVOLUCION	24.6	25.3	25.8	26.3	26.8	27.3	27.9	28.4	28.9	29.4	29.9	30.4	31.0
NUEVO CAANAN	24.2	24.9	25.3	25.8	26.3	26.8	27.3	27.9	28.4	28.9	29.4	29.9	30.4
CEIBA, LA	22.7	23.4	23.7	24.2	24.7	25.3	25.8	26.1	26.6	27.2	27.7	28.2	28.7
JESUS MARTINEZ ROSS	22.5	23.2	23.5	24.0	24.6	25.1	25.6	25.8	26.3	26.8	27.3	27.9	28.4
ITURBIDE	21.5	22.0	22.8	23.4	23.9	24.4	24.9	25.3	25.8	26.3	26.8	27.3	27.9
GALLITO, EL	16.1	16.6	16.8	17.1	17.5	17.8	18.2	18.5	18.9	19.2	19.5	19.9	20.2
Potential treatment amount total	0.0	0.0	0.0	204.7	409.8	617.3	828.6	1,834.3	2,983.8	3,974.5	4,985.0	6,161.6	8,284.5

Table H-51: Level 2 Service Projected Population in Othón P. Blanco

Year / Name of community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Service population total	1,819	1,894	1,968	5,798	10,668	11,775	18,618	19,856	29,946	41,771	48,517	59,075	71,739
PUNTA PULTICUB	361	1,800	3,302	3,791	4,311	4,845	5,386	5,931	6,498	7,064	7,629	8,193	8,757
XCALAK	440	1,840	3,302	3,791	4,311	4,845	5,386	5,931	6,498	7,064	7,629	8,193	8,757
CALDERITAS	4,976	5,137	5,298	5,404	5,510	5,616	5,722	5,829	5,935	6,041	6,147	6,253	6,359
NICOLAS BRAVO	3,893	3,968	4,044	4,125	4,206	4,287	4,368	4,449	4,530	4,611	4,692	4,773	4,854
INGENIO ALVARO OBREGON	3,533	3,676	3,821	3,898	3,975	4,052	4,129	4,205	4,281	4,357	4,433	4,509	4,585
ALVARO OBREGON	3,248	3,357	3,464	3,533	3,602	3,671	3,740	3,811	3,880	3,949	4,018	4,087	4,156
SERGIO BUTRON CASAS	2,777	2,944	3,111	3,173	3,235	3,297	3,359	3,423	3,485	3,547	3,609	3,671	3,733
MAYA BALAM	2,213	2,376	2,539	2,590	2,641	2,692	2,743	2,793	2,844	2,895	2,946	2,997	3,048
XUL-HA	2,122	2,249	2,376	2,424	2,472	2,520	2,568	2,614	2,662	2,710	2,758	2,806	2,854
CACAO	1,914	1,979	2,046	2,087	2,128	2,169	2,210	2,251	2,292	2,333	2,374	2,415	2,456
SUBTENIENTE LOPEZ	1,819	1,894	1,968	2,007	2,046	2,085	2,124	2,165	2,204	2,243	2,282	2,321	2,360
MOROCOY	1,772	1,870	1,967	2,006	2,045	2,084	2,123	2,164	2,203	2,242	2,281	2,320	2,359
PUCTE	1,840	1,878	1,917	1,955	1,993	2,031	2,069	2,109	2,147	2,185	2,223	2,261	2,299
CARLOS A. MADRAZO	1,725	1,785	1,843	1,880	1,917	1,954	1,991	2,028	2,065	2,102	2,139	2,176	2,213
KUCHUMATAN	1,687	1,733	1,778	1,814	1,850	1,886	1,922	1,956	1,992	2,028	2,064	2,100	2,136
SABIDOS	1,600	1,643	1,688	1,722	1,756	1,790	1,824	1,857	1,891	1,925	1,959	1,993	2,027
UNION, LA	1,504	1,545	1,584	1,616	1,648	1,680	1,712	1,743	1,775	1,807	1,839	1,871	1,903
CAOBAS	1,480	1,520	1,560	1,591	1,622	1,653	1,684	1,717	1,748	1,779	1,810	1,841	1,872
HUAY-PIX	1,421	1,460	1,497	1,527	1,557	1,587	1,617	1,647	1,677	1,707	1,737	1,767	1,797
JOSE NARCISO ROVIROSA	1,282	1,317	1,350	1,377	1,404	1,431	1,458	1,486	1,513	1,540	1,567	1,594	1,621
UCUM	1,257	1,291	1,325	1,352	1,379	1,406	1,433	1,458	1,485	1,512	1,539	1,566	1,593
Population total	42,864	47,262	51,780	53,663	55,608	57,581	59,568	61,567	63,605	65,641	67,675	69,707	71,739

Table H-52: Level2 Projected Treatment Amount in Othón P. Blanco

Year / Name of community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Projected treatment amount (m3/day)	314.7	327.7	340.5	1,003.0	1,845.6	2,037.1	3,221.0	3,435.1	5,180.8	7,226.4	8,393.4	10,220.1	12,410.6
PUNTA PULTICUB	62.5	311.4	571.2	655.8	745.8	838.2	931.8	1,026.1	1,124.2	1,222.1	1,319.8	1,417.4	1,514.9
XCALAK	76.1	318.3	571.2	655.8	745.8	838.2	931.8	1,026.1	1,124.2	1,222.1	1,319.8	1,417.4	1,514.9
CALDERITAS	860.8	888.7	916.6	934.9	953.2	971.6	989.9	1,008.4	1,026.8	1,045.1	1,063.4	1,081.8	1,100.1
NICOLAS BRAVO	673.5	686.5	699.6	713.6	727.6	741.7	755.7	769.7	783.7	797.7	811.7	825.7	839.7
INGENIO ALVARO OBREGON	611.2	635.9	661.0	674.4	687.7	701.0	714.3	727.5	740.6	753.8	766.9	780.1	793.2
ALVARO OBREGON	561.9	580.8	599.3	611.2	623.1	635.1	647.0	659.3	671.2	683.2	695.1	707.1	719.0
SERGIO BUTRON CASAS	480.4	509.3	538.2	548.9	559.7	570.4	581.1	592.2	602.9	613.6	624.4	635.1	645.8
MAYA BALAM	382.8	411.0	439.2	448.1	456.9	465.7	474.5	483.2	492.0	500.8	509.7	518.5	527.3
XUL-HA	367.1	389.1	411.0	419.4	427.7	436.0	444.3	452.2	460.5	468.8	477.1	485.4	493.7
CACAO	331.1	342.4	354.0	361.1	368.1	375.2	382.3	389.4	396.5	403.6	410.7	417.8	424.9
SUBTENIENTE LOPEZ	314.7	327.7	340.5	347.2	354.0	360.7	367.5	374.5	381.3	388.0	394.8	401.5	408.3
MOROCOY	306.6	323.5	340.3	347.0	353.8	360.5	367.3	374.4	381.1	387.9	394.6	401.4	408.1
PUCTE	318.3	324.9	331.6	338.2	344.8	351.4	357.9	364.9	371.4	378.0	384.6	391.2	397.7
CARLOS A. MADRAZO	298.4	308.8	318.8	325.2	331.6	338.0	344.4	350.8	357.2	363.6	370.0	376.4	382.8
KUCHUMATAN	291.9	299.8	307.6	313.8	320.1	326.3	332.5	338.4	344.6	350.8	357.1	363.3	369.5
SABIDOS	276.8	284.2	292.0	297.9	303.8	309.7	315.6	321.3	327.1	333.0	338.9	344.8	350.7
UNION, LA	260.2	267.3	274.0	279.6	285.1	290.6	296.2	301.5	307.1	312.6	318.1	323.7	329.2
CAOBAS	256.0	263.0	269.9	275.2	280.6	286.0	291.3	297.0	302.4	307.8	313.1	318.5	323.9
HUAY-PIX	245.8	252.6	259.0	264.2	269.4	274.6	279.7	284.9	290.1	295.3	300.5	305.7	310.9
JOSE NARCISO ROVIROSA	221.8	227.8	233.6	238.2	242.9	247.6	252.2	257.1	261.7	266.4	271.1	275.8	280.4
UCUM	217.5	223.3	229.2	233.9	238.6	243.2	247.9	252.2	256.9	261.6	266.2	270.9	275.6
Potential treatment amount total	7,415.4	8,176.3	8,957.8	9,283.6	9,620.3	9,961.7	10,305.2	10,651.1	11,003.5	11,355.8	11,707.6	12,059.5	12,410.6

Table H-53: Level3 Service Projected Population in Othón P. Blanco

Year / Community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total population													
BACALAR	11,639	12,439	13,237	14,075	14,913	15,751	16,589	17,428	18,266	19,104	19,942	20,780	21,618
LIMONES	5,254	6,378	7,502	8,627	9,752	10,877	12,002	13,127	14,252	15,377	16,502	17,627	18,752
Xahuachol	322	3,532	6,878	7,944	9,071	10,227	11,396	12,575	13,799	15,021	16,240	17,459	18,676
Total	17,215	22,349	27,617	30,646	33,736	36,855	39,987	43,130	46,317	49,502	52,684	55,866	59,046
Service population													
BACALAR	0	0	0	7,208	7,208	14,416	14,416	17,428	18,266	19,104	19,942	20,780	21,618
LIMONES	0	0	0	6,248	6,249	10,877	12,002	13,127	14,252	15,377	16,502	17,627	18,746
Xahuachol	0	0	0	6,225	6,225	10,227	11,396	12,575	13,799	15,021	16,240	17,459	18,676
Total	0	0	0	19,681	19,682	35,520	37,814	43,130	46,317	49,502	52,684	55,866	59,040

Table H-54: Level3 Potential Amount and Projected Treatment Capacity in Othón P. Blanco

Year / Community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Potential amount total (m3/day)													
BACALAR	2,013.5	2,151.9	2,290.0	2,435.0	2,579.9	2,724.9	2,869.9	3,015.0	3,160.0	3,305.0	3,450.0	3,594.9	3,739.9
LIMONES	908.9	1,103.4	1,297.8	1,492.5	1,687.1	1,881.7	2,076.3	2,271.0	2,465.6	2,660.2	2,854.8	3,049.5	3,244.1
Xahuachol	55.7	611.0	1,189.9	1,374.3	1,569.3	1,769.3	1,971.5	2,175.5	2,387.2	2,598.6	2,809.5	3,020.4	3,230.9
Total	2,978.1	3,866.3	4,777.7	5,301.8	5,836.3	6,375.9	6,917.7	7,461.5	8,012.8	8,563.8	9,114.3	9,664.8	10,214.9
Treatment capacity (m3/day)													
BACALAR	0.0	0.0	0.0	1,247.0	1,247.0	2,494.0	2,494.0	3,741.0	3,741.0	3,741.0	3,741.0	3,741.0	3,741.0
LIMONES	0.0	0.0	0.0	1,081.0	1,081.0	2,162.0	2,162.0	3,243.0	3,243.0	3,243.0	3,243.0	3,243.0	3,243.0
Xahuachol	0.0	0.0	0.0	1,077.0	1,077.0	2,154.0	2,154.0	3,231.0	3,231.0	3,231.0	3,231.0	3,231.0	3,231.0
Total	0.0	0.0	0.0	3,405.0	3,405.0	6,810.0	6,810.0	10,215.0	10,215.0	10,215.0	10,215.0	10,215.0	10,215.0

Table H-55: Level4 Service Projected Population in Othón P. Blanco

Year / Community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total population													
CHETUMAL	130,257	133,142	136,027	138,755	141,483	144,211	146,939	149,665	152,387	155,109	157,831	160,553	163,275
MAHAHUAL	956	8,908	17,196	26,479	35,637	44,741	53,816	62,873	65,509	68,149	70,792	73,439	76,088
Total	131,213	142,050	153,223	165,234	177,120	188,952	200,755	212,538	217,896	223,258	228,623	233,992	239,363
Service population													
CHETUMAL	37,044	37,044	68,630	115,954	115,954	115,954	146,939	149,665	152,387	155,109	157,831	160,553	163,275
MAHAHUAL	956	4,994	4,994	26,479	28,694	44,741	52,393	62,873	65,509	68,149	70,792	73,439	76,088
Total	38,000	42,038	73,624	142,433	144,648	160,695	199,332	212,538	217,896	223,258	228,623	233,992	239,363

Table H-56: Level4 Potential Amount and Projected Treatment Capacity in Othón P. Blanco

Year / Community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Potential amount total (m3/day)													
CHETUMAL	22,534.5	23,033.6	23,532.7	24,004.6	24,476.6	24,948.5	25,420.4	25,892.0	26,363.0	26,833.9	27,304.8	27,775.7	28,246.6
MAHAHUAL	165.4	1,541.1	2,974.9	4,580.9	6,165.2	7,740.2	9,310.2	10,877.0	11,333.1	11,789.8	12,247.0	12,705.0	13,163.3
Total	22,699.9	24,574.7	26,507.6	28,585.5	30,641.8	32,688.7	34,730.6	36,769.0	37,696.1	38,623.7	39,551.8	40,480.7	41,409.9
Treatment capacity (m3/day)													
CHETUMAL	6,408.6	6,408.6	11,873.0	20,060.0	20,060.0	20,060.0	28,247.0	28,247.0	28,247.0	28,247.0	28,247.0	28,247.0	28,247.0
MAHAHUAL	864.0	864.0	864.0	4,964.0	4,964.0	9,064.0	9,064.0	13,164.0	13,164.0	13,164.0	13,164.0	13,164.0	13,164.0
Total	7,272.6	7,272.6	12,737.0	25,024.0	25,024.0	29,124.0	37,311.0	41,411.0	41,411.0	41,411.0	41,411.0	41,411.0	41,411.0

Table H-57: Summary of Service Projected Communities in Felipe Carrillo Puerto

Year	Level 1	Level 2	Level 3	Level 4
2003				
2004				
2005				
2006			FELIPE CARRILLO PUERTO 1	
2007				
2008				
2009			FELIPE CARRILLO PUERTO 2	
2010	POLYUC / X-HAZIL SUR	CHUNHUHUB		
2011	SANTA ROSA SEGUNDO / X-YATIL / LAGUNA KANA / PRESIDENTE JUAREZ / PETCACAB / TUZIK 1			
2012	MIXTEQUILLA / YAXLEY / FILOMENO MATA / CHUNHUAS / YOACTUN / EMILIANO ZAPATA	TIHOSUCO	FELIPE CARRILLO PUERTO 3	
2013	SANTA MARIA PONIENTE / CHUN-YAH / BETANIA / TIXCACAL GUARDIA / NUEVO ISRAEL / IGNACIO MANUEL ALTAMIRANO / CHAN SANTA CRUZ / KAMPOKOLCHE	SENOR		
2014	RAMONAL / CHUMPON / UH MAY / DZOYOLA / KOPCHEN / SAN JOSE SEGUNDO / CHANCAH VERACRUZ / CHANCAH DERREPENTE / SAN FRANCISCO AKE / SAN FELIPE BERRIOZABAL / TABI	TEPICH		
2015	SAN ANDRES / SAN RAMON / ANDRES QUINTANA ROO / NUEVA LORIA / JOSE MARIA PINO SUAREZ / TRAPICH / REFORMA AGRARIA / CHUN ON / FRANCISCO MAY / FRANCISCO I. MADERO / SANTA LUCIA / MELCHOR OCAMPO / SAN LUIS / CHANCHEN COMANDANTE / CANZEPCHEN / HOBOMPICH / TAC-CHIVO / YODZONOT CHICO / X-KONHA / X-HAZIL NORTE / NOH-CAH / TRES REYES / CHUNYAXCHE	NOH-BEC / X-PICHIL / DZULA		

Table H-58: Level 1 Service Projected Population in Felipe Carrillo Puerto

Year / Name of community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Service population total	0	0	0	0	0	0	0	2,845	9,182	13,429	18,484	23,782	27,203
POLYUC	1,281	1,309	1,336	1,354	1,372	1,390	1,408	1,427	1,440	1,453	1,466	1,479	1,492
X-HAZIL SUR	1,274	1,302	1,328	1,346	1,364	1,382	1,400	1,418	1,431	1,444	1,457	1,470	1,483
SANTA ROSA SEGUNDO	1,139	1,164	1,187	1,203	1,219	1,235	1,251	1,268	1,280	1,292	1,304	1,316	1,328
X-YATIL	1,039	1,062	1,083	1,098	1,113	1,128	1,143	1,156	1,167	1,178	1,189	1,200	1,211
LAGUNA KANA	1,000	1,022	1,042	1,056	1,070	1,084	1,098	1,113	1,123	1,133	1,143	1,153	1,163
PRESIDENTE JUAREZ	912	932	950	963	976	989	1,002	1,015	1,025	1,035	1,045	1,055	1,065
PETCACAB	807	824	843	855	867	879	891	901	909	917	925	933	941
TUZIK 1	719	735	749	759	769	779	789	800	807	814	821	828	835
MIXTEQUILLA	652	666	680	689	698	707	716	726	733	740	747	754	761
YAXLEY	624	637	652	661	670	679	688	697	704	711	718	725	732
FILOMENO MATA	610	623	637	646	655	664	673	680	686	692	698	704	710
CHUNHUAS	602	615	628	637	646	655	664	671	677	683	689	695	701
YOACTUN	598	611	624	632	640	648	656	666	672	678	684	690	696
EMILIANO ZAPATA	582	595	606	614	622	630	638	647	653	659	665	671	677
SANTA MARIA PONIENTE	582	595	606	614	622	630	638	647	653	659	665	671	677
CHUN-YAH	570	582	596	604	612	620	628	637	643	649	655	661	667
BETANIA	548	560	571	579	587	595	603	610	616	622	628	634	640
TIXCACAL GUARDIA	531	542	555	563	571	579	587	593	599	605	611	617	623
NUEVO ISRAEL	522	533	546	553	560	567	574	583	588	593	598	603	608
IGNACIO MANUEL ALTAMIRANO	519	530	542	549	556	563	570	579	584	589	594	599	604
CHAN SANTA CRUZ	517	528	540	547	554	561	568	576	581	586	591	596	601
KAMPOKOLCHE	517	528	540	547	554	561	568	576	581	586	591	596	601
RAMONAL	499	510	520	527	534	541	548	556	561	566	571	576	581
CHUMPON	469	479	490	497	504	511	518	524	529	534	539	544	549
UH MAY	468	478	489	496	503	510	517	522	527	532	537	542	547
DZOYOLA	454	464	473	480	487	494	501	506	511	516	521	526	531
KOPCHEN	413	422	430	436	442	448	454	459	463	467	471	475	479
SAN JOSE SEGUNDO	379	387	397	402	407	412	417	424	428	432	436	440	444
CHANCAH VERACRUZ	377	385	394	399	404	409	414	421	425	429	433	437	441

Name of community / Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CHANCAH DERREPENTE	369	377	384	389	394	399	404	411	415	419	423	427	431
SAN FRANCISCO AKE	368	376	383	388	393	398	403	409	413	417	421	425	429
SAN FELIPE BERRIOZABAL	321	328	335	340	345	350	355	358	361	364	367	370	373
TABI	321	328	335	340	345	350	355	358	361	364	367	370	373
SAN ANDRES	316	323	329	334	339	344	349	352	355	358	361	364	367
SAN RAMON	298	304	312	316	320	324	328	334	337	340	343	346	349
ANDRES QUINTANA ROO	282	288	294	298	302	306	310	314	317	320	323	326	329
NUEVA LORIA	276	282	288	292	296	300	304	308	311	314	317	320	323
JOSE MARIA PINO SUAREZ	215	220	223	226	229	232	235	239	241	243	245	247	249
TRAPICH	214	219	222	225	228	231	234	237	239	241	243	245	247
REFORMA AGRARIA	207	211	217	220	223	226	229	232	234	236	238	240	242
CHUN ON	203	207	213	216	219	222	225	227	229	231	233	235	237
FRANCISCO MAY	180	184	187	190	193	196	199	200	202	204	206	208	210
FRANCISCO I. MADERO	176	180	183	185	187	189	191	195	197	199	201	203	205
SANTA LUCIA	170	174	177	179	181	183	185	189	191	193	195	197	199
MELCHOR OCAMPO	161	164	169	171	173	175	177	181	183	185	187	189	191
SAN LUIS	152	155	160	162	164	166	168	171	173	175	177	179	181
CHANCHEN COMANDANTE	143	146	149	151	153	155	157	159	160	161	162	163	164
CANZEPCHEN	140	143	147	149	151	153	155	157	158	159	160	161	162
HOBOMPICH	136	139	142	144	146	148	150	151	152	153	154	155	156
TAC-CHIVO	131	134	136	138	140	142	144	145	146	147	148	149	150
YODZONOT CHICO	131	134	136	138	140	142	144	145	146	147	148	149	150
X-KONHA	130	133	135	137	139	141	143	144	145	146	147	148	149
X-HAZIL NORTE	99	101	103	104	105	106	107	110	111	112	113	114	115
NOH-CAH	98	100	102	103	104	105	106	109	110	111	112	113	114
TRES REYES	95	97	100	101	102	103	104	107	108	109	110	111	112
CHUNYAXCHE	86	88	89	90	91	92	93	95	96	97	98	99	100
Population total	24,622	25,155	25,684	26,032	26,380	26,728	27,076	27,435	27,687	27,939	28,191	28,443	28,695

Table H-59: Level1 Projected Treatment Amount in Felipe Carrillo Puerto

Year / Name of community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Projected treatment amount (m3/day)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	492.2	1,588.5	2,323.2	3,197.5	4,114.2	4,706.3
POLYUC	221.6	226.5	231.1	234.2	237.4	240.5	243.6	246.9	249.1	251.4	253.6	255.9	258.1
X-HAZIL SUR	220.4	225.2	229.7	232.9	236.0	239.1	242.2	245.3	247.6	249.8	252.1	254.3	256.6
SANTA ROSA SEGUNDO	197.0	201.4	205.4	208.1	210.9	213.7	216.4	219.4	221.4	223.5	225.6	227.7	229.7
X-YATIL	179.7	183.7	187.4	190.0	192.5	195.1	197.7	200.0	201.9	203.8	205.7	207.6	209.5
LAGUNA KANA	173.0	176.8	180.3	182.7	185.1	187.5	190.0	192.5	194.3	196.0	197.7	199.5	201.2
PRESIDENTE JUAREZ	157.8	161.2	164.4	166.6	168.8	171.1	173.3	175.6	177.3	179.1	180.8	182.5	184.2
PETCACAB	139.6	142.6	145.8	147.9	150.0	152.1	154.1	155.9	157.3	158.6	160.0	161.4	162.8
TUZIK 1	124.4	127.2	129.6	131.3	133.0	134.8	136.5	138.4	139.6	140.8	142.0	143.2	144.5
MIXTEQUILLA	112.8	115.2	117.6	119.2	120.8	122.3	123.9	125.6	126.8	128.0	129.2	130.4	131.7
YAXLEY	108.0	110.2	112.8	114.4	115.9	117.5	119.0	120.6	121.8	123.0	124.2	125.4	126.6
FILOMENO MATA	105.5	107.8	110.2	111.8	113.3	114.9	116.4	117.6	118.7	119.7	120.8	121.8	122.8
CHUNHUAS	104.1	106.4	108.6	110.2	111.8	113.3	114.9	116.1	117.1	118.2	119.2	120.2	121.3
YOACTUN	103.5	105.7	108.0	109.3	110.7	112.1	113.5	115.2	116.3	117.3	118.3	119.4	120.4
EMILIANO ZAPATA	100.7	102.9	104.8	106.2	107.6	109.0	110.4	111.9	113.0	114.0	115.0	116.1	117.1
SANTA MARIA PONIENTE	100.7	102.9	104.8	106.2	107.6	109.0	110.4	111.9	113.0	114.0	115.0	116.1	117.1
CHUN-YAH	98.6	100.7	103.1	104.5	105.9	107.3	108.6	110.2	111.2	112.3	113.3	114.4	115.4
BETANIA	94.8	96.9	98.8	100.2	101.6	102.9	104.3	105.5	106.6	107.6	108.6	109.7	110.7
TIXCACAL GUARDIA	91.9	93.8	96.0	97.4	98.8	100.2	101.6	102.6	103.6	104.7	105.7	106.7	107.8
NUEVO ISRAEL	90.3	92.2	94.5	95.7	96.9	98.1	99.3	100.9	101.7	102.6	103.5	104.3	105.2
IGNACIO MANUEL ALTAMIRANO	89.8	91.7	93.8	95.0	96.2	97.4	98.6	100.2	101.0	101.9	102.8	103.6	104.5
CHAN SANTA CRUZ	89.4	91.3	93.4	94.6	95.8	97.1	98.3	99.6	100.5	101.4	102.2	103.1	104.0
KAMPOKOLCHE	89.4	91.3	93.4	94.6	95.8	97.1	98.3	99.6	100.5	101.4	102.2	103.1	104.0
RAMONAL	86.3	88.2	90.0	91.2	92.4	93.6	94.8	96.2	97.1	97.9	98.8	99.6	100.5
CHUMPON	81.1	82.9	84.8	86.0	87.2	88.4	89.6	90.7	91.5	92.4	93.2	94.1	95.0
UH MAY	81.0	82.7	84.6	85.8	87.0	88.2	89.4	90.3	91.2	92.0	92.9	93.8	94.6
DZOYOLA	78.5	80.3	81.8	83.0	84.3	85.5	86.7	87.5	88.4	89.3	90.1	91.0	91.9
KOPCHEN	71.4	73.0	74.4	75.4	76.5	77.5	78.5	79.4	80.1	80.8	81.5	82.2	82.9
SAN JOSE SEGUNDO	65.6	67.0	68.7	69.5	70.4	71.3	72.1	73.4	74.0	74.7	75.4	76.1	76.8
CHANCAH VERACRUZ	65.2	66.6	68.2	69.0	69.9	70.8	71.6	72.8	73.5	74.2	74.9	75.6	76.3

Name of community / Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CHANCAH DERREPENTE	63.8	65.2	66.4	67.3	68.2	69.0	69.9	71.1	71.8	72.5	73.2	73.9	74.6
SAN FRANCISCO AKE	63.7	65.0	66.3	67.1	68.0	68.9	69.7	70.8	71.4	72.1	72.8	73.5	74.2
SAN FELIPE BERRIOZABAL	55.5	56.7	58.0	58.8	59.7	60.6	61.4	61.9	62.5	63.0	63.5	64.0	64.5
TABI	55.5	56.7	58.0	58.8	59.7	60.6	61.4	61.9	62.5	63.0	63.5	64.0	64.5
SAN ANDRES	54.7	55.9	56.9	57.8	58.6	59.5	60.4	60.9	61.4	61.9	62.5	63.0	63.5
SAN RAMON	51.6	52.6	54.0	54.7	55.4	56.1	56.7	57.8	58.3	58.8	59.3	59.9	60.4
ANDRES QUINTANA ROO	48.8	49.8	50.9	51.6	52.2	52.9	53.6	54.3	54.8	55.4	55.9	56.4	56.9
NUEVA LORIA	47.7	48.8	49.8	50.5	51.2	51.9	52.6	53.3	53.8	54.3	54.8	55.4	55.9
JOSE MARIA PINO SUAREZ	37.2	38.1	38.6	39.1	39.6	40.1	40.7	41.3	41.7	42.0	42.4	42.7	43.1
TRAPICH	37.0	37.9	38.4	38.9	39.4	40.0	40.5	41.0	41.3	41.7	42.0	42.4	42.7
REFORMA AGRARIA	35.8	36.5	37.5	38.1	38.6	39.1	39.6	40.1	40.5	40.8	41.2	41.5	41.9
CHUN ON	35.1	35.8	36.8	37.4	37.9	38.4	38.9	39.3	39.6	40.0	40.3	40.7	41.0
FRANCISCO MAY	31.1	31.8	32.4	32.9	33.4	33.9	34.4	34.6	34.9	35.3	35.6	36.0	36.3
FRANCISCO I. MADERO	30.4	31.1	31.7	32.0	32.4	32.7	33.0	33.7	34.1	34.4	34.8	35.1	35.5
SANTA LUCIA	29.4	30.1	30.6	31.0	31.3	31.7	32.0	32.7	33.0	33.4	33.7	34.1	34.4
MELCHOR OCAMPO	27.9	28.4	29.2	29.6	29.9	30.3	30.6	31.3	31.7	32.0	32.4	32.7	33.0
SAN LUIS	26.3	26.8	27.7	28.0	28.4	28.7	29.1	29.6	29.9	30.3	30.6	31.0	31.3
CHANCHEN COMANDANTE	24.7	25.3	25.8	26.1	26.5	26.8	27.2	27.5	27.7	27.9	28.0	28.2	28.4
CANZEPCHEN	24.2	24.7	25.4	25.8	26.1	26.5	26.8	27.2	27.3	27.5	27.7	27.9	28.0
HOBOMPICH	23.5	24.0	24.6	24.9	25.3	25.6	26.0	26.1	26.3	26.5	26.6	26.8	27.0
TAC-CHIVO	22.7	23.2	23.5	23.9	24.2	24.6	24.9	25.1	25.3	25.4	25.6	25.8	26.0
YODZONOT CHICO	22.7	23.2	23.5	23.9	24.2	24.6	24.9	25.1	25.3	25.4	25.6	25.8	26.0
X-KONHA	22.5	23.0	23.4	23.7	24.0	24.4	24.7	24.9	25.1	25.3	25.4	25.6	25.8
X-HAZIL NORTE	17.1	17.5	17.8	18.0	18.2	18.3	18.5	19.0	19.2	19.4	19.5	19.7	19.9
NOH-CAH	17.0	17.3	17.6	17.8	18.0	18.2	18.3	18.9	19.0	19.2	19.4	19.5	19.7
TRES REYES	16.4	16.8	17.3	17.5	17.6	17.8	18.0	18.5	18.7	18.9	19.0	19.2	19.4
CHUNYAXCHE	14.9	15.2	15.4	15.6	15.7	15.9	16.1	16.4	16.6	16.8	17.0	17.1	17.3
Potential treatment amount total	4,259.3	4,351.7	4,443.5	4,503.7	4,563.8	4,624.5	4,683.9	4,746.1	4,789.8	4,833.6	4,876.6	4,920.7	4,964.4

Table H-60: Level 2 Service Projected Population in Felipe Carrillo Puerto

Year / Name of community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Service population total	0	0	0	0	0	0	0	5,170	5,218	10,352	13,335	16,060	21,664
CHUNHUHUB	4,582	4,710	4,840	4,906	4,972	5,038	5,104	5,170	5,218	5,266	5,314	5,362	5,410
TIHOSUCO	4,391	4,533	4,673	4,737	4,801	4,865	4,929	4,992	5,039	5,086	5,133	5,180	5,227
SENOR	2,522	2,577	2,630	2,666	2,702	2,738	2,774	2,810	2,836	2,862	2,888	2,914	2,940
TEPICH	2,268	2,309	2,351	2,383	2,415	2,447	2,479	2,512	2,535	2,558	2,581	2,604	2,627
NOH-BEC	1,766	1,804	1,843	1,868	1,893	1,918	1,943	1,969	1,987	2,005	2,023	2,041	2,059
X-PICHIL	1,523	1,556	1,588	1,610	1,632	1,654	1,676	1,697	1,713	1,729	1,745	1,761	1,777
DZULA	1,394	1,425	1,457	1,476	1,495	1,514	1,533	1,554	1,568	1,582	1,596	1,610	1,624
Population total	18,446	18,914	19,382	19,646	19,910	20,174	20,438	20,704	20,896	21,088	21,280	21,472	21,664

Table H-61: Level2 Projected Treatment Amount in Felipe Carrillo Puerto

Year / Name of community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Projected treatment amount (m3/day)	0	0	0	0	0	0	0	894	903	1,791	2,307	2,778	3,748
CHUNHUHUB	792.7	814.8	837.3	848.7	860.2	871.6	883	894.4	902.7	911	919.3	927.6	935.9
TIHOSUCO	759.6	784.2	808.4	819.5	830.6	841.6	852.7	863.6	871.7	879.9	888	896.1	904.3
SENOR	436.3	445.8	455	461.2	467.4	473.7	479.9	486.1	490.6	495.1	499.6	504.1	508.6
TEPICH	392.4	399.5	406.7	412.3	417.8	423.3	428.9	434.6	438.6	442.5	446.5	450.5	454.5
NOH-BEC	305.5	312.1	318.8	323.2	327.5	331.8	336.1	340.6	343.8	346.9	350	353.1	356.2
X-PICHIL	263.5	269.2	274.7	278.5	282.3	286.1	289.9	293.6	296.3	299.1	301.9	304.7	307.4
DZULA	241.2	246.5	252.1	255.3	258.6	261.9	265.2	268.8	271.3	273.7	276.1	278.5	281.0
Potential treatment amount total	3,191	3,272	3,353	3,399	3,444	3,490	3,536	3,582	3,615	3,648	3,681	3,715	3,748

Table H-62: Level3 Service Projected Population, Potential Amount and Projected Treatment Capacity in Felipe Carrillo Puerto

Name of community / Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total population													
FELIPE CARRILLO PUERTO	19,262	19,501	19,738	20,007	20,276	20,545	20,814	21,084	21,281	21,478	21,675	21,872	22,069
Service population													
FELIPE CARRILLO PUERTO	669	669	669	7,802	7,802	7,802	14,935	14,935	14,935	21,478	21,675	21,872	22,068
Potential amount (m3/day)													
FELIPE CARRILLO PUERTO	3,332.3	3,373.7	3,414.7	3,461.2	3,507.7	3,554.3	3,600.8	3,647.5	3,681.6	3,715.7	3,749.8	3,783.9	3,817.9
Treatment capacity (m3/day)													
FELIPE CARRILLO PUERTO	115.7	115.7	115.7	1,349.7	1,349.7	1,349.7	2,583.7	2,583.7	2,583.7	3,817.7	3,817.7	3,817.7	3,817.7

Table H-63: Summary of Service Projected Communities in Solidaridad

Year	Level 1	Level 2	Level 3	Level 4
2003	SOLIDAAIDAD PUERTO AVENTURAS /	AKUMAL		
2004				
2005				PLAYA DEL CARMEN new 1
2006			CIUDAD CHEMUYIL 1	NUEVO AKUMAL new1
2007				
2008			CIUDAD CHEMUYIL 2	PLAYA DEL CARMEN new 2 / NUEVO AKUMAL new3
2009				
2010	CHANCHEN I		CIUDAD CHEMUYIL 3	NUEVO AKUMAL new3
2011	SAN JUAN (SAN JU.AN DE DIOS) / HANCHEN PALUPR	COBA		PLAYA DEL CARMEN new 3
2012	JAVIER ROJO GOMEZ / YALCHEN			
2013	YAXCHE / OASIS AKUMAL			
2014	HONDZONOT / MACARIO GOMEZ	CHANCHEN NUMERO UNO		
2015	SOLIDAAIDAD PUERTO AVENTURAS / FRANCISCO UH MAY / MANUEL ANTONIO AY / JOSE MARIA PINO SUAREZ / DIAMOND RESORT	SAN SILVERIO		

Table H-64: Level 1 Service Projected Population in Solidaridad

Year / Name of community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Service population total	526	545	565	583	601	619	637	2,493	4,326	5,975	9,169	9,275	11,39
CHANCHEN I	1,481	1,535	1,588	1,638	1,688	1,738	1,788	1,839	1,716	1,593	1,470	1,347	1,224
SAN JUAN (SAN JU.AN DE DIOS)	827	857	887	915	943	971	999	1,028	1,061	1,094	1,127	1,160	1,193
HANCHEN PALUPR	682	707	730	753	776	799	822	846	874	902	930	958	986
JAVIER ROJO GOMEZ	638	661	685	707	729	751	773	793	819	845	871	897	923
YALCHEN	638	661	685	707	729	751	773	793	819	845	871	897	923
YAXCHE	631	654	677	698	719	740	761	784	810	836	862	888	914
OASIS AKUMAL	597	619	639	659	679	699	719	741	765	789	813	837	861
HONDZONOT	572	593	613	632	651	670	689	710	733	756	779	802	825
MACARIO GOMEZ	533	552	573	591	609	627	645	663	685	707	729	751	773
PUERTO AVENTURAS	526	545	565	583	601	619	637	654	675	696	717	738	759
FRANCISCO UH MAY	524	543	562	580	598	616	634	651	672	693	714	735	756
MANUEL ANTONIO AY	461	478	493	509	525	541	557	571	590	609	628	647	666
JOSE MARIA PINO SUAREZ	267	277	285	294	303	312	321	330	341	352	363	374	385
DIAMOND RESORT	141	146	152	157	162	167	172	176	182	188	194	200	206
Population total	8,518	8,828	9,134	9,423	9,712	10,001	10,290	10,579	10,742	10,905	11,068	11,231	11,394

Table H-65: Level1 Projected Treatment Amount in Solidaridad

Name of community / Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Service population total	91.0	94.3	97.7	100.9	104.0	107.1	110.2	431.2	748.5	1,033.7	1,586.2	1,604.5	1,971.2
CHANCHEN I	256.2	265.6	274.7	283.4	292.0	300.7	309.3	318.1	296.9	275.6	254.3	233.0	211.8
SAN JUAN (SAN JU.AN DE DIOS)	143.1	148.3	153.5	158.3	163.1	168.0	172.8	177.8	183.6	189.3	195.0	200.7	206.4
HANCHEN PALUPR	118.0	122.3	126.3	130.3	134.2	138.2	142.2	146.4	151.2	156.0	160.9	165.7	170.6
JAVIER ROJO GOMEZ	110.4	114.4	118.5	122.3	126.1	129.9	133.7	137.2	141.7	146.2	150.7	155.2	159.7
YALCHEN	110.4	114.4	118.5	122.3	126.1	129.9	133.7	137.2	141.7	146.2	150.7	155.2	159.7
YAXCHE	109.2	113.1	117.1	120.8	124.4	128.0	131.7	135.6	140.1	144.6	149.1	153.6	158.1
OASIS AKUMAL	103.3	107.1	110.5	114.0	117.5	120.9	124.4	128.2	132.3	136.5	140.6	144.8	149.0
HONDZONOT	99.0	102.6	106.0	109.3	112.6	115.9	119.2	122.8	126.8	130.8	134.8	138.7	142.7
MACARIO GOMEZ	92.2	95.5	99.1	102.2	105.4	108.5	111.6	114.7	118.5	122.3	126.1	129.9	133.7
PUERTO AVENTURAS	91.0	94.3	97.7	100.9	104.0	107.1	110.2	113.1	116.8	120.4	124.0	127.7	131.3
FRANCISCO UH MAY	90.7	93.9	97.2	100.3	103.5	106.6	109.7	112.6	116.3	119.9	123.5	127.2	130.8
MANUEL ANTONIO AY	79.8	82.7	85.3	88.1	90.8	93.6	96.4	98.8	102.1	105.4	108.6	111.9	115.2
JOSE MARIA PINO SUAREZ	46.2	47.9	49.3	50.9	52.4	54.0	55.5	57.1	59.0	60.9	62.8	64.7	66.6
DIAMOND RESORT	24.4	25.3	26.3	27.2	28.0	28.9	29.8	30.4	31.5	32.5	33.6	34.6	35.6
Population total	1,473.9	1,527.4	1,580.0	1,630.3	1,680.1	1,730.2	1,780.2	1,830.0	1,858.5	1,886.6	1,914.7	1,942.9	1,971.2

Table H-66: Level 2 Service Projected Population in Solidaridad

Year / Name of community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Service population total	911	1136	1357	1561	1775	1988	2184	2394	5,134	5,277	5,419	7,656	9,534
COBA	1,704	1,966	2,227	2,298	2,369	2,440	2,511	2,580	2,664	2,748	2,832	2,916	3,000
AKUMAL	911	1136	1357	1561	1775	1988	2184	2394	2470	2529	2587	2661	2716
CHANCHEN NUMERO UNO	1,230	1,409	1,588	1,638	1,688	1,738	1,788	1,839	1,899	1,959	2,019	2,079	2,139
SAN SILVERIO	1,162	1,204	1,247	1,286	1,325	1,364	1,403	1,444	1,491	1,538	1,585	1,632	1,679
Population total	5,007	5,715	6,419	6,783	7,157	7,530	7,886	8,257	8,524	8,774	9,023	9,288	9,534

Table H-67: Level 2 Projected Treatment Amount in Solidaridad

Year / Name of community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Service population total	157.6	196.5	234.8	270.1	307.1	343.9	377.8	414.2	888.2	912.9	937.5	1,324.6	1,649.4
COBA	294.8	340.1	385.3	397.6	409.8	422.1	434.4	446.3	460.9	475.4	489.9	504.5	519.0
AKUMAL	157.6	196.5	234.8	270.1	307.1	343.9	377.8	414.2	427.3	437.5	447.6	460.4	469.9
CHANCHEN NUMERO UNO	212.8	243.8	274.7	283.4	292.0	300.7	309.3	318.1	328.5	338.9	349.3	359.7	370.0
SAN SILVERIO	201.0	208.3	215.7	222.5	229.2	236.0	242.7	249.8	257.9	266.1	274.2	282.3	290.5
Population total	866.2	988.7	1,110.5	1,173.6	1,238.1	1,302.7	1,364.2	1,428.4	1,474.6	1,517.9	1,561.0	1,606.9	1,649.4

Table H-68: Level 3 Service Projected Population in Solidaridad

Year / Name of community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total population													
CIUDAD CHEMUYIL	5,368	6,685	8,000	9,800	11,600	13,400	15,200	17,000	17,867	18,734	19,601	20,468	21,335
TULUM	16,910	19,767	22,637	24,864	27,103	29,353	31,614	33,887	36,904	39,933	42,973	46,024	49,087
Total	22,278	26,452	30,637	34,664	38,703	42,753	46,814	50,887	54,771	58,667	62,574	66,492	70,422
Service population													
CIUDAD CHEMUYIL	0	0	0	7,110	7,110	13,400	14,220	17,000	17,867	18,734	19,601	20,468	21,329
TULUM	0	0	0	16,364	16,364	29,353	31,614	33,887	36,904	39,933	42,973	46,024	49,087
Total	0	0	0	23,474	23,474	42,753	45,834	50,887	54,771	58,667	62,574	66,492	70,416

Table H-69: Level 3 Potential Amount and Projected Treatment Capacity in Solidaridad

Year / Name of community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Potential amount (m3/day)													
CIUDAD CHEMUYIL	928.7	1,156.5	1,384.0	1,695.4	2,006.8	2,318.2	2,629.6	2,941.0	3,091.0	3,241.0	3,391.0	3,541.0	3,691.0
TULUM	2,925.4	3,419.7	3,916.2	4,301.5	4,688.8	5,078.1	5,469.2	5,862.5	6,384.4	6,908.4	7,434.3	7,962.1	8,492.0
Total	3,854.1	4,576.2	5,300.2	5,996.9	6,695.6	7,396.3	8,098.8	8,803.5	9,475.4	10,149.4	10,825.3	11,503.1	12,183.0
Treatment capacity (m3/day)													
CIUDAD CHEMUYIL	0.0	0.0	0.0	1,230.0	1,230.0	2,460.0	2,460.0	3,690.0	3,690.0	3,690.0	3,690.0	3,690.0	3,690.0
TULUM	0.0	0.0	0.0	2,831.0	2,831.0	5,662.0	5,662.0	8,493.0	8,493.0	8,493.0	8,493.0	8,493.0	8,493.0
Total	0.0	0.0	0.0	4,061.0	4,061.0	8,122.0	8,122.0	12,183.0	12,183.0	12,183.0	12,183.0	12,183.0	12,183.0

Table H-70: Level 4 Service Projected Population in Solidaridad

Year / Name of community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total population													
NUEVO AKUMAL	10,894	11,782	47,505	56,131	64,678	73,161	81,581	89,962	95,341	100,677	105,990	111,284	116,560
PLAYA DEL CARMEN	124,545	133,870	143,161	152,416	161,637	172,156	182,640	193,089	203,504	213,883	224,228	234,539	244,814
Total	135,439	145,652	190,666	208,547	226,315	245,317	264,221	283,051	298,845	314,560	330,218	345,823	361,374
Service population													
NUEVO AKUMAL	10,894	11,782	23,494	54,517	54,517	73,161	81,581	89,962	95,341	100,677	105,990	111,284	116,560
PLAYA DEL CARMEN	95,936	95,936	143,161	145,561	145,561	172,156	182,640	193,089	203,504	213,883	224,228	234,539	244,809
Total	106,830	107,718	166,655	200,078	200,078	245,317	264,221	283,051	298,845	314,560	330,218	345,823	361,369

Table H-71: Level 4 Potential Amount and Projected Treatment Capacity in Solidaridad

Year / Name of community	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Potential amount (m3/day)													
NUEVO AKUMAL	1,884.7	2,038.3	8,218.4	9,710.7	11,189.3	12,656.9	14,113.5	15,563.4	16,494.0	17,417.1	18,336.3	19,252.1	20,164.9
PLAYA DEL CARMEN	21,546.3	23,159.5	24,766.9	26,368.0	27,963.2	29,783.0	31,596.7	33,404.4	35,206.2	37,001.7	38,791.5	40,575.3	42,352.9
Total	23,431.0	25,197.8	32,985.3	36,078.7	39,152.5	42,439.9	45,710.2	48,967.8	51,700.2	54,418.8	57,127.8	59,827.4	62,517.8
Treatment capacity (m3/day)													
NUEVO AKUMAL	4,064.5	4,064.5	4,064.5	9,431.5	9,431.5	14,798.5	14,798.5	20,165.5	20,165.5	20,165.5	20,165.5	20,165.5	20,165.5
PLAYA DEL CARMEN	16,597.0	16,597.0	25,182.0	25,182.0	25,182.0	33,767.0	33,767.0	33,767.0	42,352.0	42,352.0	42,352.0	42,352.0	42,352.0
Total	20,661.5	20,661.5	29,246.5	34,613.5	34,613.5	48,565.5	48,565.5	53,932.5	62,517.5	62,517.5	62,517.5	62,517.5	62,517.5

H.3 Solid Waste Management Master Plan

H.3.1 Objectives, Targeted Values and Target Years

a. Principal Objectives and Targeted Values

The principal objective of the Solid Waste Management (SWM) Master Plan is;

To preserve the groundwater and the coastal aquatic environment in the study area

Targeted value is;

BOD discharge amount originated from solid waste is to be less than 2,100 ton/year by 2015.

b. Particular Objectives and Targeted Values

The master plan aims at achieving the principal objective, in addition, at accomplishing the following particular objectives inherent to solid waste management.

- ***Provision of sanitary living environment:*** by removing waste from houses and communities (waste collection)
- ***Mitigation of environmental impact cased by waste:*** by properly disposing of collected waste (proper disposal)
- ***Resource conservation:*** by contributing to establishment of a recycling-oriented society through source reduction and recycling, etc. (waste minimization)

The table below shows targeted values of the particular objectives by the municipalities.

Table H-72: Target Values of the SWM Master Plan (by Municipalities)

Items	Present (2003)		Particular Goals in 2015	
Waste minimization rate	0		Study Area: 23% OPB: 23% FCP: 15% SOL: 24%	
Collection rate ( ): inc. rural area	Study area: 61% (75%) OPB: 57% (72%) FCP: 18% (29%) SOL: 82% (88%)		Study area: 99% (86%) OPB: 99% (82%) FCP: 87% (49%) SOL:100% (95%)	
Disposal level	OPB: FCP: SOL:	open and controlled dump open dump open and landfill with gas control	Population 2,500 - 7,999: 8,000 - 34,999: 34,999 - 99,999: 100,000 and more:	Disposal level controlled dump enclosed dump landfill with gas control landfill with leachate control

OPB, Othon P Blanco; FCP, Felipe C Puerto, SOL, Solidaridad

Targeted values are also set by the urban groups. Table H-73 shows the urban groups and communities belonging to them. Table H-74 shows target values set for the respective urban groups. Table H-75 shows components of waste minimization.

Table H-73: Urban Groups

Urban G	Municipality	Community
1	OPB	CALDERITAS, CHETUMAL, XUL-HA
2	OPB	ALVARO OBREGON, INGENIO ALVARO OBREGON, SERGIO BUTRON CASAS
3	OPB	NICOLAS BRAVO
4	OPB	BACALAR, LIMONES, MAYA BALAM
5	OPB	MAHAHUAL, PUNTA PULTICUB, XAHUACHOL, XCALAK
6	FCP	FELIPE CARRILLO PUERTO, SENOR
7	FCP	CHUNHUHUB
8	FCP	TEPICH, TIHOSUCO
9	SOL	CIUDAD CHEMUYIL, NUEVO AKUMAL, PLAYA DEL CARMEN, TULUM
10	SOL	COBA

Table H-74: Target Values of the SWM Master Plan (by Urban Group)

Urban Group	Population		Waste Minimization		Collection Rate		Disposal Level	
	2003	2015	2003	2015	2003	2015	2003	2015
1	137,355	172,488	0%	25%	90%	100%	Controlled dump	Landfill with leachate control
2	9,558	12,474	0%	15%	0%	90%	Open dump	Enclosed dump
3	3,893	4,854	0%	15%	0%	80%	Open dump	Controlled dump
4	19,106	43,418	0%	15%	0%	95%	Open dump	Landfill with gas control
5	626	108,215	0%	25%	0%	100%	Open dump	Landfill with leachate control
6	21,784	25,009	0%	15%	44%	90%	Open dump	Enclosed dump
7	4,582	5,410	0%	15%	0%	80%	Open dump	Controlled dump
8	6,659	7,854	0%	15%	0%	80%	Open dump	Controlled dump
9	128,061	379,664	0%	25%	89%	100%	Landfill with gas control	Landfill with leachate control
10	1,704	3,000	0%	15%	0%	80%	Open dump	Controlled dump
Total	333,328	762,386	-	-	-	-	-	-

Table H-75: Waste Minimization Rate of the SWM Master Plan

Urban Group	Population	Minimization rate		Methods
	2015	Source reduction	Composting	
1	172,488	15%	10%	Environmental education, backyard composting, pruning waste composting
2	12,474	15%	0%	Environmental education, backyard composting
3	4,854	15%	0%	Environmental education, backyard composting
4	43,418	15%	0%	Environmental education, backyard composting
5	108,215	15%	10%	Environmental education, backyard composting, pruning waste composting
6	25,009	15%	0%	Environmental education, backyard composting
7	5,410	15%	0%	Environmental education, backyard composting
8	7,854	15%	0%	Environmental education, backyard composting
9	379,664	15%	10%	Environmental education, backyard composting
10	3,000	15%	0%	Environmental education, backyard composting, pruning waste composting
Total	762,386	-	-	-

c. Target Year

The target year for the master plan is set up as follows:

Master Plan: Year 2015

Strategic actions to achieve the objectives should be, in practice, introduced step by step approach towards the target year 2015. It is recommended to divide the period up to the target year into three phases as follows.

Phase 1:	***Short term improvement***	***(2004 to 2007)***
Phase 2:	***Medium term improvement***	***(2008 to 2011)***
Phase 3:	***Long term improvement***	***(2012 to 2015)***

H.3.2 Strategies

The following eight points are strategies to accomplish the goals.

1. ***Focusing on the urban area***
2. ***Development of SWM systems accommodating to various size of communities***
3. ***Introduction and promotion of waste minimization***
4. ***Financial self-sufficiency***
5. ***Cooperation among the three government levels***
6. ***Development of legal system***
7. ***Strengthening of executing bodies of SWM***
8. ***Establishment of a new SWM system in Costa Maya***

1. Focusing on the urban area

Although hundreds of communities are dispersed over the study area, most of population centers in some communities. Only 24 urban communities having 2,500 and over persons respectively are estimated to have 85% of total population in the target year of 2015.

Meanwhile, life in rural villages discharges small amount of waste and there are spaces to dispose of them. Therefore, demand for solid waste service is not so strong.

Consequently, the Master Plan of SWM focuses on the urban area taking into account the demand and cost-effectiveness.

2. Development of SWM systems accommodating to various size of communities

Even urban communities, population size of them are various. It is inappropriate to adopt the same SWM system to all communities having different population sizes. That is, communities with small population cannot afford and do not require 100% collection rate and sophisticated sanitary landfill.

Therefore, various type of SWM systems shall be prepared and employed corresponding to population size of communities.

3. Introduction and promotion of waste minimization

Waste amount generated per person in the study area is no so different from it in developed countries. Meanwhile, the new federal law, “Ley General para la Prevencion y Gestion Integral de los Residuos,” takes up waste minimization as an important policy. With taking

into account these issues, waste minimization shall be introduced and promoted in the study area.

4. Financial self-sufficiency

Most of SWM costs of the three municipalities are not covered with specific user charges of the SWM service, but with general funds of the municipal budget, which consist mostly of subsidies from the state and/or federal governments. Then, there is a risk that the SWM may fall into disarray if the state or the federal government changes their funding policy of municipal budgets, despite recognizing that the SWM is one of the responsibilities inherent to the municipal government. When SWM in a municipality is paid for by general funds, the likely outcome is low awareness to provide the service on the basis of careful considerations of the cost and income specific to the service. Then, SWM operated with general funds may result in careless cost management, inefficient works and low service quality, and the low awareness on SWM costs and income held by municipal authorities may spread to the general citizenry. In order to improve the said possible difficulties mentioned above, achieving financial self- sufficiency will be the goal of the financial plan.

5. Cooperation among the three government levels

Requirements for SWM is recently getting various and sophisticated such as sanitary landfilling, waste minimization, public-private partnership, hazardous waste management, etc. It will compound further in the future. Then, it is impossible for municipalities by themselves to cope with them. Therefore, a framework, where the three governments, the federal, the state and the municipal governments, are able to cooperate, shall be formulated.

6. Development of legal system

There are many actors in SWM, such as governments who are service providers or supervisors, citizens and business entities who are waste dischargers, the private sector who participates in service provision, and non government organizations who may be bridge builder between the governments and the citizens. In order them to appropriately participate in SWM, legal system shall be developed.

7. Strengthening of executing bodies of SWM

Executing bodies of SWM are required to develop their capacity in order to cope with new issues such as sanitary landfilling, waste minimization and rapid urbanization by tourism development. All of other strategies strengthen their capacity. However, those should not be carried out individually. Those should be integrated. Experiences and knowledge should be

accumulated in the executing bodies. Otherwise, they are not able to continuously develop their capacity in the future.

8. Establishment of a new SWM system in Costa Maya

In Costa Maya, various infrastructures for tourism development have been built such as roads, electricity, and a pier for liners. And, number of tourists has been increased. However, public services have not yet been developed in the area. Solid waste service is carried out in small scale by some village people. As such system will not be able to cope with future development, SWM system shall be established to protect the beautiful nature in the area.

H.3.3 Proposed Measures

H.3.3.1 Description of Proposed Measures

This section describes proposed measures to accomplish the goals. The table below summarizes the proposed measures, and each of them is subsequently explained.

Table H-76: Strategies and Proposed Measures

Strategies	Proposed Measures
1. Focusing on the urban area	11. Focusing on the urban area
2. SWM systems accommodating to various size of communities	21. Flexible arrangement of collection rate 22. Flexible arrangement of final disposal manners
3. Introduction and promotion of waste minimization	31. Environmental education on waste minimization 311. Environmental education and recycling activities in schools 312. Environmental education and recycling activities in communities 313. Advertisement of importance of waste minimization through public institutions and/or mass media 32. Promotion of backyard composting 321 Preparing and distributing materials how to make compost from garden waste 322. Establishing visit instruction system of composting 333. Demonstrating composting in public institutions 33. Pruning waste composting 34. Setting of Waste Minimization Rate
4. Financial self-sufficiency	41. Income improvement 411. General application of service charges 412. Realistic service charges 413. Timely billing and payment facility 414. Control of bill collection 415. Specific use of income 42. Cost reduction 421. Improvement of waste collection works 422. Constant monitoring
5. Cooperation among the three government levels	51. Establishment of an information system for the integral management
6. Development of legal system	61. Formulation of a municipal regulation on SWM 62. Formulation of rules for public-private partnership
7. Strengthening of executing bodies of SWM	71. Establishment of a specialized administrative unit in SEDUMA 72. Restructuring of municipal executing bodies of SWM
8. Establishment of a new SWM system in Costa Maya	81. Establishment of an organizational and institutional framework 82. Introduction of culture of waste minimization 83. Preparation of establishment of a firm SWM system

1. Focusing on the urban area

11. Focusing on the urban area

Ten urban groups consisting of 24 urban communities in the table below are basically subject to the Master Plan.

Table H-77: Urban Communities subject to the Master Plan

Urban G	Municipality	Community	Population	
			2003	2015
1	OPB	CALDERITAS, CHETUMAL, XUL-HA	137,355	172,488
2	OPB	ALVARO OBREGON, INGENIO ALVARO OBREGON, SERGIO BUTRON CASAS	9,558	12,474
3	OPB	NICOLAS BRAVO	3,893	4,854
4	OPB	BACALAR, LIMONES, MAYA BALAM	19,106	43,418
5	OPB	MAHAHUAL, PUNTA PULTICUB, XAHUACHOL, XCALAK	626	108,215
6	FCP	FELIPE CARRILLO PUERTO, SENOR	21,784	25,009
7	FCP	CHUNHUHUB	4,582	5,410
8	FCP	TEPICH, TIHOSUCO	6,659	7,854
9	SOL	CIUDAD CHEMUYIL, NUEVO AKUMAL, PLAYA DEL CARMEN, TULUM	128,061	379,664
10	SOL	COBA	1,704	3,000
Urban sub-total			333,328	762,386
Rural			101,637	130,408
Total			434,965	892,794
Urban/Total			76.6%	85.4%

2. SWM systems accommodating to various size of communities

21. Flexible arrangement of collection rate

Collection rate of waste shall be flexibly arranged corresponding to community size with taking into account not to deteriorate its living environment and to heighten cost-effectiveness of the service, as shown in the following table.

Table H-78: Collection rates adopted in the Master Plan

Population (nos.)	Collection Rate
1 – 2,499	0%
2,500 - 7,999	80%
8,000 - 34,999	90%
34,999 - 99,999	95%
100,000 -	100%

22. Flexible arrangement of final disposal manners

Final disposal manners shall be flexibly arranged corresponding to community size with taking into account not to deteriorate the environment where waste is disposed of and to heighten cost-effectiveness of operation of final disposal. Four manners of final disposal are proposed as shown in Table H-79, which can be developed in phase corresponding to growth of community.

Table H-79: Final Disposal Manners adopted in the Master Plan

Disposal manners	Contents
1:Controlled dump (population: less than 8,000)	• Inspection on incoming waste: to measure disposal amount, to control hazardous waste, etc. • Approach road, on-site road: to secure access to a dumping area • Landfill equipment: to accumulate waste
2:Enclosed dump (population: 8,000 - 34,999)	• Fence: to prohibit for unauthorized persons to enter the site • Dike: to avoid waste to be scattered, to prevent water from coming in • Buffer: to keep enough space to adjacent property • Drainage: surrounding and on-site drains
3:Landfill with gas control (population: 34,999 - 99,999)	• Soil cover: to prohibit vector proliferation, to prevent fire and mal odor, to minimize rainwater infiltration, to improve aesthetics • Gas removal facility: to prevent fire and explosion, to encourage waste decomposition • Weighbridge: important for SWM
4:Landfill with leachate control (population: 100,000 and over)	• Bottom liner: to prevent leachate to infiltrate into ground (groundwater contamination) • Leachate collection facility: to collect and discharge leachate to the outside • Leachate treatment facility: to treat leachate to a certain quality that does not give serious environment impact

3. Introduction and promotion of waste minimization

31. Environmental education on waste minimization

Importance of resource conservation and manners of waste minimization shall be disseminated through environmental education and recycling activities. The following are proposed measures.

311. Environmental education and recycling activities in schools
312. Environmental education and recycling activities in communities
313. Advertisement of importance of waste minimization through public institutions and/or mass media

32. Promotion of backyard composting

Waste component in the Study Area is accentuated in a large portion of garden waste that could be disposed of in houses by composting. Waste discharged from houses could be reduced by composting and the citizens could be encouraged in waste minimization and resource conservation through such concrete actions. The following measures are proposed for that purpose.

321 Preparing and distributing materials how to make compost from garden waste
322. Establishing visit instruction system of composting
333. Demonstrating composting in public institutions

It is expected to minimize 15% of waste generation amount at source by the environmental education and the backyard composting.

33. Pruning waste composting

A large amount of pruning waste from roadside trees is generated. Also, pruning waste that does not suit to backyard composting is discharged a lot from households. Those shall be subject to composting, not to landfilling. The amount will be 10% of total generation amount of waste.

4. Financial self-sufficiency

Income improvement and cost reduction are crucial for accomplishing financial self-sufficiency in SWM. For this purpose, it is important to secure fairness based on beneficiaries paying a fair price for the quality of service they receive, to attain improvement of service quality, to pursue transparency in accounting, and to achieve civil minimum or provision of minimum sanitary living environment. The measures that may be applied to achieve financial self-sufficiency through income improvement and cost reduction are the following.

4.1 Income improvement

4.1.1 General application of service charges

The application of service charges differs greatly in the three municipalities comprising the Study Area. Solidaridad applies service charges on households and business firms, while OPB applies the service charges only on business firms, and FCP applies no service charges. OPB and Solidaridad set their own service charges every year.

From the financial viewpoint, all users of solid waste service should pay service charges, because the solid waste service entails costs, and users of the service generally accept to pay at least partially the cost of the service. Households are important generators of solid waste, and therefore should actively participate in this cost recovery effort by paying their share of service costs. According to the proposed regulation on solid waste management, households are expected to pay fixed monthly charges, while commercial-industrial firms and institutions are expected to pay volume-based tariff as a way to introduce fairness by applying the polluter-pays-principle.

The general application of service charges seeks mainly to increase income from the SW service by incorporating households and business firms as groups of paying customers, in order to include all generators of solid waste.

4.1.2 Realistic service charges

The practice of OPB and Solidaridad to set service charges on yearly basis eliminates a troublesome rigidity in financial management. This rigidity refers to the all too common difficulty in updating service charges in response to changing service costs. Service charges should seek to recover the service costs as much as possible. However, increasing SW service charges as a means to improve income should be the last resort, rather using other measures such as updating and expanding the customer base and improving the bill collection efficiency.

The customer base of service users should be updated and expanded on a permanent basis. Double checking with other data sources will increase accuracy. Also, a better knowledge of types of service users will permit the design and implementation of measures to provide improved service tailored to the needs of diverse customer groups. This can increase the number of satisfied service users and their willingness to pay for the service.

4.1.3 Timely billing and payment facility

Billing periodicity set in the proposed regulation on solid waste management should be strictly respected, bimonthly for households, and monthly for commercial and industrial firms, as well as for institutional clients. SW service users should be given the facility to make payments not only in the main offices of each municipality, but also in places where people frequently go to, like supermarkets, as is the case with payments of any other public utilities. Every effort should be made to ensure that payments are collected in officially authorized places, and not in unofficial ways like by unauthorized drivers of SW collection trucks. In other words, payments made by the users of SW service should reach the municipal coffers instead of being diverted to private uses.

4.1.4 Control of bill collection

Bill collection should be carefully conducted in order to keep late accounts under control. This implies a clarification on the reasons why payment of a service user becomes late, and the application of fines and penalties when payments by service users are not done in a timely fashion. The period of two months after due date to initiate collection procedures should be strictly enforced, in addition to the application of fines and penalties when deemed necessary.

Bill collection should be monitored every billing period in order to increase collection efficiency (collection as percentage of billing), and to minimize the number of service users that run more than two months late in paying their bills. Even if bill collection efficiency is satisfactory, the non-paying group should be systematically monitored to get a better idea on late accounts, or the number of weeks or months during which payments are late. The data on types of service users who do not pay may permit taking appropriate actions such as information/education campaigns, imposing fines and/or penalties. The idea of automatically attaching the monetary value of late accounts on the property tax of the following year may prove to be effective.

4.1.5 Specific use of income

The income obtained as solid waste service charges should ideally be earmarked for use in the improvement of the service. The strict implementation of this recommendation may cause financial difficulties during the initial stage, if it implies that general funds can not be depended upon to finance SW service. Therefore, an exception should probably be made for the initial few years, during which a mix of general funds and service charges should be used in the SWM. Meanwhile, proper procedures should be introduced in the existing system so as to improve bill collection and earmark the service charges. Then, the Municipal Service Department can move toward operating autonomy, and can have the satisfaction of playing an active role in service improvement, actually seeing the service becoming increasingly more efficient.

4.2 Cost reduction

4.2.1 Improvement of waste collection works

As solid waste collection works usually comprise a large portion of total SWM costs (42% in OPB in 2002), reduction of solid waste collection cost can have a large impact on the reduction of the overall SWM cost. The re-design of solid waste collection routes and other improvements can induce a less wasteful use of time and resources, thereby contributing to a more efficient operation of the solid waste collection service at a lower cost.

4.2.2 Constant monitoring

Financial performance should be constantly monitored through selected quantified indicators, so as to promptly introduce improvement measures where and when the monitored indicators turn away from the acceptable range of values.

Performance indicators will serve to monitor such summary aspects as the cost per ton of solid waste collection, the cost of street sweeping, the cost of final disposal, and the cost per ton of the overall cost of solid waste management. Careful monitoring of periodic evolution of these indicators will permit taking timely corrective actions. An important indicator will be bill collection efficiency, or the ratio between the monetary amount of collection and the monetary amount of billing.

5. Cooperation among the three government levels

51. Establishment an information system for the integral management

The new law requires the creation of the Information System for the Integral Management of Wastes with the purpose to build a coordination and information methodology between three levels of government in issues related to prevention of generation, valorization, and integral management of wastes.

The Information System for the Integral Solid Waste Management (SIGIR) has been established. This system constitutes a mechanism of coordination and information among the three government levels on regards of prevention of the generation, valorization and integral management of solid waste.

Initially SEMARNAT (Quintana Roo Branch), SEDUMA and the municipalities of Othon P. Blanco, Felipe Carrillo Puerto and Solidaridad are part of SIGIR. Additionally, SIGIR will be used in order to track the implementation of the Master Plan.

It is recommended to incorporate other governmental, academic and community organizations as well as the private sector, whose activities are related to the management of solid waste and environmental protection in general.

SIGIR may be the ideal instrument for starting the organization of the Executive Unit of the Master Plan. SEDUMA is suggested as the coordinating organ for this Executive Unit.

JICA should consider an electronic connection with SIGIR and the possible Executive Unit, with the purpose of giving continuity and assistance to the implementation of the Master Plan during the period of implementation.

6. Development of legal system

61. Formulation of a municipal regulation on SWM

The draft of the "Regulation for the Rendering of the Public Service for the Integral Management of Urban Solid Waste" is being considered for its approval by the municipalities of Othon P. Blanco, Felipe Carrillo Puerto and Solidaridad.

It is expected on the short term to have an instrument that allows regulating the relationship between the municipality, the clients and the private sector on regards of the integral management of solid waste in order to preserve and recuperate the quality of the environment and the protection to public health.

The "General Law for the Prevention and Integral Management of Waste" has not had enough diffusion by part of the competent organizations. Using SIGIR should start a process of public information and coordination among the several organizations involved and to execute what has been stated in the General Law.

62. Formulation of rules for public-private partnership

The experience achieved with the participation of the private sector (PPS) on SWM has not been successful. The municipality of Solidaridad has finished the contract with the private sector. In the neighboring municipality of Benito Juarez a very difficult situation is being generated concerning the final Disposal of SW and the debts that are maintained with the contractor.

Before the PPS the municipalities should define, together with the community, about the quality of the service that will be rendered, the costs estimated, the level of the fees and the intention and willingness of payment of the population.

Because this service is considered as a public asset, it is precise that the population pays for the rights of the rendering of the service, this payment should be universal to all inhabitants and the society should subsidize the families that can not make the payment.

The Master Plan establishes the bases that should be considered in the rendering of the service and this is a guide that defines the participation of the private sector.

The legal procedures for the PPS are known by the competent authorities; the PPS on the SWM in Mexico has had successful examples in several cities.

7. Strengthening of executing bodies of SWM

71. Establishment of a specialized administrative unit in SEDUMA

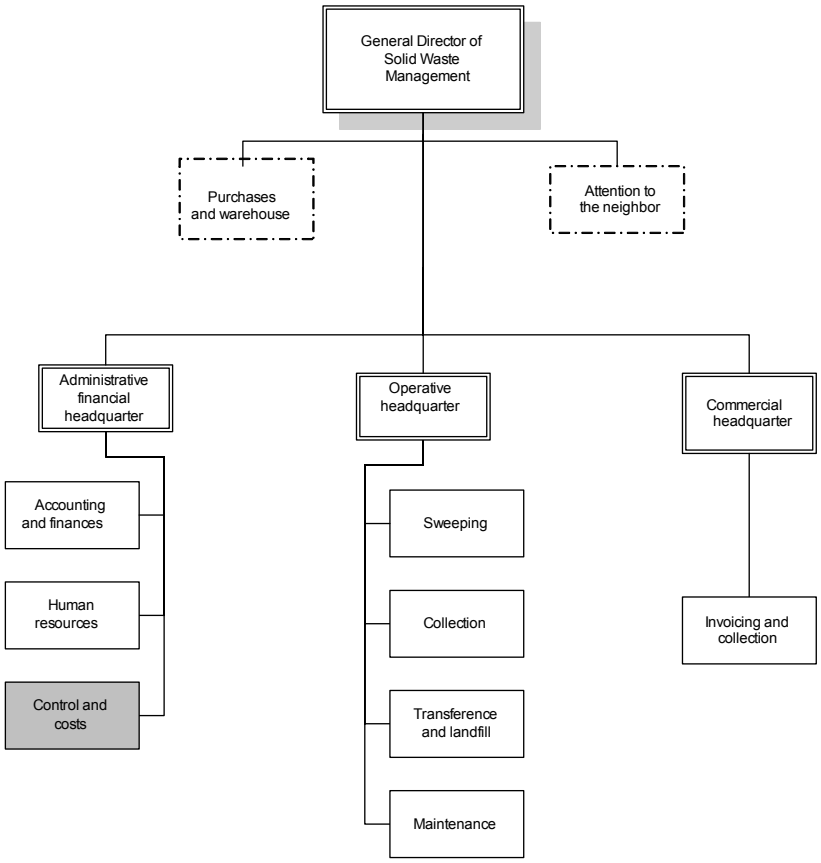
It is proposed to structure the Executive Unit of the Master Plan. This agency will have as objective the implementation of the Master Plan and the achievement of the goals proposed, as well as to strengthen and to facilitate the coordination among the three government levels, with the purpose of protecting the aquatic environment on the coast of Quintana Roo state.

It is recommended that this Executive Unit be under the coordination of SEDUMA, because this is the governing organ of urban development and environmental management at the state level.

72. Restructuring of municipal executing bodies of SWM

In the figure below appears the organizational structure proposed for SWM in the municipality of Othon P. Blanco.

Municipality of Othon P Blanco
Management of Solid Waste
Organizational Structure Proposed



Due to the importance of the SWM on the protection to health and to the preservation of natural resources, as well as its proportion on the municipal budget, it is significant to privilege the hierarchy of the administrative unit in charge of rendering the service.

The creation of a General Office for Solid Waste Management that depends directly from the bureau of the Mayor is proposed. The decision-making at a higher political level will make easier the implementation of any changes and adjustments that are raised on the Master Plan.

Purchase and Storehouse:	Oriented to give support to the unity of Maintenance with the purpose of augmenting the availability of the vehicles and facilitate the activities foreseen in the rendering of the service.
Attention to the neighbor:	To establish an information link and immediate attention with the users of the service.
Administration and Finances:	Manages the resources of the service; prepares the budget and executes it according to the operative needs. The unity of Control and Costs is in charge of verifying that the service achieves the goals of quality of the service (effectiveness) and that the use of resources is efficient.
Operations:	Renders the service according to the norms of quality established in the Regulation.
Commercial:	Offers enough incomes to achieve the sustainability of the service.

8. Establishment of a new SWM system in Costa Maya

It is forecast that number of tourists and population will increase in the future due to tourism development. However, this forecast comprehends great uncertainty, because it is affected various factors, such as economic situation in the country and all over the world, abnormal weather, other competent resorts and so forth. It is risky to construct infrastructures which require a large amount of investment and have little flexibility, such as landfills and transfer stations.

Therefore, it is recommendable at the initial stage to develop an institutional framework and to introduce culture of waste minimization, which are flexible to progress of development, then, to develop required infrastructures later. The following are proposed measures.

81. Establishment of an organizational and institutional framework

The institutional framework is constituted by the "General Law for the Prevention and Integral Management of Waste" (Official Magazine of the Federation, October 08th, 2003 and came into effect on April 08th, 2004); the document of the "Regulation for the Rendering of the Public Service for the Integral Management of Urban Solid Waste" is currently under consideration by the Municipal Council; as well as the "Regulation of Collection, Management and Final Disposal of Solid Waste in Mahahual". It is recommended the approval of the regulation by part of the municipal authorities in Othon P. Blanco.

The community of Mahahual has constituted the "Commission for the Management of Solid Waste" and it is expected the early recognition by part of the Municipality of Othon P. Blanco.

We recommend the organization of the administrative unit of urban development to include the planning and control on the management of solid waste and as well the formulation of a scheme of fair and equitable fees that allow the financial sustainability of the system.

82. Introduction of the culture of minimization

In the community of Mahahual has started the creation of a minimization culture on regards of the integral management of solid waste. Pedestrians place on a separate way their wastes on the stations that have been placed on the coastal streets.

The students of the Tele High school have taken under their responsibility the management of products coming from such separation and have constructed a composter that will treat the organic wastes generated by restaurants.

The group ECOCE, formed by the main companies that bottle beverages in Mexico, has been interested in collecting all PET bottles. The high school is constructing, for such aim, a small gathering centre within the limits of its property.

The authorities of the three government levels coincide in that the minimization is the correct way for the sustainable management of solid waste.

It is recommended to encourage, to facilitate and to establish the culture of minimization using the incentives created in the General Law.

83. Preparation of establishing a firm SWM system

The municipality of Othon P. Blanco has decided to intervene directly in the integral management of solid waste in Mahahual.

Likewise, they have started the pertinent actions in order to obtain support from FONATUR regarding the construction of the sanitary landfill in Costa Maya, with a cost that overpass the 20 million pesos and which includes the mechanical equipment for the operation.

This construction will be part of the infrastructure, necessary for the touristic development of Costa Maya. It is recommended that the competent authorities support the requirement made by the municipality of Othon P. Blanco to FONATUR.

H.3.3.2 Burden Sharing of the Proposed Measures

The following table shows burden sharing of the proposed measures among the stakeholders.

Table H-80: Burden Sharing of the Proposed Measures

Stakeholders / Proposed Measures	Federal	State	Municipal	Private sector/ NGO	Citizens
symbols	R responsible, S supporting, P participation/cooperation				
11. Focusing on the urban area			R		
21. Flexible arrangement of collection rate			R		
22. Flexible arrangement of final disposal manners			R		
31. Environmental education on waste minimization 311. Environmental education and recycling activities in schools 312. Environmental education and recycling activities in communities 313. Advertisement of importance of waste minimization through public institutions and/or mass media		R	R	P	P
32. Promotion of backyard composting 321. Preparing and distributing materials how to make compost from garden waste 322. Establishing visit instruction system of composting 333. Demonstrating composting in public institutions		S	R	P	P
33. Pruning waste composting		S	R	P	
34. Setting of Waste Minimization Rate		S	R		
41. Income improvement 411. General application of service charges 412. Realistic service charges and income improvement 413. Timely billing and payment facility 414. Control of bill collection 415. Specific use of income			R	P	P
42. Cost reduction 421. Improvement of waste collection works 422. Constant monitoring			R	P	
51. Establishment an information system for the integral management	R	R	R		
61. Formulation of a municipal regulation on SWM		S	R		
62. Formulation of rules for public-private partnership		S	R		
71. Establishment of a specialized administrative unit in SEDUMA		R			
72. Restructuring of municipal executing bodies of SWM			R		

Stakeholders / Proposed Measures	Federal	State	Municipal	Private sector/ NGO	Citizens
symbols	R responsible, S supporting, P participation/cooperation				
81. Establishment of an organizational and institutional framework 82. Introduction of culture of waste minimization 83. Preparation of establishment of a firm SWM system		S	R	P	P

H.3.4 Waste Stream

This section describes waste streams of the Master Plan.

Table H-81: Waste Stream of the Master Plan in 2007

Item		Unit	Urban			Sub-total	Rural	Total
			OPB	FCP	SOL			
1. Population								
population	a	nos.	241,173	35,166	228,969	505,308	113,117	618,425
2. Waste amount								
1) At source								
generation	b	ton/day	287.0	39.9	300.8	627.7	106.3	734.0
source reduction	c	ton/day	11.5	1.5	12.0	25.0	0.0	25.0
self-disposal	d	ton/day	14.4	11.5	0.8	26.7	106.3	133.0
discharge	e	ton/day	261.1	26.9	288.0	576.0	0.0	576.0
2) Collection								
mixed waste	f	ton/day	256.4	26.9	282.0	565.3	0.0	565.3
garden waste	g	ton/day	4.7	0.0	6.0	10.7	0.0	10.7
3) Intermediate								
for composting	h	ton/day	4.2	0.0	5.4	9.6	0.0	9.6
residue	i	ton/day	0.5	0.0	0.6	1.1	0.0	1.1
4) Disposal								
disposal	j	ton/day	256.9	26.9	282.6	566.4	0.0	566.4
3. Rates								
collection	(f+g)/(d+e)	%	94.8	70.1	99.7	95.6	0.0	81.2
minimization	(c+h)/b	%	5.5	3.8	5.8	5.5	0.0	4.7

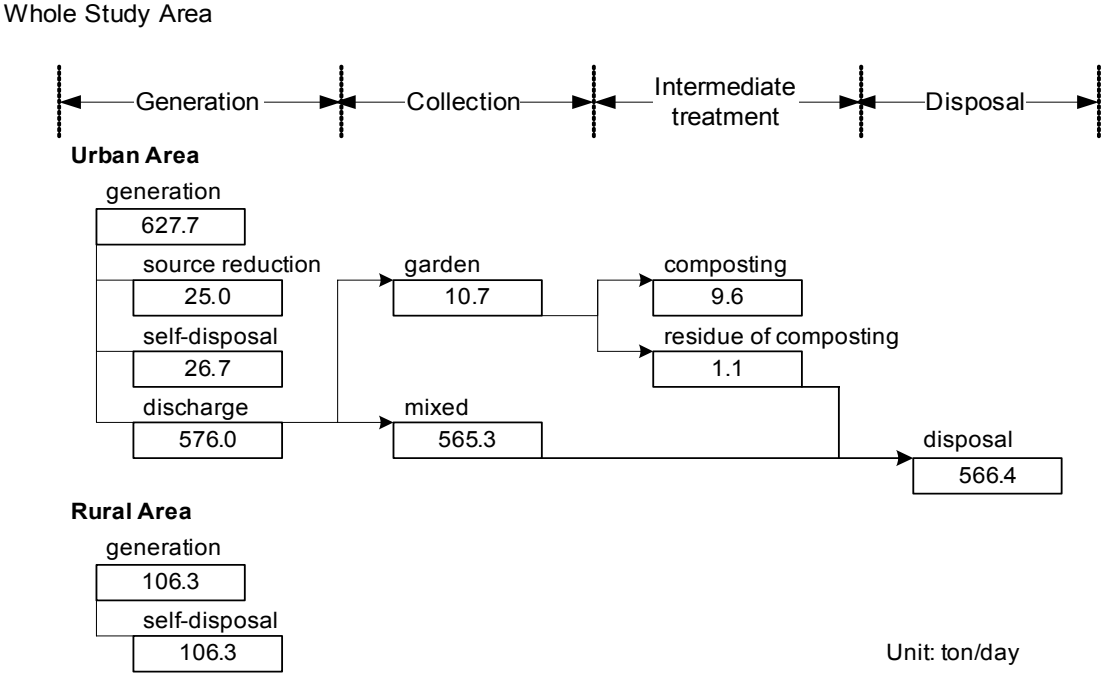


Figure H-22: Waste Stream of the Master Plan in 2007

Table H-82: Waste Stream of the Master Plan in 2007 (Othon P Blanco)

Item		Unit	Urban 1	Urban 2	Urban 3	Urban 4	Urban 5	Sub-tot	Rural	Total
1. Population										
population	a	nos.	149,465	10,812	4,206	27,306	49,384	241,173	63,916	305,089
2. Waste amount										
1) At source										
generation	b	ton/day	176.3	12.7	5.0	32.2	60.8	287.0	63.3	350.3
source reduction	c	ton/day	7.1	0.5	0.2	1.3	2.4	11.5	0.0	11.5
self-disposal	d	ton/day	0.0	3.7	1.4	9.3	0.0	14.4	63.3	77.7
discharge	e	ton/day	169.2	8.5	3.4	21.6	58.4	261.1	0.0	261.1
2) Collection										
mixed waste	f	ton/day	165.7	8.5	3.4	21.6	57.2	256.4	0.0	256.4
garden waste	g	ton/day	3.5	0.0	0.0	0.0	1.2	4.7	0.0	4.7
3) Intermediate										
for composting	h	ton/day	3.1	0.0	0.0	0.0	1.1	4.2	0.0	4.2
residue	i	ton/day	0.4	0.0	0.0	0.0	0.1	0.5	0.0	0.5
4) Disposal										
disposal	j	ton/day	166.1	8.5	3.4	21.6	57.3	256.9	0.0	256.9
3. Rates										
collection	(f+g)/(d+e)	%	100.0	69.7	70.8	69.9	100.0	94.8	0.0	77.1
minimization	(c+h)/b	%	5.8	3.9	4.0	4.0	5.8	5.5	0.0	4.5

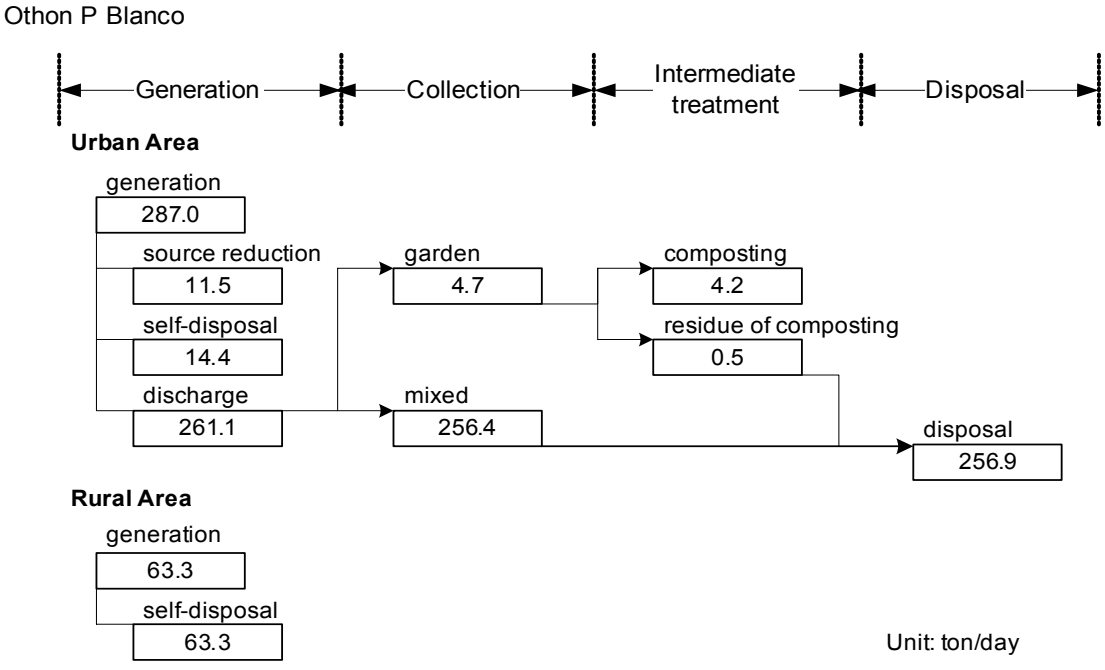


Figure H-23: Waste Stream of the Master Plan in 2007 (Othon P Blanco)

Table H-83: Waste Stream of the Master Plan in 2007 (Felipe C Puerto)

Item		Unit	Urban 6	Urban 7	Urban 8	Sub-total	Rural	Total
1. Population								
population	a	nos.	22,978	4,972	7,216	35,166	32,767	67,933
2. Waste amount								
1) At source								
generation	b	ton/day	26.1	5.6	8.2	39.9	26.3	66.2
source reduction	c	ton/day	1.0	0.2	0.3	1.5	0.0	1.5
self-disposal	d	ton/day	7.5	1.6	2.4	11.5	26.3	37.8
discharge	e	ton/day	17.6	3.8	5.5	26.9	0.0	26.9
2) Collection								
mixed waste	f	ton/day	17.6	3.8	5.5	26.9	0.0	26.9
garden waste	g	ton/day	0.0	0.0	0.0	0.0	0.0	0.0
3) Intermediate								
for composting	h	ton/day	0.0	0.0	0.0	0.0	0.0	0.0
residue	i	ton/day	0.0	0.0	0.0	0.0	0.0	0.0
4) Disposal								
disposal	j	ton/day	17.6	3.8	5.5	26.9	0.0	26.9
3. Rates								
collection	(f+g)/(d+e)	%	70.1	70.4	69.6	70.1	0.0	41.6
minimization	(c+h)/b	%	3.8	3.6	3.7	3.8	0.0	2.3

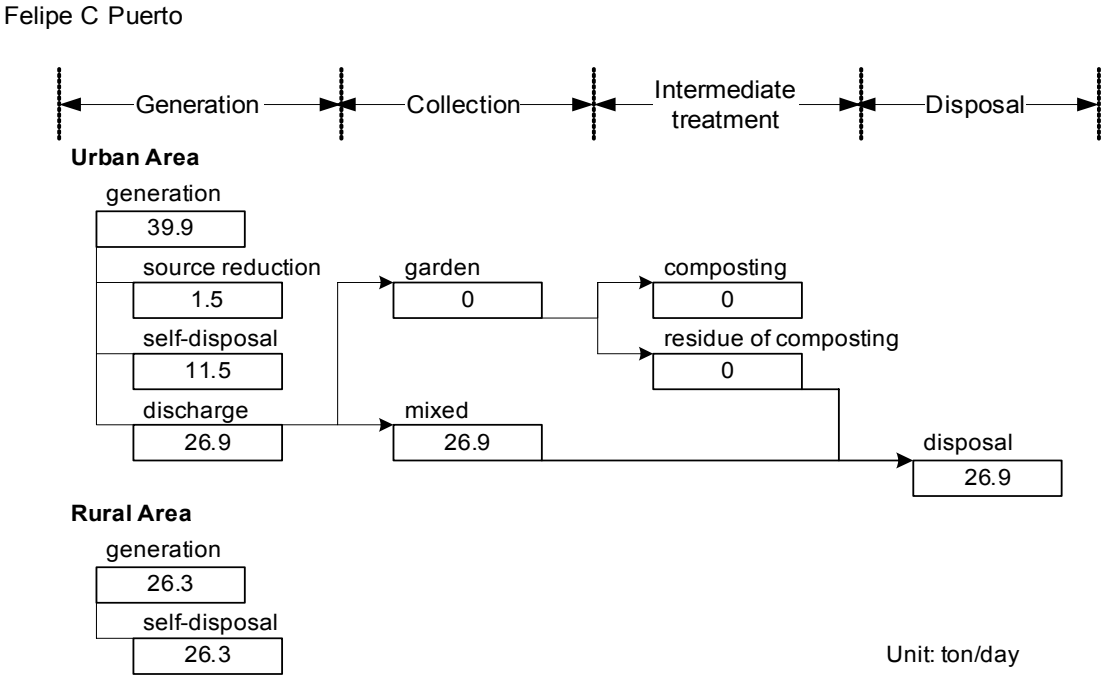


Figure H-24: Waste Stream of the Master Plan in 2007 (Felipe C Puerto)

Table H-84: Waste Stream of the Master Plan in 2007 (Solidaridad)

Item		Unit	Urban 9	Urban 10	Sub-total	Rural	Total
1. Population							
population	a	nos.	226,600	2,369	228,969	16,434	245,403
2. Waste amount							
1) At source							
generation	b	ton/day	298.1	2.7	300.8	16.7	317.5
source reduction	c	ton/day	11.9	0.1	12.0	0.0	12.0
self-disposal	d	ton/day	0.0	0.8	0.8	16.7	17.5
discharge	e	ton/day	286.2	1.8	288.0	0.0	288.0
2) Collection							
mixed waste	f	ton/day	280.2	1.8	282.0	0.0	282.0
garden waste	g	ton/day	6.0	0.0	6.0	0.0	6.0
3) Intermediate							
for composting	h	ton/day	5.4	0.0	5.4	0.0	5.4
residue	i	ton/day	0.6	0.0	0.6	0.0	0.6
4) Disposal							
disposal	j	ton/day	280.8	1.8	282.6	0.0	282.6
3. Rates							
collection	(f+g)/(d+e)	%	100.0	69.2	99.7	0.0	94.3
minimization	(c+h)/b	%	5.8	3.7	5.8	0.0	5.5

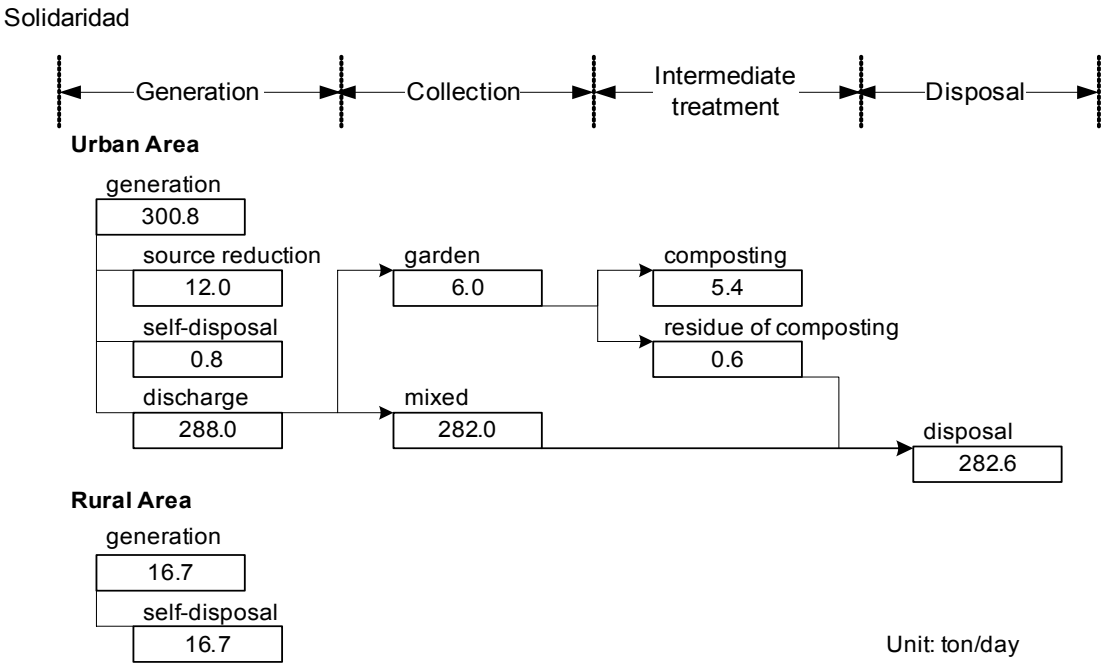


Figure H-25: Waste Stream of the Master Plan in 2007 (Solidaridad)

Table H-85: Waste Stream of the Master Plan in 2011

Item		Unit	Urban			Sub-total	Rural	Total
			OPB	FCP	SOL			
1. Population								
population	a	nos.	300,821	36,909	310,596	648,326	122,544	770,870
2. Waste amount								
1) At source								
generation	b	ton/day	356.3	42.3	404.0	802.6	115.1	917.7
source reduction	c	ton/day	32.0	3.8	36.4	72.2	0.0	72.2
self-disposal	d	ton/day	4.1	5.2	0.6	9.9	115.1	125.0
discharge	e	ton/day	320.2	33.3	367.0	720.5	0.0	720.5
2) Collection								
mixed waste	f	ton/day	302.4	33.3	342.9	678.6	0.0	678.6
garden waste	g	ton/day	17.8	0.0	24.1	41.9	0.0	41.9
3) Intermediate								
for composting	h	ton/day	16.1	0.0	21.7	37.8	0.0	37.8
residue	i	ton/day	1.7	0.0	2.4	4.1	0.0	4.1
4) Disposal								
disposal	j	ton/day	304.1	33.3	345.3	682.7	0.0	682.7
3. Rates								
collection	(f+g)/(d+e)	%	98.7	86.5	99.8	98.6	0.0	85.2
minimization	(c+h)/b	%	13.5	9.0	14.4	13.7	0.0	12.0

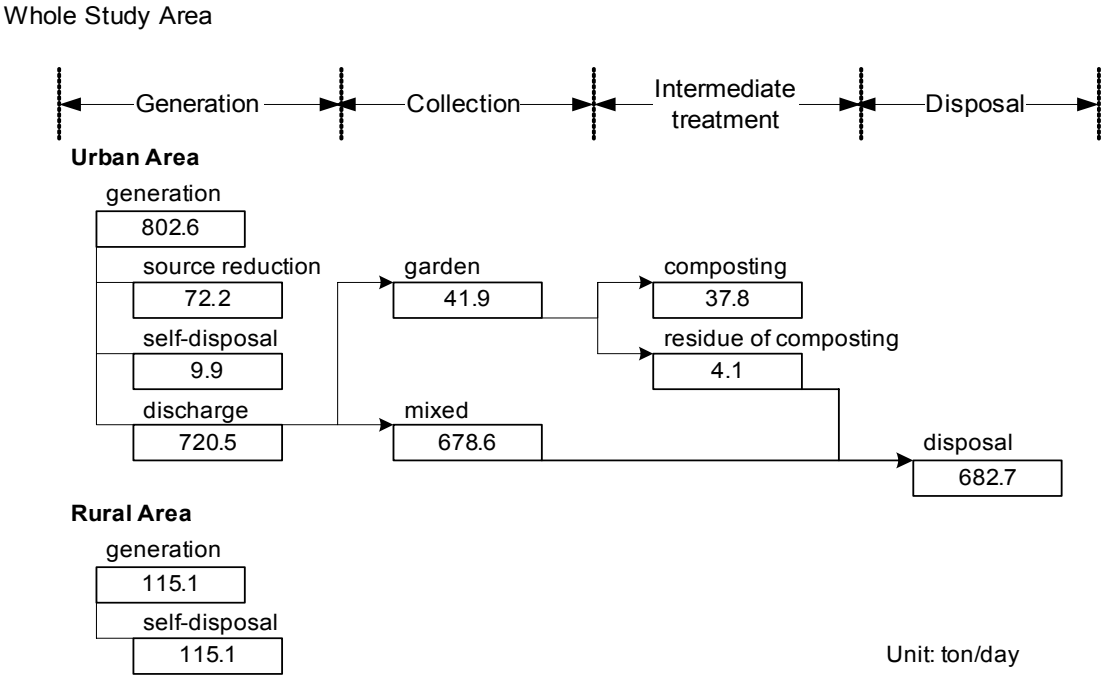


Figure H-26: Waste Stream of the Master Plan in 2011

Table H-86: Waste Stream of the Master Plan in 2011 (Othon P Blanco)

Item		Unit	Urban 1	Urban 2	Urban 3	Urban 4	Urban 5	Sub-tot	Rural	Total
1. Population										
population	a	nos.	160,984	11,646	4,530	35,362	88,299	300,821	68,856	369,677
2. Waste amount										
1) At source										
generation	b	ton/day	189.2	13.7	5.3	41.6	106.5	356.3	68.1	424.4
source reduction	c	ton/day	17.0	1.2	0.5	3.7	9.6	32.0	0.0	32.0
self-disposal	d	ton/day	0.0	1.2	1.0	1.9	0.0	4.1	68.1	72.2
discharge	e	ton/day	172.2	11.3	3.8	36.0	96.9	320.2	0.0	320.2
2) Collection										
mixed waste	f	ton/day	160.8	11.3	3.8	36.0	90.5	302.4	0.0	302.4
garden waste	g	ton/day	11.4	0.0	0.0	0.0	6.4	17.8	0.0	17.8
3) Intermediate										
for composting	h	ton/day	10.3	0.0	0.0	0.0	5.8	16.1	0.0	16.1
residue	i	ton/day	1.1	0.0	0.0	0.0	0.6	1.7	0.0	1.7
4) Disposal										
disposal	j	ton/day	161.9	11.3	3.8	36.0	91.1	304.1	0.0	304.1
3. Rates										
collection	(f+g)/(d+e)	%	100.0	90.4	79.2	95.0	100.0	98.7	0.0	81.6
minimization	(c+h)/b	%	14.4	8.8	9.4	8.9	14.5	13.5	0.0	11.3

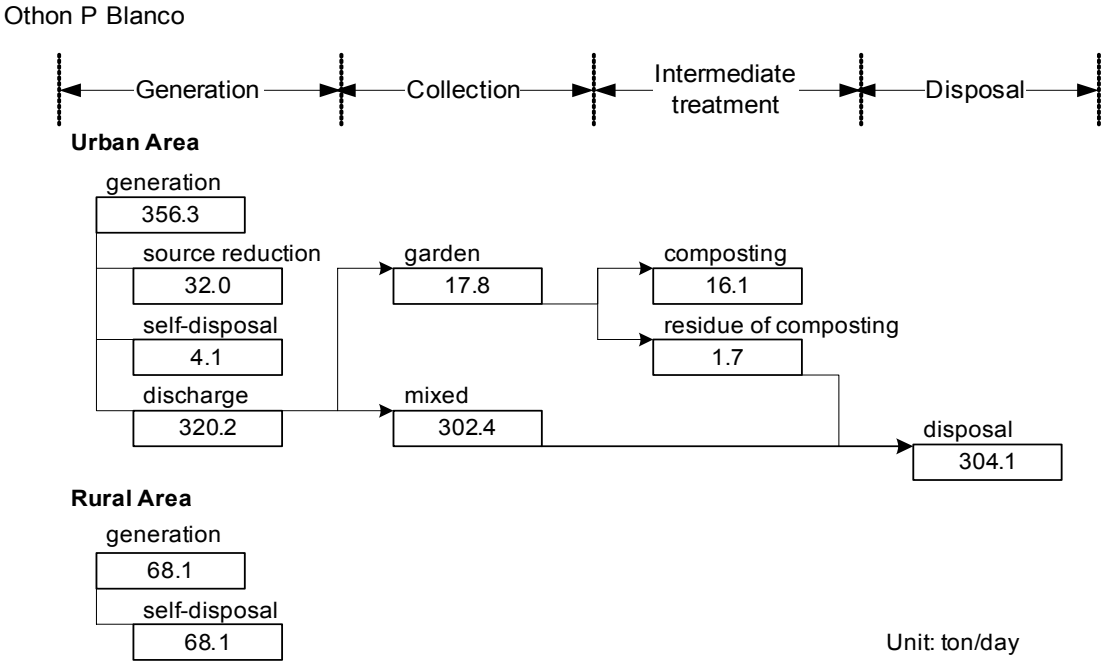


Figure H-27: Waste Stream of the Master Plan in 2011 (Othon P Blanco)

Table H-87: Waste Stream of the Master Plan in 2011 (Felipe C Puerto)

Item		Unit	Urban 6	Urban 7	Urban 8	Sub-total	Rural	Total
1. Population								
population	a	nos.	24,117	5,218	7,574	36,909	34,400	71,309
2. Waste amount								
1) At source								
generation	b	ton/day	27.6	6.0	8.7	42.3	27.5	69.8
source reduction	c	ton/day	2.5	0.5	0.8	3.8	0.0	3.8
self-disposal	d	ton/day	2.5	1.1	1.6	5.2	27.5	32.7
discharge	e	ton/day	22.6	4.4	6.3	33.3	0.0	33.3
2) Collection								
mixed waste	f	ton/day	22.6	4.4	6.3	33.3	0.0	33.3
garden waste	g	ton/day	0.0	0.0	0.0	0.0	0.0	0.0
3) Intermediate								
for composting	h	ton/day	0.0	0.0	0.0	0.0	0.0	0.0
residue	i	ton/day	0.0	0.0	0.0	0.0	0.0	0.0
4) Disposal								
disposal	j	ton/day	22.6	4.4	6.3	33.3	0.0	33.3
3. Rates								
collection	(f+g)/(d+e)	%	90.0	80.0	79.7	86.5	0.0	50.5
minimization	(c+h)/b	%	9.1	8.3	9.2	9.0	0.0	5.4

Felipe C Puerto

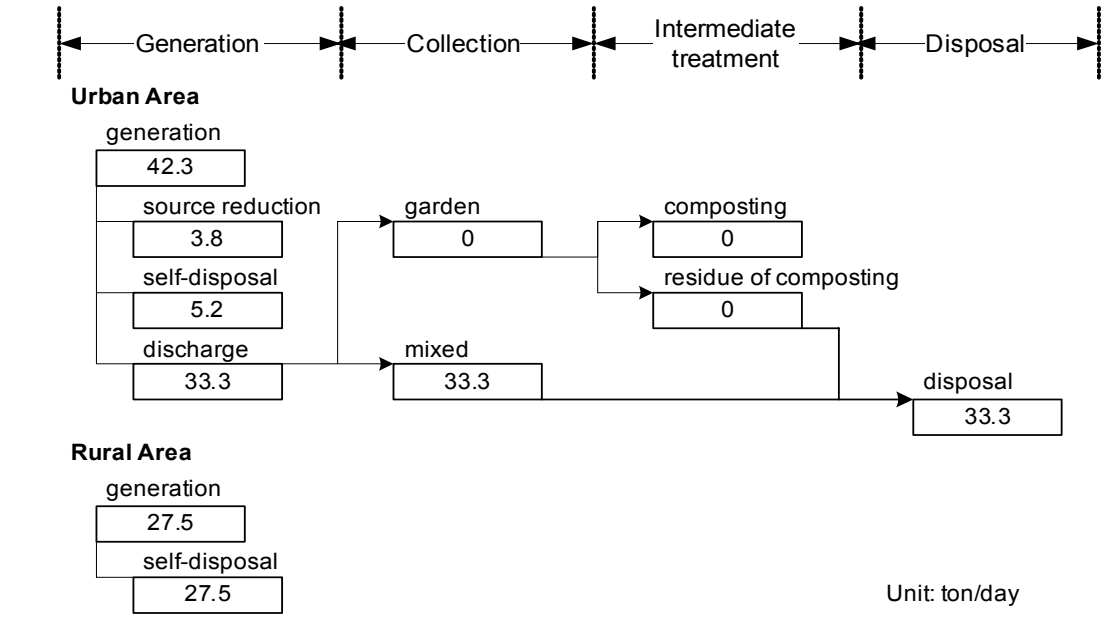


Figure H-28: Waste Stream of the Master Plan in 2011 (Felipe C Puerto)

Table H-88: Waste Stream of the Master Plan in 2011 (Solidaridad)

Item		Unit	Urban 9	Urban 10	Sub-total	Rural	Total
1. Population							
population	a	nos.	307,932	2,664	310,596	19,288	329,884
2. Waste amount							
1) At source							
generation	b	ton/day	400.9	3.1	404.0	19.5	423.5
source reduction	c	ton/day	36.1	0.3	36.4	0.0	36.4
self-disposal	d	ton/day	0.0	0.6	0.6	19.5	20.1
discharge	e	ton/day	364.8	2.2	367.0	0.0	367.0
2) Collection							
mixed waste	f	ton/day	340.7	2.2	342.9	0.0	342.9
garden waste	g	ton/day	24.1	0.0	24.1	0.0	24.1
3) Intermediate							
for composting	h	ton/day	21.7	0.0	21.7	0.0	21.7
residue	i	ton/day	2.4	0.0	2.4	0.0	2.4
4) Disposal							
disposal	j	ton/day	343.1	2.2	345.3	0.0	345.3
3. Rates							
collection	(f+g)/(d+e)	%	100.0	78.6	99.8	0.0	94.8
minimization	(c+h)/b	%	14.4	9.7	14.4	0.0	13.7

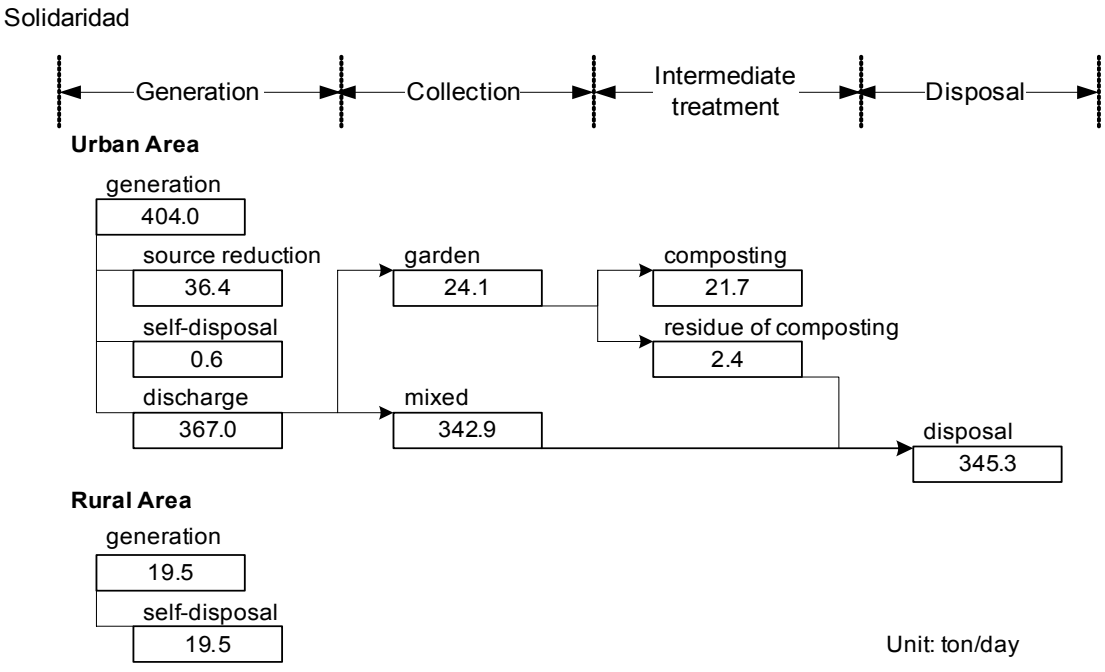


Figure H-29: Waste Stream of the Master Plan in 2011 (Solidaridad)

Table H-89: Waste Stream of the Master Plan in 2015

Item		Unit	Urban			Sub-total	Rural	Total
			OPB	FCP	SOL			
1. Population								
population	a	nos.	341,449	38,273	382,664	762,386	130,408	892,794
2. Waste amount								
1) At source								
generation	b	ton/day	406.1	44.0	495.6	945.7	122.9	1,068.6
source reduction	c	ton/day	61.0	6.6	74.3	141.9	0.0	141.9
Self-disposal	d	ton/day	4.4	5.0	0.6	10.0	122.9	132.9
discharge	e	ton/day	340.7	32.4	420.7	793.8	0.0	793.8
2) Collection								
mixed waste	f	ton/day	307.2	32.4	371.5	711.1	0.0	711.1
garden waste	g	ton/day	33.5	0.0	49.2	82.7	0.0	82.7
3) Intermediate								
for composting	h	ton/day	30.2	0.0	44.3	74.5	0.0	74.5
residue	i	ton/day	3.3	0.0	4.9	8.2	0.0	8.2
4) Disposal								
disposal	j	ton/day	310.5	32.4	376.4	719.3	0.0	719.3
3. Rates								
collection	(f+g)/(d+e)	%	98.7	86.6	99.9	98.8	0.0	85.7
minimization	(c+h)/b	%	22.5	15.0	23.9	22.9	0.0	20.3

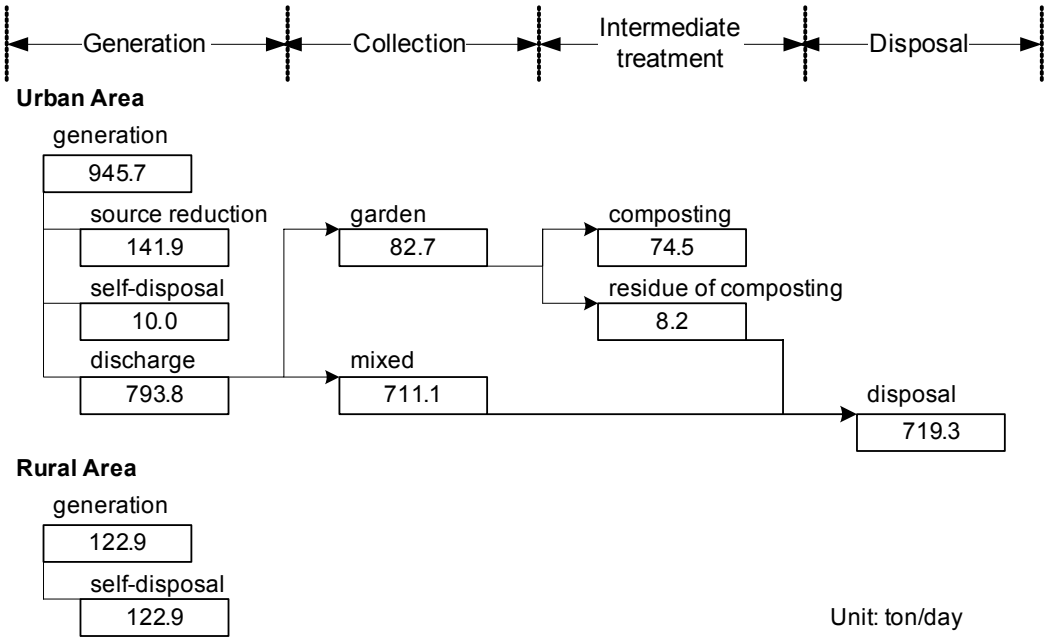


Figure H-30: Waste Stream of the Master Plan in 2015

Table H-90: Waste Stream of the Master Plan in 2015 (Othon P Blanco)

Item		Unit	Urban 1	Urban 2	Urban 3	Urban 4	Urban 5	Sub-tot	Rural	Total
1. Population										
population	a	nos.	172,488	12,474	4,854	43,418	108,215	341,449	73,740	415,189
2. Waste amount										
1) At source										
generation	b	ton/day	203.8	14.7	5.7	51.3	130.6	406.1	73.0	479.1
source reduction	c	ton/day	30.6	2.2	0.9	7.7	19.6	61.0	0.0	61.0
self-disposal	d	ton/day	0.0	1.2	1.0	2.2	0.0	4.4	73.0	77.4
discharge	e	ton/day	173.2	11.3	3.8	41.4	111.0	340.7	0.0	340.7
2) Collection										
mixed waste	f	ton/day	152.8	11.3	3.8	41.4	97.9	307.2	0.0	307.2
garden waste	g	ton/day	20.4	0.0	0.0	0.0	13.1	33.5	0.0	33.5
3) Intermediate										
for composting	h	ton/day	18.4	0.0	0.0	0.0	11.8	30.2	0.0	30.2
residue	i	ton/day	2.0	0.0	0.0	0.0	1.3	3.3	0.0	3.3
4) Disposal										
disposal	j	ton/day	154.8	11.3	3.8	41.4	99.2	310.5	0.0	310.5
3. Rates										
collection	(f+g)/(d+e)	%	100.0	90.4	79.2	95.0	100.0	98.7	0.0	81.5
minimization	(c+h)/b	%	24.0	15.0	15.8	15.0	24.0	22.5	0.0	19.0

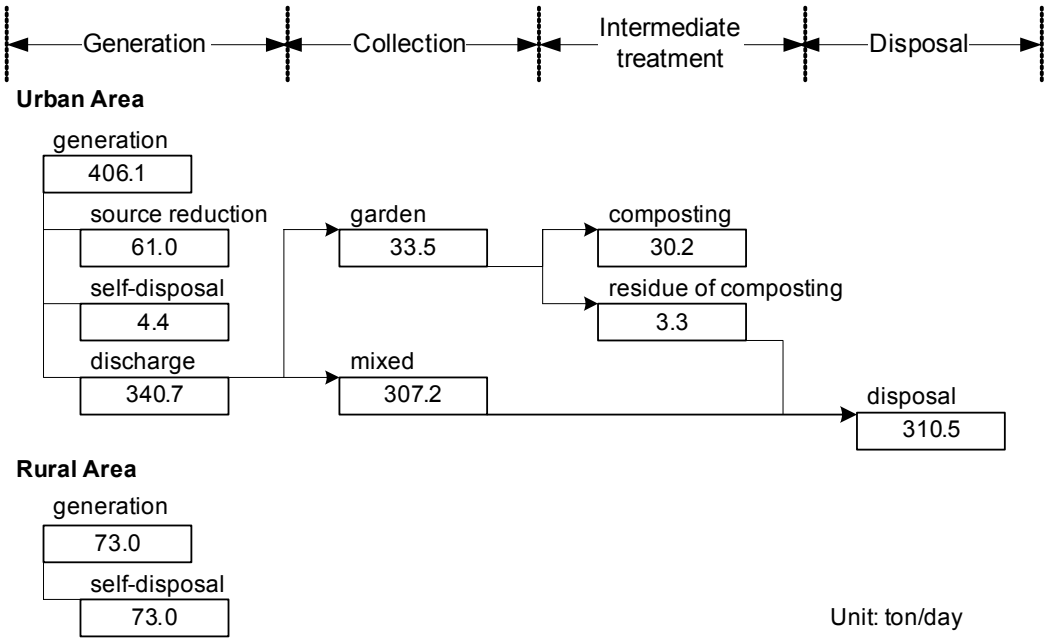


Figure H-31: Waste Stream of the Master Plan in 2015 (Othon P Blanco)

Table H-91: Waste Stream of the Master Plan in 2015 (Felipe C Puerto)

Item		Unit	Urban 6	Urban 7	Urban 8	Sub-total	Rural	Total
1. Population								
population	a	nos.	25,009	5,410	7,854	38,273	35,628	73,901
2. Waste amount								
1) At source								
generation	b	ton/day	28.8	6.2	9.0	44.0	28.7	72.7
source reduction	c	ton/day	4.3	0.9	1.4	6.6	0.0	6.6
self-disposal	d	ton/day	2.4	1.1	1.5	5.0	28.7	33.7
discharge	e	ton/day	22.1	4.2	6.1	32.4	0.0	32.4
2) Collection								
mixed waste	f	ton/day	22.1	4.2	6.1	32.4	0.0	32.4
garden waste	g	ton/day	0.0	0.0	0.0	0.0	0.0	0.0
3) Intermediate								
for composting	h	ton/day	0.0	0.0	0.0	0.0	0.0	0.0
residue	i	ton/day	0.0	0.0	0.0	0.0	0.0	0.0
4) Disposal								
disposal	j	ton/day	22.1	4.2	6.1	32.4	0.0	32.4
3. Rates								
collection	(f+g)/(d+e)	%	90.2	79.2	80.3	86.6	0.0	49.1
minimization	(c+h)/b	%	14.9	14.5	15.6	15.0	0.0	9.1

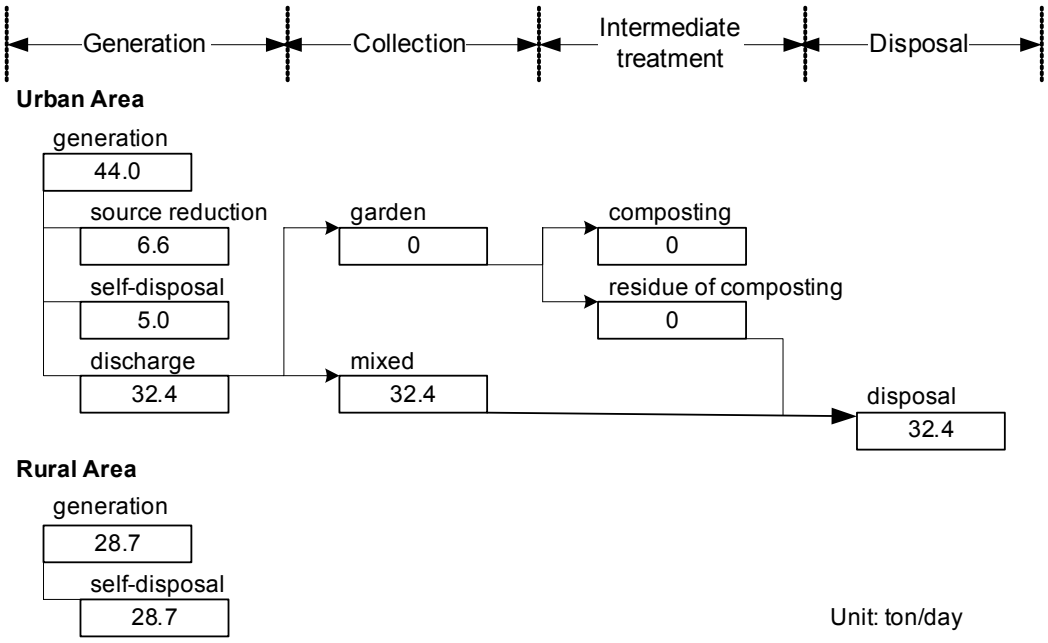


Figure H-32: Waste Stream of the Master Plan in 2015 (Felipe C Puerto)

Table H-92: Waste Stream of the Master Plan in 2015 (Solidaridad)

Item		Unit	Urban 9	Urban 10	Sub-total	Rural	Total
1. Population							
population	a	nos.	379,664	3,000	382,664	21,040	403,704
2. Waste amount							
1) At source							
generation	b	ton/day	492.1	3.5	495.6	21.2	516.8
source reduction	c	ton/day	73.8	0.5	74.3	0.0	74.3
self-disposal	d	ton/day	0.0	0.6	0.6	21.2	21.8
discharge	e	ton/day	418.3	2.4	420.7	0.0	420.7
2) Collection							
mixed waste	f	ton/day	369.1	2.4	371.5	0.0	371.5
garden waste	g	ton/day	49.2	0.0	49.2	0.0	49.2
3) Intermediate							
for composting	h	ton/day	44.3	0.0	44.3	0.0	44.3
residue	i	ton/day	4.9	0.0	4.9	0.0	4.9
4) Disposal							
disposal	j	ton/day	374.0	2.4	376.4	0.0	376.4
3. Rates							
collection	(f+g)/(d+e)	%	100.0	80.0	99.9	0.0	95.1
minimization	(c+h)/b	%	24.0	14.3	23.9	0.0	22.9

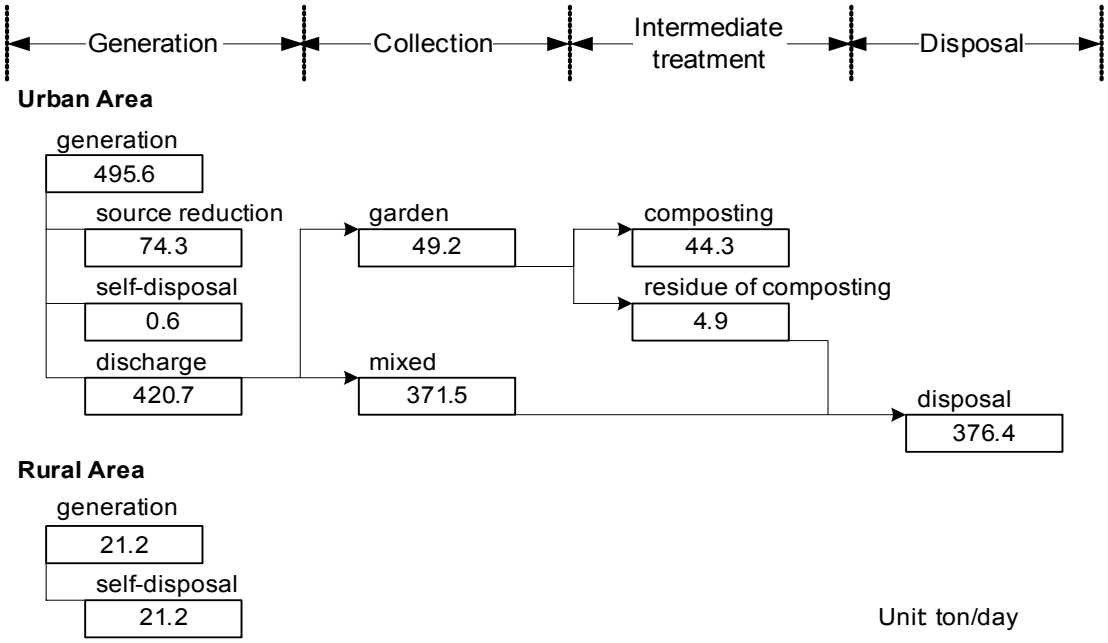


Figure H-33: Waste Stream of the Master Plan in 2015 (Solidaridad)

H.3.5 Cost Estimation

a. Basic Conditions

This Section presents basic condition for cost estimation of the SWM Master Plan.

The price and foreign exchange rates are based on them in November 2003.

Exchange Rates

US$ 1.00 = 11.00 Mexican pesos = JP¥110

Service Life

Backyard compost bin : 5 years

Equipment : 7 years

Unit Costs

The table below shows unit costs for the cost estimation.

Table H-93: Unit Costs

Description	Unit	Price (peso)	Price (USD)
Personnel			
Manager	person/year	200,000.00	-
engineer	person/year	150,000.00	-
supervisor	person/year	120,000.00	-
mechanic	person/year	100,000.00	-
mechanic assistant	person/year	70,000.00	-
driver	person/year	70,000.00	-
worker	person/year	60,000.00	-
secretary	person/year	70,000.00	-
street sweeper	person/year	30,000.00	-
Earthwork			
machine excavation, 200 m transport and stockpiling	m3	50.00	-
machine excavation, 500 m transport and stockpiling	m3	50.00	-
machine excavation, 1,000 m transport and stockpiling	m3	50.00	-
construction of embankment, machine filling and compaction	m3	100.00	-
synthetic liner (HDPE)	m2	100.00	-
clay liner (60 cm)	m2	40.00	-
Installation of liner	m2	20.00	-
Drainage			
s/t/p 100 mm PVC-drainage pipe (earthwork is not included)	LM	100.00	-
s/t/p 200 mm PVC-drainage pipe (earthwork is not included)	LM	150.00	-
s/t/p 300 mm PVC-drainage pipe (earthwork is not included)	LM	200.00	-
s/t/p 300 mm concrete pipe (earthwork is not included)	LM	250.00	-
s/t/p 400 mm concrete pipe (earthwork is not included)	LM	300.00	-
s/t/p 500 mm concrete pipe (earthwork is not included)	LM	350.00	-
Building			
s/t/p premixed concrete 180 kg/cm2 (2,500 lb./in2)	m3	1,100.00	-
s/t/p premixed concrete 210 kg/cm2 (3,000 lb./in2)	m3	1,200.00	-

Description	Unit	Price (peso)	Price (USD)
s/t/p premixed concrete 280 kg/cm2 (4,000 lb./in2)	m3	1,500.00	-
Office building R/C including all works	m2	4,000.00	-
Shop, steel structure	m2	2,000.00	-
Roof (slate covered)	m2	300.00	-
Wall (block)	m2	200.00	-
Road Work			
s/t/p concrete road pavement (t=0.15m)	m2	220.00	-
s/t/p hot-mix asphalt road pavement (t=0.1m)	m2	85.00	-
s/t/p gravel road (t=0.3 m) and subgrade preparation	m2	55.00	-
Miscellaneous			
weighbridge, 60 ton, with computerized data log system	set	-	70,000.00
s/t/p plant trees 2 to 5 m in height	tree	600.00	-
s/t/p fence (H=2.5 m)	m	150.00	-
s/t/p gabion, 1 m x 1 m x 2 m	m3	150.00	-
s/t/p gas removal pipe, 200 mm perforated HDPE	m	130.00	-
Basic Materials			
diesel oil	gallon	4.90	-
gasoline	gallon	5.70	-
crushed rock	m3	145.00	-
sand	m3	145.00	-
reinforced bar	ton	7,500.00	-
Equipment (New)			
Compactor truck 20 yd3 or 15.29 m3	unit	-	85,000.00
Compactor truck 16 yd3 or 12 m3	unit	-	80,000.00
Compactor truck 8 yd3 or 8 m3	unit	-	70,000.00
Dump truck (6 ton)	unit	-	55,000.00
Dump truck (10 ton)	unit	-	75,000.00
Tractor-trailer 20t (inc. 85 yd3 trailer)	unit	-	120,000.00
Tractor (pay load 20t)	unit	-	75,000.00
85 yd3trailer (hydraulic ejector blade)	unit	-	45,000.00
Hoist truck (for 30 yd3 container)	unit	-	65,000.00
30 yd3 container for hoist truck	unit	-	32,000.00
Water-tank truck (15,000 liters)	unit	-	75,000.00
Water-tank truck (10,000 liters)	unit	-	65,000.00
Road sweeper	unit	-	80,000.00
Wheel loader (100 kw)	unit	-	172,000.00
Wheel loader (70 kw)	unit	-	90,000.00
Bulldozer (CAT D6 class)	unit	-	235,000.00
Bulldozer (CAT D7 class)	unit	-	312,000.00
Landfill compactor (CAT 826)	unit	-	235,000.00
Fork lift (40 kw)	unit	-	25,000.00
Excavator (100 kw)	unit	-	190,000.00
Excavator (75 kw)	unit	-	150,000.00
Container (4.5 m3)	unit	-	700.00
Handcart	unit	480.00	-

b. Source Reduction

It is assumed that the municipalities would subsidize 50% of container price when the citizens purchase it. The tables below show amount of subsidies required for the source reduction.

Table H-94: Cost of Source Reduction by Municipality

	year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Study Area (Total)														
source reduction	ton/year	0	3,981	6,389	9,128	14,785	18,434	22,451	26,356	36,723	41,429	46,466	51,796	277,938
participant	% of total households	0%	11%	16%	21%	32%	37%	43%	48%	64%	69%	75%	80%	
participant	nos. of household	0	10,860	17,679	25,424	41,018	51,214	62,370	73,395	102,166	115,341	129,236	143,848	
purchase of container	nos.	0	10,860	6,819	7,745	15,594	10,196	22,016	28,704	43,335	36,514	39,685	35,964	257,432
cost (subsidy)	1000pesos/year	0	1,193	749	852	1,716	1,121	2,421	3,156	4,768	4,017	4,366	3,957	28,316
unit cost	pesos/ton of reduction	-	300	117	93	116	61	108	120	130	97	94	76	102
OPB														
source reduction	ton/year	0	1,826	2,921	4,199	6,717	8,323	10,076	11,681	16,172	18,032	20,075	22,266	122,288
participant	% of total households	0%	11%	16%	21%	32%	37%	43%	48%	64%	69%	75%	80%	
participant	nos. of household	0	5,238	8,478	12,135	19,448	24,141	29,249	34,055	46,941	52,512	58,341	64,425	
purchase of container	nos.	0	5,238	3,240	3,657	7,313	4,693	10,346	13,284	19,783	16,541	17,835	15,885	117,815
cost (subsidy)	1000pesos/year	0	576	356	402	805	516	1,138	1,460	2,177	1,819	1,962	1,748	12,959
unit cost	pesos/ton of reduction	-	315	122	96	120	62	113	125	135	101	98	79	106
FCP														
source reduction	ton/year	0	293	438	548	877	1,059	1,242	1,388	1,863	2,081	2,264	2,410	14,463
participant	% of total households	0%	11%	16%	21%	32%	37%	43%	48%	64%	69%	75%	80%	
participant	nos. of household	0	862	1,310	1,769	2,689	3,178	3,679	4,178	5,623	6,147	6,680	7,222	
purchase of container	nos.	0	862	448	459	920	489	1,363	1,809	2,352	1,903	1,942	1,532	14,079
cost (subsidy)	1000pesos/year	0	94	49	50	101	54	150	199	259	210	214	169	1,549
unit cost	pesos/ton of reduction	-	321	112	91	115	51	121	143	139	101	95	70	107
SOL														
source reduction	ton/year	0	1,862	3,030	4,381	7,191	9,052	11,133	13,287	18,688	21,316	24,127	27,120	141,187
participant	% of total households	0%	11%	16%	21%	32%	37%	43%	48%	64%	69%	75%	80%	
participant	nos. of household	0	4,760	7,891	11,520	18,881	23,895	29,442	35,162	49,602	56,682	64,215	72,201	
purchase of container	nos.	0	4,760	3,131	3,629	7,361	5,014	10,307	13,611	21,200	18,070	19,908	18,547	125,538
cost (subsidy)	1000pesos/year	0	523	344	400	810	551	1,133	1,497	2,332	1,988	2,190	2,040	13,808
unit cost	pesos/ton of reduction	-	281	114	91	113	61	102	113	125	93	91	75	98

Table H-95: Cost of Resource Reduction by Urban Group

Urban 1 (OPB)	year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
source reduction	ton/year	0	1,241	1,898	2,592	3,942	4,672	5,439	6,205	8,432	9,308	10,220	11,169	
participant	% of total households	0%	11%	16%	21%	32%	37%	43%	48%	64%	69%	75%	80%	
participant	nos. of household	0	3,615	5,531	7,520	11,498	13,668	15,910	18,225	24,734	27,265	29,869	32,545	
purchase of container	nos.	0	3,615	1,916	1,989	3,978	2,170	5,857	7,846	10,414	8,498	8,752	7,088	62,123
cost (subsidy)	1000pesos/year	0	398	211	219	438	239	644	863	1,146	935	963	780	6,836

Urban 2 (OPB)	year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
source reduction	ton/year	0	73	146	183	292	329	402	438	621	657	730	803	
participant	% of total households	0%	11%	16%	21%	32%	37%	43%	48%	64%	69%	75%	80%	
participant	nos. of household	0	262	400	544	832	989	1,151	1,318	1,789	1,972	2,160	2,354	
purchase of container	nos.	0	262	138	144	288	157	424	567	753	615	633	513	4,494
cost (subsidy)	1000pesos/year	0	29	15	16	32	17	47	62	83	68	70	56	495

Urban 3 (OPB)	year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
source reduction	ton/year	0	37	37	73	110	146	146	183	256	256	292	329	
participant	% of total households	0%	11%	16%	21%	32%	37%	43%	48%	64%	69%	75%	80%	
participant	nos. of household	0	102	156	212	324	385	448	513	696	767	841	916	
purchase of container	nos.	0	102	54	56	112	61	165	221	293	239	247	199	1,749
cost (subsidy)	1000pesos/year	0	11	6	6	12	7	18	24	32	26	27	22	191

Urban 4 (OPB)	year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
source reduction	ton/year	0	219	329	475	767	949	1,132	1,351	1,935	2,190	2,482	2,811	
participant	% of total households	0%	11%	16%	21%	32%	37%	43%	48%	64%	69%	75%	80%	
participant	nos. of household	0	586	954	1,374	2,213	2,759	3,356	4,003	5,642	6,441	7,291	8,192	
purchase of container	nos.	0	586	368	420	839	546	1,183	1,601	2,427	2,058	2,235	2,044	14,307
cost (subsidy)	1000pesos/year	0	64	40	46	92	60	130	176	267	226	246	225	1,572

Urban 5 (OPB)	year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
source reduction	ton/year	0	256	511	876	1,606	2,227	2,957	3,504	4,928	5,621	6,351	7,154	
participant	% of total households	0%	11%	16%	21%	32%	37%	43%	48%	64%	69%	75%	80%	
participant	nos. of household	0	673	1,437	2,485	4,581	6,340	8,384	9,996	14,080	16,067	18,180	20,418	
purchase of container	nos.	0	673	764	1,048	2,096	1,759	2,717	3,049	5,896	5,131	5,968	6,041	35,142
cost (subsidy)	1000pesos/year	0	74	84	115	231	193	299	335	649	564	656	665	3,865

Urban 6 (FCP)	year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
source reduction	ton/year	0	183	292	365	584	694	803	913	1,205	1,351	1,460	1,570	
participant	% of total households	0%	11%	16%	21%	32%	37%	43%	48%	64%	69%	75%	80%	
participant	nos. of household	0	563	856	1,156	1,757	2,077	2,404	2,730	3,674	4,017	4,365	4,719	
purchase of container	nos.	0	563	293	300	601	320	890	1,182	1,537	1,244	1,269	1,001	9,200
cost (subsidy)	1000pesos/year	0	62	32	33	66	35	98	130	169	137	140	110	1,012

Urban 7 (FCP)	year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
source reduction	ton/year	0	37	73	73	110	146	183	183	256	292	329	329	
participant	% of total households	0%	11%	16%	21%	32%	37%	43%	48%	64%	69%	75%	80%	
participant	nos. of household	0	122	185	250	380	449	520	591	795	869	944	1,021	
purchase of container	nos.	0	122	63	65	130	69	193	256	332	269	274	217	1,990
cost (subsidy)	1000pesos/year	0	13	7	7	14	8	21	28	37	30	30	24	219

Urban 8 (FCP)	year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
source reduction	ton/year	0	73	73	110	183	219	256	292	402	438	475	511	
participant	% of total households	0%	11%	16%	21%	32%	37%	43%	48%	64%	69%	75%	80%	
participant	nos. of household	0	177	269	363	552	652	755	857	1,154	1,261	1,371	1,482	
purchase of container	nos.	0	177	92	94	189	100	280	371	483	390	399	314	2,889
cost (subsidy)	1000pesos/year	0	19	10	10	21	11	31	41	53	43	44	35	318

Urban 9 (SOL)	year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
source reduction	ton/year	0	1,825	2,993	4,344	7,118	8,979	11,060	13,177	18,542	21,170	23,944	26,937	
participant	% of total households	0%	11%	16%	21%	32%	37%	43%	48%	64%	69%	75%	80%	
participant	nos. of household	0	4,704	7,804	11,401	18,697	23,674	29,182	34,860	49,187	56,219	63,701	71,635	
purchase of container	nos.	0	4,704	3,100	3,597	7,296	4,977	10,212	13,482	21,024	17,925	19,755	18,419	124,491
cost (subsidy)	1000pesos/year	0	517	341	396	803	547	1,123	1,483	2,313	1,972	2,173	2,026	13,694

Urban 10 (FCP)	year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
source reduction	ton/year	0	37	37	37	73	73	73	110	146	146	183	183	
participant	% of total households	0%	11%	16%	21%	32%	37%	43%	48%	64%	69%	75%	80%	
participant	nos. of household	0	56	87	119	184	221	260	302	415	463	514	566	
purchase of container	nos.	0	56	31	32	65	37	95	129	176	145	153	128	1,047
cost (subsidy)	1000pesos/year	0	6	3	4	7	4	10	14	19	16	17	14	114

c. Collection and Transport

Required costs for collection and transport are shown in the following tables.

Table H-96: Cost of Collection and Transport (Whole Study Area)

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	341.2	427.9	494.6	576	606.4	649.4	688.7	720.5	727.7	750.2	772.4	793.8	
collection amount	1000ton/year	125	156	178	209	220	237	251	262	265	274	282	290	2,749
required number of vehicle														
compactor	nos.	47	64	70	81	86	89	93	97	96	97	98	100	
dump truck	nos.	0	0	3	4	4	6	7	10	11	12	14	16	
purchase of vehicle														
compactor	nos.	10	21	10	15	10	8	8	14	20	11	16	12	155
dump truck	nos.	0	0	3	1	0	2	1	3	1	4	3	2	20
Cost in pesos														
Investment	1000pesos/year	11,187	23,507	13,475	17,545	11,176	10,483	9,724	17,963	23,155	15,378	20,207	14,960	188,760
O&M	1000pesos/year	22,814	31,053	35,288	41,063	43,494	45,815	48,191	51,458	51,392	52,316	53,669	55,517	532,070
Total	1000pesos/year	34,001	54,560	48,763	58,608	54,670	56,298	57,915	69,421	74,547	67,694	73,876	70,477	720,830

Table H-97: Cost of Collection and Transport (Othon P Blanco)

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	152.1	189.2	220	261.1	272.8	291.5	309.1	320.2	320.3	327.3	334.3	340.7	
collection amount	1000ton/year	56	69	79	95	99	107	113	116	116	119	122	124	1215
required number of vehicle														
compactor	nos.	21	29	31	37	40	40	42	43	43	43	43	44	
dump truck	nos.	0	0	2	2	2	3	3	5	5	5	6	7	
purchase of vehicle														
compactor	nos.	3	11	6	10	8	5	6	4	11	6	10	9	89
dump truck	nos.	0	0	2	0	0	1	0	2	0	2	1	1	9
Cost in pesos														
Investment	1000pesos/year	3,355	12,309	8,239	11,187	8,943	6,358	6,721	6,017	12,309	8,250	11,957	10,835	106,480
O&M	1000pesos/year	10,197	14,069	15,917	18,832	20,295	20,724	21,692	23,056	23,056	23,056	23,485	24,409	238,788
Total	1000pesos/year	13,552	26,378	24,156	30,019	29,238	27,082	28,413	29,073	35,365	31,306	35,442	35,244	345,268

Table H-98: (Felipe C Puerto)

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	12.5	18.7	21.5	26.9	26.7	29.3	29.4	33.3	32.5	32.5	32.5	32.4	
collection amount	1000ton/year	5	7	7	9	9	10	10	12	12	12	12	12	117
required number of vehicle														
compactor	nos.	2	4	4	5	5	5	5	6	5	5	5	5	
dump truck	nos.	0	0	0	0	0	0	0	0	0	0	0	0	
purchase of vehicle														
compactor	nos.	1	3	0	1	0	0	0	2	2	0	1	0	10
dump truck	nos.	0	0	0	0	0	0	0	0	0	0	0	0	0
Cost in pesos														
Investment	1000pesos/year	1,122	3,366	0	1,122	0	0	0	2,233	2,244	0	1,122	0	11,209
O&M	1000pesos/year	968	1,936	1,936	2,420	2,420	2,420	2,420	2,915	2,420	2,420	2,420	2,420	27,115
Total	1000pesos/year	2,090	5,302	1,936	3,542	2,420	2,420	2,420	5,148	4,664	2,420	3,542	2,420	38,324

Table H-99: Cost of Collection and Transport (Solidaridad)

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	176.6	220	253.1	288	306.9	328.6	350.2	367	374.9	390.4	405.6	420.7	
collection amount	1000ton/year	64	80	92	105	112	120	128	134	137	143	148	154	1,417
required number of vehicle														
compactor	nos.	24	31	35	39	41	44	46	48	48	49	50	51	
dump truck	nos.	0	0	1	2	2	3	4	5	6	7	8	9	
purchase of vehicle														
compactor	nos.	6	7	4	4	2	3	2	8	7	5	5	3	56
dump truck	nos.	0	0	1	1	0	1	1	1	1	2	2	1	11
Cost in pesos														
Investment	1000pesos/year	6,710	7,832	5,236	5,236	2,233	4,125	3,003	9,713	8,602	7,128	7,128	4,125	71,071
O&M	1000pesos/year	11,649	15,048	17,435	19,811	20,779	22,671	24,079	25,487	25,916	26,840	27,764	28,688	266,167
Total	1000pesos/year	18,359	22,880	22,671	25,047	23,012	26,796	27,082	35,200	34,518	33,968	34,892	32,813	337,238

Table H-100: Cost of Collection and Transport by Urban Group

Urban 1 (OPB)

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	152.1	159.3	160	169.2	168.6	169.7	170.8	172.2	169.7	170.9	172.2	173.2	
collection amount	1000ton/year	56	58	58	62	62	62	62	63	62	62	63	63	
required number of vehicle														
compactor	nos.	21	22	22	23	23	22	22	22	22	21	21	21	
dump truck	nos.	0	0	1	1	1	2	2	3	3	3	4	4	
purchase of vehicle														
compactor	nos.	3	4	4	5	5	4	4	3	4	3	5	5	49
dump truck	nos.	0	0	1	0	0	1	0	1	0	1	1	0	5
Cost in pesos														
Investment	1000pesos/year	3,355	4,477	5,236	5,588	5,588	5,236	4,477	4,125	4,477	4,125	6,358	5,588	58,630
O&M	1000pesos/year	10,197	10,681	11,121	11,605	11,605	11,550	11,550	11,990	11,990	11,506	11,935	11,935	137,665
Total	1000pesos/year	13,552	15,158	16,357	17,193	17,193	16,786	16,027	16,115	16,467	15,631	18,293	17,523	196,295

Urban 2 (OPB)

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	0	3.7	6.1	8.5	8.5	9.8	9.9	11.3	11.1	11.2	11.2	11.3	
collection amount	1000ton/year	0	1	2	3	3	4	4	4	4	4	4	4	
required number of vehicle														
compactor	nos.	0	1	1	2	2	2	2	2	2	2	2	2	
dump truck	nos.	0	0	0	0	0	0	0	0	0	0	0	0	
purchase of vehicle														
compactor	nos.	0	1	0	1	0	0	0	0	1	0	1	0	4
dump truck	nos.	0	0	0	0	0	0	0	0	0	0	0	0	0
Cost in pesos														
Investment	1000pesos/year	0	1,122	0	1,122	0	0	0	0	1,122	0	1,122	0	4,488
O&M	1000pesos/year	0	484	484	968	968	968	968	968	968	968	968	968	9,680
Total	1000pesos/year	0	1,606	484	2,090	968	968	968	968	2,090	968	2,090	968	14,168

Urban 3 (OPB)

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	0	1.4	2.4	3.4	3.3	3.4	3.4	3.8	3.8	3.8	3.8	3.8	
collection amount	1000ton/year	0	1	1	1	1	1	1	1	1	1	1	1	
required number of vehicle														
compactor	nos.	0	1	1	1	1	1	1	1	1	1	1	1	
dump truck	nos.	0	0	0	0	0	0	0	0	0	0	0	0	
purchase of vehicle														
compactor	nos.	0	1	0	0	0	0	0	0	1	0	0	0	2
dump truck	nos.	0	0	0	0	0	0	0	0	0	0	0	0	0
Cost in pesos														
Investment	1000pesos/year	0	1,122	0	0	0	0	0	0	1,122	0	0	0	2,244
O&M	1000pesos/year	0	484	484	484	484	484	484	484	484	484	484	484	5,324
Total	1000pesos/year	0	1,606	484	484	484	484	484	484	1,606	484	484	484	7,568

Urban 4 (OPB)

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	0	8.1	14.6	21.6	22.7	27.4	32.4	36	36.8	38.4	40	41.4	
collection amount	1000ton/year	0	3	5	8	8	10	12	13	13	14	15	15	
required number of vehicle														
compactor	nos.	0	2	2	3	4	4	5	5	5	6	6	6	
dump truck	nos.	0	0	0	0	0	0	0	0	0	0	0	0	
purchase of vehicle														
compactor	nos.	0	2	0	1	1	0	1	0	2	1	1	1	10
dump truck	nos.	0	0	0	0	0	0	0	0	0	0	0	0	0
Cost in pesos														
Investment	1000pesos/year	0	2,233	0	1,122	1,122	0	1,122	0	2,233	1,122	1,122	1,122	11,198
O&M	1000pesos/year	0	968	968	1,452	1,947	1,947	2,431	2,431	2,431	2,915	2,915	2,915	23,320
Total	1000pesos/year	0	3,201	968	2,574	3,069	1,947	3,553	2,431	4,664	4,037	4,037	4,037	34,518

Urban 5 (OPB)

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	0	16.7	36.9	58.4	69.7	81.2	92.6	96.9	98.9	103	107.1	111	
collection amount	1000ton/year	0	6	13	21	25	30	34	35	36	38	39	41	
required number of vehicle														
compactor	nos.	0	3	5	8	10	11	12	13	13	13	13	14	
dump truck	nos.	0	0	1	1	1	1	1	2	2	2	2	3	
purchase of vehicle														
compactor	nos.	0	3	2	3	2	1	1	1	3	2	3	3	24
dump truck	nos.	0	0	1	0	0	0	0	1	0	1	0	1	4
Cost in pesos														
Investment	1000pesos/year	0	3,355	3,003	3,355	2,233	1,122	1,122	1,892	3,355	3,003	3,355	4,125	29,920
O&M	1000pesos/year	0	1,452	2,860	4,323	5,291	5,775	6,259	7,183	7,183	7,183	7,183	8,107	62,799
Total	1000pesos/year	0	4,807	5,863	7,678	7,524	6,897	7,381	9,075	10,538	10,186	10,538	12,232	92,719

Urban 6 (FCP)

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	12.5	14.8	14.9	17.6	17.4	20	20.1	22.6	22.1	22.1	22.1	22.1	
collection amount	1000ton/year	5	5	5	6	6	7	7	8	8	8	8	8	
required number of vehicle														
compactor	nos.	2	2	2	3	3	3	3	4	3	3	3	3	
dump truck	nos.	0	0	0	0	0	0	0	0	0	0	0	0	
purchase of vehicle														
compactor	nos.	1	1	0	1	0	0	0	2	0	0	1	0	6
dump truck	nos.	0	0	0	0	0	0	0	0	0	0	0	0	0
Cost in pesos														
Investment	1000pesos/year	1,122	1,122	0	1,122	0	0	0	2,233	0	0	1,122	0	6,721
O&M	1000pesos/year	968	968	968	1,452	1,452	1,452	1,452	1,947	1,452	1,452	1,452	1,452	16,467
Total	1000pesos/year	2,090	2,090	968	2,574	1,452	1,452	1,452	4,180	1,452	1,452	2,574	1,452	23,188

Urban 7 (FCP)

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	0	1.6	2.7	3.8	3.8	3.8	3.8	4.4	4.2	4.2	4.2	4.2	
collection amount	1000ton/year	0	1	1	1	1	1	1	2	2	2	2	2	
required number of vehicle														
compactor	nos.	0	1	1	1	1	1	1	1	1	1	1	1	
dump truck	nos.	0	0	0	0	0	0	0	0	0	0	0	0	
purchase of vehicle														
compactor	nos.	0	1	0	0	0	0	0	0	1	0	0	0	2
dump truck	nos.	0	0	0	0	0	0	0	0	0	0	0	0	0
Cost in pesos														
Investment	1000pesos/year	0	1,122	0	0	0	0	0	0	1,122	0	0	0	2,244
O&M	1000pesos/year	0	484	484	484	484	484	484	484	484	484	484	484	5,324
Total	1000pesos/year	0	1,606	484	484	484	484	484	484	1,606	484	484	484	7,568

Urban 8 (FCP)

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	0	2.3	3.9	5.5	5.5	5.5	5.5	6.3	6.2	6.2	6.2	6.1	
collection amount	1000ton/year	0	1	1	2	2	2	2	2	2	2	2	2	
required number of vehicle														
compactor	nos.	0	1	1	1	1	1	1	1	1	1	1	1	
dump truck	nos.	0	0	0	0	0	0	0	0	0	0	0	0	
purchase of vehicle														
compactor	nos.	0	1	0	0	0	0	0	0	1	0	0	0	2
dump truck	nos.	0	0	0	0	0	0	0	0	0	0	0	0	0
Cost in pesos														
Investment	1000pesos/year	0	1,122	0	0	0	0	0	0	1,122	0	0	0	2,244
O&M	1000pesos/year	0	484	484	484	484	484	484	484	484	484	484	484	5,324
Total	1000pesos/year	0	1,606	484	484	484	484	484	484	1,606	484	484	484	7,568

Urban 9 (SOL)

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	176.6	219.2	251.8	286.2	305.1	326.7	348.2	364.8	372.7	388.1	403.3	418.3	
collection amount	1000ton/year	64	80	92	104	111	119	127	133	136	142	147	153	
required number of vehicle														
compactor	nos.	24	30	34	38	40	43	45	47	47	48	49	50	
dump truck	nos.	0	0	1	2	2	3	4	5	6	7	8	9	
purchase of vehicle														
compactor	nos.	6	6	4	4	2	3	2	8	6	5	5	3	54
dump truck	nos.	0	0	1	1	0	1	1	1	1	2	2	1	11
Cost in pesos														
Investment	1000pesos/year	6,710	6,710	5,236	5,236	2,233	4,125	3,003	9,713	7,480	7,128	7,128	4,125	68,827
O&M	1000pesos/year	11,649	14,564	16,951	19,327	20,295	22,187	23,595	25,003	25,432	26,356	27,280	28,204	260,843
Total	1000pesos/year	18,359	21,274	22,187	24,563	22,528	26,312	26,598	34,716	32,912	33,484	34,408	32,329	329,670

Urban 10 (SOL)

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	0	0.8	1.3	1.8	1.8	1.9	2	2.2	2.2	2.3	2.3	2.4	
collection amount	1000ton/year	0	0	0	1	1	1	1	1	1	1	1	1	
required number of vehicle														
compactor	nos.	0	1	1	1	1	1	1	1	1	1	1	1	
dump truck	nos.	0	0	0	0	0	0	0	0	0	0	0	0	
purchase of vehicle														
compactor	nos.	0	1	0	0	0	0	0	0	1	0	0	0	2
dump truck	nos.	0	0	0	0	0	0	0	0	0	0	0	0	0
Cost in pesos														
Investment	1000pesos/year	0	1,122	0	0	0	0	0	0	1,122	0	0	0	2,244
O&M	1000pesos/year	0	484	484	484	484	484	484	484	484	484	484	484	5,324
Total	1000pesos/year	0	1,606	484	484	484	484	484	484	1,606	484	484	484	7,568

d. Intermediate Treatment (composting)

Required costs for intermediate treatment (composting) are shown in the following tables.

Table H-101: Cost of Intermediate Treatment (Composting), Whole Study Area

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	0	0	4.9	10.7	17.3	24.9	33.2	41.9	51	60.9	71.4	82.7	
collection amount	1000ton/year	0	0	2	4	6	9	12	15	19	22	26	30	146
required number of equipment														
wheel loader	nos.	0	0	3	3	4	4	6	6	7	9	11	11	
shredder	nos.	0	0	3	3	3	4	4	6	7	7	9	11	
purchase of vehicle														
wheel loader	nos.	0	0	3	0	1	0	2	0	1	5	2	1	15
shredder	nos.	0	0	3	0	0	1	0	2	1	3	2	2	14
Cost in pesos														
Investment	1000pesos/year	0	0	3,135	0	704	352	1,408	704	1,045	4,543	2,101	1,397	15,389
O&M	1000pesos/year	0	0	1,683	1,683	1,892	2,244	2,662	3,366	3,938	4,356	5,478	6,182	33,484
Total	1000pesos/year	0	0	4,818	1,683	2,596	2,596	4,070	4,070	4,983	8,899	7,579	7,579	48,873

Table H-102: Cost of Intermediate Treatment (Composting) by Municipality

Othon P Blanco

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	0	0	2.2	4.7	7.6	10.8	14.3	17.8	21.4	25.2	29.2	33.5	
collection amount	1000ton/year	0	0	0.8	1.7	2.8	4	5.2	6.5	7.8	9.2	10.7	12.2	60.9
required number of equipment														
wheel loader	nos.	0	0	2	2	2	2	3	3	3	4	5	5	
shredder	nos.	0	0	2	2	2	2	2	3	3	3	4	5	
purchase of vehicle														
wheel loader	nos.	0	0	2	0	0	0	1	0	0	3	1	0	7
shredder	nos.	0	0	2	0	0	0	0	1	0	2	1	1	7
Cost in pesos														
Investment	1000pesos/year	0	0	2,090	0	0	0	704	352	0	2,794	1,056	352	7,348
O&M	1000pesos/year	0	0	1,122	1,122	1,122	1,122	1,331	1,683	1,683	1,892	2,453	2,805	16,335
Total	1000pesos/year	0	0	3,212	1,122	1,122	1,122	2,035	2,035	1,683	4,686	3,509	3,157	23,683

Felipe C Puerto

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day													
collection amount	1000ton/year													0
required number of equipment														
wheel loader	nos.													
shredder	nos.													
purchase of vehicle														
wheel loader	nos.													0
shredder	nos.													0
Cost in pesos														
Investment	1000pesos/year	0	0	0	0	0	0	0	0	0	0	0	0	0
O&M	1000pesos/year	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1000pesos/year	0	0	0	0	0	0	0	0	0	0	0	0	0

SOL

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	0.0	0.0	2.7	6.0	9.7	14.1	18.9	24.1	29.6	35.7	42.2	49.2	
collection amount	1000ton/year	0.0	0.0	1.0	2.2	3.5	5.1	6.9	8.8	10.8	13.0	15.4	18.0	84.7
required number of equipment														
wheel loader	nos.	0	0	1	1	2	2	3	3	4	5	6	6	
shredder	nos.	0	0	1	1	1	2	2	3	4	4	5	6	
purchase of vehicle														
wheel loader	nos.	0	0	1	0	1	0	1	0	1	2	1	1	8
shredder	nos.	0	0	1	0	0	1	0	1	1	1	1	1	7
Cost in pesos														
Investment	1000pesos/year	0	0	1,045	0	704	352	704	352	1,045	1,749	1,045	1,045	8,041
O&M	1000pesos/year	0	0	561	561	770	1,122	1,331	1,683	2,255	2,464	3,025	3,377	17,149
Total	1000pesos/year	0	0	1,606	561	1,474	1,474	2,035	2,035	3,300	4,213	4,070	4,422	25,190

Table H-103: Cost of Intermediate Treatment (Composting) by Urban Group

Urban 1 (OPB)

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	0	0	1.7	3.5	5.4	7.3	9.3	11.4	13.5	15.7	18	20.4	
collection amount	1000ton/year	0	0	0.6	1.3	2	2.7	3.4	4.2	4.9	5.7	6.6	7.4	38.8
required number of equipment														
wheel loader	nos.	0	0	1	1	1	1	2	2	2	2	3	3	
shredder	nos.	0	0	1	1	1	1	1	2	2	2	2	3	
purchase of equipment														
wheel loader	nos.	0	0	1	0	0	0	1	0	0	1	1	0	4
shredder	nos.	0	0	1	0	0	0	0	1	0	1	0	1	4
Cost in pesos														
Investment	1000pesos/year	0	0	1,045	0	0	0	704	352	0	1,045	704	352	4,202
O&M	1000pesos/year	0	0	561	561	561	561	770	1,122	1,122	1,122	1,331	1,683	9,394
Total	1000pesos/year	0	0	1,606	561	561	561	1,474	1,474	1,122	2,167	2,035	2,035	13,596

Urban 5 (OPB)

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	0	0	0.5	1.2	2.2	3.5	5	6.4	7.9	9.5	11.2	13.1	
collection amount	1000ton/year	0	0	0.2	0.4	0.8	1.3	1.8	2.3	2.9	3.5	4.1	4.8	22.1
required number of equipment														
wheel loader	nos.	0	0	1	1	1	1	1	1	1	2	2	2	
shredder	nos.	0	0	1	1	1	1	1	1	1	1	2	2	
purchase of equipment														
wheel loader	nos.	0	0	1	0	0	0	0	0	0	2	0	0	3
shredder	nos.	0	0	1	0	0	0	0	0	0	1	1	0	3
Cost in pesos														
Investment	1000pesos/year	0	0	1,045	0	0	0	0	0	0	1,749	352	0	3,146
O&M	1000pesos/year	0	0	561	561	561	561	561	561	561	770	1,122	1,122	6,941
Total	1000pesos/year	0	0	1,606	561	561	561	561	561	561	2,519	1,474	1,122	10,087

Urban 9 (SOL)

Item	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
collection amount 365-base	ton/day	0.0	0.0	2.7	6.0	9.7	14.1	18.9	24.1	29.6	35.7	42.2	49.2	
collection amount	1000ton/year	0.0	0.0	1.0	2.2	3.5	5.1	6.9	8.8	10.8	13.0	15.4	18.0	84.7
required number of equipment														
wheel loader	nos.	0	0	1	1	2	2	3	3	4	5	6	6	
shredder	nos.	0	0	1	1	1	2	2	3	4	4	5	6	
purchase of equipment														
wheel loader	nos.	0	0	1	0	1	0	1	0	1	2	1	1	8
shredder	nos.	0	0	1	0	0	1	0	1	1	1	1	1	7
Cost in pesos														
Investment	1000pesos/year	0	0	1,045	0	704	352	704	352	1,045	1,749	1,045	1,045	8,041
O&M	1000pesos/year	0	0	561	561	770	1,122	1,331	1,683	2,255	2,464	3,025	3,377	17,149
Total	1000pesos/year	0	0	1,606	561	1,474	1,474	2,035	2,035	3,300	4,213	4,070	4,422	25,190

e. Final Disposal

Required costs for final disposal are shown in the following tables. Construction costs of Level 1, 2 and 3 are assumed as operation and operation costs. 40% of construction cost of Level 4 is assumed to be spent in the first year, 30 % in the 5th year and 30% in the 10th year.

Table H-104: Cost of Final Disposal by Municipality

Unit: 1,000 pesos

	Present	Short term				Middle term				Long term				
Municipality	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
OPB	1,808	6,107	6,891	7,541	9,616	12,899	11,023	11,598	13,469	13,626	11,903	12,035	13,328	131,844
Investment	0	0	0	0	0	2,486	0	0	1,593	1,865	0	0	1,195	7,139
O&M	1,808	6,107	6,891	7,541	9,616	10,413	11,023	11,598	11,876	11,761	11,903	12,035	12,133	124,705
FCP	43	151	225	379	465	461	514	516	583	570	570	570	568	5,615
Investment	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O&M	43	151	225	379	465	461	514	516	583	570	570	570	568	5,615
SOL	6,384	7,090	8,811	10,029	11,296	11,922	12,630	13,322	19,808	13,922	14,321	14,695	19,550	163,780
Investment	0	0	0	0	0	0	0	0	6,006	0	0	0	4,505	10,511
O&M	6,384	7,090	8,811	10,029	11,296	11,922	12,630	13,322	13,802	13,922	14,321	14,695	15,045	153,269
Total	8,235	13,348	15,927	17,949	21,377	25,282	24,167	25,436	33,861	28,118	26,794	27,300	33,446	301,239
Investment	0	0	0	0	0	2,486	0	0	7,600	1,865	0	0	5,700	17,650
O&M	8,235	13,348	15,927	17,949	21,377	22,796	24,167	25,436	26,261	26,253	26,794	27,300	27,746	283,589

Table H-105: Investment Cost of Final Disposal by Urban Group

Unit: 1,000 pesos

		Present	Short term				Middle term				Long term			
Urban G	Municipality	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	OPB						2,486				1,865			
2	OPB													
3	OPB													
4	OPB													
5	OPB									1,593				1,195
6	FCP													
7	FCP													
8	FCP													
9	SOL									6,006				4,505
10	SOL													
Total	-	0	0	0	0	0	2,486	0	0	7,600	1,865	0	0	5,700

Table H-106: Operation and Maintenance Costs of Final Disposal by Urban Group

Unit: 1,000 pesos

		Present	Short term				Middle term				Long term			
Urban G	Municipality	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	OPB	1,808	6,107	6,396	6,364	6,669	6,573	6,549	6,520	6,500	6,328	6,296	6,263	6,215
2	OPB	0	0	45	122	171	171	197	199	227	223	225	225	227
3	OPB	0	0	17	29	41	40	41	41	46	46	46	46	46
4	OPB	0	0	98	293	434	911	1,100	1,301	1,445	1,478	1,542	1,606	1,662
5	OPB	0	0	335	733	2,301	2,718	3,136	3,537	3,658	3,686	3,794	3,895	3,983
6	FCP	43	151	178	299	353	349	402	404	454	444	444	444	444
7	FCP	0	0	19	33	46	46	46	46	53	51	51	51	51
8	FCP	0	0	28	47	66	66	66	66	76	75	75	75	73
9	SOL	6,384	7,090	8,801	10,013	11,274	11,900	12,607	13,298	13,776	13,896	14,293	14,667	15,016
10	SOL	0	0	10	16	22	22	23	24	26	26	28	28	29
Total	-	8,235	13,348	15,927	17,949	21,377	22,796	24,167	25,436	26,261	26,253	26,794	27,300	27,746

Table H-107: Cost of Final Disposal by Urban Group

Unit: 1,000 pesos

		Present	Short term				Middle term				Long term				
Urban G	Municipality	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
1	OPB	1,808	6,107	6,396	6,364	6,669	9,059	6,549	6,520	6,500	8,193	6,296	6,263	6,215	82,939
2	OPB	0	0	45	122	171	171	197	199	227	223	225	225	227	2,032
3	OPB	0	0	17	29	41	40	41	41	46	46	46	46	46	439
4	OPB	0	0	98	293	434	911	1,100	1,301	1,445	1,478	1,542	1,606	1,662	11,870
5	OPB	0	0	335	733	2,301	2,718	3,136	3,537	5,251	3,686	3,794	3,895	5,178	34,564
6	FCP	43	151	178	299	353	349	402	404	454	444	444	444	444	4,409
7	FCP	0	0	19	33	46	46	46	46	53	51	51	51	51	493
8	FCP	0	0	28	47	66	66	66	66	76	75	75	75	73	713
9	SOL	6,384	7,090	8,801	10,013	11,274	11,900	12,607	13,298	19,782	13,896	14,293	14,667	19,521	163,526
10	SOL	0	0	10	16	22	22	23	24	26	26	28	28	29	254
Total	-	8,235	13,348	15,927	17,949	21,377	25,282	24,167	25,436	33,861	28,118	26,794	27,300	33,446	301,239

f. Total Cost

Total cost required for implementation of the Master Plan is shown in the following tables.

Table H-108: Total Cost of the SWM Master Plan (Whole Study Area)

Unit: 1,000 pesos

	Short				Middle				Long				
Item	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
source reduction (O&M)	0	1,193	749	852	1,716	1,121	2,421	3,156	4,768	4,017	4,366	3,957	28,316
collection	34,001	54,560	48,763	58,608	54,670	56,298	57,915	69,421	74,547	67,694	73,876	70,477	720,830
Investment	11,187	23,507	13,475	17,545	11,176	10,483	9,724	17,963	23,155	15,378	20,207	14,960	188,760
O&M	22,814	31,053	35,288	41,063	43,494	45,815	48,191	51,458	51,392	52,316	53,669	55,517	532,070
recycling (compost)	0	0	4,818	1,683	2,596	2,596	4,070	4,070	4,983	8,899	7,579	7,579	48,873
Investment	0	0	3,135	0	704	352	1,408	704	1,045	4,543	2,101	1,397	15,389
O&M	0	0	1,683	1,683	1,892	2,244	2,662	3,366	3,938	4,356	5,478	6,182	33,484
final disposal	13,348	15,927	17,949	21,377	25,282	24,167	25,436	33,861	28,118	26,794	27,300	33,446	293,004
Investment	0	0	0	0	2,486	0	0	7,600	1,865	0	0	5,700	17,650
O&M	13,348	15,927	17,949	21,377	22,796	24,167	25,436	26,261	26,253	26,794	27,300	27,746	275,354
sub-total	47,349	71,680	72,279	82,520	84,264	84,182	89,842	110,508	112,416	107,404	113,121	115,459	1,091,023
Investment	11,187	23,507	16,610	17,545	14,366	10,835	11,132	26,267	26,065	19,921	22,308	22,057	221,799
O&M	36,162	48,173	55,669	64,975	69,898	73,347	78,710	84,241	86,351	87,483	90,813	93,402	869,224
administration (10% of O&M))	3,616	4,818	5,567	6,498	6,990	7,335	7,872	8,425	8,636	8,748	9,081	9,341	86,927
total	50,965	76,498	77,846	89,018	91,254	91,517	97,714	118,933	121,052	116,152	122,202	124,800	1,177,950
Investment	11,187	23,507	16,610	17,545	14,366	10,835	11,132	26,267	26,065	19,921	22,308	22,057	221,799
O&M	39,778	52,991	61,236	71,473	76,888	80,682	86,582	92,666	94,987	96,231	99,894	102,743	956,151

Table H-109: Total Cost of the SWM Master Plan (Othon P Blanco)

Unit: 1,000 pesos

	Short				Middle				Long				
Item	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
source reduction (O&M)	0	576	356	402	805	516	1,138	1,460	2,177	1,819	1,962	1,748	12,959
collection	13,552	26,378	24,156	30,019	29,238	27,082	28,413	29,073	35,365	31,306	35,442	35,244	345,268
Investment	3,355	12,309	8,239	11,187	8,943	6,358	6,721	6,017	12,309	8,250	11,957	10,835	106,480
O&M	10,197	14,069	15,917	18,832	20,295	20,724	21,692	23,056	23,056	23,056	23,485	24,409	238,788
recycling (compost)	0	0	3,212	1,122	1,122	1,122	2,035	2,035	1,683	4,686	3,509	3,157	23,683
Investment	0	0	2,090	0	0	0	704	352	0	2,794	1,056	352	7,348
O&M	0	0	1,122	1,122	1,122	1,122	1,331	1,683	1,683	1,892	2,453	2,805	16,335
final disposal	6,107	6,891	7,541	9,616	12,899	11,023	11,598	13,469	13,626	11,903	12,035	13,328	130,036
Investment	0	0	0	0	2,486	0	0	1,593	1,865	0	0	1,195	7,139
O&M	6,107	6,891	7,541	9,616	10,413	11,023	11,598	11,876	11,761	11,903	12,035	12,133	122,897
sub-total	19,659	33,845	35,265	41,159	44,064	39,743	43,184	46,037	52,851	49,714	52,948	53,477	511,946
Investment	3,355	12,309	10,329	11,187	11,429	6,358	7,425	7,962	14,174	11,044	13,013	12,382	120,967
O&M	16,304	21,536	24,936	29,972	32,635	33,385	35,759	38,075	38,677	38,670	39,935	41,095	390,979
administration (10% of O&M)	1,630	2,154	2,494	2,997	3,264	3,339	3,576	3,808	3,868	3,867	3,994	4,110	39,101
total	21,289	35,999	37,759	44,156	47,328	43,082	46,760	49,845	56,719	53,581	56,942	57,587	551,047
Investment	3,355	12,309	10,329	11,187	11,429	6,358	7,425	7,962	14,174	11,044	13,013	12,382	120,967
O&M	17,934	23,690	27,430	32,969	35,899	36,724	39,335	41,883	42,545	42,537	43,929	45,205	430,080

Table H-110: Total Cost of the SWM Master Plan (Felipe C Puerto)

Unit: 1,000 pesos

	Short				Middle				Long				
Item	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
source reduction (O&M)	0	94	49	50	101	54	150	199	259	210	214	169	1,549
collection	2,090	5,302	1,936	3,542	2,420	2,420	2,420	5,148	4,664	2,420	3,542	2,420	38,324
Investment	1,122	3,366	0	1,122	0	0	0	2,233	2,244	0	1,122	0	11,209
O&M	968	1,936	1,936	2,420	2,420	2,420	2,420	2,915	2,420	2,420	2,420	2,420	27,115
recycling (compost)	0	0	0	0	0	0	0	0	0	0	0	0	0
Investment	0	0	0	0	0	0	0	0	0	0	0	0	0
O&M	0	0	0	0	0	0	0	0	0	0	0	0	0
final disposal	151	225	379	465	461	514	516	583	570	570	570	568	5,572
Investment	0	0	0	0	0	0	0	0	0	0	0	0	0
O&M	151	225	379	465	461	514	516	583	570	570	570	568	5,572
sub-total	2,241	5,621	2,364	4,057	2,982	2,988	3,086	5,930	5,493	3,200	4,326	3,157	45,445
Investment	1,122	3,366	0	1,122	0	0	0	2,233	2,244	0	1,122	0	11,209
O&M	1,119	2,255	2,364	2,935	2,982	2,988	3,086	3,697	3,249	3,200	3,204	3,157	34,236
administration (10% of O&M)	112	226	236	294	298	299	309	370	325	320	320	316	3,425
total	2,353	5,847	2,600	4,351	3,280	3,287	3,395	6,300	5,818	3,520	4,646	3,473	48,870
Investment	1,122	3,366	0	1,122	0	0	0	2,233	2,244	0	1,122	0	11,209
O&M	1,231	2,481	2,600	3,229	3,280	3,287	3,395	4,067	3,574	3,520	3,524	3,473	37,661

Table H-111: Total Cost of the SWM Master Plan (Solidaridad)

Unit: 1,000 pesos

	Short				Middle				Long				
Item	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
source reduction (O&M)	0	523	344	400	810	551	1,133	1,497	2,332	1,988	2,190	2,040	13,808
collection	18,359	22,880	22,671	25,047	23,012	26,796	27,082	35,200	34,518	33,968	34,892	32,813	337,238
Investment	6,710	7,832	5,236	5,236	2,233	4,125	3,003	9,713	8,602	7,128	7,128	4,125	71,071
O&M	11,649	15,048	17,435	19,811	20,779	22,671	24,079	25,487	25,916	26,840	27,764	28,688	266,167
recycling (compost)	0	0	1,606	561	1,474	1,474	2,035	2,035	3,300	4,213	4,070	4,422	25,190
Investment	0	0	1,045	0	704	352	704	352	1,045	1,749	1,045	1,045	8,041
O&M	0	0	561	561	770	1,122	1,331	1,683	2,255	2,464	3,025	3,377	17,149
final disposal	7,090	8,811	10,029	11,296	11,922	12,630	13,322	19,808	13,922	14,321	14,695	19,550	157,396
Investment	0	0	0	0	0	0	0	6,006	0	0	0	4,505	10,511
O&M	7,090	8,811	10,029	11,296	11,922	12,630	13,322	13,802	13,922	14,321	14,695	15,045	146,885
sub-total	25,449	32,214	34,650	37,304	37,218	41,451	43,572	58,540	54,072	54,490	55,847	58,825	533,632
Investment	6,710	7,832	6,281	5,236	2,937	4,477	3,707	16,071	9,647	8,877	8,173	9,675	89,623
O&M	18,739	24,382	28,369	32,068	34,281	36,974	39,865	42,469	44,425	45,613	47,674	49,150	444,009
administration (10% of O&M)	1,874	2,438	2,837	3,207	3,428	3,697	3,987	4,247	4,443	4,561	4,767	4,915	44,401
total	27,323	34,652	37,487	40,511	40,646	45,148	47,559	62,787	58,515	59,051	60,614	63,740	578,033
Investment	6,710	7,832	6,281	5,236	2,937	4,477	3,707	16,071	9,647	8,877	8,173	9,675	89,623
O&M	20,613	26,820	31,206	35,275	37,709	40,671	43,852	46,716	48,868	50,174	52,441	54,065	488,410

H.3.6 Financial Analysis

H.3.6.1 Financial Analysis

a. Scenarios

For the purpose of financial analyses, it was necessary to set a series of scenarios because of the many variables that depend greatly on the decisions to be made by the corresponding authorities on the basis of political and management criteria. These variables include: (a) service charges, whether or not to impose user charges, on whom and how much; (b) non-household waste generators, how to estimate their numbers (CEPIS guidelines and local conditions); and (c) bill collection efficiency or amount of money collected in relation to the amount billed.

As for the application of service charges, following the considerations given above, all generators of solid waste, households and business firms, were assumed to pay service charges. The amounts of service charges for households were assumed to vary from 30 Pesos to 40 Pesos and 50 Pesos per month, while business firms were assumed to pay correspondingly higher rates varying from 100 Pesos to 150 Pesos and 200 Pesos per month.

Concerning the number of business firms, the lower bound was taken to be 10% of the number of households, as recommended by CEPIS. However, as the data on OPB indicated the actual number of paying business firms to range between 15% and 19% of the number of households, the scenarios assumed business firms to comprise 10%, 15% and 20% of the number of households. This can be justified on grounds that in places where tourism is active, the number of business firms can be expected to be higher than in non-tourist places.

The last variable concerns the bill collection efficiency. It is difficult to assess the response of service users when service charges are introduced where the service used to be provided free of charge. It depends a lot on the preparation of the mind set of service users by the municipal authorities, it will depend heavily on how much the public can be made aware of environmental problems and the resulting public's positive reaction to do something about the environment. In the case of Felipe Carrillo Puerto where the public can readily notice the improvements that have taken place in solid waste management recently, the timing is perfect for introducing service charges, and can have a good response from service users. In general, it was assumed that initially the business firms would be a lot more willing to pay than households, but 5 years into the Master Plan implementation, payments by both households and business firms were assumed to reach 90% in 2009 and remain at that level thereafter.

The considerations presented above resulted in three basic scenarios for each municipality and also for the Study Area as a whole. The basic scenarios were differentiated by the assumed monthly service charges as follows:

Scenario 1: Household 30 Pesos, business 100 Pesos

Scenario 2: Household 40 Pesos, business 150 Pesos

Scenario 3: Household 50 Pesos, business 200 Pesos

Within each scenario, the number of business firms was varied as a proportion of the number of households, and the bill collection ratio was assumed to increase year by year.

b. Results

b.1 Othon P. Blanco

Financial self-sufficiency and viability of SWM would be achieved when service charges were assumed to be 50 Pesos per month for households and 200 Pesos per month for business firms, which were assumed to comprise 15% of the number of households, and a bill collection efficiency of 90% from 2009 on. The resulting FIRR was 18.9% (See Table H-113).

b.2 Felipe Carrillo Puerto

Financial self-sufficiency and viability of SWM would be achieved when service charges were assumed to be 40 Pesos per month for households and 150 Pesos (100 Pesos) per month for business firms, which were assumed to comprise 15% of the number of households, and a bill collection efficiency of 90% from 2009 on. The resulting FIRR was 37.4 % (10.7%) (See Table H-114).

b.3 Solidaridad

Financial self-sufficiency and viability of SWM would be achieved when service charges were assumed to be 50 Pesos per month for households and 200 Pesos per month for business firms, which were assumed to comprise 15% of the number of households, and a bill collection efficiency of 90% from 2009 on. The resulting FIRR was 11.4% (See Table H-115).

b.4 Study Area

Financial self-sufficiency and viability of SWM would be achieved when service charges were assumed to be 50 Pesos per month for households and 200 Pesos per month for business firms, which were assumed to comprise 15% of the number of households, and a bill collection efficiency of 90% from 2009 on. The resulting FIRR was 18.1% (See Table H-116).

c. Comments

Assuming that even when service charges are applied on all waste generators, if political considerations rule out service charges higher than 30 Pesos per month for households and 100 Pesos per month for business firms, and assuming that business firms comprise the minimum or

10% of the number of households, each municipality, except Felipe Carrillo Puerto, would incur financial deficit in every year of the Master Plan period and will have to apply general funds to SWM as indicated in the following Table.

Table H-112: SWM Financial Deficit with Service Charges $30 Hholds & $100 Business

Year	OPB	FCP	Solidaridad	Study Area
2004	15.93	1.40	23.30	40.64
2005	25.98	4.20	25.55	55.73
2006	22.50	0.24	23.28	46.02
2007	23.68	1.37	21.07	46.11
2008	22.17	0	16.22	38.19
2009	15.15	0	17.50	32.26
2010	17.15	0	17.75	34.56
2011	19.20	2.54	31.14	52.88
2012	25.03	2.02	25.03	52.09
2013	20.86	0	23.73	44.29
2014	23.19	0.78	23.46	47.43
2015	22.80	0	24.75	47.12

In the case of Othon P. Blanco when service charges are 30 Pesos per month for households and 100 Pesos per month for businesses, the largest required amounts of 25.98 Million Pesos in 2005 and 25.03 Million Pesos in 2012, are not much higher than the nearly 25 Million Pesos spent on SWM in 2002, but the quality of service will be much improved.

In the case of Felipe Carrillo Puerto, even with service charges of 30 Pesos per month for households and 100 Pesos per month for businesses, SWM can produce some financial surpluses in 2008, 2009, 2010, 2013 and 2015.

In the case of Solidaridad when service charges are 30 Pesos per month for households and 100 Pesos per month for businesses, the required application of general funds to SWM would range from 16.22 Million Pesos in 2008 to 31.14 Million Pesos in 2011.

For the Study Area as a whole when service charges are 30 Pesos per month for households and 100 Pesos per month for businesses, the required application of general funds to SWM would range from 32.26 Million Pesos in 2009 to 55.73 Million Pesos in 2005.

H.3.6.2 Financial Self-sufficiency or Revenue Shortfall

From the analysis conducted and presented above, the proposed SWM Master Plan can be financially self-sufficient or may require the use of general funds, depending on the political and management decisions taken and the resulting conditions. The basic assumption is that service charges, albeit low, will be imposed on all solid waste generators. Then, the use of general funds should not be equated with the case “without the Master Plan”, as even when the use of general funds is needed, it will be required only to fill the gap between the estimated costs and the

revenues estimated under a set of assumptions. And the SWM service will be much improved when compared with the case "without the Master Plan".

As already presented above, financial self-sufficiency would be achieved when all waste generators pay for the SW service at the tune of 50 Pesos per month for households and 200 Pesos per month for business firms. On the other hand, the required use of general funds was estimated by assuming the lowest SW service charges, that is, 30 Pesos per month for households and 100 Pesos per month for business firms, which were assumed to comprise 10% of the number of households.

Table H-113: Cost and Income of Solid Waste Management Service with Monthly Charges of 50 Pesos Hholds. & 200 Pesos Business Firms (Othon P Blanco)

Household user charges: Pesos/month	50
Business user charges: Pesos/month	200

Item		Unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total	
Residential Customers	Population	number	170,538	189,359	208,179	224,676	241,173	257,670	274,167	290,664	300,821	310,978	321,135	331,292	341,449	-	
	Households		40,221	44,660	49,099	52,990	56,880	60,771	64,662	68,553	70,948	73,344	75,739	78,135	80,530	-	
Business Customers	10% Hholds.		4,022	4,466	4,910	5,299	5,688	6,077	6,466	6,855	7,095	7,334	7,574	7,814	8,053	-	
	15% Hholds.		6,033	6,699	7,365	7,949	8,532	9,116	9,699	10,283	10,642	11,002	11,361	11,720	12,080	-	
	20% Hholds.		8,044	8,932	9,820	10,598	11,376	12,154	12,932	13,711	14,190	14,669	15,148	15,627	16,106	-	
Bill Collection Efficiency	Hholds.	%	5	10	30	50	70	85	90	90	90	90	90	90	90	-	
	Business		50	70	80	90	90	90	90	90	90	90	90	90	90	-	
Revenues (User Charges)	Hholds.	million Pesos		2.68	8.84	15.90	23.89	30.99	34.92	37.02	38.31	39.61	40.90	42.19	43.49	358.73	
	Bus/Hhold10%		4.83	7.50	9.43	11.45	12.29	13.13	13.97	14.81	15.32	15.84	16.36	16.88	17.39	169.19	
	Bus/Hhold15%			11.25	14.14	17.17	18.43	19.69	20.95	22.21	22.99	23.76	24.54	25.32	26.09	246.54	
	Bus/Hhold20%		9.65	15.01	18.85	22.89	24.57	26.25	27.93	29.61	30.65	31.68	32.72	33.75	34.79	338.38	
Total Hhold & Business Revenues	Bus/Hhold10%		4.83	10.18	18.26	27.34	36.18	44.12	48.88	51.83	53.64	55.45	57.26	59.07	60.88	527.92	
	Bus/Hhold15%		0.00	13.93	22.98	33.07	42.32	50.68	55.87	59.23	61.30	63.37	65.44	67.51	69.58	605.27	
	Bus/Hhold20%		9.65	17.69	27.69	38.79	48.46	57.25	62.85	66.63	68.96	71.29	73.62	75.95	78.28	697.10	
Total	Cost			21.29	36.00	37.76	44.16	47.33	43.08	46.76	49.85	56.72	53.58	56.94	57.59	551.05	FIRR
Financial Balance	Bus/Hhold10%			-11.11	-17.73	-10.42	-7.98	-3.21	5.80	5.07	3.79	-1.27	3.68	2.13	3.29	-27.96	-
	Bus/Hhold15%			-7.36	-13.02	-4.69	-1.84	3.36	12.79	12.47	11.45	6.65	11.86	10.57	11.99	54.22	18.9%
	Bus/Hhold20%			-3.60	-8.31	1.03	4.31	9.92	19.77	19.87	19.12	14.57	20.04	19.01	20.69	136.40	55.4%

Table H-114: Cost and Income of Solid Waste Management Service with Monthly Charges of 40 Pesos Hholds. & 150 Pesos Business Firms (Felipe C Puerto)

Household user charges: Pesos/month	40
Business user charges: Pesos/month	150

Item		Unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total	
Residential Customers	Population	number	33,025	33,630	34,232	34,699	35,166	35,633	36,100	36,568	36,909	37,250	37,591	37,932	38,273	-	
	Households		7,789	7,932	8,074	8,184	8,294	8,404	8,514	8,625	8,705	8,785	8,866	8,946	9,027	-	
Business Customers	10% Hholds.		779	793	807	818	829	840	851	863	871	879	887	895	903	-	
	15% Hholds.		1,168	1,190	1,211	1,228	1,244	1,261	1,277	1,294	1,306	1,318	1,330	1,342	1,354	-	
	20% Hholds.		1,558	1,586	1,615	1,637	1,659	1,681	1,703	1,725	1,741	1,757	1,773	1,789	1,805	-	
Bill Collection Efficiency	Hholds.	%	5	10	30	50	70	85	90	90	90	90	90	90	90	-	
	Business		50	70	80	90	90	90	90	90	90	90	90	90	90	-	
Revenues (User Charges)	Hholds.	million Pesos		0.38	1.16	1.96	2.79	3.43	3.68	3.73	3.76	3.80	3.83	3.86	3.90	36.28	
	Bus/Hhold10%			1.00	1.16	1.33	1.34	1.36	1.38	1.40	1.41	1.42	1.44	1.45	1.46	16.15	
	Bus/Hhold15%			1.50	1.74	1.99	2.02	2.04	2.07	2.10	2.12	2.13	2.15	2.17	2.19	24.23	
	Bus/Hhold20%			2.00	2.33	2.65	2.69	2.72	2.76	2.79	2.82	2.85	2.87	2.90	2.92	32.30	
Total Hhold & Business Revenues	Bus/Hhold10%		0	1.38	2.33	3.29	4.13	4.79	5.06	5.12	5.17	5.22	5.27	5.31	5.36	52.43	
	Bus/Hhold15%			1.88	2.91	3.95	4.80	5.47	5.75	5.82	5.88	5.93	5.98	6.04	6.09	60.50	
	Bus/Hhold20%		0	2.38	3.49	4.62	5.47	6.15	6.44	6.52	6.58	6.64	6.70	6.76	6.82	68.58	
Total	Cost			2.35	5.85	2.60	4.35	3.28	3.29	3.40	6.30	5.82	3.52	4.65	3.47	48.87	FIRR
Financial Balance	Bus/Hhold10%			-0.97	-3.52	0.69	-0.22	1.51	1.77	1.73	-1.13	-0.60	1.75	0.67	1.89	3.56	-
	Bus/Hhold15%			-0.47	-2.94	1.35	0.45	2.19	2.46	2.43	-0.42	0.11	2.46	1.39	2.62	11.63	37.4%
	Bus/Hhold20%			0.03	-2.36	2.02	1.12	2.87	3.15	3.13	0.28	0.82	3.18	2.12	3.35	19.71	86.1%

Table H-115: Cost and Income of Solid Waste Management Service with Monthly Charges of 50 Pesos Hholds. & 200 Pesos Business Firms (Solidaridad)

Household user charges: Pesos/month	50
Business user charges: Pesos/month	200

Item		Unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total	
Residential Customers	Population	number	129,765	141,997	189,227	209,098	228,969	250,173	271,377	292,579	310,596	328,613	346,630	364,647	382,664	-	
	Households		30,605	33,490	44,629	49,316	54,002	59,003	64,004	69,004	73,254	77,503	81,752	86,002	90,251	-	
Business Customers	10% Hholds.		3,061	3,349	4,463	4,932	5,400	5,900	6,400	6,900	7,325	7,750	8,175	8,600	9,025	-	
	15% Hholds.		4,591	5,024	6,694	7,397	8,100	8,850	9,601	10,351	10,988	11,625	12,263	12,900	13,538	-	
	20% Hholds.		6,121	6,698	8,926	9,863	10,800	11,801	12,801	13,801	14,651	15,501	16,350	17,200	18,050	-	
Bill Collection Efficiency	Hholds.	%	5	10	30	50	70	85	90	90	90	90	90	90	90	-	
	Business		50	70	80	90	90	90	90	90	90	90	90	90	90	-	
Revenues (User Charges)	Hholds.	million Pesos		2.01	8.03	14.79	22.68	30.09	34.56	37.26	39.56	41.85	44.15	46.44	48.74	370.17	
	Bus/Hhold10%		3.67	5.63	8.57	10.65	11.66	12.74	13.82	14.90	15.82	16.74	17.66	18.58	19.49	169.95	
	Bus/Hhold15%			8.44	12.85	15.98	17.50	19.12	20.74	22.36	23.73	25.11	26.49	27.86	29.24	249.42	
	Bus/Hhold20%		7.35	11.25	17.14	21.30	23.33	25.49	27.65	29.81	31.65	33.48	35.32	37.15	38.99	339.90	
Total Hhold & Business Revenues	Bus/Hhold10%		3.67	7.64	16.60	25.45	34.35	42.84	48.39	52.17	55.38	58.59	61.80	65.02	68.23	540.12	
	Bus/Hhold15%			10.45	20.89	30.77	40.18	49.21	55.30	59.62	63.29	66.96	70.63	74.31	77.98	619.58	
	Bus/Hhold20%			13.26	25.17	36.10	46.01	55.58	62.21	67.07	71.20	75.33	79.46	83.59	87.72	702.72	
Total	Cost			27.32	34.65	37.49	40.51	40.65	45.15	47.56	62.79	58.52	59.05	60.61	63.74	578.03	FIRR
Financial Balance	Bus/Hhold10%			-19.69	-18.05	-12.04	-6.17	2.19	3.24	4.61	-7.41	0.08	2.75	4.40	4.49	-41.59	-
	Bus/Hhold15%			-16.87	-13.77	-6.71	-0.33	8.56	10.15	12.06	0.50	8.45	11.58	13.69	14.24	41.55	11.4%
	Bus/Hhold20%			-14.06	-9.48	-1.39	5.50	14.93	17.06	19.51	8.42	16.82	20.41	22.98	23.98	124.69	32.5%

Table H-116: Cost and Income of Solid Waste Management Service with Monthly Charges of 50 Pesos Hholds. & 200 Pesos Business Firms (Study Area)

Household user charges: Pesos/month	50
Business user charges: Pesos/month	200

Item		Unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total	
Residential Customers	Population	number	333,328	364,986	431,638	468,473	505,308	543,476	581,644	619,811	648,326	676,841	705,356	733,871	762,386	-	
	Households		78,615	86,082	101,802	110,490	119,176	128,178	137,180	146,182	152,907	159,632	166,357	173,083	179,808	-	
Business Customers	10% Hholds.		7,862	8,608	10,180	11,049	11,918	12,818	13,718	14,618	15,291	15,963	16,636	17,308	17,981	-	
	15% Hholds.		11,792	12,912	15,270	16,574	17,876	19,227	20,577	21,927	22,936	23,945	24,954	25,962	26,971	-	
	20% Hholds.		15,723	17,216	20,360	22,098	23,835	25,636	27,436	29,236	30,581	31,926	33,271	34,617	35,962	-	
Bill Collection Efficiency	Hholds.	%	5	10	30	50	70	85	90	90	90	90	90	90	90	-	
	Business		50	70	80	90	90	90	90	90	90	90	90	90	90	-	
Revenues (User Charges)	Hholds.	million Pesos	2.36	5.16	18.32	33.15	50.05	65.37	74.08	78.94	82.57	86.20	89.83	93.46	97.10	776.60	
	Bus/Hhold10%		9.43	14.46	19.55	23.87	25.74	27.69	29.63	31.58	33.03	34.48	35.93	37.39	38.84	361.61	
	Bus/Hhold15%		14.15	21.69	29.32	35.80	38.61	41.53	44.45	47.36	49.54	51.72	53.90	56.08	58.26	542.41	
	Bus/Hhold20%		18.87	28.92	39.09	47.73	51.48	55.37	59.26	63.15	66.06	68.96	71.87	74.77	77.68	723.22	
Total Hhold & Business Revenues	Bus/Hhold10%		11.79	19.63	37.87	57.01	75.80	93.06	103.71	110.51	115.60	120.68	125.77	130.85	135.93	1,138.21	
	Bus/Hhold15%		16.51	26.86	47.64	68.95	88.67	106.90	118.52	126.30	132.11	137.92	143.73	149.54	155.35	1,319.01	
	Bus/Hhold20%		21.23	34.09	57.42	80.88	101.54	120.74	133.34	142.09	148.63	155.16	161.70	168.24	174.77	1,499.82	
Total	Cost			50.97	76.50	77.85	89.02	91.25	91.52	97.71	118.93	121.05	116.15	122.20	124.80	1,177.95	FIRR
Financial Balance	Bus/Hhold10%			-31.34	-38.63	-20.83	-13.22	1.80	12.19	12.80	-3.33	-0.37	9.61	8.65	11.13	-51.53	-
	Bus/Hhold15%			-24.11	-28.85	-8.90	-0.35	15.65	27.01	28.59	13.18	16.87	27.58	27.34	30.55	124.55	18.1%
	Bus/Hhold20%			-16.88	-19.08	3.03	12.52	29.49	41.82	44.37	29.69	34.11	45.55	46.03	49.97	300.64	46.0%

H.3.7 The Solid Waste Management Master Plan

This section summarizes the Solid Waste Management Master Plan described above in the following tables.

Table H-117: The SWM Master Plan, Whole Study Area 1, (Waste Amount)

		Present	Short				Middle				Long			
Item	unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1. Population														
population	nos.	333,328	364,986	431,638	468,473	505,308	543,476	581,644	619,811	648,326	676,841	705,356	733,871	762,386
household	nos.	78,615	86,082	101,801	110,489	119,176	128,178	137,180	146,182	152,907	159,632	166,358	173,083	179,808
2. Waste amount														
1) At source														
generation	ton/day	426.1	465.5	539.7	583.4	627.7	673.8	720.4	767.5	802.6	838.1	873.5	909.6	945.7
sorce reduction	ton/day	0.0	0.0	10.9	17.5	25.0	40.5	50.5	61.5	72.2	100.6	113.5	127.3	141.9
self-disposal	ton/day	106.2	124.3	100.9	71.3	26.7	26.9	20.5	17.3	9.9	9.8	9.8	9.9	10.0
discharge	ton/day	319.9	341.2	427.9	494.6	576.0	606.4	649.4	688.7	720.5	727.7	750.2	772.4	793.8
2) Collection														
mixed waste	ton/day	319.9	341.2	427.9	489.7	565.3	589.1	624.5	655.5	678.6	676.7	689.3	701.0	711.1
garden waste	ton/day	0.0	0.0	0.0	4.9	10.7	17.3	24.9	33.2	41.9	51.0	60.9	71.4	82.7
3) Disposal														
disposal	ton/day	319.9	341.2	427.9	490.3	566.4	590.8	627.0	658.8	682.7	681.9	695.5	708.1	719.3
3. Waste minimization	%	0	0	2	4	6	9	10	12	14	18	20	22	24
source reduction	%	0	0	2	3	4	6	7	8	9	12	13	14	15
recycling	%	0	0	0	1	2	3	3	4	5	6	7	8	9

Table H-118: The SWM Master Plan, Whole Study Area 2, (Technical System)

		Present	Short				Middle				Long			
Item	unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
4. Technical System														
1) Source reduction														
participant (household)	%	0%	0%	11%	16%	21%	32%	37%	43%	48%	64%	69%	75%	80%
participant (household)	nos.	-	0	10,860	17,679	25,424	41,018	51,214	62,370	73,395	102,166	115,341	129,236	143,848
purchase of container	nos.	-	0	10,860	6,819	7,745	15,594	10,196	22,016	28,704	43,335	36,514	39,685	35,964
2) Collection														
collection rate	%	75	73	81	87	96	96	97	98	99	99	99	99	99
compactor (required)	nos.	-	47	64	70	81	86	89	93	97	96	97	98	100
dump truck (required)	nos.	-	0	0	3	4	4	6	7	10	11	12	14	16
compactor (purchase)	nos.	-	10	21	10	15	10	8	8	14	20	11	16	12
dump truck (purchase)	nos.	-	0	0	3	1	0	2	1	3	1	4	3	2
3) Recycling (compost)														
wheel loader (required)	nos.	-	0	0	3	3	4	4	6	6	7	9	11	11
shredder (required)	nos.	-	0	0	3	3	3	4	4	6	7	7	9	11
wheel loader (purchase)	nos.	-	0	0	3	0	1	0	2	0	1	5	2	1
shredder (purchase)	nos.	-	0	0	3	0	0	1	0	2	1	3	2	2
4) Final disposal														
phased development			several levels of landfilling are to be adopted depending on community size											

Table H-119: The SWM Master Plan, Whole Study Area 3, (Cost and Revenue)

		Present	Short				Middle				Long				
Item	unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
5. SWM cost															Total
source reduction	1000pesos	-	0	1,193	749	852	1,716	1,121	2,421	3,156	4,768	4,017	4,366	3,957	28,316
collection	1000pesos	-	34,001	54,560	48,763	58,608	54,670	56,298	57,915	69,421	74,547	67,694	73,876	70,477	720,830
recycling (compost)	1000pesos	-	0	0	4,818	1,683	2,596	2,596	4,070	4,070	4,983	8,899	7,579	7,579	48,873
final disposal	1000pesos	-	13,348	15,927	17,949	21,377	25,282	24,167	25,436	33,861	28,118	26,794	27,300	33,446	293,004
sub-total	1000pesos	-	47,349	71,680	72,279	82,520	84,264	84,182	89,842	110,508	112,416	107,404	113,121	115,459	1,091,023
administration	1000pesos	-	3,616	4,818	5,567	6,498	6,990	7,335	7,872	8,425	8,636	8,748	9,081	9,341	86,927
total	1000pesos	-	50,965	76,498	77,846	89,018	91,254	91,517	97,714	118,933	121,052	116,152	122,202	124,800	1,177,950
6. Revenue (1)															
household	1000pesos	-	5,165	18,324	33,147	50,054	65,371	74,077	78,938	82,570	86,201	89,833	93,465	97,096	774,241
business entity	1000pesos	-	21,693	29,319	35,799	38,613	41,530	44,446	47,363	49,542	51,721	53,900	56,079	58,258	528,263
other sources	1000pesos	-	0	0	0	0	0	0	0	0	0	0	0	0	0
total	1000pesos	-	26,858	47,643	68,946	88,667	106,901	118,523	126,301	132,112	137,922	143,733	149,544	155,354	1,302,504
7. Balance															
balance	1000pesos		-24,107	-28,855	-8,900	-0,351	15,646	27,007	28,587	13,180	16,870	27,580	27,342	30,554	124,553

Note: (1) Service charges were assumed to be 50 pesos per month for households and 200 pesos for business firms.

Table H-120: The SWM Master Plan, Othon P Blanco 1, (Waste Amount)

		Present	Short				Middle				Long			
Item	unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1. Population														
population	nos.	170,538	189,359	208,179	224,676	241,173	257,670	274,167	290,664	300,821	310,978	321,135	331,292	341,449
household	nos.	40,221	44,660	49,099	52,990	56,880	60,771	64,662	68,553	70,948	73,344	75,739	78,135	80,530
2. Waste amount														
1) At source														
generation	ton/day	208.4	229.1	250.0	268.5	287.0	306.0	325.1	344.2	356.3	368.7	380.9	393.6	406.1
sorce reduction	ton/day	0.0	0.0	5.0	8.0	11.5	18.4	22.8	27.6	32.0	44.3	49.4	55.0	61.0
self-disposal	ton/day	58.3	77.0	55.8	40.5	14.4	14.8	10.8	7.5	4.1	4.1	4.2	4.3	4.4
discharge	ton/day	150.1	152.1	189.2	220.0	261.1	272.8	291.5	309.1	320.2	320.3	327.3	334.3	340.7
2) Collection														
mixed waste	ton/day	150.1	152.1	189.2	217.8	256.4	265.2	280.7	294.8	302.4	298.9	302.1	305.1	307.2
garden waste	ton/day	0.0	0.0	0.0	2.2	4.7	7.6	10.8	14.3	17.8	21.4	25.2	29.2	33.5
3) Disposal														
disposal	ton/day	150.1	152.1	189.2	218.1	256.9	265.9	281.8	296.2	304.1	301.1	304.7	308.0	310.5
3. Waste minimization	%	0	0	2	4	6	8	10	12	14	18	20	21	23
source reduction	%	0	0	2	3	4	6	7	8	9	12	13	14	15
recycling	%	0	0	0	1	2	2	3	4	5	6	7	7	8

Table H-121: The SWM Master Plan, Othon P Blanco 2, (Technical System)

		Present	Short				Middle				Long			
Item	unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
4. Technical System														
1) Source reduction														
participant (household)	%	0%	0%	11%	16%	21%	32%	37%	43%	48%	64%	69%	75%	80%
participant (household)	nos.	-	0	5,238	8,478	12,135	19,448	24,141	29,249	34,055	46,941	52,512	58,341	64,425
purchase of container	nos.	-	0	5,238	3,240	3,657	7,313	4,693	10,346	13,284	19,783	16,541	17,835	15,885
2) Collection														
collection rate	%	72	66	77	84	95	95	96	98	99	99	99	99	99
compactor (required)	nos.	-	21	29	31	37	40	40	42	43	43	43	43	44
dump truck (required)	nos.	-	0	0	2	2	2	3	3	5	5	5	6	7
compactor (purchase)	nos.	-	3	11	6	10	8	5	6	4	11	6	10	9
dump truck (purchase)	nos.	-	0	0	2	0	0	1	0	2	0	2	1	1
3) Recycling (compost)														
wheel loader (required)	nos.	-	0	0	2	2	2	2	3	3	3	4	5	5
shredder (required)	nos.	-	0	0	2	2	2	2	2	3	3	3	4	5
wheel loader (purchase)	nos.	-	0	0	2	0	0	0	1	0	0	3	1	0
shredder (purchase)	nos.	-	0	0	2	0	0	0	0	1	0	2	1	1
4) Final disposal														
phased development			several levels of landfilling are to be adopted depending on community size											

Table H-122: The SWM Master Plan, Othon P Blanco 3, (Cost and Revenue)

		Present	Short				Middle				Long				
Item	unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
5. SWM cost															Total
source reduction	1000pesos	-	0	576	356	402	805	516	1,138	1,460	2,177	1,819	1,962	1,748	12,959
collection	1000pesos	-	13,552	26,378	24,156	30,019	29,238	27,082	28,413	29,073	35,365	31,306	35,442	35,244	345,268
recycling (compost)	1000pesos	-	0	0	3,212	1,122	1,122	1,122	2,035	2,035	1,683	4,686	3,509	3,157	23,683
final disposal	1000pesos	-	6,107	6,891	7,541	9,616	12,899	11,023	11,598	13,469	13,626	11,903	12,035	13,328	130,036
sub-total	1000pesos	-	19,659	33,845	35,265	41,159	44,064	39,743	43,184	46,037	52,851	49,714	52,948	53,477	511,946
administration	1000pesos	-	1,630	2,154	2,494	2,997	3,264	3,339	3,576	3,808	3,868	3,867	3,994	4,110	39,101
total	1000pesos	-	21,289	35,999	37,759	44,156	47,328	43,082	46,760	49,845	56,719	53,581	56,942	57,587	551,047
6. Revenue (2)															
household	1000pesos	-	2,680	8,838	15,897	23,890	30,993	34,917	37,019	38,312	39,606	40,899	42,193	43,486	358,730
business entity	1000pesos	-	11,254	14,141	17,169	18,429	19,690	20,950	22,211	22,987	23,763	24,539	25,316	26,092	246,541
other sources	1000pesos	-	0	0	0	0	0	0	0	0	0	0	0	0	0
total	1000pesos	-	13,934	22,979	33,066	42,319	50,683	55,867	59,230	61,299	63,369	65,438	67,509	69,578	605,271
7. Balance															
balance	1000pesos		-7,355	-13,020	-4,693	-1,837	3,355	12,785	12,470	11,454	6,650	11,857	10,567	11,991	54,224

Note: (2) Service charges were assumed to be 50 pesos per month for households and 200 pesos for business firms.

Table H-123: The SWM Master Plan, Felipe C Puerto 1, (Waste Amount)

		Present	Short				Middle				Long			
Item	unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1. Population														
population	nos.	33,025	33,630	34,232	34,699	35,166	35,633	36,100	36,568	36,909	37,250	37,591	37,932	38,273
household	nos.	7,789	7,932	8,074	8,184	8,294	8,404	8,514	8,625	8,705	8,785	8,866	8,946	9,027
2. Waste amount														
1) At source														
generation	ton/day	37.1	37.9	38.6	39.1	39.9	40.4	41.1	41.8	42.3	42.7	43.2	43.7	44.0
sorce reduction	ton/day	0.0	0.0	0.8	1.2	1.5	2.4	2.9	3.4	3.8	5.1	5.7	6.2	6.6
self-disposal	ton/day	26.3	25.4	19.1	16.4	11.5	11.3	8.9	9.0	5.2	5.1	5.0	5.0	5.0
discharge	ton/day	10.8	12.5	18.7	21.5	26.9	26.7	29.3	29.4	33.3	32.5	32.5	32.5	32.4
2) Collection														
mixed waste	ton/day	10.8	12.5	18.7	21.5	26.9	26.7	29.3	29.4	33.3	32.5	32.5	32.5	32.4
garden waste	ton/day	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3) Disposal														
disposal	ton/day	10.8	12.5	18.7	21.5	26.9	26.7	29.3	29.4	33.3	32.5	32.5	32.5	32.4
3. Waste minimization	%	0	0	2	3	4	6	7	8	9	12	13	14	15
source reduction	%	0	0	2	3	4	6	7	8	9	12	13	14	15
recycling	%	0	0	0	0	0	0	0	0	0	0	0	0	0

Table H-124: The SWM Master Plan, Felipe C Puerto 2, (Technical System)

		Present	Short				Middle				Long			
Item	unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
4. Technical System														
1) Source reduction														
participant (household)	%	0%	0%	11%	16%	21%	32%	37%	43%	48%	64%	69%	75%	80%
participant (household)	nos.	-	0	862	1,310	1,769	2,689	3,178	3,679	4,178	5,623	6,147	6,680	7,222
purchase of container	nos.	-	0	862	448	459	920	489	1,363	1,809	2,352	1,903	1,942	1,532
2) Collection														
collection rate	%	29	33	49	57	70	70	77	77	86	86	87	87	87
compactor (required)	nos.	-	2	4	4	5	5	5	5	6	5	5	5	5
dump truck (required)	nos.	-	0	0	0	0	0	0	0	0	0	0	0	0
compactor (purchase)	nos.	-	1	3	0	1	0	0	0	2	2	0	1	0
dump truck (purchase)	nos.	-	0	0	0	0	0	0	0	0	0	0	0	0
3) Recycling (compost)														
wheel loader (required)	nos.	-	0	0	0	0	0	0	0	0	0	0	0	0
shredder (required)	nos.	-	0	0	0	0	0	0	0	0	0	0	0	0
wheel loader (purchase)	nos.	-	0	0	0	0	0	0	0	0	0	0	0	0
shredder (purchase)	nos.	-	0	0	0	0	0	0	0	0	0	0	0	0
4) Final disposal														
phased development			several levels of landfilling are to be adopted depending on community size											

Table H-125: The SWM Master Plan, Felipe C Puerto 3, (Cost and Revenue)

		Present	Short				Middle				Long				
Item	unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
5. SWM cost															Total
source reduction	1000pesos	-	0	94	49	50	101	54	150	199	259	210	214	169	1,549
collection	1000pesos	-	2,090	5,302	1,936	3,542	2,420	2,420	2,420	5,148	4,664	2,420	3,542	2,420	38,324
recycling (compost)	1000pesos	-	0	0	0	0	0	0	0	0	0	0	0	0	0
final disposal	1000pesos	-	151	225	379	465	461	514	516	583	570	570	570	568	5,572
sub-total	1000pesos	-	2,241	5,621	2,364	4,057	2,982	2,988	3,086	5,930	5,493	3,200	4,326	3,157	45,445
administration	1000pesos	-	112	226	236	294	298	299	309	370	325	320	320	316	3,425
total	1000pesos	-	2,353	5,847	2,600	4,351	3,280	3,287	3,395	6,300	5,818	3,520	4,646	3,473	48,870
6. Revenue (3)															
household	1000pesos	-	0,381	1,163	1,964	2,787	3,429	3,678	3,726	3,761	3,795	3,830	3,865	3,900	36,279
business entity	1000pesos	-	1,499	1,744	1,989	2,015	2,042	2,069	2,096	2,115	2,135	2,154	2,174	2,194	24,226
other sources	1000pesos	-	0	0	0	0	0	0	0	0	0	0	0	0	0
total	1000pesos	-	1,880	2,907	3,953	4,802	5,471	5,747	5,822	5,876	5,930	5,984	6,039	6,094	60,505
7. Balance															
balance	1000pesos		-0,473	-2,940	1,353	0,451	2,191	2,460	2,427	-0,424	0,112	2,464	1,393	2,621	11,635

Note: (3) Service charges were assumed to be 40 pesos per month for households and 150 pesos for business firms.

Table H-126: The SWM Master Plan, Solidaridad 1, (Waste Amount)

		Present	Short				Middle				Long			
Item	unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1. Population														
population	nos.	129,765	141,997	189,227	209,098	228,969	250,173	271,377	292,579	310,596	328,613	346,630	364,647	382,664
household	nos.	30,605	33,490	44,629	49,316	54,002	59,003	64,004	69,004	73,254	77,503	81,752	86,002	90,251
2. Waste amount														
1) At source														
generation	ton/day	180.6	198.5	251.1	275.8	300.8	327.4	354.2	381.5	404.0	426.7	449.4	472.3	495.6
sorce reduction	ton/day	0.0	0.0	5.1	8.3	12.0	19.7	24.8	30.5	36.4	51.2	58.4	66.1	74.3
self-disposal	ton/day	21.6	21.9	26.0	14.4	0.8	0.8	0.8	0.8	0.6	0.6	0.6	0.6	0.6
discharge	ton/day	159.0	176.6	220.0	253.1	288.0	306.9	328.6	350.2	367.0	374.9	390.4	405.6	420.7
2) Collection														
mixed waste	ton/day	159.0	176.6	220.0	250.4	282.0	297.2	314.5	331.3	342.9	345.3	354.7	363.4	371.5
garden waste	ton/day	0.0	0.0	0.0	2.7	6.0	9.7	14.1	18.9	24.1	29.6	35.7	42.2	49.2
3) Disposal														
disposal	ton/day	159.0	176.6	220.0	250.7	282.6	298.2	315.9	333.2	345.3	348.3	358.3	367.6	376.4
3. Waste minimization	%	0	0	2	4	6	9	11	13	15	19	21	23	25
source reduction	%	0	0	2	3	4	6	7	8	9	12	13	14	15
recycling	%	0	0	0	1	2	3	4	5	6	7	8	9	10

Table H-127: The SWM Master Plan, Solidaridad 2, (Technical System)

		Present	Short				Middle				Long			
Item	unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
4. Technical System														
1) Source reduction														
participant (household)	%	0%	0%	11%	16%	21%	32%	37%	43%	48%	64%	69%	75%	80%
participant (household)	nos.	-	0	4,760	7,891	11,520	18,881	23,895	29,442	35,162	49,602	56,682	64,215	72,201
purchase of container	nos.	-	0	4,760	3,131	3,629	7,361	5,014	10,307	13,611	21,200	18,070	19,908	18,547
2) Collection														
collection rate	%	88	89	89	95	100	100	100	100	100	100	100	100	100
compactor (required)	nos.	-	24	31	35	39	41	44	46	48	48	49	50	51
dump truck (required)	nos.	-	0	0	1	2	2	3	4	5	6	7	8	9
compactor (purchase)	nos.	-	6	7	4	4	2	3	2	8	7	5	5	3
dump truck (purchase)	nos.	-	0	0	1	1	0	1	1	1	1	2	2	1
3) Recycling (compost)														
wheel loader (required)	nos.	-	0	0	1	1	2	2	3	3	4	5	6	6
shredder (required)	nos.	-	0	0	1	1	1	2	2	3	4	4	5	6
wheel loader (purchase)	nos.	-	0	0	1	0	1	0	1	0	1	2	1	1
shredder (purchase)	nos.	-	0	0	1	0	0	1	0	1	1	1	1	1
4) Final disposal														
phased development			several levels of landfilling are to be adopted depending on community size											

Table H-128: The SWM Master Plan, Solidaridad 3, (Cost and Revenue)

		Present	Short				Middle				Long				
Item	unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
5. SWM cost															Total
source reduction	1000pesos	-	0	523	344	400	810	551	1,133	1,497	2,332	1,988	2,190	2,040	13,808
collection	1000pesos	-	18,359	22,880	22,671	25,047	23,012	26,796	27,082	35,200	34,518	33,968	34,892	32,813	337,238
recycling (compost)	1000pesos	-	0	0	1,606	561	1,474	1,474	2,035	2,035	3,300	4,213	4,070	4,422	25,190
final disposal	1000pesos	-	7,090	8,811	10,029	11,296	11,922	12,630	13,322	19,808	13,922	14,321	14,695	19,550	157,396
sub-total	1000pesos	-	25,449	32,214	34,650	37,304	37,218	41,451	43,572	58,540	54,072	54,490	55,847	58,825	533,632
administration	1000pesos	-	1,874	2,438	2,837	3,207	3,428	3,697	3,987	4,247	4,443	4,561	4,767	4,915	44,401
total	1000pesos	-	27,323	34,652	37,487	40,511	40,646	45,148	47,559	62,787	58,515	59,051	60,614	63,740	578,033
6. Revenue (4)			By MaO												
household	1000pesos	-	2,009	8,033	14,795	22,681	30,092	34,562	37,262	39,557	41,852	44,146	46,441	48,736	370,166
business entity	1000pesos	-	8,439	12,853	15,978	17,497	19,117	20,737	22,357	23,734	25,111	26,488	27,865	29,241	249,417
other sources	1000pesos	-	0	0	0	0	0	0	0	0	0	0	0	0	0
total	1000pesos	-	10,448	20,886	30,773	40,178	49,209	55,299	59,619	63,291	66,963	70,634	74,306	77,977	619,583
7. Balance															
balance	1000pesos		-16,875	-13,766	-6,714	-0,333	8,563	10,151	12,060	0,504	8,448	11,583	13,692	14,237	41,550

Note: (4) Service charges were assumed to be 50 pesos per month for households and 200 pesos for business firms.

H.3.8 Implementation Plan

H.3.8.1 Overall Implementation Plan

The following tables show how to implement the Master Plan in Phases.

Table H-129: Implementation Plan (Phase 1: 2004-2007)

Item	Othon P Blanco	Felipe C Puerto	Solidaridad
1. Basic strategy	• Focusing on the urban area		
2. Technical system			
1) Source reduction	• To begin backyard composting in the all urban groups		
2) Collection & transport	• To begin expansion of collection area • To begin improvement of waste collection works		
3) Intermediate treatment	• To begin pruning waste composting in Urban Group 1 and 5	-	• To begin pruning waste composting in Urban Group 9
4) Final disposal	• To construct a sanitary landfill with leachate control in Urban Group 1 • To improve the dump site in Urban Group 2 up to enclosed dump site • To improve the dump site in Urban Group 4 up to enclosed dump site • To improve the dump site in Urban Group 5 up to landfill with gas control	• To improve the dump site in Urban Group 6 up to enclosed dump site	• To operate existing disposal sites
3. Management system			
1) Planning & operations	• To plan and operate SWM according to the M/P • To follow operation manuals and suggestions made by the Model Projects		
2) Commercial & financial	• To begin improvement of income		
3) Administration	• To establish a specialized administrative unit in SEDUMA • To take action for restructuring of municipal executing bodies of SWM		
4) Monitoring	• To begin monitoring of performance indicators of SWM		
4. Legal & institutional system	• To establish an information system for the integral SWM • To take action for formulation of a municipal regulation on SWM		
5. Public private partnership	• To review existing public private partnership • To formulate rules of public private partnership, if necessary		
6. Citizens participation	• To begin environmental education on waste minimization		
7. Newly developed urban area	• To initiate establishment of a new SWM system in Costa Maya	-	-

Table H-130: Implementation Plan (Phase 2: 2008-2011)

Item	Othon P Blanco	Felipe C Puerto	Solidaridad
1. Basic strategy	• Focusing on the urban area		
2. Technical system			
1) Source reduction	• To expand backyard composting in the all urban groups		
2) Collection & transport	• To continue expansion of collection area • To continue improvement of waste collection works		
3) Intermediate treatment	• To expand pruning waste composting in Urban Group 1 and 5	-	• To expand pruning waste composting in Urban Group 9
4) Final disposal	• To begin operation of the sanitary landfill with leachate control in Urban Group 1 • To construct and to begin operation of a sanitary landfill with leachate control in Urban Group 5	• To continue to operate the disposal sites	• To construct and to begin operation of a sanitary landfill with leachate control in Urban Group 9
3. Management system			
1) Planning & operations	• To plan and operate SWM according to the M/P • To follow operation manuals and suggestions made by the Model Projects		
2) Commercial & financial	• To continue improvement of income		
3) Administration	• To operate the specialized administrative unit in SEDUMA • To operate restructurized municipal executing bodies of SWM		
4) Monitoring	• To continue monitoring of performance indicators of SWM		
4. Legal & institutional system	• To operate the information system for the integral SWM • To supervise SWM services according to the municipal regulation		
5. Public private partnership	• To review existing public private partnership • To formulate rules of public private partnership, if necessary		
6. Citizens participation	• To continue environmental education on waste minimization		
7. Newly developed urban area	• To establish a firm SWM system in Costa Maya	-	-

Table H-131: Implementation Plan (Phase 3: 2012-2015)

Item	Othon P Blanco	Felipe C Puerto	Solidaridad
1. Basic strategy	• Focusing on the urban area		
2. Technical system			
1) Source reduction	• To expand backyard composting in the all urban groups		
2) Collection & transport	• To continue expansion of collection area • To continue improvement of waste collection works		
3) Intermediate treatment	• To expand pruning waste composting in Urban Group 1 and 5	-	• To expand pruning waste composting in Urban Group 9
4) Final disposal	• To continue to operate the disposal sites	• To continue to operate the disposal sites	• To continue to operate the disposal sites
3. Management system			
1) Planning & operations	• To plan and operate SWM according to the M/P • To follow operation manuals and suggestions made by the Model Projects		
2) Commercial & financial	• To continue improvement of income		
3) Administration	• To operate the specialized administrative unit in SEDUMA • To operate restructurized municipal executing bodies of SWM		
4) Monitoring	• To continue monitoring of performance indicators of SWM		
4. Legal & institutional system	• To operate the information system for the integral SWM • To supervise SWM services according to the municipal regulation		
5. Public private partnership	• To review existing public private partnership • To formulate rules of public private partnership, if necessary		
6. Citizens participation	• To continue environmental education on waste minimization		
7. Newly developed urban area	• To establish a firm SWM system in Costa Maya	-	-

H.3.8.2 Implementation Plan of Technical System

This section explains how to implement the technical system yearly.

a. Source Reduction

The following tables show how to implement source reduction at waste generation source.

Table H-132: Implementation Plan of Source Reduction (by Municipality)

Whole Study Area

Phase	year	source reduction	participant	participant	purchase of container
		ton/year	% of total households	nos. of household	nos.
phase 1	2004	0	0%	0	0
	2005	3,981	11%	10,860	10,860
	2006	6,389	16%	17,679	6,819
	2007	9,128	21%	25,424	7,745
phase 2	2008	14,785	32%	41,018	15,594
	2009	18,434	37%	51,214	10,196
	2010	22,451	43%	62,370	22,016
	2011	26,356	48%	73,395	28,704
phase 3	2012	36,723	64%	102,166	43,335
	2013	41,429	69%	115,341	36,514
	2014	46,466	75%	129,236	39,685
	2015	51,796	80%	143,848	35,964

Othon P Blanco

Phase	year	source reduction	participant	participant	purchase of container
		ton/year	% of total households	nos. of household	nos.
phase 1	2004	0	0%	0	0
	2005	1,826	11%	5,238	5,238
	2006	2,921	16%	8,478	3,240
	2007	4,199	21%	12,135	3,657
phase 2	2008	6,717	32%	19,448	7,313
	2009	8,323	37%	24,141	4,693
	2010	10,076	43%	29,249	10,346
	2011	11,681	48%	34,055	13,284
phase 3	2012	16,172	64%	46,941	19,783
	2013	18,032	69%	52,512	16,541
	2014	20,075	75%	58,341	17,835
	2015	22,266	80%	64,425	15,885

Felipe C Puerto

phase	year	source reduction	participant	participant	purchase of container
		ton/year	% of total households	nos. of household	nos.
phase 1	2004	0	0%	0	0
	2005	293	11%	862	862
	2006	438	16%	1,310	448
	2007	548	21%	1,769	459
phase 2	2008	877	32%	2,689	920
	2009	1,059	37%	3,178	489
	2010	1,242	43%	3,679	1,363
	2011	1,388	48%	4,178	1,809
phase 3	2012	1,863	64%	5,623	2,352
	2013	2,081	69%	6,147	1,903
	2014	2,264	75%	6,680	1,942
	2015	2,410	80%	7,222	1,532

Solidaridad

phase	year	source reduction	participant	participant	purchase of container
		ton/year	% of total households	nos. of household	nos.
phase 1	2004	0	0%	0	0
	2005	1,862	11%	4,760	4,760
	2006	3,030	16%	7,891	3,131
	2007	4,381	21%	11,520	3,629
phase 2	2008	7,191	32%	18,881	7,361
	2009	9,052	37%	23,895	5,014
	2010	11,133	43%	29,442	10,307
	2011	13,287	48%	35,162	13,611
phase 3	2012	18,688	64%	49,602	21,200
	2013	21,316	69%	56,682	18,070
	2014	24,127	75%	64,215	19,908
	2015	27,120	80%	72,201	18,547

Table H-133: Implementation Plan of Source Reduction (by Urban Group)

Urban Group 1 (OPB)

phase	year	source reduction	participant	participant	purchase of container
		ton/year	% of total households	nos. of household	nos.
phase 1	2004	0	0%	0	0
	2005	1,241	11%	3,615	3,615
	2006	1,898	16%	5,531	1,916
	2007	2,592	21%	7,520	1,989
phase 2	2008	3,942	32%	11,498	3,978
	2009	4,672	37%	13,668	2,170
	2010	5,439	43%	15,910	5,857
	2011	6,205	48%	18,225	7,846
phase 3	2012	8,432	64%	24,734	10,414
	2013	9,308	69%	27,265	8,498
	2014	10,220	75%	29,869	8,752
	2015	11,169	80%	32,545	7,088

Urban Group 2 (OPB)

phase	year	source reduction	participant	participant	purchase of container
		ton/year	% of total households	nos. of household	nos.
phase 1	2004	0	0%	0	0
	2005	73	11%	262	262
	2006	146	16%	400	138
	2007	183	21%	544	144
phase 2	2008	292	32%	832	288
	2009	329	37%	989	157
	2010	402	43%	1,151	424
	2011	438	48%	1,318	567
phase 3	2012	621	64%	1,789	753
	2013	657	69%	1,972	615
	2014	730	75%	2,160	633
	2015	803	80%	2,354	513

Urban Group 3 (OPB)

phase	year	source reduction	participant	participant	purchase of container
		ton/year	% of total households	nos. of household	nos.
phase 1	2004	0	0%	0	0
	2005	37	11%	102	102
	2006	37	16%	156	54
	2007	73	21%	212	56
phase 2	2008	110	32%	324	112
	2009	146	37%	385	61
	2010	146	43%	448	165
	2011	183	48%	513	221
phase 3	2012	256	64%	696	293
	2013	256	69%	767	239
	2014	292	75%	841	247
	2015	329	80%	916	199

Urban Group 4 (OPB)

phase	year	source reduction	participant	participant	purchase of container
		ton/year	% of total households	nos. of household	nos.
phase 1	2004	0	0%	0	0
	2005	219	11%	586	586
	2006	329	16%	954	368
	2007	475	21%	1,374	420
phase 2	2008	767	32%	2,213	839
	2009	949	37%	2,759	546
	2010	1,132	43%	3,356	1,183
	2011	1,351	48%	4,003	1,601
phase 3	2012	1,935	64%	5,642	2,427
	2013	2,190	69%	6,441	2,058
	2014	2,482	75%	7,291	2,235
	2015	2,811	80%	8,192	2,044

Urban Group 5 (OPB)

phase	year	source reduction	participant	participant	purchase of container
		ton/year	% of total households	nos. of household	nos.
phase 1	2004	0	0%	0	0
	2005	256	11%	673	673
	2006	511	16%	1,437	764
	2007	876	21%	2,485	1,048
phase 2	2008	1,606	32%	4,581	2,096
	2009	2,227	37%	6,340	1,759
	2010	2,957	43%	8,384	2,717
	2011	3,504	48%	9,996	3,049
phase 3	2012	4,928	64%	14,080	5,896
	2013	5,621	69%	16,067	5,131
	2014	6,351	75%	18,180	5,968
	2015	7,154	80%	20,418	6,041

Urban Group 6 (FCP)

phase	year	source reduction	participant	participant	purchase of container
		ton/year	% of total households	nos. of household	nos.
phase 1	2004	0	0%	0	0
	2005	183	11%	563	563
	2006	292	16%	856	293
	2007	365	21%	1,156	300
phase 2	2008	584	32%	1,757	601
	2009	694	37%	2,077	320
	2010	803	43%	2,404	890
	2011	913	48%	2,730	1,182
phase 3	2012	1,205	64%	3,674	1,537
	2013	1,351	69%	4,017	1,244
	2014	1,460	75%	4,365	1,269
	2015	1,570	80%	4,719	1,001

Urban Group 7 (FCP)

phase	year	source reduction	participant	participant	purchase of container
		ton/year	% of total households	nos. of household	nos.
phase 1	2004	0	0%	0	0
	2005	37	11%	122	122
	2006	73	16%	185	63
	2007	73	21%	250	65
phase 2	2008	110	32%	380	130
	2009	146	37%	449	69
	2010	183	43%	520	193
	2011	183	48%	591	256
phase 3	2012	256	64%	795	332
	2013	292	69%	869	269
	2014	329	75%	944	274
	2015	329	80%	1,021	217

Urban Group 8 (FCP)

phase	year	source reduction	participant	participant	purchase of container
		ton/year	% of total households	nos. of household	nos.
phase 1	2004	0	0%	0	0
	2005	73	11%	177	177
	2006	73	16%	269	92
	2007	110	21%	363	94
phase 2	2008	183	32%	552	189
	2009	219	37%	652	100
	2010	256	43%	755	280
	2011	292	48%	857	371
phase 3	2012	402	64%	1,154	483
	2013	438	69%	1,261	390
	2014	475	75%	1,371	399
	2015	511	80%	1,482	314

Urban Group 9 (SOL)

phase	year	source reduction	participant	participant	purchase of container
		ton/year	% of total households	nos. of household	nos.
phase 1	2004	0	0%	0	0
	2005	1,825	11%	4,704	4,704
	2006	2,993	16%	7,804	3,100
	2007	4,344	21%	11,401	3,597
phase 2	2008	7,118	32%	18,697	7,296
	2009	8,979	37%	23,674	4,977
	2010	11,060	43%	29,182	10,212
	2011	13,177	48%	34,860	13,482
phase 3	2012	18,542	64%	49,187	21,024
	2013	21,170	69%	56,219	17,925
	2014	23,944	75%	63,701	19,755
	2015	26,937	80%	71,635	18,419

Urban Group 10 (FCP)

phase	year	source reduction	participant	participant	purchase of container
		ton/year	% of total households	nos. of household	nos.
phase 1	2004	0	0%	0	0
	2005	37	11%	56	56
	2006	37	16%	87	31
	2007	37	21%	119	32
phase 2	2008	73	32%	184	65
	2009	73	37%	221	37
	2010	73	43%	260	95
	2011	110	48%	302	129
phase 3	2012	146	64%	415	176
	2013	146	69%	463	145
	2014	183	75%	514	153
	2015	183	80%	566	128

b. Collection and Transport

The following tables show how to implement waste collection. Compactor trucks are to be for mixed waste, and dump trucks are to be for pruning waste.

Table H-134: Implementation Plan for Collection (by Municipality)

Whole Study Area

Phase	Year	collection amount 365-base	collection amount	required number of vehicle		purchase of vehicle	
				compactor	dump truck	compactor	dump truck
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	341.2	125	47	0	10	0
	2005	427.9	156	64	0	21	0
	2006	494.6	178	70	3	10	3
	2007	576.0	209	81	4	15	1
Phase 2	2008	606.4	220	86	4	10	0
	2009	649.4	237	89	6	8	2
	2010	688.7	251	93	7	8	1
	2011	720.5	262	97	10	14	3
Phase 3	2012	727.7	265	96	11	20	1
	2013	750.2	274	97	12	11	4
	2014	772.4	282	98	14	16	3
	2015	793.8	290	100	16	12	2

Othon P Blanco

Phase	Year	collection amount 365-base	collection amount	required number of vehicle		purchase of vehicle	
				compactor	dump truck	compactor	dump truck
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	152.1	56	21	0	3	0
	2005	189.2	69	29	0	11	0
	2006	220.0	79	31	2	6	2
	2007	261.1	95	37	2	10	0
Phase 2	2008	272.8	99	40	2	8	0
	2009	291.5	107	40	3	5	1
	2010	309.1	113	42	3	6	0
	2011	320.2	116	43	5	4	2
Phase 3	2012	320.3	116	43	5	11	0
	2013	327.3	119	43	5	6	2
	2014	334.3	122	43	6	10	1
	2015	340.7	124	44	7	9	1

Felipe C Puerto

Phase	Year	collection amount 365-base	collection amount	required number of vehicle		purchase of vehicle	
				compactor	dump truck	compactor	dump truck
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	12.5	5	2	0	1	0
	2005	18.7	7	4	0	3	0
	2006	21.5	7	4	0	0	0
	2007	26.9	9	5	0	1	0
Phase 2	2008	26.7	9	5	0	0	0
	2009	29.3	10	5	0	0	0
	2010	29.4	10	5	0	0	0
	2011	33.3	12	6	0	2	0
Phase 3	2012	32.5	12	5	0	2	0
	2013	32.5	12	5	0	0	0
	2014	32.5	12	5	0	1	0
	2015	32.4	12	5	0	0	0

Solidaridad

Phase	Year	collection amount 365-base	collection amount	required number of vehicle		purchase of vehicle	
				compactor	dump truck	compactor	dump truck
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	176.6	64	24	0	6	0
	2005	220.0	80	31	0	7	0
	2006	253.1	92	35	1	4	1
	2007	288.0	105	39	2	4	1
Phase 2	2008	306.9	112	41	2	2	0
	2009	328.6	120	44	3	3	1
	2010	350.2	128	46	4	2	1
	2011	367.0	134	48	5	8	1
Phase 3	2012	374.9	137	48	6	7	1
	2013	390.4	143	49	7	5	2
	2014	405.6	148	50	8	5	2
	2015	420.7	154	51	9	3	1

Table H-135: Implementation Plan of Collection & Transport (by Urban Group)

Urban Group 1 (OPB)

Phase	Year	collection amount 365-base	collection amount	required number of vehicle		purchase of vehicle	
				compactor	dump truck	compactor	dump truck
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	152.1	56	21	0	3	0
	2005	159.3	58	22	0	4	0
	2006	160	58	22	1	4	1
	2007	169.2	62	23	1	5	0
Phase 2	2008	168.6	62	23	1	5	0
	2009	169.7	62	22	2	4	1
	2010	170.8	62	22	2	4	0
	2011	172.2	63	22	3	3	1
Phase 3	2012	169.7	62	22	3	4	0
	2013	170.9	62	21	3	3	1
	2014	172.2	63	21	4	5	1
	2015	173.2	63	21	4	5	0

Urban Group 2 (OPB)

Phase	Year	collection amount 365-base	collection amount	required number of vehicle		purchase of vehicle	
				compactor	dump truck	compactor	dump truck
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	0	0	0	0	0	0
	2005	3.7	1	1	0	1	0
	2006	6.1	2	1	0	0	0
	2007	8.5	3	2	0	1	0
Phase 2	2008	8.5	3	2	0	0	0
	2009	9.8	4	2	0	0	0
	2010	9.9	4	2	0	0	0
	2011	11.3	4	2	0	0	0
Phase 3	2012	11.1	4	2	0	1	0
	2013	11.2	4	2	0	0	0
	2014	11.2	4	2	0	1	0
	2015	11.3	4	2	0	0	0

Urban Group 3 (OPB)

Phase	Year	collection amount 365-base	collection amount	required number of vehicle		purchase of vehicle	
				compactor	dump truck	compactor	dump truck
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	0	0	0	0	0	0
	2005	1.4	1	1	0	1	0
	2006	2.4	1	1	0	0	0
	2007	3.4	1	1	0	0	0
Phase 2	2008	3.3	1	1	0	0	0
	2009	3.4	1	1	0	0	0
	2010	3.4	1	1	0	0	0
	2011	3.8	1	1	0	0	0
Phase 3	2012	3.8	1	1	0	1	0
	2013	3.8	1	1	0	0	0
	2014	3.8	1	1	0	0	0
	2015	3.8	1	1	0	0	0

Urban Group 4 (OPB)

Phase	Year	collection amount 365-base	collection amount	required number of vehicle		purchase of vehicle	
				compactor	dump truck	compactor	dump truck
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	0	0	0	0	0	0
	2005	8.1	3	2	0	2	0
	2006	14.6	5	2	0	0	0
	2007	21.6	8	3	0	1	0
Phase 2	2008	22.7	8	4	0	1	0
	2009	27.4	10	4	0	0	0
	2010	32.4	12	5	0	1	0
	2011	36	13	5	0	0	0
Phase 3	2012	36.8	13	5	0	2	0
	2013	38.4	14	6	0	1	0
	2014	40	15	6	0	1	0
	2015	41.4	15	6	0	1	0

Urban Group 5 (OPB)

Phase	Year	collection amount 365-base	collection amount	required number of vehicle		purchase of vehicle	
				compactor	dump truck	compactor	dump truck
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	0	0	0	0	0	0
	2005	16.7	6	3	0	3	0
	2006	36.9	13	5	1	2	1
	2007	58.4	21	8	1	3	0
Phase 2	2008	69.7	25	10	1	2	0
	2009	81.2	30	11	1	1	0
	2010	92.6	34	12	1	1	0
	2011	96.9	35	13	2	1	1
Phase 3	2012	98.9	36	13	2	3	0
	2013	103	38	13	2	2	1
	2014	107.1	39	13	2	3	0
	2015	111	41	14	3	3	1

Urban Group 6 (FCP)

Phase	Year	collection amount 365-base	collection amount	required number of vehicle		purchase of vehicle	
				compactor	dump truck	compactor	dump truck
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	12.5	5	2	0	1	0
	2005	14.8	5	2	0	1	0
	2006	14.9	5	2	0	0	0
	2007	17.6	6	3	0	1	0
Phase 2	2008	17.4	6	3	0	0	0
	2009	20	7	3	0	0	0
	2010	20.1	7	3	0	0	0
	2011	22.6	8	4	0	2	0
Phase 3	2012	22.1	8	3	0	0	0
	2013	22.1	8	3	0	0	0
	2014	22.1	8	3	0	1	0
	2015	22.1	8	3	0	0	0

Urban Group 7 (FCP)

Phase	Year	collection amount 365-base	collection amount	required number of vehicle		purchase of vehicle	
				compactor	dump truck	compactor	dump truck
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	0	0	0	0	0	0
	2005	1.6	1	1	0	1	0
	2006	2.7	1	1	0	0	0
	2007	3.8	1	1	0	0	0
Phase 2	2008	3.8	1	1	0	0	0
	2009	3.8	1	1	0	0	0
	2010	3.8	1	1	0	0	0
	2011	4.4	2	1	0	0	0
Phase 3	2012	4.2	2	1	0	1	0
	2013	4.2	2	1	0	0	0
	2014	4.2	2	1	0	0	0
	2015	4.2	2	1	0	0	0

Urban Group 8 (FCP)

Phase	Year	collection amount 365-base	collection amount	required number of vehicle		purchase of vehicle	
				compactor	dump truck	compactor	dump truck
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	0	0	0	0	0	0
	2005	2.3	1	1	0	1	0
	2006	3.9	1	1	0	0	0
	2007	5.5	2	1	0	0	0
Phase 2	2008	5.5	2	1	0	0	0
	2009	5.5	2	1	0	0	0
	2010	5.5	2	1	0	0	0
	2011	6.3	2	1	0	0	0
Phase 3	2012	6.2	2	1	0	1	0
	2013	6.2	2	1	0	0	0
	2014	6.2	2	1	0	0	0
	2015	6.1	2	1	0	0	0

Urban Group 9 (SOL)

Phase	Year	collection amount 365-base	collection amount	required number of vehicle		purchase of vehicle	
				compactor	dump truck	compactor	dump truck
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	176.6	64	24	0	6	0
	2005	219.2	80	30	0	6	0
	2006	251.8	92	34	1	4	1
	2007	286.2	104	38	2	4	1
Phase 2	2008	305.1	111	40	2	2	0
	2009	326.7	119	43	3	3	1
	2010	348.2	127	45	4	2	1
	2011	364.8	133	47	5	8	1
Phase 3	2012	372.7	136	47	6	6	1
	2013	388.1	142	48	7	5	2
	2014	403.3	147	49	8	5	2
	2015	418.3	153	50	9	3	1

Urban Group 10 (SOL)

Phase	Year	collection amount 365-base	collection amount	required number of vehicle		purchase of vehicle	
				compactor	dump truck	compactor	dump truck
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	0	0	0	0	0	0
	2005	0.8	0	1	0	1	0
	2006	1.3	0	1	0	0	0
	2007	1.8	1	1	0	0	0
Phase 2	2008	1.8	1	1	0	0	0
	2009	1.9	1	1	0	0	0
	2010	2	1	1	0	0	0
	2011	2.2	1	1	0	0	0
Phase 3	2012	2.2	1	1	0	1	0
	2013	2.3	1	1	0	0	0
	2014	2.3	1	1	0	0	0
	2015	2.4	1	1	0	0	0

c. Intermediate Treatment (Composting)

The following tables show how to implement composting of pruning waste.

Table H-136: Implementation Plan of Composting of Pruning Waste

Study Area

Phase	Year	collection amount 365-base	collection amount	required number of equipment		purchase of vehicle	
				wheel loader	shredder	wheel loader	shredder
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	0	0	0	0	0	0
	2005	0	0	0	0	0	0
	2006	4.9	1.8	3	3	3	3
	2007	10.7	3.9	3	3	0	0
Phase 2	2008	17.3	6.3	4	3	1	0
	2009	24.9	9.1	4	4	0	1
	2010	33.2	12.1	6	4	2	0
	2011	41.9	15.3	6	6	0	2
Phase 3	2012	51.0	18.6	7	7	1	1
	2013	60.9	22.2	9	7	5	3
	2014	71.4	26.1	11	9	2	2
	2015	82.7	30.2	11	11	1	2

Othon P Blanco

Phase	Year	collection amount 365-base	collection amount	required number of equipment		purchase of vehicle	
				wheel loader	shredder	wheel loader	shredder
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	0	0	0	0	0	0
	2005	0	0	0	0	0	0
	2006	2.2	0.8	2	2	2	2
	2007	4.7	1.7	2	2	0	0
Phase 2	2008	7.6	2.8	2	2	0	0
	2009	10.8	4.0	2	2	0	0
	2010	14.3	5.2	3	2	1	0
	2011	17.8	6.5	3	3	0	1
Phase 3	2012	21.4	7.8	3	3	0	0
	2013	25.2	9.2	4	3	3	2
	2014	29.2	10.7	5	4	1	1
	2015	33.5	12.2	5	5	0	1

Solidaridad

Phase	Year	collection amount 365-base	collection amount	required number of equipment		purchase of vehicle	
				wheel loader	shredder	wheel loader	shredder
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	0	0	0	0	0	0
	2005	0	0	0	0	0	0
	2006	2.7	1.0	1	1	1	1
	2007	6.0	2.2	1	1	0	0
Phase 2	2008	9.7	3.5	2	1	1	0
	2009	14.1	5.1	2	2	0	1
	2010	18.9	6.9	3	2	1	0
	2011	24.1	8.8	3	3	0	1
Phase 3	2012	29.6	10.8	4	4	1	1
	2013	35.7	13.0	5	4	2	1
	2014	42.2	15.4	6	5	1	1
	2015	49.2	18.0	6	6	1	1

Table H-137: Implementation Plan of Composting of Pruning Waste (by Urban Groups)

Urban Group 1 (OPB)

Phase	Year	collection amount 365-base	collection amount	required number of equipment		purchase of equipment	
				wheel loader	shredder	wheel loader	shredder
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	0	0	0	0	0	0
	2005	0	0	0	0	0	0
	2006	1.7	0.6	1	1	1	1
	2007	3.5	1.3	1	1	0	0
Phase 2	2008	5.4	2.0	1	1	0	0
	2009	7.3	2.7	1	1	0	0
	2010	9.3	3.4	2	1	1	0
	2011	11.4	4.2	2	2	0	1
Phase 3	2012	13.5	4.9	2	2	0	0
	2013	15.7	5.7	2	2	1	1
	2014	18.0	6.6	3	2	1	0
	2015	20.4	7.4	3	3	0	1

Urban Group 5 (OPB)

Phase	Year	collection amount 365-base	collection amount	required number of equipment		purchase of equipment	
				wheel loader	shredder	wheel loader	shredder
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	0	0	0	0	0	0
	2005	0	0	0	0	0	0
	2006	0.5	0.2	1	1	1	1
	2007	1.2	0.4	1	1	0	0
Phase 2	2008	2.2	0.8	1	1	0	0
	2009	3.5	1.3	1	1	0	0
	2010	5.0	1.8	1	1	0	0
	2011	6.4	2.3	1	1	0	0
Phase 3	2012	7.9	2.9	1	1	0	0
	2013	9.5	3.5	2	1	2	1
	2014	11.2	4.1	2	2	0	1
	2015	13.1	4.8	2	2	0	0

Urban Group 9 (SOL)

Phase	Year	collection amount 365-base	Collection amount	required number of equipment		purchase of equipment	
				wheel loader	shredder	wheel loader	shredder
		ton/day	1000ton /year	nos.	nos.	nos.	nos.
Phase 1	2004	0	0	0	0	0	0
	2005	0	0	0	0	0	0
	2006	2.7	1.0	1	1	1	1
	2007	6.0	2.2	1	1	0	0
Phase 2	2008	9.7	3.5	2	1	1	0
	2009	14.1	5.1	2	2	0	1
	2010	18.9	6.9	3	2	1	0
	2011	24.1	8.8	3	3	0	1
Phase 3	2012	29.6	10.8	4	4	1	1
	2013	35.7	13.0	5	4	2	1
	2014	42.2	15.4	6	5	1	1
	2015	49.2	18.0	6	6	1	1

d. Final Disposal

The table below shows how to implement the final disposal in respective urban groups.

Table H-138: Implementation Plan of Final Disposal

Landfill Level	
1	controlled dump
2	enclosed dump
3	landfill with gas control
4	landfill with leachate control

Phase	Urban G	1	2	3	4	5	6	7	8	9	10
	Municipality	OPB	OPB	OPB	OPB	OPB	FCP	FCP	FCP	SOL	SOL
Phase 1	2004	3	1	1	1	1	1	1	1	3	1
	2005	3	1	1	1	2	1	1	1	3	1
	2006	3	2	1	2	2	2	1	1	3	1
	2007	3	2	1	2	3	2	1	1	3	1
Phase 2	2008	4	2	1	3	3	2	1	1	3	1
	2009	4	2	1	3	3	2	1	1	3	1
	2010	4	2	1	3	3	2	1	1	3	1
	2011	4	2	1	3	4	2	1	1	4	1
Phase 3	2012	4	2	1	3	4	2	1	1	4	1
	2013	4	2	1	3	4	2	1	1	4	1
	2014	4	2	1	3	4	2	1	1	4	1
	2015	4	2	1	3	4	2	1	1	4	1

H.4 Initial Environmental Examination

The Initial Environmental Examination (IEE) is a process aiming to determine whether Environmental Impact Assessment (EIA) is required and if so, what types of impacts should be further studied. The former is often called "screening" and latter "scoping". On the stage of Master Plan, in which only preliminary design is carried out, IEE is acceptable prior to EIA.

H.4.1 Outline of EIA

a. EIA at National Level

The EIA is prescribed in ARTICLE 28-35 of General Law of Ecological Balance and Environmental Protection (LGEEPA). The individuals or companies trying to conduct the following works or activities shall be required to have a prior authorization on environmental impact issued by SEMARNAT:

- Hydraulic works, general means of communication, oil pipelines, gas pipelines, coal pipelines and multipurpose pipelines;
- The oil, petrochemical, chemical, iron and steel, paper, sugar, cement and electrical industries;
- Exploration, exploitation and extraction of minerals and substances reserved to the Federation in terms of the Mining Laws and Regulatory Law, Article 27 of the Constitution on Nuclear Matters;
- The facilities for treatment, confinement or disposal of hazardous waste, as well as radioactive waste;
- Forest exploitation in tropical rainforest and species of difficult regeneration;
- Forest plantations;
- Changes in use of land in forest areas, as well as in jungles and arid areas;
- Industrial parks where the execution of highly risky activities is anticipated;
- Real estate developments affecting coastal ecosystems;
- Works and activities in mangrove swamps, lakes, rivers, lagoons and tideland linked to the sea, as well as in littorals or federal areas;
- Works in natural protected areas under Federal jurisdiction;
- Fishing, aquatic or agricultural and livestock activities endangering the preservation of one or more species or causing damage to the ecosystems, and
- Works or activities related to federal authority matters, which may cost important and irreparable ecological imbalances, damage to the public health or to the ecosystems, or surpass the limits and conditions established in the legal provisions related to the preservation of ecological balance and environmental protection.

For the purposes referred to in the last section above, SEMARNAT gives 'notice to the interested parties regarding its decision in order for them to submit the corresponding work or activity to the procedure of EIA, giving justification for that effect in order for them to submit the reports, experts reports and considerations they deem appropriate, within ten days. Once the documents of the interested parties have been received, SEMARNAT, within thirty days,

informs the interested parties whether the submittal of an EIA report is applicable or not, as well as the method and terms to conduct the same.'

The environmental impact that may be caused by those works or activities not included above 'shall be assessed by the authorities of the Federal District or the States, in coordination with the corresponding municipalities, when due to their location, dimensions or characteristics they cause important environmental impacts and are expressly established in the state environmental legislation.'

Since the works and activities included in M/P of this study consist of management and treatment of municipal waste, non-hazardous industrial waste and wastewater, and not correspondent to the list of works or activities shown above, EIA for project components of M/P should be carried out in accordance with the state environmental legislation.

b. EIA at State Level

b.1 Regulation of State

In regard to study area, EIA process is prescribed in Article 24 to39 of The Regulation of the Environmental Balance and Protection of Quintana Roo State (LEEPA). Kinds of project which should be subject to EIA procedure of the state are as follows:

- Public works
- State and rural road
- Food processing, slaughterhouse, natural rubber, beverage, brick production, textile, tannery, car and glass industry, etc.
- Irrigation and flood control in agriculture land and pasture
- Facility for water storage with considerable volume
- Industrial area (without hazardous production)
- Exploitation of construction material like rocks
- Management and disposal of non-hazardous waste
- Facility for treatment and disposal of municipal waste and non-hazardous industrial waste
- House construction and real state development neither located in coastal area nor new population area
- Hotel, restaurant, commercial center not located in Federal jurisdiction
- Public and private transportation center at State level
- Hospital and others with hazardous activities
- Activities coordinated with Federal
- Facility for wastewater treatment and water supply
- Extensive development of agricultural land and stock farm
- Project in Natural Protection Area of State and Municipality
- Change of land use for acahuales[3]
- Activities to generate environmental unbalance and irreparable damage to public health, and to exceed the standard for environmental balance and protection

Project components of M/P are correspondent to these project lists. Now that there exists no definition of project size obligated to do EIA in the Regulation, Institute of Environmental Impact and Risks (IIRA) decides and declares each time which project shall be subject to EIA procedure. The IIRA, which is an independent organization set up on April 25th, 2003 apart from SEDUMA, consists of 5 departments (10 personnel), i.e. Administration and Finance, Juridical Affairs, Environmental Impact, Environmental Risk and Geo-information.

b.2 EIA Procedure of State

Procedure of EIA in the State is as shown in Figure H-34. Outline of the procedure is as follows.

1. Preventive Report

At first preventive report, instead of EIA report, should be submitted to the IIRA, whenever:

- NOM (Mexican Official Norms) is applied to the project;
- The project is a part of the program like urban development plan,
- The project is located in an Industrial Park, and
- The project may not cause any impact on the environment according to the technical criteria for environment.

Preventive report consists of the followings:

- Project name and location
- Data of project proponent
- Responsible person of report
- Mexican Official Standard (NOM), if any
- Urban development plan, if the project is included in it
- Information of Industrial Park, if the project is located there
- Description of project
- Substances or product to give impact the environment
- Estimation and control measures of impact
- Measures of prevention and mitigation of significant impact
- Location map
- Additional condition required by the IIRA

2. Evaluation EIA

The IIRA decides and notifies the project proponent within 30 workdays whether the project is subject to EIA procedure or not.

[3] Land after closure of livestock breeding

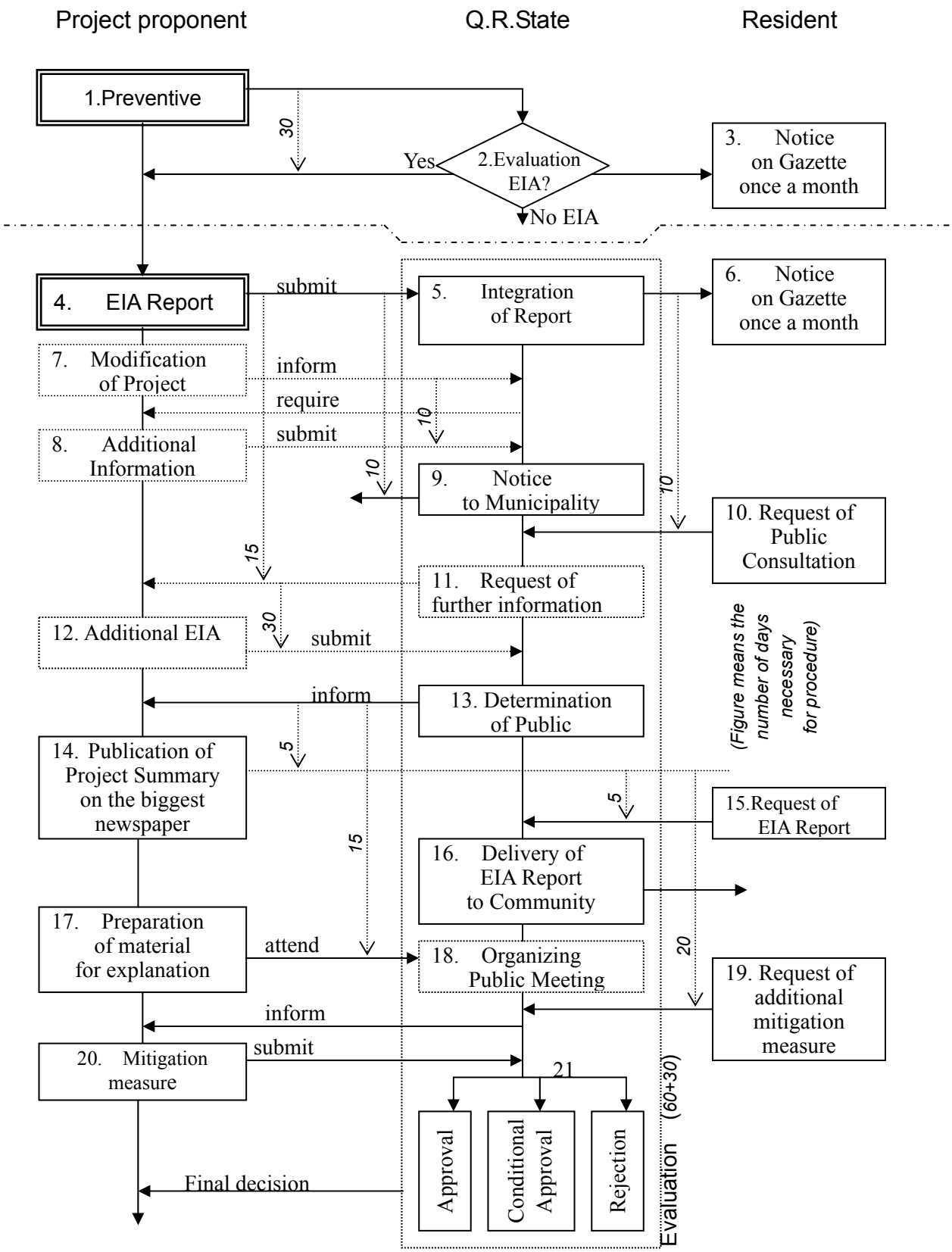


Figure H-34 Environmental Impact Assessment procedure in Quintana Roo State

3. Notice on Gazette once a month

The IIRA publishes monthly a list of preventive reports on the State Gazette.

4. EIA Report

The project proponent submits EIA report to the IIRA. EIA report can be made only by individuals or organizations registered and certified by IIRA. In the state there registered presently more than 24 individuals and organizations in total which can conduct EIA.

5. Integration of Report

The IIRA integrates files within 10 workdays to make EIA report available to the citizens.

6. Notice on Gazette once a month

The IIRA publishes monthly a list of EIA reports on the State Gazette.

7. Modification of Project

If the project is modified after submission of EIA, the project proponent shall give the information of modification to IIRA.

8. Additional Information

In case that the IIRA requires more information of modified project, the project proponent shall submit additional information to the IIRA.

9. Notice to Municipality

The IIRA informs, within 10 workdays after submission of EIA report, of the fact that the IIRA received EIA report and evaluates it, to the municipality where the project site is located.

10. Request of Public Consultation

Any citizen request IIRA to have a public consultation within 10 workdays after publication of a list of EIA report on State Gazette.

11. Request of further information

In case that EIA report does not present information enough to be evaluated, the IIRA can request within 15 workdays after integration of file the project proponent to provide further information.

12. Additional EIA

The project proponent has to submit additional information to the IIRA within 30 workdays after receiving the direction and, if not, the procedure of EIA evaluation can be expired.

13. Determination of Public Consultation

The IIRA notifies the project proponent of conclusion regarding whether IIRA has public consultation or not, within 5 workdays after receiving request from a citizen.

14. Publication of Project Summary on the biggest newspaper

The project proponent publishes a summary of the project on the newspaper whose readers are most in the state, within 5 workdays after notification of the IIRA

15. Request of EIA Report

Any citizen in the relevant community can request the IIRA to deliver EIA report to the community within 5 workdays after publication of project summary.

16. Delivery of EIA Report to Community

The IIRA delivers EIA report to the community where a citizen requested EIA report.

17. Preparation of material for explanation

The project proponent prepares material to explain environmental aspects and mitigation measures at public meeting in case that the IIRA organizes Public Meeting.

18. Organizing Public Meeting

The IIRA can organizes Public Meeting within 15 workdays after decision of public consultation if the project causes possibly irreparable damage to public health or to ecosystem in coordination with the municipality

19. Request of Additional mitigation measure

Anyone concerned can propose additional mitigation measures to IIRA within 20 workdays after publication of project summary on the newspaper.

20. Mitigation Measure

The project proponent plans mitigation measures and submit to the IIRA if it is recommended.

21. Final Decision

IIRA evaluates the EIA report according to NOMS, urban development program, ecological ordinances, natural protection areas and other regulations within 60 workdays. In case of

complicated project the IIRA can require exceptionally additional 30 workdays for evaluation of EIA report.

The result of evaluation will be one of the followings.

- Approval
- Conditional approval
- Rejection

b.3 Content of EIA Report

Content of EIA report is as follows:

I. General data from the petitioner
  a) Name of the physical or moral person. (Company, organization, association).
  b) Nationality of the physical or moral person (Company, organization, association).
  c) Activity of the Company or Organization.
  d) Address to hear and/or receive notifications
  e) Chamber or association to which belongs the company or organization (mentioning number of register, date of register and federal taxpayer identification number).
  f) Name of legal representative.

II. Description of the projected work or activity in the stages of preparation of site, operation and maintenance, mentioning:
  a) Project name.
  b) type of project, giving a brief description of every stage of the project, mentioning projected capacity and required investment; mentioning the following:
    1. Material and substances to be use, presenting a list with volumes.
    2. Equipment and facilities required, presenting a list where actual installed capacity is shown.
    3. Waste to be disposed to the atmosphere, soil, water and others.
    4. Source of electrical supply and/or fuel.
    5. Requirements of raw water or potable water, mentioning volume and means of supply.
    6. Description of the procedure for the disposal, treatment and/or final disposal of the solid and liquid wastes.
    7. In case of use of material like rocks, it is necessary to prove its legal origin (by presenting the receipts).
    8. Civil works required for land preparation.
    9. Manpower requirements.
    10. Works and/or supporting services to be use.
    11. Volume pretended to be stored, exploited and/or produced. (In case of mining of stony material, gas stations, stores, asphalt, concrete and rock grinder plants).
    12. System or technical procedure to be use for the storage, mining or transformation. (In case of mining of stony material, gas stations, retailers, asphalt, concrete and rocks grinder plants).
    13. Distance between the surface and the aquifer. (In case of mining of stony material)
  c) Useful life of the project.
  d) Working schedule.
  e) Physical location of project.(mentioning municipality, locality, micro and macro localization, dimensions and boundaries)
  f) Available area for the project and required lay out area with a description of the activities carried out at the boundaries.
  g) Ways to access marine and/or terrestrial.
  h) Alternative site for the development of the works or activities.
  i) Mention the amount, percentage and species of natural resources to be use, as well as the final destination of the no projected to be use.

III. General aspects about socioeconomics and natural environment of the area where is pretended to develop the work or activity.

IV. Consistency of the work or activity with the regulations regarding to land use into the corresponding area and with the normative enact of the ecological ordinance for the specific area.

V. Identification and description of the environmental impacts that would cause the execution of the work or activity.

VI. Measures of prevention and mitigation or compensation for every one of the environmental impacts identified in every stage.
VII. Description of probable modified environmental scenery for the work or activity in regards.
VIII. documents required:

a) Property certificate or its equivalent.
Constitutive certification of the company.
b) Set of project plans, work or activity, signed by an expert responsible for the work.
c) Resolution of land use compatibility with the project.
d) Permission for construction.
e) Energy supply feasibility issued by the electricity company.
f) Water supply and/or sewerage feasibility issued by the corresponding authority.
g) feasibility document issued by the national commission for water regarding to:
1. waste water treatment
2. Drilling of deep wells for:
- Use of the aquifer.
- Final disposal site of waste water.
- Other use.

h) Opinion from the state ministry of planning and regional development, (in case of land fractionation, housing unit, new population centers, rural roads, access roads, road enlargements and streets)
i) Program for the area restoration; elaborated by an environmental impact service supplier authorized by the mentioned ministry. (In case of mining of stony materials and in accordance with the annexed format).
j) Accident prevention program. (In case of gas stations and retailers).
k) Risk study. (In case of gas stations and retailers).
l) Installation lay out submitted to the inspection of an expert on this matter that has been registered at the direction office of civil protection. (In case of gas stations and retailers).
m) Operation program for the plant. (in case of the asphalt, concrete and rock grinder plants)

Source: IIRA (Institute of Environmental Impact and Risks)

b.4 Environmental Items to be assessed in EIA

Environmental items to be assessed in EIA are described as follows in LEEPA:

- Natural environment (Flora and Fauna, Landscape)
- Pollution (Air, Water/Water ecosystem, Soil/Underground, Noise, Vibration, Thermal/ Light energy)

In regard with EIA reports for three projects of construction of waste disposal site which have been planned recently in three municipalities, i.e., Othon P. Blanco, Felipe Carrillo Puerto and Solidaridad, nine or ten of environmental items are selected as shown in Table H-139.

Table H-139: Environmental items selected for construction project of waste disposal site in study area

Environmental Items		Chetumal in Othon P. Blanco	Felipe Carrillo Puerto In Felipe Carrillo Puerto	Tulum in Solodaridad
Socio-economic	Employment	○	○	○
	Local & Regional Economy	○	○	○
	Services	○	○	○
	Public & Personal Health Damage	○	○	○
Natural	Flora & Fauna	○	○	○
	Landscape	X	○	○
	Air	○	○	○
	Water	○	○	○
	Soil	○	○	○
	Noise	○	○	○

Although a guideline for state EIA is not established, environmental items to be considered for EIA are as follows, according to Guideline for Presentation of Environmental Impact Assessment Report (Statement) prepared by SEMARNAT.

- Air quality
- Noise and vibration
- Geology and geomorphology
- Surface water and groundwater
- Soil
- Flora
- Fauna
- Landscape
- Demography
- Socio-cultural factor
- Primary sector
  Change of land use (agriculture, livestock, forestry), influence on fishing and land price, etc.
- Secondary sector
  Number of workers involved in the project, type of services, increase of commercial activities, etc

It is considered that the method instructed by the JICA Guideline can be used for IEE because it employs a matrix approach where 24 environmental items are listed so that attention is paid to all aspects from the initial stage and the items shown above are all inclusive.

Environmental items in JICA Guideline are as follows:

Social environment
- Resettlement
- Economic Activities
- Transport
- Public Facilities

- Division of Community
- Historical Heritage/ Cultural Properties
- Water right/Access right
- Public Health
- Waste
- Accidents /Risks

Natural Environment

- Topography and Geology
- Soil Erosion
- Groundwater
- Hydrological Condition
- Coastal zone
- Fauna and Flora
- Meteorology
- Landscape/ Aesthetics

Pollution

- Air Pollution
- Water Pollution
- Soil Contamination
- Noise and Vibration
- Land Subsidence
- Offensive Odor

H.4.2 Initial Environmental Examination

The possibility of environmental impact should be considered as far as possible within information available at this stage of M/P. Evaluation is ranked from A to D as follows.

Rank A: Serious impacts might be caused

Rank B: Some Impacts might be caused

Rank C: Extent of Impact is unknown because sufficient information is lacking, and/or it depends on the project location.

Rank D: There will be no impact

From items ranked as A, B or C, those which should be studied further at the stage of Feasibility Study or a detail design following this M/P will be chosen and the contents of the work will be defined.

a. Evaluation of Environmental Items

Environmental items of JICA Guideline are listed in the first column of Table H-140. In the second, third and fourth columns, possible effects are explained in general terms which could be occurred during the construction, operation and closure stages of the project. During the construction stage, land acquisition, felling of trees, land occupation, use of construction

equipment and traffic of construction tracks will be the main causes of impacts. During the next operation stage, activities such as transport of solid waste, and operation of heavy machine and the concerned facility are the causal factors. After closure of waste disposal site, leachate and landfill gas discharged continuously from the site will affect significance of impact.

The right half of the table shows the evaluation by A-D ranking of each environmental item for two components of M/P with reasons for the evaluation.

Table H-140: Evaluation of Environmental Items

Evaluation Items	Possible Cause & Effect			Master Plan			
				Wastewater Management		Solid Waste Management	
	Construction	Operation	Post closure	Rank	Reasons	Rank	Reasons
Social Environment							
Resettlement	Resettlement of people living in the proposed land or on the access route			D	There is no need to resettle any residents.	D	There is no need to resettle any residents.
Economic Activities	Disturbance of economic activities. Employment	Employment.		B	Workers are employed. New staff may be employed to operate the facility.	B	Workers are employed. New staff may be employed to control the landfill site.
Transport	Increase in traffic and accidents	Increase in traffic and accidents		C	Impact depends on the location of the site.	C	Impact depends on the location of the site.
Public Facilities	Impacts on school, hospitals, etc. by traffic and noise	Impacts on schools, hospitals, etc, by traffic and noise.		C	Impact depends on the location of the site.	C	Impact depends on the location of the site.
Division of Community	Geographical separation of community or interruption of its communication			D	The area for project is not so vast as to separate a community.	D	The area for project is not so vast as to separate a community.
Historical Heritage /Cultural Properties	Loss and/or devaluation of historical heritage or cultural properties such as churches, archaeological remains and historical assets.	Devaluation of them of waste transport vehicles passing nearby.		D	Candidate site for project should be selected avoiding historical heritage and cultural properties.	D	Candidate site for project should be selected avoiding historical heritage and cultural properties
Water Rights /Access Rights	Obstruction of fishing rights, water rights and rights of common access.			D	The site owned by the state or the municipality will be selected and neither water rights nor access rights will be associated with the land.	D	The site owned by the state or the municipality will be selected and neither water rights nor access rights will be associated with the land.
Public		Degradation of public		D		B	Wastes are transported by

Evaluation Items	Possible Cause & Effect			Master Plan			
				Wastewater Management		Solid Waste Management	
	Construction	Operation	Post closure	Rank	Reasons	Rank	Reasons
Health		health due to wastes fallen from the collection vehicles, existence of a great amount of wastes in a limited area, and /or vermin/pathogens proliferation there.					compacter tracks to minimize the litter. Landfill operation practice should be well planned so that the site does not attract unduly vermin or pathogens.
Waste	Generation of construction wastes and debris.			C	Impact depends on the location of the project site. In case of forest many trees need to be felled and cleared.	C	Impact depends on the location of the project site. In case of forest many trees need to be felled and cleared.
Accidents /Risks		Landfill gas explosion, intrusion of CO2 into residence, refuse fires, landslides.		D	The facility design and practice will minimize possible risks.	B	As the site receives only non-hazardous wastes, chemical reactions will not be caused. The landfill design and practice will minimize possible risks.
Natural Environment							
Topography & Geology	Change in valuable topography and geology due to excavation	Change in valuable topography and geology due to landfill works.		D	Change in topography is inevitable, but the topography and geology of the site is not particularly valuable.	D	Change in topography is inevitable, but the topography and geology of the site is not particularly valuable.
Soil Erosion	Increase in soil erosion due to land preparation and/or deforestation.			D	Vegetation will be removed for facility construction. But the site is designed and constructed to prevent soil erosion.	D	Vegetation will be removed for landfill cell preparation. But the landfill work starts right after the cell preparation, thus it is unlikely to cause soil erosion.
Groundwater		Change in quality and level of groundwater due to leachate.		D	The facility is designed not to infiltrate in to the ground.	B	Appropriate leachate management technique should be employed.
Hydrological Situation	Changes in river discharge and riverbed condition.	Changes in river discharge and riverbed condition due to inflow from the		D	There are no surface water bodies to be affected.	D	There are no surface water bodies to be affected.

Evaluation Items	Possible Cause & Effect			Master Plan			
				Wastewater Management		Solid Waste Management	
	Construction	Operation	Post closure	Rank	Reasons	Rank	Reasons
		site					
Coastal Zone	Impacts on coastal environment.	Impacts on coastal environment.		D	There is no coast near the site. In case of project in coastal area, EIA should be carried out in accordance with Federal Law.	D	There is no coast near the site. In case of project in coastal area, EIA should be carried out in accordance with Federal Law.
Fauna & Flora	Obstruction of breeding of natural species and/or extinction of them due to interruption or loss of their habitats.			C	It should be examined whether there are any important species of fauna and/or flora to be protected, what the level of their importance is and what the distance is between the site and their habitat.	C	It should be examined whether there are any important species of fauna and/or flora to be protected, what the level of their importance is and what the distance is between the site and their habitat.
Meteorology	Changes in temperature, wind direction and/or intensity, etc.	Changes in temperature, wind direction and/or intensity, etc.		D	The scale of the project is not large enough to cause any change in meteorology.	D	The scale of the project is not large enough to cause any change in meteorology.
Landscape /Aesthetic	Change in landscape.	Decrease in aesthetic values due to the existence of landfill or wastewater treatment facility		B	The facility may result in a change in landscape.	B	The landfill work may result in a change in landscape.
Pollution							
Air Pollution	Deterioration of air quality due to the increased traffic.	Deterioration of air quality due to the increased traffic and dust from wastes, delivered by tracks, the landfill gases and/or smoke/dust from the site operation.	Continuous emission of landfill gas	D	Traffic does not increase except for transportation of personnel. No air pollutants are emitted.	B	Traffic may increase from the current level. Dust from landfill works should be minimized. Landfill gas control should be considered.
Water Pollution	Deterioration of water quality of surface water and/or	Deterioration of water quality of surface water and/or	Continuous discharge of leachate	B	Discharge of treated water should be controlled strictly.	B	Appropriate leachate management technique should be employed.

Evaluation Items	Possible Cause & Effect			Master Plan			
				Wastewater Management		Solid Waste Management	
	Construction	Operation	Post closure	Rank	Reasons	Rank	Reasons
	groundwater due to the flow of sand/silt from land preparation work.	groundwater due to the inflow of leachate from the site.					
Soil Contamination		Contamination of soil by leakage of leachate		D	Discharge of treated water is controlled.	B	Appropriate leachate management technique should be employed.
Noise & Vibration	Noise and vibration caused by the construction operation and/or the construction tracks.	Noise and vibration caused y the waste vehicles and/or the landfill site equipment.		D	Noise and vibration level is negligible.	C	Impact depends on the location of the site.
Land Subsidence	Land subsidence due to the land deformation.			D	Land subsidence is only limited to the facility area.	D	Land subsidence is only limited to the landfill area.
Offensive Odor		Odor caused by scattered wastes from waste vehicles, wastes filled at the site and/or wastewater treatment facility.		B	Mitigation measures will be adopted. Wind direction and location of residential area should be examined.	B	Wastes is closed up in collection vehicles. After filled, waste is covered with soil. Wind direction and location of residential area should be examined.

b. Scoping of Environmental Items

What works should be done with prudent attention during the following EIA process were considered. They are summarized in Table H-141.

As the table shows, there are two types of works. One is information collection and its examination with a purpose to well understand the possible cause and effect and to figure out the countermeasures, if needed. The other is the elaboration of facility designs to mitigate anticipated environmental impacts.

Table H-141: Scoping

Evaluation Items	Wastewater Management		Solid Waste Management	
	Rank	Work description	Rank	Work description
Economic Activities	B	・To collect information of local economy. ・ To confirm construction schedule of facility and personnel plan for operation.	B	・To collect information of local economy. ・To confirm personnel plan for operation.
Transport	C	・To collect information of current traffic, road condition and location of residential area around the site.	C	・To collect information of current traffic, road condition and location of residential area around the site.
Public Facility	C	・To collect information of public facility and its distance from the site.	C	・To collect information of location of public facility along the transportation route and distance from the site.
Public Health	-		B	・To ensure appropriate landfill operation to prevent unduly proliferation of vermin and/or pathogens.
Waste	C	・To check land use of site. ・ To ensure debris to be disposed appropriately, if any.	C	To check land use of the site.
Accidents/ Risks	-		B	・To check the distance from the site to residential area. ・To ensure appropriate landfill operation minimize possible risks.
Groundwater	-		B	・ To examine groundwater hydrology. ・To obtain baseline data of groundwater quality. ・To ensure landfill technologies to e appropriate for groundwater hydrology.
Fauna & Flora	C	・To collect information about wildlife in the area. ・To study the level of impact on them by the project if important species are within the influential area.	C	・To collect information about wildlife in the area. ・To study the level of impact on them by the project if important species are within the influential area.
Landscape Aesthetic/	B	・ To examine a change in landscape and assess its impact.	B	・ To examine a change in landscape and assess its impact.
Air Pollution	-		B	・To collect information about the route of waste transport ・To study meteorology ・To ensure landfill practice to minimize dust from waste and to control landfill gas.

Evaluation Items	Wastewater Management		Solid Waste Management	
	Rank	Work description	Rank	Work description
Water Pollution	B	・To collect information about surface water hydrology. ・To obtain baseline data of surface water quality. ・To ensure facility to control discharge of treated water.	B	・To collect information about surface water hydrology. ・To obtain baseline data of surface water quality. ・To ensure landfill design to control leachate.
Soil Contamination	-		B	・To collect information about soil characteristics. ・To obtain baseline data of soil quality. ・To ensure leachate control measures to be employed.
Noise & Vibration	-		C	・To analyze noise level on the site and its periphery. ・To collect information of the route of waste transport.
Offensive Odor	B	・To collect information about wind direction and location of residential area. ・To assess impacts on residential area if it is within the influential area. ・To ensure appropriate operation to minimize the odor effect.	B	・To collect information about wind direction and location of residential area. ・To assess impacts on residential area if it is within the influential area.

H.5 Evaluation of the Master Plan

H.5.1 Economic Evaluation

a. Concept of Evaluation

The challenge in the Study Area is "to pursue a sustainable development while balancing preservation of the rich coastal environment and tourism development." The information obtained so far indicates that inappropriate management of wastewater and solid waste would result in serious groundwater contamination and destruction of the coastal environment due to the peculiar geological characteristic－karstic formation－ of Yucatan Peninsula. The Master Plan aims at prevention of the water contamination and destruction of the environment, which may cause serious damage to tourism, to the rich biodiversity, to the unique water resource and to the human health in the Study Area. These are assumed as benefits to be brought about by the implementation of the Master Plan.

For analytical purposes in this economic evaluation, incremental cost is assumed as the cost needed to bring about the benefits. The incremental cost is the difference between the cost required to implement the Master Plan and the cost required to continue the current Wastewater Management and Solid Waste Management systems (without the Master Plan).

The economic evaluation basically tries to make a comparison between the benefit and the cost of the Master Plan.

b. Cost

The table below shows the incremental cost of the Master Plan amounting to 3,304 Million Pesos for Wastewater Management and 441 Million Pesos for Solid Waste Management, for a total of 3,745 Million Pesos for the Master Plan.

Table H-142: Incremental Cost of the M/P

Unit: million pesos

Year	Wastewater management	Solid waste management	Total
2004	175	14	189
2005	481	32	513
2006	120	29	149
2007	529	37	566
2008	274	35	309
2009	414	31	445
2010	290	33	323
2011	206	51	257
2012	196	49	245
2013	187	42	229
2014	211	44	255
2015	221	44	265
Total	3,304	441	3,745

c. Benefit

The Master Plan aims ***to preserve the groundwater and the coastal aquatic environment in the Study Area*** by protecting them from inappropriate management of wastewater and solid waste, and is expected to bring about the following benefits:

1) ***Keeping of attractions to tourists:*** *to avoid negative impact on tourism due to environmental degradation*

2) ***Preservation of biodiversity:*** *to avoid loss of resources that could be utilized for foods and/or medicine in the future*

3) ***Protection of the water source for drinking water:*** *to avoid the cost of treatment of contaminated groundwater, and to prevent disease outbreaks*

Prosperity by tourism development cannot be achieved once the image of the concerned place is damaged[4]. Contamination by wastewater and solid waste has been recently emphasized as one of the major threats to coastal environment, in addition to direct threats such as overexploitation of beaches. Seawater contamination by wastewater in Acapulco, which is one of the famous resorts in Mexico, has been reported and damaged its image recently. In 1990 the numbers of tourists to Acapulco and Cancun were almost the same, standing at about 1.5 million. However, there was a large difference between them in 2001, about 3 million in Cancun and about 2.2 million in Acapulco. Several factors can be considered as possible causes of the difference, such as tourist resources, abnormal weather, etc. Contamination of the coastal area caused by inappropriate management of wastewater and solid waste is also considered an important factor among them. In Mexico, a decrease in the number of tourists seriously damages both the regional and national economies. In 2000, the tourism sector occupied 8.4% of Gross National Product (GNP), 5.5% of employees over the country and the third position as earner of foreign currency amounting to 8,295 Million Dollars[5]. Quintana Roo is one of the important States in regard to tourism. It is estimated that the State earns one-third of the income. As just described, the tourism is important to both the regional and national economies. Hence, the benefit to be derived from tourism is quantitatively evaluated here.

Mexico has a rich biodiversity due to the great variety of ecosystems in the country. The number of species of mammals is the top and the one of reptiles is the second in the world. And a great number of plants and animals are endemic species to Mexico. In Quintana Roo State where the Study Area is located in, 669 species of animals and about 1500 species of

[4] Guidelines for Integral Management of Coastal and Marine Areas, UNEP, 1995
[5] SECTUR

plants make their habitats, including many endangered species such as green turtles (*Chelonia mydas*), manatees (*Trichechus manatus*) and jaguars (*Panthera onca*) [6]. Biodiversity is a highly valued economic resource all over the world, e.g., as potential sources of foods and medicine in the future. An indication of its value consists of the ratification of the treaty of "Conservation on Biological Diversity" by over 180 countries. However, an economic method has not been established to quantitatively evaluate the value of biodiversity. This does not mean that the biodiversity is economically unworthy, but only that its quantification requires the establishment of a practical method. Consequently, although the value of the biodiversity in the Study Area is qualitatively highly respected, the Study does not attempt a quantitative analysis.

Protection of water source for drinking water has a beneficial effect on prevention of epidemics. It is reported[7] that the number of intestinal infection cases per 100,000 persons in Yucatan Peninsula is higher than the national average, which in 1999 was 4,955.2, while the State averages were 8,698.3 in Yucatan, 6,005.9 in Campeche and 6,178.9 in Quintana Roo. It is generally accepted that contamination of groundwater would be a main cause; and economic losses caused by sick leaves is significant. It is obvious that the implementation of the Master Plan will protect water sources for drinking water and will contribute to the prevention of epidemics. However, it is hard to quantitatively identify to what degree the Master Plan can lower the morbidity. Accordingly, although the beneficial effect on prevention of intestinal diseases is duly respected, quantitative evaluation is not attempted here.

d. Quantitative Economic Evaluation on Tourism Revenue

It is obvious that a tourism area cannot flourish once its image is damaged, although there has been no theory or empirical proof to explain the correlation between the degree of water contamination/environmental degradation and the decrease in tourism revenue. Quintana Roo has many historic sites of Mayan culture that are attractive to tourists. However, the most important attraction is its coastal area having white sand beaches and turquoise blue water, which is nourished by clear and abundant groundwater. Therefore, it is considered reasonable to estimate that the destruction of the coastal environment caused by the contamination of groundwater and seawater would seriously decrease the tourism revenue.

d.1 Forecast of Tourist Number without the Master Plan

During about ten years between 1990 and 2001, the number of tourists had increased from 1.5 to 3.0 million/year in Cancun, and from 1.5 to 2.2 million/year in Acapulco. This

[6] SEMARNAT

difference of 0.8 million/year between Cancun and Acapulco is considerably large. Comparing the increase rate of tourist number in Acapulco with that of national average and that of Cancun, the rate of 3.7%/year in Acapulco is 1.6%/year lower than the national average of 5.3%/year and 2.3%/year lower than the rate of 6.0%/year in Cancun.

It makes no sense at all to assume that only water contamination and the resulting negative image had lowered the increase rate of tourists in Acapulco. Therefore, the economic evaluation of this Study conservatively estimates the adverse effects of water contamination/environmental degradation on the tourism in the case "without the Master Plan", by defining the adverse effect as 1%/year decrease with respect to the forecasted increase rate after 2006, then 10% decrease in 2015.

Table H-143: Number of Tourists (1990-2001)

Unit: 1,000 persons

Year	Cancun	Acapulco	Mexico
1990	1,566	1,466	22,260
1991	1,904	1,581	22,403
1992	2,036	1,784	22,188
1993	1,974	1,902	21,976
1994	1,958	1,930	22,077
1995	2,155	1,782	27,483
1996	2,306	1,914	29,460
1997	2,640	1,860	31,456
1998	2,652	1,899	33,164
1999	2,819	4,226	41,948
2000	3,043	2,178	40,782
2001	2,986	2,197	39,091

Source: Anuario Estadistico de los Estados Unidos Mexicanos EDICION 2002, INEGI

Table H-144: Growth Rate of Number of Tourists (1990-2001)

Year	Cancun	Acapulco	Mexico
1990	100.0%	100.0%	100.0%
1991	121.6%	107.8%	100.6%
1992	130.0%	121.7%	99.7%
1993	126.1%	129.7%	98.7%
1994	125.0%	131.7%	99.2%
1995	137.6%	121.6%	123.5%
1996	147.3%	130.6%	132.3%
1997	168.6%	126.9%	141.3%
1998	169.3%	129.5%	149.0%
1999	180.0%	288.3%	188.4%
2000	194.3%	148.6%	183.2%
2001	190.7%	149.9%	175.6%

[7] Impacto delas enfermedades diarreicas agudas en la Península de Yucatán

Table H-145: Annual Growth Rate of Number of Tourists (1990-2001)

Year	Cancun	Acapulco	Mexico
1991	21.6%	7.8%	0.6%
1992	6.9%	12.8%	-1.0%
1993	-3.0%	6.6%	-1.0%
1994	-0.8%	1.5%	0.5%
1995	10.1%	-7.7%	24.5%
1996	7.0%	7.4%	7.2%
1997	14.5%	-2.8%	6.8%
1998	0.5%	2.1%	5.4%
1999	6.3%	122.5%	26.5%
2000	7.9%	-48.5%	-2.8%
2001	-1.9%	0.9%	-4.1%
Average	6.0%	3.7%	5.3%

d.2 Forecasts of Tourist Number and Tourism Revenue

Forecast of tourist number is available in a development plan of Quintana Roo State[8]. Also, tourism revenue per tourist was estimated as USD604 in 2000 according to the same plan. In the case "with Master Plan", it is supposed that a decrease in the number of tourists caused by water contamination would not occur, as a deterioration of groundwater quality is not anticipated. In the case "without Master Plan", it is supposed that the number of tourists would decrease by 1%/year with respect to the forecasted growth rates starting in 2006, as discussed above. The Table below shows the result of calculation.

Table H-146: Forecasts of Tourist Number and Tourist Revenue

Year	No. of tourists		Revenue (million pesos)	
	w/ the M/P	w/o the M/P	w/ the M/P	w/o the M/P
2004	1,945,788	1,945,788	12,928	12,928
2005	2,156,471	2,156,471	14,328	14,328
2006	2,275,250	2,252,498	15,117	14,966
2007	2,387,939	2,340,180	15,865	15,548
2008	2,495,671	2,420,801	16,581	16,084
2009	2,599,220	2,495,251	17,269	16,578
2010	2,699,138	2,564,181	17,933	17,036
2011	2,795,833	2,628,083	18,576	17,461
2012	2,889,614	2,687,341	19,199	17,855
2013	2,980,722	2,742,264	19,804	18,220
2014	3,069,348	2,793,107	20,393	18,557
2015	3,155,645	2,840,081	20,966	18,869
Total	31,450,639	29,866,045	208,959	198,430

d.3 Benefit

The difference in revenues between the cases "with Master Plan" and "without Master Plan" is considered as the benefit. As the table below shows, the cumulative benefit by 2015 is calculated as 10,529 Million Pesos.

Table H-147: Benefit of the Master Plan

Unit: million pesos

Year	Revenue		Benefit (balance)
	w/ the M/P	w/o the M/P	
2004	12,928	12,928	0
2005	14,328	14,328	0
2006	15,117	14,966	151
2007	15,865	15,548	317
2008	16,581	16,084	497
2009	17,269	16,578	691
2010	17,933	17,036	897
2011	18,576	17,461	1,115
2012	19,199	17,855	1,344
2013	19,804	18,220	1,584
2014	20,393	18,557	1,836
2015	20,966	18,869	2,097
Total	208,959	198,430	10,529

d.4 Evaluation

Net Present Value (NPV), Benefit Cost Ratio (B/C), and Internal Rate of Return (IRR) were calculated from the streams of Costs and Benefits. Results were, as shown in the Table below, NPV = 2,545 Million Pesos, B/C ratio = 2.06, IRR = 39.00%.

Table H-148: NPV, B/C Ratio, and IRR of the Master Plan (decreasing rate: 1.0% per year from the forecasted rates)

Unit: million pesos

Year	Benefit	Cost	Balance	Discount rate=10%		
				Benefit	Cost	Cash flow
2004	0	189	-189	0	189	-189
2005	0	513	-513	0	466	-655
2006	151	149	2	125	123	-653
2007	317	566	-249	238	425	-840
2008	497	309	188	339	211	-712
2009	691	445	246	429	276	-559
2010	897	323	574	506	182	-235
2011	1,115	257	858	572	132	205
2012	1,344	245	1,099	627	114	718
2013	1,584	229	1,355	672	97	1,293
2014	1,836	255	1,581	708	98	1,903
2015	2,097	265	1,832	735	93	2,545
Total	10,529	3,745	6,784	4,951	2,406	
					NPV=	2,545
					B/C=	2.06
					IRR=	39.00%

[8] Programa Estatal de Desarrollo del Estado de Quintana Roo (PEDU)

d.5 Sensitivity Analysis

Two cases were set for sensitivity analysis, 0.5%/year decrease (Case 1) and 1.5%/year decrease (Case 3) from the forecasted increase rate of tourists after 2006. Table H-149 and Figure H-35 show the number of tourists every year in Case 1 and Case 3, together with Case 2 (1%/year decrease) that was previously analyzed. Results of the sensitivity analysis were NPV = 68 Million Pesos, B/C = 1.03 and IRR = 10.87% in Case 1; NPV = 5,020 Million Pesos, B/C = 3.09, and IRR = 50.68% in Case 3.

Table H-149: Cases of Sensitivity Analysis

Unit: number of tourist

Year	w/ the M/P	Case 1 (-0.5%)	Case 2 (-1.0%)	Case 3 (-1.5%)
2004	1,945,788	1,945,788	1,945,788	1,945,788
2005	2,156,471	2,156,471	2,156,471	2,156,471
2006	2,275,250	2,263,874	2,252,498	2,241,121
2007	2,387,939	2,364,060	2,340,180	2,316,301
2008	2,495,671	2,458,236	2,420,801	2,383,366
2009	2,599,220	2,547,236	2,495,251	2,443,267
2010	2,699,138	2,631,660	2,564,181	2,496,703
2011	2,795,833	2,711,958	2,628,083	2,544,208
2012	2,889,614	2,788,478	2,687,341	2,586,205
2013	2,980,722	2,861,493	2,742,264	2,623,035
2014	3,069,348	2,931,227	2,793,107	2,654,986
2015	3,155,645	2,997,863	2,840,081	2,682,298

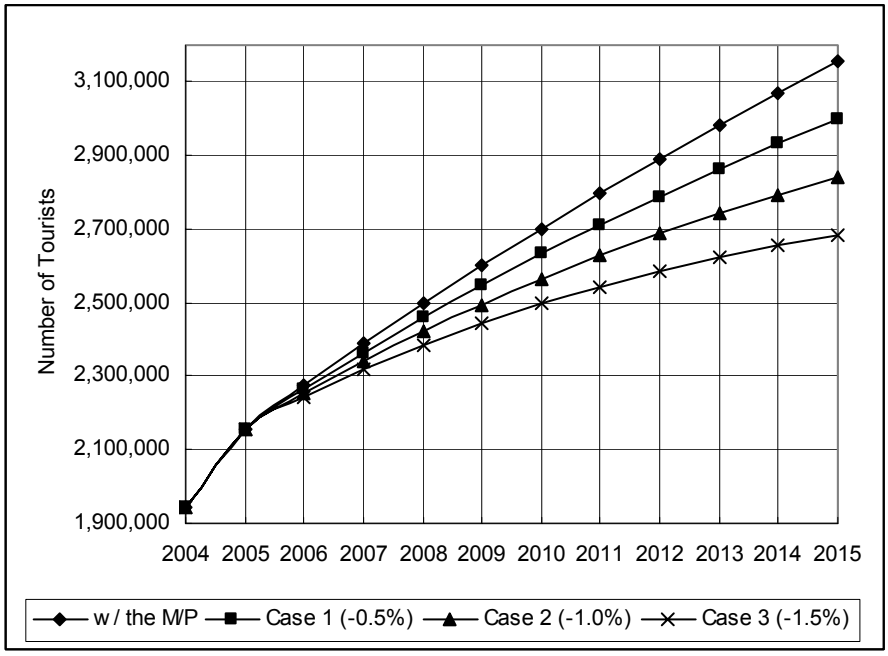


Figure H-35: Cases of Sensitivity Analysis

Table H-150: Sensitivity Analysis at Decreasing Rate of 0.5% per year

Unit: million pesos

Year	Benefit	Cost	Balance	Discount rate=10%		
				Benefit	Cost	Cash flow
2004	0	189	-189	0	189	-189
2005	0	513	-513	0	466	-655
2006	76	149	-73	63	123	-715
2007	158	566	-408	119	425	-1,021
2008	248	309	-61	169	211	-1,063
2009	345	445	-100	214	276	-1,125
2010	448	323	125	253	182	-1,054
2011	558	257	301	286	132	-900
2012	672	245	427	313	114	-701
2013	792	229	563	336	97	-462
2014	918	255	663	354	98	-206
2015	1,048	265	783	367	93	68
Total	5,263	3,745	1,518	2,474	2,406	
					NPV=	68
					B/C=	1.03
					IRR=	10.87%

Table H-151: Sensitivity Analysis at Decreasing Rate of 1.5% per year

Unit: million pesos

Year	Benefit	Cost	Balance	Discount rate=10%		
				Benefit	Cost	Cash flow
2004	0	189	-189	0	189	-189
2005	0	513	-513	0	466	-655
2006	227	149	78	188	123	-590
2007	475	566	-91	357	425	-658
2008	746	309	437	510	211	-359
2009	1,036	445	591	643	276	8
2010	1,345	323	1,022	759	182	585
2011	1,672	257	1,415	858	132	1,311
2012	2,016	245	1,771	940	114	2,137
2013	2,377	229	2,148	1,008	97	3,048
2014	2,753	255	2,498	1,061	98	4,011
2015	3,145	265	2,880	1,102	93	5,020
Total	15,792	3,745	12,047	7,426	2,406	
					NPV=	5,020
					B/C=	3.09
					IRR=	50.68%

Table H-152: Summary of Sensitivity Analysis

Item	Case 1(-0.5%)	Case 2 (-1.0%)	Case 3 (-1.5%)
NPV (million pesos)	68	2,545	5,020
B/C	1.03	2.06	3.09
IRR	10.87%	39.00%	50.68%

e. Conclusion

It should be recognized that the Master Plan is a set of preventive measures to avoid destruction of the groundwater and the coastal aquatic environment. Once those are devastated, economic loss is enormous, recovery is very difficult and expensive, and complete recovery is impossible, as indicated by many historic cases such as the Love Canal in USA.

Preservation of the groundwater and the coastal aquatic environment aimed at by the Master Plan is expected to bring about three benefits, which are summarized in the Table below. Quantitative analysis of the benefits from tourism was conducted supposing that without the Master Plan the increase rate of tourist number would decrease by 1%/year from the forecasted rate after 2006. Although the decrease rate is arguable, the analysis illustrated that a small decrease in the growth rate of tourist number would result in large economic damages as the sensitivity analysis showed. In other words, the tourism revenue is considerably larger than the cost of the Master Plan.

As discussed above, the Master Plan is to prevent economic losses with respect to tourism, biodiversity and human health, which are likely to bring about benefits that are considered as significantly larger than the cost of the M/P. Accordingly, the M/P is evaluated as economically feasible.

Table H-153: Summary of Economic Evaluation of the Master Plan

No.	Benefit	Evaluation
1	**Keeping of attractions to tourists:** to avoid negative impact on tourism due to environmental degradation	The tourism in the Study Area is important not only for the regional economy but also for the national economy. The M/P tries to avoid negative image caused by environmental degradation. Quantitative economic evaluation resulted in NPV=2,545 Million Pesos, B/C=2.06, IRR=39.00%
2	**Preservation of biodiversity:** to avoid loss of resources that could be utilized for foods and/or medicine in the future	The Study Area encompasses a unique aquatic environment and valuable ecosystems where rich biodiversity is found. The M/P contributes to preserve this biodiversity.
3	**Protection of the water source for drinking water:** to avoid added treatment cost of contaminated groundwater, and to prevent disease outbreaks	The number of intestinal infection cases caused by contamination of drinking water is higher in Yucatan Peninsula than the national average. The economic loss caused by this intestinal sickness absenteeism is significant. The M/P contributes to avoid this loss.

H.5.2 Financial Evaluation

a. The Wastewater Management Master Plan

The Wastewater Master Plan is financially viable under the assumed conditions, but needs to be implemented as a whole plan, because if the implementation is to be carried out by each municipality, Othon P. Blanco and Felipe Carrillo Puerto would not be financially able to do so. Fortunately, CAPA is a State-Municipal entity and would be able to implement such a plan that may show financial difficulties on a municipality basis but is financially viable as a whole. Then, the income surplus estimated to occur in Solidaridad can be applied to cover the income shortfall in OPB and FCP in order to make the whole Wastewater Master Plan financially viable. It should be noted that the financial evaluation was based on water consumption for daily domestic use, without consideration of industrial or commercial uses.

Although the estimated income from wastewater user charges alone may be barely enough to implement the Wastewater Master Plan, the sensitivity analysis showed the significant effects of changing conditions affecting cost and income. Above all, its financial viability depends on users paying the assumed wastewater service charges according to the assumed expansion of wastewater treatment. Since this is an uncertain factor, it is safer to consider additional income sources. Suggested income sources were one internal to CAPA, the possible surplus of income from water supply, and one external to CAPA consisting of the share of the tour industry in the cost of the Wastewater Master Plan. The contribution of the tour industry, or the participation of the private sector, may be considered as reasonable, since the tour industry is the group that will benefit the most from the preservation of the coastal aquatic environment. Other sources, possibly subsidies from higher levels of government should be considered according to the experience of CAPA in the implementation of prior projects.

b. The Solid Waste Management Master Plan

The Solid Waste Master Plan in the Study Area can be financially viable depending on some hard decisions. These administrative/management decisions refer to imposing user charges on all waste generators, the level of these user charges, and the bill collection efficiency. The indicative user charges to achieve financial viability and self-sufficiency were 50 Pesos per month for households and 200 Pesos per month for business firms, provided business firms comprise 15% of the number of households, and bill collection efficiency reach 90% by 2009. Under these conditions, FIRR for the Master Plan as a whole would be around 18%.

The same conditions would make the Solid Waste Master Plan financially viable and self-sufficient in two of the three Municipalities, as indicated by FIRR of 18% in Othon P. Blanco and 11% in Solidaridad. In the case of Felipe Carrillo Puerto, under less demanding conditions consisting of user charges of 40 Pesos per month for households and 100 Pesos per

month for business firms, again assuming business firms to comprise 15% of the number of households and bill collection efficiency of 90% by 2009, the FIRR would be around 11%.

Results from the Model Projects are expected to contribute to the financial viability and self-sufficiency of the Solid Waste Master Plan. The improved operation efficiency, the routine calculation and control of the service costs, and the change in attitude to focus the service provision on income and expenditures specific to the service are expected to contribute to the financial viability of the Master Plan.

Needless to say, if the hard decisions cannot be made and financial self-sufficiency is not pursued, the required funds must be obtained from other sources. Then, the question arises concerning the possible difficulties in procuring the necessary funds, which would be increasing year after year.

H.5.3 Environmental Sanitation Evaluation

The Master Plan aims to preserve the groundwater and the coastal aquatic environment in the Study Area through appropriate management of wastewater and solid waste. In concrete terms, it proposes to control the quality of groundwater at 1.0 mg/litter or less of BOD concentration through reduction of contaminants from wastewater and solid waste. This value has been adopted in Japan as an environmental standard in order to preserve a water body for natural environment and as drinking water source that only requires simple purification. Therefore, it can be said that the value is appropriate taking into consideration of the status of water usage and the rich coastal aquatic environment in the Study Area.

The groundwater is the exclusive drinking water source in the Study Area and it nurtures the rich coastal aquatic environment that forms a part of the second biggest coral reef, Mesoamerica Coral Reef. Therefore, to preserve the groundwater leads to protect health of residents and some millions of tourists and the coastal aquatic environment.

Environmental sanitation in large and densely populated cities can be easily deteriorated, and its impact on the human health and the environment is serious. Meanwhile, environmental impact caused in small cities is relatively small and it can be assimilated in the environment. Furthermore, although infrastructures of the wastewater management and the solid waste management require a large amount of investment, unit investment will bring a larger benefit in large cities due to the scale of the economy. Consequently, it is appropriate that the Master Plan prioritizes measures in large cities.

It is needles to say that efforts by the public administrations which provide services are significant to protect the environmental sanitation, but also actions by the citizens who receive the services are indispensable in order to obtain expected outcomes, e.g., to bear cost

for connection of domestic sewer pipes and to cooperate in waste minimization. In order to induce such actions, the residents, the tourists and the business firms should be aware on the environment protection through appropriate environmental education. In the Study, the Environmental Education Model Project was carried out under coordination of organizations concerned. Such coordination will give the Mater Plan sustainability and expansibility.

The Master Plan focuses on reduction of contaminants originated from wastewater and solid waste. Although these two are principle pollution sources as industries have not been developed in the Study Area, other pollution sources may arise in the future such as storm water discharge in the urban area. In order to overlook if the proposed measures of the Master Plan are appropriately carries out, if those measures effectively work or if there are other serious problems than wastewater and solid waste, it is expected to establish a monitoring system on the groundwater and the coastal water.

H.5.4 Technical Evaluation

a. The Wastewater Management Master Plan

The Wastewater Management Master Plan proposes different level of treatment depending on population size of communities taking into account amount of pollution generation and assimilation capacity of the environment.

High level of treatment system which is proposed for a larger city in the Master Plan has been operated in Playa del Carmen and Chetumal in the Study Area. CAPA and other institutions concerned have acquired technologies that are necessary for its planning, designing, construction, operation and maintenance. It is expected that those technologies will be improved through implementation of the Master Plan.

Meanwhile, CAPA constructed new treatment facilities in three small cities and, as of July 2004, final preparation works for operation were carried out. Construction of the facilities was the first experience for CAPA, thus, various technical problems had arisen. However, those problems had been overcome with efforts by CAPA and advices by the Study Team. The experience obtained here will make the implementation of the Master Plan viable.

One of major problems in the sector of wastewater management is lack of number of connected houses to the sewer system as the residents hate to bear the connection cost, e.g., the treatment plant in Chetumal receives wastewater that is only 15% of the capacity of the plant. In the Village Type Wastewater Model Project carried out during the Study, meetings with local residents were held with environmental education activities and a fund for reducing financial burden was established in order to promote connection to the sewer system, then, those measures were successful. Those measures will be applicable in other

areas, not only in areas which will have new systems but also in areas which have existing systems. Then, it will work to increase the sewer coverage as proposed in the Master Plan.

b. Solid Waste Management Master Plan

The Solid Waste Management Master Plan also proposes higher level of a SWM system for a larger city and simpler system for smaller city taking into account distribution of population and population size of respective community in the Study Area. The Master Plan has following three objectives inherent to SWM, i.e., 1) provision of sanitary living environment through improvement of waste collection works, 2) mitigation of environmental impact through proper waste disposal, and 3) contribution to resource conservation through waste minimization measures.

Waste collection coverage is set between 80 and 100% depending on population sizes of communities taking into account different degree of their demands for waste collection service. In order to raise the collection coverage, it is preferable to make the existing collection works efficient, then, to expand collection area with excess capacity. The Collection Improvement Model Project carried out in Felipe C Puerto actually improved the collection coverage from 50% up to 90%. Viability and effectiveness of the measures proposed in the Model Project were proved and the municipal personnel concerned acquired knowledge and technique to carry out the measures. Then, it can be said that the implementation of the Master Plan has begun and the municipalities are ready to continue it.

Regarding waste disposal, four levels of technical measures depending on population size of community have been proposed. The first three levels are improvement of existing disposal sites. The fourth level proposes construction of sanitary landfill which has leachate collection and treatment system. The Improvement of the Existing Disposal Site Model Project in Othon P Blanco upgraded the open dump site to the level three which has a landfill with gas removal facility. In results, proper landfilling such as waste compaction and soil cover has been practiced and generation of leachate that is a main pollution source of groundwater has been reduced to a large degree. Furthermore, introduction of the weighbridge has made it possible to know waste amount brought in the site, then, it allows the municipality to plan the operation. Knowledge and skills acquired through the Model Project will serve a foundation for realizing the suspended new sanitary landfill project.

Activities related to waste minimization were found in the Study Area beforetime, however, those were not strategic approach such as recycling by the informal sector and sporadic events concerning to environmental education conducted by organizations concerned. The Master Plan proposes environmental education and recycling activities in schools and communities. A part of the proposal has been conducted in the Environmental Education

Model Project where an environmental education method was transferred to the Mexican counterpart and teachers, and environmental education classes subsequently were held in some schools using education materials provided by JICA under coordination of organizations concerned. Therefore, it can be said the proposed measures listed in the Master Plan has begun and the organizations and persons concerned have acquired capacity to continue and develop the measures.

H.5.5 Institutional Evaluation

The State of Quintana Roo has legal and administrative frameworks which promote and regulate all activities related to the implementation of the Master Plan.

On a federal level, legislation concerning the management of solid waste has been complemented with the enforcement of the "General Law for the Prevention and Integral Management of Waste". Subsidiarily, with the approval of the "Regulation for the Rendering of the Public Service for the Integral Management of Urban Solid Waste", the municipalities will have a regulatory framework for the rendering of the services.

The management of wastewater is regulated on a federal level through the "Law of National Waters" and the "Federal Law for the Rights as Regards of Water"; the former law is in process of modification.

On a state level, CAPA is regulated through the "Law of Drinkable Water and Sewer System of the State of Quintana Roo", which in its article 36 states that the owners or proprietors of improved real estate and, business, industrial and other type of properties that by their nature are obliged to the use of drinkable water, **are also obliged to the connection to the sewer system in places where this service exists, within the fixed terms.**

The normative exists but unfortunately this is not executed. That is the case of the intra household connections that should connect to the sewerage system in order to protect the aquifer from free discharges to the septic tanks. A new effort to promote the connections is being carried out in the community of Subteniente López with funds of JICA.

The information and coordination among the three government levels should be fluid and of routine with the purpose of gaining synergy. The Master Plan has left installed the "Information System for the Integral Management of Waste" (SIGIR), which may be enlarged in order to incorporate other organizations and achievements.

In the M/P there is a document about the creation an Executing Agency of the Master Plan. This agency has as main objective the implementation of the Master Plan and the achievement of the goals proposed; as well as to strengthen and facilitate the coordination

among the three government levels with the purpose of protecting the aquatic environment of the Coast of Quintana Roo.

H.5.6 Overall Evaluation

The proposed Master Plan will preserve the groundwater and the coastal aquatic environment in the Study Area. Contamination and deterioration of those will induce reduction of tourism revenue, increase of medical cost, loss of employment opportunity and loss of biodiversity. Those will be enormous economic losses compared to the cost of the Master Plan, then it can be said that the Master Plan is economically viable.

The Wastewater Management Master Plan is financially viable under the current tariff system of CAPA. However, analyzing the municipalities separately, Othon P Blanco and Felipe C Puerto will fall in financial deficit. The Wastewater Management Master Plan will be financially viable, when considering the three municipalities as a whole.

Solid waste service has not been appropriately charged in the Study Area excluding Solidaridad. The Solid Waste Management Master Plan will be financially feasible if a political decision to charge the beneficiaries for the service is made.

The Master Plan will contribute to protection of health of residents and tourists, as it will preserve the groundwater which is the only drinking water source in the Study Area. And also, the Master Plan will contribute to conserve the worldwide unique ecosystem in a large extent.

CAPA which is in charge of wastewater management in the Study Area has technical capability to implement the Master Plan. Meanwhile, the municipalities which are in charge of solid waste management have acquired knowledge and skills through the Model Projects to carry out the Master Plan. Thus, it can be said the Master Plan is technically viable and it is expected for those organizations to develop their capability through implementation of the Master Plan.

Consequently, it is judged that implementation of the Master Plan is reasonable and viable overall, and it will formulate a foundation for a sustainable development of the Study Area in the future.

Annex I

Recommendations on Groundwater Management

Contents

Page :

List of Tables

Page :

I Recommendations on Groundwater Management

The Study focuses on the sectors of Wastewater Management and Solid Waste Management according to the Scope of Work agreed by the both the Mexican Side and The Japanese side. However, it is understood importance of Groundwater Management that has close relation to the WWM and SWM due to the geologic characteristic of the Study Area. Therefore, this chapter gives general recommendations on the GWM.

I.1 Risk Assessment

The management of groundwater basin implies a program of development and utilization of subsurface water for some stated purpose, usually of a social or economical nature. In general, the desired goal is to obtain the maximum quantity of water to meet predetermined quality requirement at least cost[1].

Considering vulnerable characteristics of aquifers and growing water demand in tourism in the Peninsula of Yucatan, groundwater situation will progressively become critical in the future. Therefore, the management goal of the Study Area must be set up based on the risk assessment which is anticipated at present.

Risk 01

Saltwater intrusion or "*Upconing*" may occur due to overdraft of groundwater.

- According to water balance calculation in Quintana Roo State[2], an approximate 13,350 Mm^3/year of water is estimated to recharge the limestone aquifers. An estimated amount of extraction is 350 Mm^3/year. It occupies only 2.6 % of the recharge. On the other hand, evapo-transpiration and discharge run up 6,300 Mm^3/year (47.2%) and 5,850 Mm^3/year (43.8 %), respectively. Extraction volume seems still very small compared to recharge at present. In addition, increasing volume of extraction may be compensated by decreasing volume of discharge to sea and other area. However, it should be noted that most of pumping wells are concentrated in the coastal urban areas. Considering water balance in the coastal urban area, if groundwater is overdrafted more than recharge, seawater easily intrudes into the aquifer and compensates the recharge. Especially, the aquifer in the Peninsula of Yucatan contains an underlying saltwater layer and groundwater is being pumped by wells penetrating only the upper freshwater layer. A local rise of the

[1] Todd, D.K.(1980): Groundwater Hydrology, Second Edition, John Wiley & Sons

interface between fresh and saltwater layers below the wells occurs when it is excessively pumped[3]. Accordingly, groundwater will be totally deteriorated and water supply will be seriously damaged unless groundwater extraction is controlled.

Risk 02

Groundwater contamination may occur due to wastewater, animal waste, fertilizer pesticides, septic tanks and so on.

- Although saline water is the most common pollutant in fresh groundwater as mentioned above, groundwater contamination may occur by filtration of various pollutants through the vadose zone and/or directly in the aquifer mainly caused by disposal of wastewater. Limestone aquifer generally has wide variety of density, porosity and permeability depending on degree of consolidation and development of permeable zones after deposition. Openings in limestone may range from microscopic original pores to large solution caverns forming subterranean channels sufficiently large to carry water flow. Actually, many large caverns are found in the Peninsula of Yucatan and some of them are utilized for tourist places. Considering such a large pore or cavity and high permeability in the limestone, contaminated groundwater may spread over entire aquifer system very rapidly[4].
- Presently in the Study Area, the coverage rate of sewer system is very low even in urban area. Treated waste water in CAPA sewer system is being injected into saltwater layer underlying the freshwater layer through injection well. Wastewater from service, such as hotels and restaurants, and industry are also injected into saltwater layer. However, it is doubtful whether water is injected after treatment at septic tank or not. Most of wastewater in uncovered area of the sewer system is discharged into sink hole as well as -domestic wastewater in the rural area. There's a high possibility of contamination by animal waste, fertilizer, pesticides and so on in the rural area as well. In addition to the above, waste disposal site may cause another contaminant source since the waste is dumped and covered by soil but no prevention measure is undertaken against seepage.

[2] SECRETARIA DE AGRICULTURA Y RECURSOS HIDRALICOS, COMISION NACIONAL DEL AGUA (1989) :SINOPSIS GEOHIDROLOGICA DEL ESTADO DE QUITANA ROO,
[3] This phenomenon is known as "*Upconing*"
[4] Generally, a contaminant plume from a point source tends to be long and thin when groundwater is moving relatively rapidly. But where the flow rate is low, the pollutant tends to spread more laterally.

I.2 Management Goal

Based on the risk assessment, the goals for groundwater management can be set up as follows.

Goal 1

To control groundwater extraction based on the evaluation of "the perennial yield".

The "perennial yield" of a groundwater basin defines the rate at which water can be withdrawn perennially under specified conditions without producing an undesired result[5]. An undesired result is an adverse situation such as progressive reduction of the water resource, development of uneconomic conditions, degradation of groundwater quality and land subsidence etc. This concept can be applied to the management goal for the limestone aquifers in the Peninsula of Yucatan. As mentioned earlier, groundwater is a sole source for water supply in this area. Saltwater intrusion caused by overdraft is an undesired result and must be avoided. Therefore, strict groundwater extraction control becomes a final goal of the management. Once a "perennial yield" is determined, a permissible groundwater extraction can be allocated for each urban and rural area considering socio-economic constraints. The achievement ratio of control may be obtained through observation of the monitoring wells and record of pumping. However, a comprehensive and basin-wide hydrogeological study is required in the long run in order to achieve this goal.

Goal 2

To protect aquifer from contamination caused by domestic, industrial, agricultural sources and so on.

- Aquifer protection could be achieved ultimately construction of sewer system and containment of pollution source. However, possible protection measures should be undertaken in the process of attainment of such facilities and establishment of proper institutional and legal settings. It is indispensable to establish groundwater monitoring networks in order to observe water quality and water levels in the short and medium term. In addition, existing wells, such as CAPA production wells for municipal water supply, should be regularly monitored from the point of national drinking water standard.

- As the Peninsula of Yucatan is made up of karst topography, no surface water exists except the River Hondo and "*Cenote*". In order to conserve coastal sea water body,

wastewater is injected into underground saltwater layer and this way of disposal may last a long time in the future. Nevertheless, behavior of injected water and its effect on the freshwater layer are not well understood at present. Although the injection well is registered at the CNA, the design of injection well, equipment and facility, injection record etc are not stored in the database. Information on, such as the depth of screen position, detection of saltwater/freshwater interface, acquisition of hydrogeologic parameters, method of sealing in the annular space between bore wall and casing etc are main issues concerning standardization of design and construction of the injection well. Groundwater management must also clearly focus on this issue.

[5] Todd, D.K（1980, aforementioned）

I.3 Improvement Measures

Proposed improvement measures corresponding to the groundwater management goal are shown in the table below.

Table I-1: Proposed Improvement Measures on Groundwater Management

Strategies		Contents (Proposed Improvement Measures)
Groundwater Management System	Groundwater Database Establishment	Groundwater database, which is necessary for planning, implementation, monitoring and evaluation of groundwater resource, is established and maintained. 1) Collection of existing well data • collection of data from users and drilling companies • construction of well inventory 2) Collection of relevant data and construction of GIS • collection of materials for GIS (natural conditions, land use, population, water supply etc) • construction of GIS system linked with well inventory 3) Establishment of reporting, inspection, analysis and evaluation system using GIS linked groundwater data base • institutional and legal settings • maintenance of the data base (regular updating and modification)
	Construction of Monitoring Network	Groundwater monitoring networks are expanded and monitoring method is improved in order to prevent limestone aquifers from contamination and annual decline of water levels. 1)Automation at existing monitoring wells • examination of well structure, water levels and quality • automation at existing stations • periodical visit and check of equipment 2) Expansion and construction of monitoring network • analysis of existing well data • groundwater leveling in selected existing wells • interpretation of geologic conditions • geophysical survey • drilling of monitoring boreholes (core borings when necessary) • water quality analysis • installation of equipment • establishment of collection and processing methodology of monitoring record • annual publication of monitoring data 3) Evaluation of monitoring data • annual appraisal meeting held at CNA • administrative guidance based on evaluation • field investigations
	Establishment of the Standard on the Injection Well Design, Construction and O&M	A technical standard for design, construction and O&M of the injection well is established in order to prevent fresh water layer from contamination. 1) Examination of existing injection wells and drilling companies • examination of well construction method, structure, injected water quality and rate, record of injection at selected existing wells • examination of drilling companies in terms of equipment ,construction method, materials, experiences 2) Monitoring of water levels and water quality in surrounding areas of injection wells • regular groundwater leveling and water quality analysis • analysis of data 3) Preparation of technical standard • clarification of behavior of injected water in the seawater layer • field investigations and construction test of injection well • establishment of standard design and construction method • establishment of O&M of standard based on the monitoring • administrative and technical guidance by CNA