NO.

Japan International Cooperation Agency (JICA)
Ministry of the Environment and Natural Resources of Mexico (SEMARNAT)

THE STUDY OF MANAGEMENT ON SANITATION ENVIRONMENT IN THE COAST OF QUINTANA ROO STATE IN THE UNITED MEXICAN STATES

Final Report
Volume I
SUMMARY

OCTOBER 2004

Kokusai Kogyo Co., Ltd.

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PREFACE

In response to a request from the Government of the United Mexican States, the Government of Japan decided to conduct a development study on Management on Sanitation Environment in the Coast of Quintana Roo State and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected a study team headed by Mr. Hiroshi Kato of KOKUSAI KOGYO CO., LTD. and dispatched the team to Mexico four times between March 2003 and August 2004.

In addition, JICA set up an advisory committee headed by Mr. Kenichi Tanaka, a senior advisor of the Institute for International Cooperation, which examined the study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of Mexico and conducted field surveys in the study area. Upon returning to Japan, the team prepared this final report.

I hope that this report will contribute to the implementation of this plan and to the enhancement of friendly relations between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the United Mexican States for their close cooperation extended to the study.

October, 2004

Etsuo KITAHARA
Vice President
Japan International Cooperation Agency

October 2004

Mr. Etsuo KITAHARA
Vice President
Japan International Cooperation Agency

Letter of Transmittal

Dear Mrs. OGATA,

We are pleased to submit the report of the Study of Management on Sanitation Environment in the Coast of Quintana Roo State in the United Mexican Sates.

The report consists of three components: a study on the present practices of environmental sanitation management in three southern municipalities in the State of Quintana Roo on the Yucatan Peninsula; formulation of the environmental sanitation master plan until the year 2015; and model projects drawn from measures listed in the master plan.

Due to the peculiar geological characteristic – karstic formation – of the Yucatan Peninsula, rainfall percolates into the ground and forms veins consisting of cenotes and caves, which nurture the rich coastal aquatic environment such as mangrove forests and the second largest Mesoamerican Coral Reef in the world. Then, from the viewpoint of environmental sanitation, it was clarified through the study on present practices that the groundwater is considerably vulnerable to the rapid urbanization being continued in the study area.

The master plan was formulated aiming at controlling pollution loads from sewage and solid waste, with the principal objective of preserving the coastal aquatic environment. In order to achieve the principal objective, technical, legal, organization and financial systems have been formulated.

Furthermore, nine model projects, which were urgent measures listed in the master plan, were carried out within the study period; one in the field of wastewater management, six in solid waste management, one in groundwater management and one in environmental education that encompasses the previous three fields. These model projects have been continued and expanded by the Mexican side. Thus, the master plan has already been implemented and the study is actually yielding fruitful results.

We would like to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs, the Ministry of Land, Infrastructure and Transport, and the Ministry of Environment of Japan. We would also like to extend our deep appreciation to the Government of Mexico, the Embassy of Japan and the JICA office in Mexico for their vital cooperation during the implementation of the study in Mexico.

Last but not least, we hope that the output of the study presented here will contribute to the sustainable development not only in the study area but also the State of Quintana Roo and the Yucatan Peninsula.

Respectfully,

Hiroshi KATO
Team Leader
The Study of Management on Sanitation Environment in the Coast of Quintana Roo State in the United Mexican States

Outline of the Master Plan

1 Outline of the Study

1.1 Objectives of the Study

1) Preparation of Environmental Sanitation Management Master Plan integrating wastewater and solid waste management, with the objective of preserving the aquatic environment along the eastern coast of Quintana Roo State, setting 2015 as the target year.
2) Implementation of a feasibility study on priority projects (model projects) to be selected on the basis of the above mentioned Environmental Sanitation Management Master Plan.
3) Technology transfer to the Mexican counterpart (C/P) during the implementation of the Study.

1.2 Study Area

The Study Area was composed of three Municipalities（Othón P. Blanco, Felipe C. Puerto, Solidaridad）along the eastern coast of Quintana Roo State (See "Map of the Study Area").

1.3 Study Schedule

The Study commenced in March 2003 based on the Scope of Works agreed on by the Government of Mexico and the Government of Japan, and all works in Mexico were completed in August 2004.

The term of the Study was basically divided into four phases as follows.

Phase I: Basic Study (Investigation of the current situation), March – July 2003

Phase II: Formulation of Environmental Sanitation Management Master Plan, August – October 2003

Phase III: Implementation of Model Projects, November 2003 – May 2004

Phase IV: Evaluation of Model Projects, June – August 2004

2 The Master Plan

2.1 Basic Concept

2.1.1 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

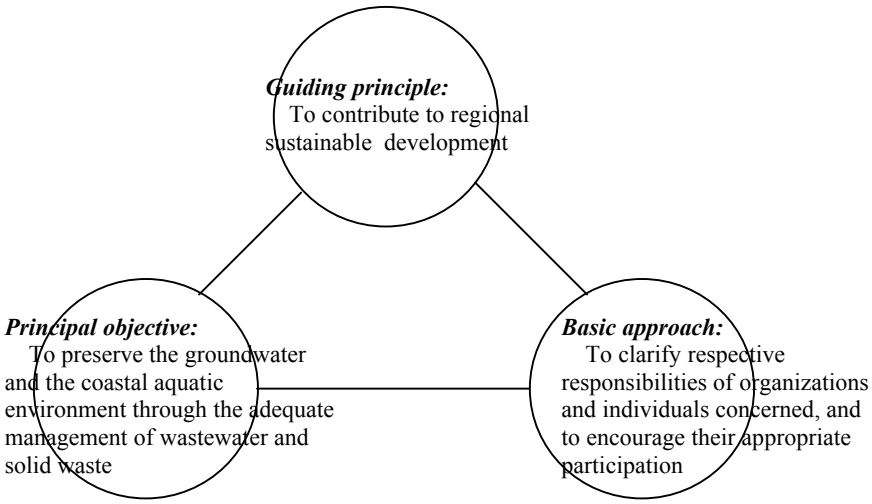
To contribute to regional sustainable development of the Yucatan Peninsula

b. Principal Objective

To preserve the groundwater and the coastal aquatic environment in southern Quintana Roo State, or the 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 Environmental Sanitation Management



2.1.2 Target Value of the Master Plan

The target value of the principal objective of the Master Plan is as follows:

The BOD discharge amount originating from wastewater and solid waste is to be less than 5,200 tons/year by 2015, aiming at controlling the BOD concentration of groundwater at 1.0 mg/liter and below.

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

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

2.2 Wastewater Management Master Plan

2.2.1 Objectives, Target Values and Target Year

a. Principal Objective 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

The target value is as follows;

The BOD discharge amount originating from wastewater is to be around 3,100 tons/year by 2015.

b. Particular Objectives and Target Values

The master plan formulated should aim at achieving the principal objective, as well as at accomplishing the following particular objective inherent to wastewater management.

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

In order to accomplish the objective, the target values regarding sewer service coverage and treated water quality shown in Table 1 and Table 2 have been set.

Table 1: Target Values of the Wastewater Management Master Plan

Items	Municipalities	Present	Goals in 2015
Number of connections	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 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 the master plan is set as: ***Year 2015***

2.2.2 Cost Estimation

The cost of the Wastewater Management Master Plan is estimated as follows.

Table 3: Overall Coast of the Master Plan

unit: million pesos

Item	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
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 C 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

2.2.3 Financial Analysis

The flow of income and costs of the Wastewater Master Plan over the Master Plan period was examined as regards to its financial viability using the following indices: the financial internal rate of return (FIRR), the 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 4: 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

2.3 Solid Waste Management Master Plan

2.3.1 Objectives, Target Values and Target Years

a. Principal Objectives and Target 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

The target value is as follows;

The BOD discharge amount originating from solid waste is to be less than 2,100 tons/year by 2015.

b. Particular Objectives and Target Values

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

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

The table below shows target values of the particular objectives by municipality.

Table 5: Target Values of the SWM Master Plan (by Municipality)

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: 75% (61%) OPB: 72% (57%) FCP: 29% (18%) SOL: 88% (82%)		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

c. Target Year

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

Master Plan: Year 2015

Strategic actions to achieve the objectives should be, in practice, introduced step by step 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)***

2.3.2 Cost Estimation

The total cost required for implementation of the Master Plan is shown in the following table.

Table 6: Cost of the SWM Master Plan

Unit: 1,000 pesos

Item	Short				Middle				Long				Total
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Source reduction	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

2.3.3 Financial Analysis

a. Scenarios

For the purpose of financial analyses, three basic scenarios were set 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: 30 Pesos for households, 100 Pesos for businesses
Scenario 2: 40 Pesos for households, 150 Pesos for businesses
Scenario 3: 50 Pesos for households, 200 Pesos for businesses

The results of the analysis are shown in the following table.

Table 7: Results of Financial Analysis of the Solid Waste Management Master Plan

Item	OPB	FCP	SOL	Study Area
Scenario	3	2	3	3
FIRR (%)	18.9	37.4	11.4	18.1

2.4 Evaluation of the Master Plan

a. Cost

The table below shows the incremental costs 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 8: 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

b. 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 a negative impact on tourism due to environmental degradation*

2) ***Preservation of biodiversity:*** *to avoid loss of resources that could be utilized for food 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*

c. 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.

The economic evaluation of this Study conservatively estimates the adverse effects of water contamination/environmental degradation on tourism in the case "without the Master Plan", by defining the adverse effect as a 1%/year decrease with respect to the forecasted increase rate after 2006, and then a 10% decrease in 2015.

The difference in revenues between the cases "with the Master Plan" and "without the Master Plan" is considered as the benefit. As the table below shows, the cumulative benefit by 2015 is calculated as 10,529 Million Pesos.

Net Present Value (NPV), Benefit Cost Ratio (B/C), and Internal Rate of Return (IRR) were calculated from the streams of Costs and Benefits. The results were, as shown in the Table below, NPV = 2,545 Million Pesos, B/C ratio = 2.06, and IRR = 39.00%.

Table 9: 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%

In addition, two cases were set for a sensitivity analysis, i.e. a 0.5%/year decrease (Case 1) and a 1.5%/year decrease (Case 3) from the forecasted increase rate of tourists after 2006. The results of the sensitivity analysis were NPV = 68 Million Pesos, B/C = 1.03, and IRR = 10.87% in Case 1; and NPV = 5,020 Million Pesos, B/C = 3.09, and IRR = 50.68% in Case 3.

Table 10: Results 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%

d. Conclusion

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 11: 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	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 the negative image caused by environmental degradation. Quantitative economic evaluation resulted in NPV=2,545 Million Pesos, B/C=2.06, and IRR=39.00%
2	**Preservation of biodiversity:** to avoid loss of resources that could be utilized for food 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 preserving this biodiversity.
3	**Protection of the water source for drinking water:** to avoid the 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 the Yucatan Peninsula than the national average. The economic loss caused by this intestinal sickness absenteeism is significant. The M/P contributes to avoiding this loss.

3 Conclusion and Recommendations

3.1 Conclusion

3.1.1 Preservation of Groundwater

a. Threats to Groundwater

Groundwater nurtures the coastal aquatic environment, which is important as a resource for tourism and a habitat for various animals and plants, and is a unique source for drinking water in the Yucatan Peninsula.

The fresh water layer in the peninsula is thin due to the intrusion of sea water. In areas close to the coastal line, groundwater becomes saline water under 5 or 10 m from the surface. Most of the extraction wells for water supply are located in the interior about 20 or 30 km from the coastal line where fresh water is developed to a depth of around 50 m or more; however, over exploitation may cause local salinization.

It is considered that the most serious threat to the groundwater is domestic wastewater from houses and hotels. Sewerage coverage rates in the Study Area are very low such as 16% in Othon P Blanco, 1% in Felipe C Puerto and 5% in Solidaridad. Even in areas covered by the sewerage system, residents hesitate to connect their in-house drainages to the public sewer due to economic reasons. Furthermore, because of the absence of rivers on the surface, treated wastewater from sewage plants is discharged into the saline water layer under the ground, and then it contaminates the groundwater.

Waste collection works in urban communities in Othon P Blanco and Solidaridad have been relatively well done. However, disposal of waste is inadequate, which causes a large amount of leachate and contaminates the groundwater.

The service industry focusing on tourism is the most important industry in the Study Area. The manufacturing industry has not yet been developed and agriculture is not widespread. Therefore, it is assumed that domestic wastewater and solid waste from houses and the service industry, namely from residents and tourists, are principal pollution sources to the groundwater. The Study estimated that 60 % of the pollution load originates from domestic wastewater and 40 % from solid waste.

b. What would happen in the Future?

A rapid increase in the population and tourists is forecasted in the Study Area. The forecasted population in 2015 is 893,000, which is twofold of the estimated population of 435,000 in 2003. Meanwhile, the 1,757,000 tourists in 2003 are estimated to become 3,156,000 in 2015.

If no new measures are taken in the sectors of wastewater and solid waste, it is predicted that the groundwater will be contaminated to a level of 4.9 mg/liter of BOD due to the pollution load originating in the sectors. This level of contamination is categorized as Class C in the environmental standard for river water in Japan, which means the groundwater will not be suitable as a source for drinking water. Furthermore, it will deteriorate the coastal aquatic environment such as cenotes, caves and reefs.

Such environmental deterioration will bring about loss of attraction as a tourist resort, loss of biodiversity and health hazards. It is estimated that foreign currency earnings by tourism until 2015 will be 10,529 million pesos below the original forecast.

It is concluded that the pollution load originating from wastewater and solid waste will contaminate the groundwater; which will lead to deterioration of the coastal aquatic environment; consequently, sustainable development of the Study Area will be hampered.

3.1.2 The Master Plan

a. Basic Concept

The proposed Master Plan sets "to contribute to regional sustainable development of the Yucatan Peninsula" as the guiding principle, "to preserve the groundwater and the coastal aquatic environment in southern Quintana Roo State through the adequate management of wastewater and solid waste" as the principal objective, and "to clarify respective responsibilities of the public sector, the private sector, the residents and the tourists, and to encourage their appropriate participation in Environmental Sanitation Management" as the basic approach.

As the target value of the Master Plan, it is proposed that the BOD discharge amount originating from wastewater and solid waste is to be less than 5,200 tons/year by 2015, aiming at controlling the BOD concentration of groundwater at 1.0 mg/liter and below; less than 3,100 tons/year from wastewater, and less than 2,100 tons/year from solid waste.

b. The Wastewater Management Master Plan

In order to achieve the target mentioned above, the Wastewater Management Master Plan proposes various treatment levels taking into account the characteristic of population distribution in the Study Area; a higher treatment level (more reduction of pollution load) for larger populations and a lower treatment level for smaller populations. The reduced pollution load amount per cost is greater in a larger facility. Thus, the Master Plan proposes to prioritize projects in larger communities taking into account cost-effectiveness. The responsible institution is CAPA (Commission of Potable Water and Sewerage).

The total cost of the Master Plan is 3,300 million pesos until 2015. The results of the financial analysis say that the current tariff can basically cover the total cost when considering the Study Area as a unit; however, the tariff cannot cover the cost in Othon P Blanco and Felipe C Puerto when considering the municipalities individually.

c. The Solid Waste Management Master Plan

The Solid Waste Management Master Plan targets urban communities that will have a population of more than 25,000 in 2015, taking into consideration the relationship between community size and the demand for solid waste services. It also proposes higher waste collection rates and more sophisticated waste disposal manners for larger communities. In addition, waste minimization is proposed, as it leads to reduction of pollution load and conservation of resources. The responsible authorities are the municipal governments, and SEDUMA will guide and support them.

The total cost of the Master Plan is 1,178 million pesos by the year 2015. However, the incremental cost is only 441 million pesos as the solid waste service is currently provided. The financial analysis says that in order to cover the total cost of 1,178 million pesos, it is necessary to charge residents from 40 to 50 pesos/month/house and business entities from 150 to 200 pesos/month/entity. Then, financial self-sufficiency can be achieved.

d. Benefits

The expected benefits, which the Master Plan will bring about, are 1) keeping of attraction to tourists, 2) preservation of biodiversity and 3) protection of the water source for drinking water. A quantitative economic evaluation was carried out targeting the first benefit. As a result, EIRR (Economic Internal Rate of Return) was 39.0%, NPV (Net Present Value) was 2,545 million pesos and B/C (Benefit – Cost Ratio) was 2.06. Therefore, it is concluded that the Master Plan is economically feasible.

3.1.3 Model Projects

An investigation on hydrogeological conditions and some measures listed in the Master Plan were carried out as Model Projects.

Urban Type Wastewater Treatment carried out at Playa del Carmen in Solidaridad clarified that the current manner of treated wastewater injection is not appropriate in view of the hydrogeological conditions of the site and there is room for improvement. In addition, ammonia was found in the groundwater, which indicates that the groundwater was artificially contaminated.

Residents are responsible for connection of in-house drainage to the public sewer. However, financial burden for the connection and lack of knowledge about environmental conservation discouraged the residents from doing so. Consequently, although CAPA constructed the public sewers, actual sewerage coverage was not increased. To cope with this problem, Village Type Wastewater Treatment established a fund to ease the financial burden and provided explanations to residents along with environmental education. As a result, the connection was promoted.

Establishment of an Integral Solid Waste Management Information System formulated a framework where SEDUMA and the municipalities exchange information on Solid Waste Management; the former is an institution of the state government and the latter are responsible for provision of solid waste services. The system is also to respond to a requirement of a new federal law, "General Law for the Preservation and Management of Waste." In regard to this Model Project, it is proposed to establish an Executive Unit in SEDUMA for promoting and supervising implementation of the Master Plan and to enact a new municipal ordinance of Solid Waste Management based on the Master Plan.

Capacity Building of Executing Agency in Othon P Blanco aimed at establishing a method for controlling the solid waste service cost. This Model Project was carried out in collaboration with two other Model Projects, i.e. Improvement of the Existing Disposal Site and Collection Improvement. Namely, technical data obtained from these Model Projects were combined with cost data, and then the results of analysis of the combined data were sent back for improvement of the disposal site operation and the collection works. Accordingly, the Model Project is to strengthen a core capability of Integral Solid Waste Management. Information on cost was dispersed over several sections of the municipal government so it was difficult to gather information at the beginning. However, communication channels among the sections were established and awareness of improvement among the municipal personnel was boosted through the Model Project.

Through Improvement of the Existing Disposal Site in Othon P Blanco, dispersed waste over the disposal site was gathered in a certain area, compacted and covered with soil, which improved sanitary conditions; and an access road was constructed which significantly improved workability of the site. In addition, the amount of waste brought to the site was determined due to installation of a weighbridge. Information on waste amount is one of the most important information in Solid Waste Management. The average amount of waste disposed of during the Model Project was 160 tons/day.

Collection Service Improvement was carried out in Othon P Blanco and Felipe C Puerto. Through the Model Project, a method for planning collection routes, recording operation data

and evaluating the data was established. As a result, a reduction in the operation time of collection vehicles and an increase in the collected waste amount per crew were confirmed in Othon P Blanco. Those data indicate a possibility of cost reduction. In Felipe C Puerto, the Model Project increased collection coverage up to 80% from 50 % before the Model Project.

In the Model Project of Establishment of Solid Waste Management System in Costa Maya, several stations for separate collection were installed aiming at waste minimization; the stations were managed by a newly established committee on Solid Waste Management in a local community; and negotiation with traders regarding collected PET bottles and cans got was started. Namely, a new Solid Waste Management System has begun to work.

Environmental Education and Recycling Activities prepared educational materials such as a video and texts, established a method for environmental education using the materials, and realized a paper recycling activity. These activities are carried out and expanded by the Mexican counterpart themselves.

3.2 Recommendations

3.2.1 Recommendations for implementation of the Master Plan

a. The Wastewater Management Master Plan

1. Improvement of Sewerage Coverage

- In the development of sewerage systems in urban communities, priority shall be given to those that are cost effective in view of reducing the pollution load and those communities that generate a large amount of the pollution load.
- The manual and experience acquired through the Model Project of Village Type Wastewater Management shall be utilized for the construction and operation of sewerage systems in small communities in the future.
- CAPA shall seek the required investment cost for development of sewerage system in coordination with CNA.

2. Promotion of In-house Drainage Connection

- CAPA shall formulate a project team for promoting the in-house drainage connection. The team shall be composed of personnel from various sections such as planning, construction, operation and maintenance, and community relations.
- The promotion shall be conducted not only in areas where sewerage system exists, but also in areas where construction of a sewerage system is planned. The promotion shall be carried out beforehand, e.g., before or at an early stage of construction works.
- In order to ease the financial burden on residents, the fund established in the Model Project of Village Type Wastewater Treatment shall be expanded and further utilized.
- In order to raise residents' awareness on environmental conservation, explanations to residents shall be given along with environmental education.

3. Income Improvement and Cost Reduction

- The tariff on sewerage services, which is currently set as 20% of the water supply charge, shall be raised according to expansion of the sewerage services.
- Installment of micrometers shall be promoted and the fee collection rate shall be improved.
- The indirect cost, which currently accounts for about 50% of the total cost, shall be reduced.

b. The Solid Waste Management Master Plan

1. Improvement of waste collection coverage

- Improvement of collection works shall be continued based on the manuals prepared and the experience acquired through the Model Project of Collection Service Improvement.
- Capacity reserved in the improvement shall be utilized for expansion of collection coverage.

2. Implementation of Proper Waste Disposal

- The existing disposal sites shall be improved referring to the manual and experience acquired through the Model Project of Improvement of the Existing Disposal Site in Othon P Blanco.
- The current disposal operation shall be moved to a sanitary landfill in Chetumal, Riviera Maya and Costa Maya according to schedule set in the Master Plan.
- Othon P Blanco Municipality shall seek the required investment cost for construction of a sanitary landfill in Costa Maya in coordination with FONATUR.

3. Promotion of Waste Minimization

- The Model Project of Environmental Education and Recycling Activities shall be continued and expanded in coordination with the Ministry of Education and other institutions concerned.
- Paper recycling that was launched in the Model Project shall be expanded.
- Recycling of PET shall be promoted in coordination with ECOSE.
- Pruning waste composting shall be started in the near future.

4. Actions towards Financial Self-sufficiency

- Fee collection of solid waste services shall be considered and implemented as soon as possible.
- A system to charge tourists for solid waste services shall be considered as soon as possible.

5. Strengthening of Institutional System

- An Executive Unit that is to be in charge of guidance and support of Solid Waste Management shall be established in SEDUMA.
- The municipalities shall consider the proposed ordinance regarding Solid Waste Management.

3.2.2 Recommendations for Groundwater Preservation

1. Establishment of a Groundwater Monitoring System

- CNA shall establish a monitoring system that is capable of comprehending groundwater status quantitatively.
- Monitoring results shall be utilized for proper implementation of the Master Plan, e.g., if monitoring results say that contamination of the groundwater is serious in a certain area, a recommendation of prioritizing construction of sewerage in the area can be induced.

2. Improvement and strengthening of Institutional System

- In order to make it possible that evaluation of monitoring results leads to necessary actions to protect the groundwater, the current institutional system shall be improved and strengthened, e.g., if the quality of the groundwater is regulated quantitatively, results of monitoring can be evaluated according to the regulation and then actions can be taken immediately such as further studies or guidance.
- CNA shall begin to establish regulations on the injection well considering the results of the Model Project of Urban Type Wastewater Management.

3.2.3 Recommendations for Conservation of the Coastal Aquatic Environment

1. Water Quality Monitoring in Nearshore Waters

- The relationship between the quality of the groundwater and of the seawater shall be studied in coordination with monitoring conducted by the Navy in nearshore waters.
- The Navy's monitoring works shall be diagnosed and evaluated. If necessary, measures shall be taken for improvement of the monitoring system.

2. Promotion of Cooperation with Projects and/or Institutions Concerned

- Information shall be interchanged among related projects such as Mesoamerican Coastal Reef Conservation, and possible coordination shall be sought.
- Information shall be interchanged among institutions dealing with environmental conservation such as University of Quintana Roo, ITCH (Instituto Tecnologico de Chetumal) and ECOSUR (El Colegio de la Frontera Sur).

In conclusion, the Study Team would like to express its appreciation to organizations and individuals in both Mexico and Japan having participated in or cooperated with this Study. We expect that what we have done together will lead to sustainable development of the Study Area, the State of Quintana Roo and the Yucatan Peninsula.

The Study of Management on Sanitation Environment in the Coast of Quintana Roo State in the United Mexican States

List of Volumes

Volume I	Summary
Volume I (S)	Summary (Spanish Version)
Volume II	Main Report
Volume II (S)	Main Report (Spanish Version)
Volume III	Annex I
Volume III (S)	Annex I (Spanish Version)
Volume IV	Annex II
Volume IV (S)	Annex II (Spanish Version)

This is the Summary

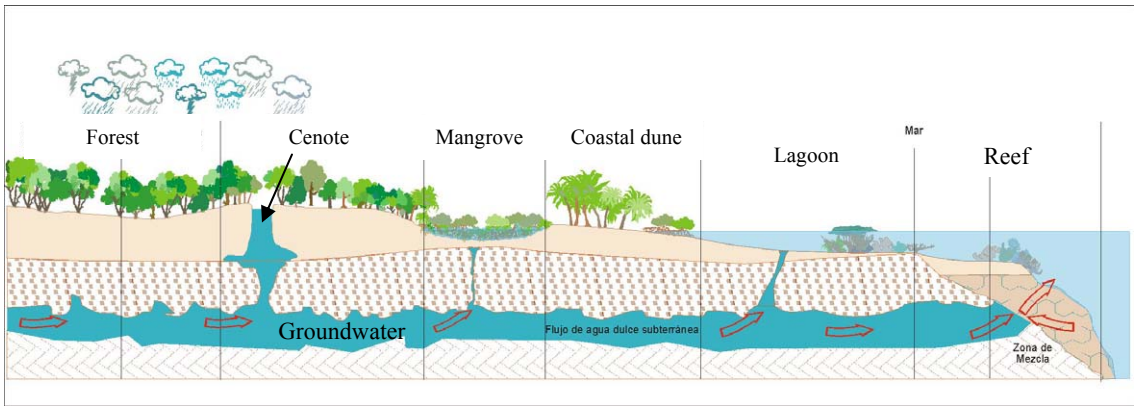
In this report, the project cost is estimated by using the November 2003 price and an exchange rate of US$1.00 = 11.00 Mexican pesos = JP¥ 110.

STUDY AREA


Mexico North America
United Mexican States
Solidaridad
Felipe Carrillo Puerto
Othón P. Blanco
Study Area
SCALE 1:700,000
0 10 20 30 40 70
Kilometer
BELIZE
CHETUMAL
CANCÚN
ISLA COZUMEL
MAR CARIBE (MAR DE LAS ANTILLAS)

Plate 1 Features of the Study Area

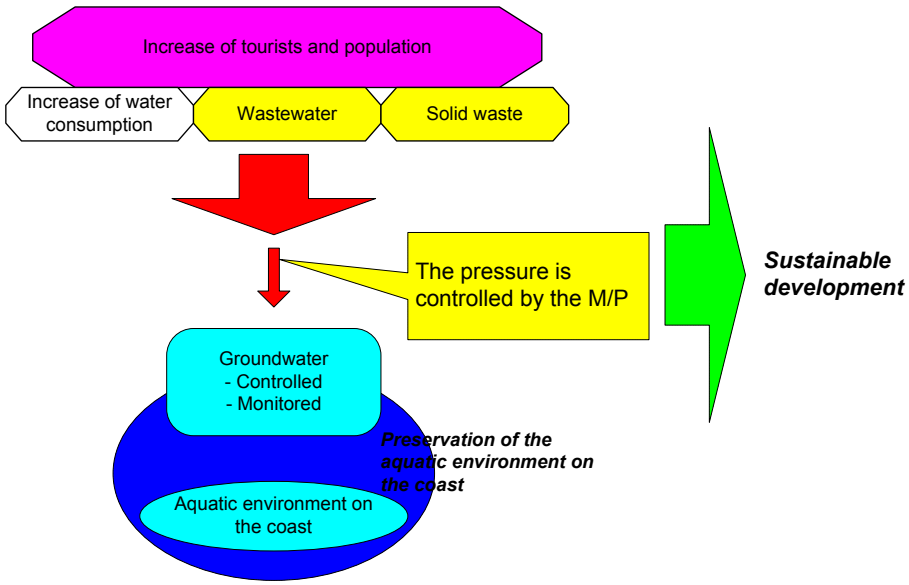
The Peninsula of Yucatan is a geologic unit composed mainly of limestone which is highly permeable and soluble. Dissolution of the rock has created a karst topography with cenotes and caves. The underground stream is connected to lagoons and reefs, then nurtures rich aquatic environment in the Study Area



Lagoon (Laguna Bacalar)

A beach in Costa Maya

It is feared that inadequate management of wastewater and solid waste would pollute the groundwater, then, deteriorate the aquatic environment. The Master Plan proposed in the Study aims to control pollution load from wastewater and solid waste as shown in the following figure.



Meetings and seminars were held aiming at interchanging information and technology among the Mexican Counterpart, the JICA Study Team and other institutions concerned.

Periodical Meeting

Meetings between the Mexican Counterpart and the JICA Study Team were held every two weeks periodically. This was the principal tool for the technology transfer and consensus building.

Seminars

Seminars were held from time to time during the Study, presentations were basically made by the Mexican Counterpart. They explained what they were doing at the time and/or announced what they were going to do after the time.

Not only adults but also children participated in the seminars, who experienced classes that were conducted as one of components of Environmental Education and Recycling Activity Model Project.

Model Project of Urban Type Wastewater Treatment was carried out in Playa del Carmen, Solidaridad Municipality, with purposes of investigating hydrogeological conditions and groundwater quality at the site.

Geophysical Survey

A geophysical survey by transient electromagnetic method (TEM) was carried out. The primary objective of the survey was to determine the composition and distribution of limestone aquifers as well as fresh-saline water interface in the study area.

Monitoring Well

Based on the geophysical survey, the monitoring wells were constructed at different depths in order to confirm lithology of aquifers, distribution of fractures, presence of cavity, fresh water-saltwater interface and water quality.

Water Quality Analysis

Groundwater was sampled from the monitoring wells and its quality was analyzed to verify contamination.

Model Project of Village Type Wastewater Treatment was carried out in Subteniente Lopez in Othon P Blanco Municipality, with purposes of verifying a new wastewater treatment plant for a small community and encouraging residents to connect their domestic wastewater with the pubic sewer.

Wastewater Treatment Plant

CAPA developed a small scale treatment plant to cope with problems regarding wastewater in small communities. The JICA Study Team made some suggestions and training regarding operation and maintenance of the plant.

Explanation to Residents

Several meetings were held for bringing importance of groundwater conservation to the residents' attention and for encouraging them to connect to the public sewer.

In-house Connection

A fund to financially help residents connect to the public sewer was established. And about 100 households made the connection.

Plate 5 Model Project "Establishment of an Integral Solid Waste Management Information System" and "Capacity Building of Executing Agency in Othon P Blanco"

Model Project of Establishment of an Integral Solid Waste Management Information System aimed at setting up a framework where institutions concerned could interchange information, then strengthen coordination among them. Use of the system will lead to monitoring implementation of the Master Plan formulated in the Study.

Model Project of Capacity Building of Executing Agency in Othon P Blanco aimed at establishing a manner of calculation and control of the cost of solid waste management in a routine way by introducing software.

Some computers were equipped to offices of the Mexican Counterpart with required software and training for carrying out the Model Projects.

SEDUMA (Ministry of Urban Development and Environment, Government of Quintana Roo State)

Municipality of Othon P Blanco

Municipality of Felipe C Puerto

Model Project of Improvement of the Existing Disposal Site in Othon P Blanco was carried out having the following components:

- improvement of the existing disposal site by constructing dikes, compacting waste, covering waste with soil and installing gas removal pipes,
- technology transfer of proper landfilling with an operation manual, and
- introduction of an incoming waste weighing system with installation of a weighbridge.

Site Improvement

Before Improvement

The site showed intolerably unsanitary conditions, such as waste was scattered, the access road was inundated, and a great number of fries and birds was observed.

Under Improvement

Waste was compiled and compacted, then covered with soil.

After Improvement

Sanitary conditions and workability of the site were well improved. The site was ready for daily operation.

Weighbridge Installation

A weighbridge was installed and a manner how to record data of incoming waste was established. To know waste amount is crucial for entire Solid Waste Management, which gives information necessary for planning and operation in both technical and financial aspects.


A weighbridge was installed at the entrance of the site. A rule how to get on it, e.g., crews except driver shall get off, vehicles shall slowly get on and off the weighbridge, was established.

A computer was installed. That is connected to the weighbridge and records data. Some personnel were trained about how to use it.

A gate was installed at the entrance of the site. It can avoid entry of unauthorized vehicles and persons.

Model Project of Collection Service Improvement in Othon P Blanco was carried out in Chetumal City. The principal objective was to improve efficiency of waste collection works, which leaded to cost reduction.

Model Project of Collection Service improvement in Felipe C Puerto was conducted in Felipe C Puerto City. It also aimed at improving efficiency. In addition, remaining capacity caused by the improvement of efficiency was turned to expansion of collection service area.

Diagnosis of the Current Situation

First, the current situation of collection works was investigated by following vehicles.

Data Analysis and Planning

Data collected during the diagnosis was analyzed, and new collection routes and work schedule were planned based on the analysis.

Improvement of Collection Works

New collection routes and work schedule were practiced. Explanation and training of the new routes and schedule were out to collection crews on the streets.

Model Project of Establishment of Solid Waste Management System in Costa Maya was carried out in Mahahual, Othon P Blanco Municipality, aiming at introducing a minimization culture.

Solid Waste Management Committee


A committee on Solid Waste Management was created in Mahahual, then, it was acknowledged by the Municipality of Othon P Blanco.

Beach Cleaning

Recycling

Several stations for separate collection of waste were installed. Collected bottles and cans were sorted again and temporary stored, then, sold to traders.

Model Project of Environmental Education and Recycling Activities was carried out over the Study Area aiming at providing an education program that can make children be acquainted with importance of resource conservation and recycling through harmonized coordination of different institutions.

Workshops


First, a workshop was held targeting the Mexican Counterpart, where a method of environmental education was established through discussion and experimental trials. Second, the Counterpart held several workshop inviting teachers to transfer the education method.

Environmental Education in Schools

Teachers having participated in the workshops went back to their schools and had classes regarding environmental conservation and recycling.

Recycling


Children actually participated in a paper recycling activity and visited a paper recycling company.

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Abbreviations

AMSLM	Average Mean Sea Level Meters
AC	Civil Association
APAS	Potable Water, Sewerage and Sanitation
B/C	Benefit Cost
BANOBRAS	National Bank of Public Works and Services (*Banco Nacional de Obras y Servicios Públcios*)
BOD	Biochemical Oxygen Demand
C/P	Counterpart
CAPA	Commission of Potable Water and Sewerage (*Comisión de Agua Potable y Alcantarillado*)
CECADESU	Training Center for Sustainable Development
CEPIS	Panamerican Center for Sanitary Enginnering and Environmental Siences (*Centro Panamericano de Ingeniería Sanitaria y Ciencias del Ambiente*)
CNA	National Committee of Water (*Comisión Nacional del Agua*)
CNANP	National Committee of Natural Protected Areas (*Comision Nacional de Aguas Naturales Protegidas*)
COD	Chemical Oxygen Demand
COESPO	State Council of Population
CONAPO	National Council of Population
COSEPRE	Cost of Services Provided
DF/R	Draft Final Report
EAP	Economic Activity Population
EC	Electric Conductivity
ECLAC	Economic Commission for Latin America and the Caribbean
ECOSE	Ecology and Business Commitment
ECOSUR	College of the Southern Border (*El Colegio de la Frontera Sur*)
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EM	Electro Magnetic
F/R	Final Report
F/S	Feasibility Study
FCP	Felipe Carrillo Puerto
FIDECARIBE	Caribbean Trusteeship, State Tourism Agency
FONATUR	Tourism National Found (*Fondo Nacional para el Turismo*)
GDP	Gross Domestic Product
GIS	Geographic Information System
GNI	Gross National Income
GNP	Gross National Product
GWM	Ground Water Management
HDI	Human Development Index
IC/R	Inception Report
IEE	Initial Environmental Examination
IIRA	Institute of Environmental Impact and Risk
IMSS	Mexican Institute for Health Insurance
IMTA	Mexican Institute of Water Technology
INE	National Ecology Institute
INEGI	General Census of Population and Housing (*Instituto Nacional de Estadística, Geografía e Informatica*)
INI	National Institute for Indigenous People

ISSTE	Health Insurance Institute for State Workers
It/R	Interim Report
JICA	Japan International Cooperation Agency
LEEPA	Regulation of the Environment Balance and Protection of Quintana Roo State
LGEEPA	General Law of Ecological Balance and Environmental Protection
LGPGIR	General Law for the Prevention and Integral Management of Waste
M/M	Minutes of Meetings
M/P	Master Plan
MBPS	Municipal Bureau of Public Services
MLSS	Mixed-Liquor Volatile Suspended Solids
Mo/P	Model Project
MPNISP	Model of National and International Practices in Public Service
NA	Not Available
NGO	Non-Governmental Organization
NPV	Net Present Value
O&M	Operating and Maintenance
OD	Oxygen Demand
OPB	Othón Pompeyo Blanco
P/R	Progress Report
PDSD	Phased Disposal Site Development
PEDI	Integral Development Strategic Plan
PEDU	State Program of Urban Development (*Programa Estatal de Desarrollo Urbano*)
PEMEX	Oil Mexican Company
PMDU	Urban Development Municipality Programs
PND	National Development Plan
PNDU	National Program of Urban Development
POET	Program of Territorial and Ecological Ordinance
PROFEPA	Federal Environmental Protection Agency
SARH	Secretariat of Agricultural and Hydraulic Resources
SEANAP	System Estate of Natural Protected Areas
SECTUR	Ministry of Tourism
SEDEMAR	Navy
SEDENA	National Army Secretariat
SEDESOL	Ministry of Social Development (*Secretaría de Desarrollo Social*)
SEDUE	Secretariat of Urban Development and Ecology
SEDUMA	Ministry of Urban Development and Environment, Government of Quintana Roo State (*Secretaría de Desarrollo Urbano y Meido Ambiente, Gobierno del Estado de Quintana Roo*)
SEMARNAT	Ministry of Environment and Natural Resources (*Secretaría de Medio Ambiente y Recuross Naturales*)
SEPLADER	Secretariat of Regional Planning and Development
SIGIR	Information System for the Integral Management of Waste
SOL	Solidaridad
SS	Suspended Solids
SSA	Secretariat of Health and Assistance
SVI	Sludge Volume Index
SW	Solid Waste
SWM	Solid Waste Management
TDEM	Time-Domain Electromagnetic Method
TDS	Total Dissolved Solid
TEM	Transient Electromagnetic Method

TS	Total Solid
TSS	Total Suspended Solids
UNEP	United Nation Environment Program
UNESCO	United Nation Educational, Scientific, and Cultural Organization
USAID	United States Agency for International Development
USMN	Unit of the Meteorological National Service
VES	Vertical Electric Sounding
VSS	Volatile Suspended Solids
WTP	Water Treatment Plant
WWM	Wastewater Management

1 Outline of the Study

1.1 Background of the Study

The State of Quintana Roo in Mexico has an area of around 50,800 km^2, and a population of 870,000, of which 400,000 live in Cancun in year 2000. Within the State of Quintana Roo, the eastern coast stretches over approximately 500km, being an area of rich natural environment, inhabited by numerous tribal people who live off the abundant natural resources. Historical ruins are also plentiful, giving rise to tourism promoted at the national level as a source of hard currency.

However, tourism development without sufficient environmental considerations, coupled with explosive population growth, has exposed the difficulty facing many cities and towns to keep up with the necessary social infrastructure concerning wastewater and solid waste disposal. The result has been the deterioration of the natural environment of the area in recent years. The central and regional governments of Mexico have faced the situation with legislative and administrative countermeasures. However, insufficient and slow results call attention to the adverse effects on the coastal environment and the living environment of the residents.

In March 2001, JICA dispatched a joint Japanese-American Project Formation Study Team, and clarified the high priority of aid for the environmental preservation of the said coastal area. In July 2002, JICA implemented a preliminary study, and confirmed the urgency of aid concerning sewage and solid waste disposal, which have adverse effects on the coastal environment. Subsequently, in October 2002, JICA sent a Preparatory Mission, which signed the S/W of the Study, and selected Kokusai Kogyo Co., Ltd. as the consulting firm for implementation of the Study.

1.2 Objectives of the Study

1) Preparation of an Environmental Sanitation Management Master Plan integrating wastewater and solid waste management, with the objective of preserving the aquatic environment along the eastern coast of Quintana Roo State, setting 2015 as the target year.
2) Implementation of a feasibility study on priority projects (model projects) to be selected on the basis of the above mentioned Environmental Sanitation Management Master Plan.
3) Technology transfer to the Mexican counterpart (C/P) during implementation of the Study.

1.3 Study Area

The Study Area was composed of three Municipalities（Othón P. Blanco, Felipe C. Puerto, Solidaridad）along the eastern coast of Quintana Roo State (See "Map of the Study Area").

1.4 Study Schedule

The Study commenced in March 2003 based on the Scope of Works agreed by the Government of Mexico and the Government of Japan, and all works in Mexico were completed in August 2004.

The term of the Study was basically divided in four phases as follows.

Phase I: Basic Study (Investigation of the current situation), March – July 2003

Phase II: Formulation of Environmental Sanitation Management Master Plan, August – October 2003

Phase III: Implementation of Model Projects, November 2003 – May 2004

Phase IV: Evaluation of Model Projects, June – August 2004

1.5 Organization for Study Implementation

The Study was carried out jointly by the Study Team and Mexican Counterpart Team, following the guidance and advice given by the Steering Committee, composed of representatives from related Mexican agencies, and the Advisory Committee set up by JICA in Japan.

1.5.1 Study Organization

The organizations concerned with the Study will have the following relationship.

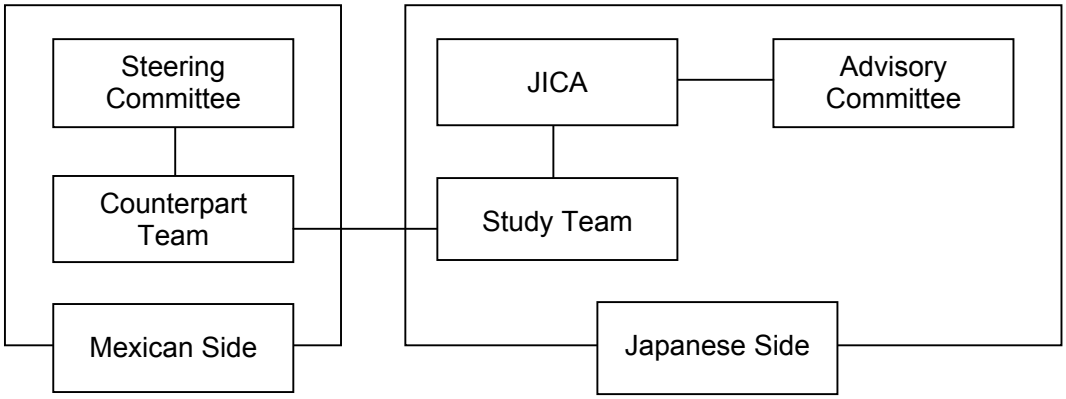


Figure 1: Organization Chart of the Study

1.5.2 Study Team

The Study Team is composed of 15 members as shown in the table below

Responsibility	Name
Leader／Environmental Sanitation Management／Wastewater Management (1)	Hiroshi Kato
Wastewater Management (2) ／ Hydrogeology ／ Groundwater Analysis ／ Electromagnetic Exploration	Akira Kamata
Planning & Design of Wastewater Treatment Facilities	Osamu Nahata
Sub-Leader／Solid Waste Management Plan	Ikuo Mori
Planning & Design of Solid Waste Management Facilities	Ximena Alegria
Organization／Legal Structure／Social Survey	Victor Ojeda
Economic & Financial Analyses	Masaru Obara
Initial Environmental Examination	Shinya Kawada
Regional Planning	Toshiro Hamada
Community Participation／Environmental Education	Masaharu Kina
Model Projects	Ichiro Kono
Well Data Processing	Mario Valle
Water Balance Analysis	Peifeng Lei
Administrative Coordinator (1)	Hiroyuki Nakai
Administrative Coordinator (2)	Ikuko Kunitsuka

1.5.3 Advisory Committee

In order to provide the necessary advice to the Study Team, JICA has set up an Advisory Committee composed as follows.

Responsibility	Name	Agency
Committee Leader	Kenichi Tanaka	Institute for International Cooperation, JICA
Committee Member	Takeshi Yahashi	Japan Education Center of Environmental Sanitation

1.5.4 Counterpart Team

The Counterparts who jointly worked with the Study Team are shown in the table below.

Name	Institution	Responsibility
1. Environmental Sanitation Management		
Lic. Francisco Hernández Franco	SEMARNAT-QR	Sub delegate of Planning
Lic. Gustavo Hidalgo Sánchez	SEMARNAT-QR	Department of Planning and Foreign Affairs
Ing. Gustavo Olivares Alanis	SEMARNAT-QR	Chief of Planning and Environment Policy Office
2. Hydrology		
Ing. Iván Gamboa Rosas	CNA- Regional Office	Regional Manager
Ing. Carlos Fernando Chable Mendicuti	CNA- Regional Office	In charge of the Technical Area
Ing. Catherine Magnum Burnier	CNA- Regional Office	In Charge of Basin Council Program
Ing. José Luis Acosta Rodríguez	CNA- Regional Office	Technical-Regional Sub Manager
Ing. Anselmo Ordaz Ayala	CNA-México	CNA México
Ing. Eliseo Váquez	CNA-México	Specialist on Hydraulic
Tte. Roberto Flores Rodríguez	SEDEMAR	Chief of the Sea Contamination Program
3. Elecromagnetic Sounding Analysis		
Ing. Guillermo Cuevas Landeros	CNA- Regional Office	Specialist on Hydraulic
Ing. Artemio Araujo Mendieta	CNA-México	Specialist on Hydraulic
4. Sewerage System Plannin		
Ing. Juventino Castillo Pinzón	CAPA	Coordinator of Planning and Development
Ing. Jaime Quiñones Baas	CAPA	Chief of Projects

Name	Institution	Responsibility
5. Waste Water Treatment Enginnering		
Ing. Roberto Chim Iterián	CAPA	Head of Operations
M.C. Miguel Angel García Salgado	CONANP	Monitoring Coordinator of the XI Region of CONANP
6. Solid Waste Management		
Biól. Adolfina Bertha Villalobos	SEMARNAT-QR	Chief of the Department of Environmental Impact and Risk
Ing. Carlos Acosta Loría	SEDUMA	Director of Prevention and Pollution Control
José Guerrero	SEDUMA	In Charge of the Department of Monitoring Environment
Ing. Mónica Chargoy Rosas	Municipality of OPB	Specialist on Solid Waste Management
José Méndez García	Municipality of OPB	Chief of the Collection Department
Ing. Eduardo Escalante Rodríguez	Municipality of FCP	Director of Public Works
Manuel Góngora Reyes	Municipality of FCP	Assistant
Biól. Juan Antonio Huerta Illescas	Municipality of Solidaridad	Director of Environment
7. Solid Waste Management Facilities		
Ing. Carlos Acosta Loría	SEDUMA	Director of Prevention and Pollution Control
MVZ. Rodrigo Camín Cardín	Municipality of OPB	Specialist on Solid Waste Management
José Tut Uan	Municipality of OPB	Director of Public Image
Ing. Eduardo Escalante Rodríguez	Municipality of FCP	Director of Public Works
Biól. Juan Antonio Huerta Illescas	Municipality of Solidaridad	Director of Environment
8. Organization, Institution and Legal System		
Lic. Rosa Elena Carbajal Valiente	SEMARNAT-QR	Chief of Legal Affair
9. Financial and Economic Analysis		
Ing. Gilberto Mena Rivero	CAPA	Director of Project Assessment Area
Arq. Héctor Morín Lázaro	Municipality of OPB	Director of Urban Development and Ecology.
10. Environment Assestment		
Biól. Carlos Llorens Cruset	SEMARNAT-QR	Sub delegate of Environment Protection
Lic. Adrián Neftalí Pérez Zaldivar	Municipality of Solidaridad	Sub-Director of Environmental Norms
Ing Giovanni Contreras Rivero	SEDUMA	Director of Environmental Protection
Biól. Tomás Sánchez Cabrera	Municipality of OPB	Chief of the Department of Ecology
11. Regional Development Planning/Social Survey		
Ing. Gustavo Olivares Alanis	SEMARNAT-QR	Chief of the Planning and Environment Policy Area
Biól. Cedrela Median Gasca	SEDUMA	Director of Planning and Environmental Policy
Ing. Juventino Cartillo Pinzón	CAPA	Coordinator of Planning and Development
Arq. Roger Alvarado Rivero	Municipality of OPB	Department of Urban Development
12. Community Participation and Environmentla Education		
Biól. Teresa Jimémez Almaraz	SEMARNAT-QR	Chief of the Department of Environmental Education
M.C. Bárbara Reveles González	CONANP	Sub director of Chinchorro Shoal Biosphere Reservation and X'calak Reef National Park
Ing. Jorge Jiménez Alvarado	CAPA	Coordinator of Social Participation Area
Ing. Miguel Acopa	CAPA	Chief of Department of Social Participation
Lic. Salim Chamlati	CAPA	Professional Analyst
Biól. Manuel Hernández	SEDUMA	Director of Natural Protection Area, Sanctuary of the Manatee
Ing. José Grabriel McLiberty Pacheco	SEDUMA	Sub Secretary of the Environment Sub Secretary
Ing. Abigail Hernández Santiago	SEDUMA	Responsible of the Environmental Education Program
Alvaro Gorocica Polanco	SEDUMA	Assistant of the Environmental Education Program
Biól. Gonzalo Vidaña Espejo	Municipality of OPB	Director of Ecology
Biól. Lilibeth Arjona Pérez	Municipality of OPB	Chief of Projects and Environmental Office
Ing. Eduardo Escalante Rodríguez	Municipality of FCP	Director of Public Works
Biól. Juan Antonio Huerta Illescas	Municipality of Solidaridad	Director of Environment

1.5.5 Steering Committee

Members of the steering committee who made important decisions are listed below.

Name	Institution	Responsibility
Ing. José de Jesús Infante de Alba	SEMARNAT	Delegate of Quintana Roo
Lic. Francisco Hernández Franco	SEMARNAT	
Ing. Jorge Mariano Morales Calzada	SEDUMA	Ministry
Ing. Juan Manuel Herrera	Commission of Ecology, Forestry and Fishery	President
Ministro Gerardo Lozano	Ministry of Foreign Affairs	Director of technical cooperation
Ing. Francisco Aranguré Monroy	CNA	Delegate in Quintana Roo
Biól. Alfredo Arellano Guillermo	CONANP	Coordinator
Ing. Andrés Ruiz Morcillo	CAPA	General Director
Lic. Eduardo Espinosa Abuxapqui	Municipality of Othón P Blanco	Municipal President
Prof. Francisco Novelo Ordoñez	Municipality of Felipe Carrillo Puerto	Municipal President
C.P. Gabriel Mendicuti Díaz	Municipality de Solidaridad	Municipal President
Ar. Baltasar Linares Díaz	BANOBRAS	Delegate of Quintana Roo
Ing. María Antonia Hernández Rivas	FONATUR	Coordinator

1.6 Reports

The following reports were prepared and submitted to the Mexican side, followed by explanations and discussions.

Report		Language
Inception Report		English, Spanish
Progress Report（1）		English, Spanish
Interim Report		English, Spanish
Progress Report（2）		English, Spanish
Draft Final Report	Summary	English, Spanish, Japanese
	Main Report	English, Spanish
	Supporting Report	English, Spanish
Final Report	Summary	English, Spanish, Japanese
	Main Report	English, Spanish
	Supporting Report	English, Spanish

1.7 Technology Transfer

The following technology transfers were carried out during the Study period.

Technology Transfer	Target	Content	Frequency
On-the-job Training	Counterpart	Study method; analysis & evaluation of study results; problem identification; countermeasures; formulation & implementation of projects; formulation, implementation & evaluation of model projects, etc.	As needed during the Study period
Technical Discussions	Counterpart	Study policy & schedule, progress & results; plan formulation method; thinking for alternative plan formulation; selection method of the most appropriate plan; project evaluation method; presentation of sewerage treatment & solid waste management in Japan and other countries, etc.	Every other week
Explanation of Reports	Counterpart and Members of Steering Committee	Policy & results at each stage of the Study; problems & countermeasures, etc.	Five times: IC/R、P/R(1)、IT/R、P/R(2)、DF/R
Technology Transfer Seminar	Counterpart, Members of Steering Committee, NGOs, International Organizations, etc.	Knowledge & recommendations resulting from the Study	Three times, coinciding with DF/R explanation
Counterpart Training	Counterpart	Visit to facilities related with environmental sanitation management in Japan, increasing awareness on management methods and possible problems	Twice

2 Present Status of Environmental Sanitation

2.1 Profile of the Study Area

2.1.1 Natural Conditions

a. Location and Climate

The State is located in the Southeastern part of the country between the following coordinates: 21°37' and 17°53' latitude north, and 86°42' and 89°20' longitude west. Quintana Roo borders Yucatan State and the Gulf of Mexico to the north; the Caribbean Sea to the east; the Chetumal Bay and Belize to the south; and Campeche and Yucatan State to the west. [1]

The climate in the Study Area is classified as hot sub-humid and/or hot humid. The average temperature is 25.5 C°.

Table 1: Average Temperature in the Study Area

Units: °C

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Solidaridad	22.3	22.5	24.1	25.4	26.5	27.0	26.7	26.6	26.5	25.2	23.9	22.5	24.9
FCP	23.4	24.1	25.3	26.8	27.6	27.8	27.6	27.5	27.4	26.3	24.8	23.8	26.0
OPB	22.7	23.4	25.1	26.7	27.8	27.7	27.4	27.6	27.4	26.4	24.7	23.3	25.8
Benito Juárez	23	23	25	26	27.6	27.9	28.1	28.1	27.6	26.3	25	23	25.9
Lázaro Cárdenas	22	22	24	25	26.6	26.9	26.9	26.8	26.6	25.5	24	22	24.9
José Ma. Morelos	23	23	26	27	28.5	28.3	27.8	27.8	27.4	26.4	25	24	26.1
State Average	22.6	23.1	24.5	26.1	27.2	27.5	27.4	27.4	27.1	25.9	24.4	23.1	25.5

Source: elaborated by the S/T with data from CNA

The rainy season is considered to last between 6 and 7 months (from May to October/November) and the dry season is considered to last between 6 and 5 months (from November/December to April). The average precipitation in Quintana Roo State is approximately 500 mm higher than the national average (772 mm).

Table 2: Average Precipitation (1941-2001)

Unit: mm

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Quintana Roo	66	38	31	34	100	175	121	140	209	165	95	82	1 256
National	26	18	15	19	40	103	138	137	141	74	32	29	772

Source: Estadísticas del Agua en México, Edición 2003, SEMARNAT/CNA

[1] Geostatistical Framework, INEGI, 2000

b. Hydrogeology

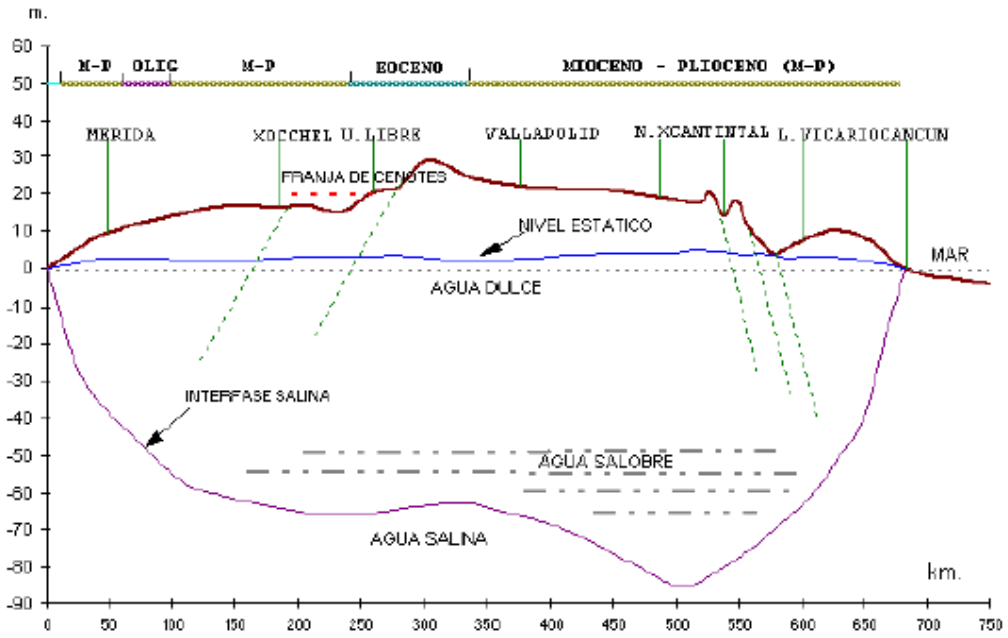
The Peninsula of Yucatan is a geologic unit composed mainly of limestone which is highly permeable and soluble. Dissolution of the rock has created a karst topography with sinkholes (*Cenote*).

High precipitation in the rainy season directly infiltrates underground through fractures and sinkholes, then flows through the porous and fractured media and finally discharges into the sea.

According to the structural geologic analysis, at least two aquifer regions are identified in Quintana Roo State. The first one is distributed in the southern part of the state. The second aquifer is distributed mainly in the eastern part along the coast and the northern part of the state.

The groundwater of these aquifers can be divided into three groups from a salinity point of view. They are fresh water, brackish water and seawater. A fresh water lens, resulting from the infiltration of rainwater, lies above a brackish water zone, which overlies seawater. The content of salts dissolved in the groundwater increases with depth and its ionic concentration pattern finally becomes very similar to that presented in the seawater.

Figure 2 shows a schematic hydrogeological cross section in northern Yucatan Peninsula from Cancun to Mérida.



Fuente: CNA

Figure 2: Schematic Hydrogeological Cross Section in Northern Yucatan Peninsula

2.1.2 Population

a. Population

The population of Quintana Roo State in 2000 was 875,000 in total. An important characteristic of the Quintana Roo population is its distribution pattern. The population is dispersed in many small rural communities. It is vital to understand this population distribution structure for planning appropriate sanitation systems for respective communities.

Table 3: Population in the Study Area

Municipality	Population based on community size			Total
	Rural (1 – 2,499)	Semi urban (2,500 – 14,999)	Urban (15,000 -)	
Othón P. Blanco	63,307	23,225	121,602	208,134
Felipe Carrillo P.	33,657	8,163	18,545	60,365
Solidaridad	13,406	6,733	43,613	63,752
Number of Communities	1,245	8	3	1,256
Total Population	110,370	38,121	183,760	332,251
Percentage	33%	12%	55%	100%

Source; INEGI, 2000, XII Censo General de Población y Vivienda

b. Tourists

Quintana Roo State has abundant tropical forests, lagoons, bays, as well as culture and history, which attract tourists from all over the world. According to the state ministry of tourism, the number of incoming tourists is as follows.

Table 4: Number of incoming tourists in Quintana Roo

Year	1999	2000	2001	2002
Cancun	2,818,326	3,044,682	2,987,841	2,827,406
Cozumel	398,737	421,541	455,620	383,676
Chetumal	157,821	207,582	205,216	204,371
Isla Mujeres	140,534	144,793	141,785	141,548
Riviera Maya	767,541	1,184,249	1,504,052	1,793,864
Total	4,282,959	5,002,847	5,294,514	5,350,865

Source; State Ministry of Tourism, Quintana Roo

2.1.3 Regional Economy

Tourism development in Quintana Roo State during the past 30 years has had the effect of greatly improving the GRP of the State, as one-third of the tourism income of Mexico is estimated to be generated in Quintana Roo. The GRP of Quintana Roo State valued at 1993 prices was 14,847 Million Pesos in 1993 and 19,555 Million Pesos in 2000, implying a yearly growth rate of 4.0% between 1993 and 2000. This growth rate was slightly higher than the country as a whole during the same period. Sector performance differed, as the yearly growth rate was negative for the agriculture sector (-6.0%), while positive for the industrial sector

(1.8%) and the service sector (4.3%). The same data also indicated the increasing share of the service sector and the declining shares of the agriculture and industrial sectors in the GRP of Quintana Roo State between 1993 and 2000, as indicated in the following table.

Table 5: Gross Regional Product (GRP) of Quintana Roo State

Sector	GRP 1993 (Million Pesos)	GRP 2000 (Million Pesos)	1993 Sector Share (%)	2000 Sector Share (%)	1993-2000 Growth Rates (%)
Total GDP	14,847	19,555	100.0	100.0	4.0
Agriculture	275	178	1.8	0.9	-6.0
Industry	1,021	1,160	6.9	5.9	1.8
Service	13,551	18,217	91.3	93.2	4.3

Source: Anuario Estadistico 2002, Quintana Roo, INEGI

2.1.4 Land Use

A vast area of the territory is covered with forest and jungle, and is not highly utilized. Only a tiny portion of the state is intensively utilized. According to the official figure of the Quintana Roo government, the state area is 50,843km^2, in which the area inhabited by more than 2,500 populations, is only 9,832ha (0.2%).

Land use used to be controlled mainly by Federal (SEMARNAT) and State (SEDUMA) governments, and partially by Municipalities. However, this system of land use control was altered in 2000, giving much power to the Municipal government.

a. POET

Most of the coastal areas are controlled according to POET (Programa de Ordenamiento Ecológico), which illustrates detailed land use and restrictions. The following figure shows the location of areas covered by each POET and the covered area by PEOT & ANP (National Protected Area).

POET Bacalar is currently in process. Six other POETs are already enacted. In the Study area, there are the following three POETs.

1. Costa Maya area (6 oct. 2000)
2. Sian Ka'an Biosphere Reservation area (14 May 2002)
3. Cancun –Tulum Corridor (16 Nov.2001)

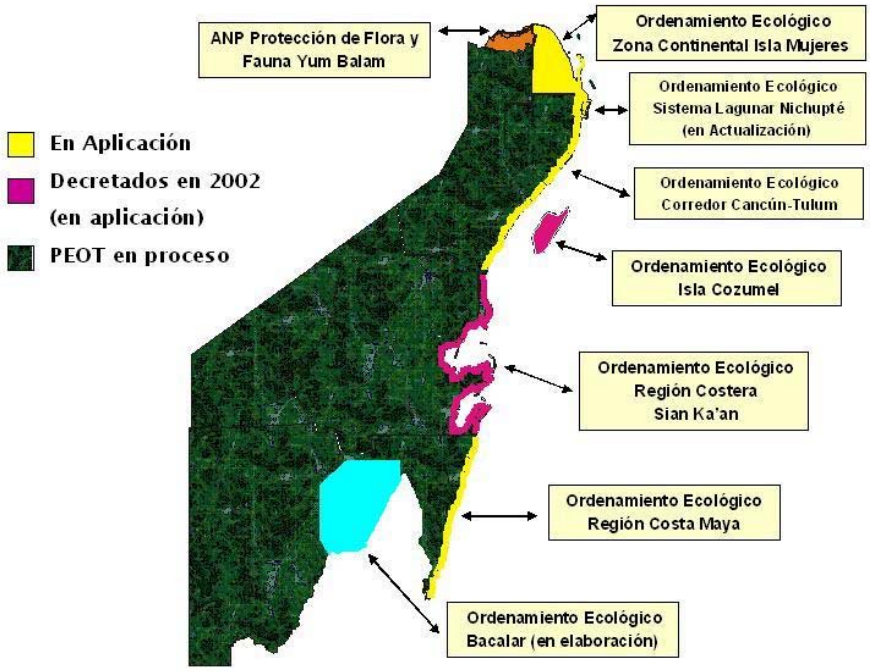


Figure 3: Location of POET area and PEOT coverage

b. Nature protection area

Besides the above, there are ten nature protection and conservation areas controlled by the federal government. Among the ten, the following five areas are within the Study area.

Table 6: Natural Protection Area under Federal Control in Study Area

	Category	Location	Date of Decree	Area (ha)
1	Archeological monument in Tulum (National Tulum Park)	Solidaridad	15 Dec 19989	691
2	Biosphere reservation of Sian Ka'an	Felipe C Puerto, Solidaridad	20 Jan 1986	528,147
3	Coral reef reservation of Sian Ka'an	Felipe C Puerto, Solidaridad	2 Feb 1998	34,927
4	Flora and fauna protection area in Uaymil	Felipe C Puerto, Othón P Blanco	17 Nov 1994	89,118
5	Biosphere reservation of Chinchorro coral reef	Othón P Blanco	19 Jul 1996	144,360
Total				797,243

Source: Gobierno del Estado de Quintana Roo

Quintana Roo State by itself designated six areas of natural protection. Among those, the following two areas are in the Study area.

Table 7: Natural Protection Area under State Control

	Category	Location	Date of Decree	Area (ha)
1	Ecological conservation zone, Sea turtle sanctuary	Xcacel-Xcacelito Solidaridad	21 Feb 1998	362
2	Ecological conservation zone, Manatee sanctuary	Chetumal bay Othón P Blanco	24 Oct 1996	281,320
Total				281,682

Source: Gobierno del Estado de Quintana Roo

2.2 Key Data of the Present Environmental Sanitation

2.2.1 Wastewater Management

Table 8 describes an outline of the sewer system and Table 9shows its service coverage.

Table 8: Outline of Sewer System

Item	State of Quintana Roo	Othon P. Blanco	Felipe C Puerto	Solidaridad
1. Basic item				
Area of administrative boundary (km2)	50,843	18,760	13,806	4,419
Population of administrative boundary	1,233,490	240,971	65,861	111,533
Service projected area (km2)	76.02	6.35	0.02	13.24
Water production amount (1,000 m3/year)	112,737.78	27,659.70	6,223.25	12,406.35
Effective (billing) water supply amount (1,000 m3/year)	45,700.42	7,200.32	1,405.47	3,946.38
Water supply population	1,171,816	234,000	57,220	105,600
Unit water production amount (l/day/person)	263.58	323.8	297.97	321.88
Effective Unit water supply amount (l/day/person)	106.84	84.3	66.39	102.39
Sewage generation rate for planning (l/person/day)	75% of water supply amount*			
Unit sewage pollution load (g/person/day) BOD	54	54	54	54
SS	52	52	52	52
2. Service projected and present served population for wastewater management				
Sewer system(off-site) Plan	372,994	38,851	567	37,091
Actual	370,955	37,044	567	6,655
On-site system Plan	-	589 (year2002)	0	1,767 (year2002)
Actual	-	0	0	0
Latrine system Plan	0	0	0	0
Actual	Not available	Not available	Not available	not available
No-system Plan	-	167,338	56,653	5,006
Actual	800,861	169,045	56,653	35,442
3. Off site sewer system				
Responsible authority	C.A.P.A.			
Construction	C.A.PA.			
O & M	ORG. OPER.			
Service area (km2)	62.38	5.81	0.02	8.23
Service population	370,955	37,044	567	6,655
Number of connections	90,698	8,799	114	1,770
Service coverage rate (population)	30.07	39.23	2.88	25.59
Length of pipe line	1,088,376	444,528	6,804	79,860
Number of pump station	-	12	0	3
STP intake amount (lps)	1,251.83	20.48	1.34	64.21
Sewage production per capita	291.6	47.8	204.2	2,024,927
Sewage treatment plant (STP)				
Number of STP	16	1	1	3
Treatment method	Activated sludge			
Treatment Capacity	1,432	137	5	65
Annual average intake amount				
Intake waste quality (Jan. to June/2003) BOD	-	139	100.8	322.89
COD	-	393	249.99	507.27
SS	-	265	68.33	455
Treated water quality (Jan. to June/2003) BOD		1.90	2.15	11.18
COD		39.90	12.64	55.19
SS		2.00	6.00	19

Source : CAPA July 2003, * Manual de Agua Potable, Alcantrillado y Saneamiento Ver 2.0, 2001, CNA

Table 9: Service Coverage of Sewer System in 2000

Municipality	City	Population	Service coverage		
			Water supply	Sewer line	Sewage treatment capacity
OTHON P. BLANCO	CHETUMAL	118,553	96%	50%	40%
	BACALAR	9,047	88%	0%	0%
	CALDERITAS	4,617	92%	0%	0%
	INGENIO ALVARO OBREGON	3,331	97%	0%	0%
	NICOLAS BRAVO	3,524	92%	0%	0%
	ALVARO OBREGON	3,019	91%	0%	0%
	SERGIO BUTRON CASAS	2,712	98%	0%	0%
	Total	144,803	95%	41%	33%
FELIPE CARRILLO PUERTO	FELIPE CARRILLO PUERTO	17,690	86%	0%	0%
	CHUNHUHUB	4,338	86%	38%	0%
	TIHOSUCO	4,188	93%	0%	0%
	Total	26,216	87%	6%	0%
SOLIDARIDAD	PLAYA DEL CARMEN	39,005	50%	30%	15%(21.9%*)
	TULUM	7,975	79%	0%	0%
	Total	46,980	55%	25%	13%
State total		720,567	95%	57%	73%

Source: CAPA Plan Estratégico APAS 2001-2025, * EVALUACIÓN SOCIOECONÓMICA PROYECTO DE REHABILITACIÓN DE LA PLANTA DE TRATAMIENTO DE AGU RESIDUALES DE PLAYA DEL CARMEN, SOLIDARIDAD, QUINTANA ROO, MAYO DE 2002/ CNA

2.2.2 Solid Waste Management

The table below shows key data on Solid Waste Management.

Table 10: Present Situation of Solid Waste Management

Item	Othon P Blanco	Felipe C Puerto	Solidaridad
Section in charge	Direction Office of Municipal Public Services	Direction Office of Municipal Public Services	Private contractor
Served area	The service is aimed at mainly the city of Chetumal, but the following communities also have irregular services; Subteniengte Lopez, Xul-Ha, Huay-Pix, Rqudales, Laguna Guerrero, Luis Echeverria, Bacalar, Nicolas Bravo, Calderitas, Javier Rojo Gomez, Alvaro Obregon, Mahahual	Felipe C Puerto City	Playa del Carmen, Tulum, other tourism locations
Service coverage	57%	18%	82%
Storage & discharge	supermarket plastic bag, plastic container, drum	bag, drum	plastic bag, drum, containers for separate collection (Playa del Carmen)
Collection frequency	daily for down town, three times a week for residential area (Chetumal)	daily for down town, three times a week for residential area	various; daily to once a week
method	door to door	door to door	door to door
routes and vehicles	31 collection routes with 17 vehicles, 10 vehicles for special works, vehicles are generally in poor condition	two vehicles in poor condition	16 collection routes with eight vehicles
Transport	direct haulage	direct haulage	direct haulage
Disposal	1) One open dump in Calderitas 15km from the city center, 2 bulldozers are assigned to the site but in poor condition 2) Several open dumps in local communities	One open dump, 6 km from the city center	1) Landfill with gas control, 13 km from Playa del Carmen 2) Open dump, 8km from Tulm 3) Abandoned open dump in Akumal
Sweeping	50% of avenues in Chetumal is covered with manual and mechanical sweeping	Down town is covered with manual sweeping	Down town of Playa del Carmen is covered
No of employees	collection 150, sweeping 75, disposal 5	collection 8	Private contractor 79

2.2.3 Groundwater Management

a. Wells

The table below shows the number of registered extraction and injection wells in the Study Area.

Table 11: Number of Registered Wells

Item	Othon P Blanco	Felipe C Puerto	Solidaridad
1. Extraction well			
Pubic water supply	147	74	29
Aguriculture	658	336	35
Service sector	209	4	129
Others		35	29
Total	1,014	449	222
2. Injection well			
Pubic sewer	2	1	2
Service sector	82	20	169
Others	7		13
Total	91	21	184

b. Present Status of Monitoring

There are no CNA monitoring wells in the municipality of Othon P.Blanco. However, CAPA regularly conducts monitoring of water quality. Parameters monitored are, $CaCO_3$, chloride, alkalinity, acid degree, pH, colour, electric conductivity, temperature, turbidity, TDS and coliform. In addition to monitoring groundwater, the navy carried out monitoring of surface water in Chetumal Bay and Lake Bacalar Area.

In Felipe C Puerto, CNA has not yet constructed monitoring wells. CAPA is conducting water analysis of the production wells at six (6) month intervals.

In Solidaridad, thirty (30) monitoring wells have been installed recently by CNA. Water levels and quality can be monitored in the coastal area of Solidaridad.

2.3 Assessment of the Present Situation and Confirmation of Key Problems

An assessment of the present situation and key problems describing what the present situation should be in the future are presented in this section.

2.3.1 Wastewater Management

The table below presents an assessment of the present situation and key problems in the field of wastewater management.

Table 12: Assessment and Key Problems in Wastewater Management

No.	Assessment	Key Problems
10	State level	
101	• Various observations on coastal water bodies and freshwater bodies in and around the study area have been carried out by various institutions. The navy conducts periodical and fixed point observation targeting those water bodies. CAPA carries out periodical observations on wells such as hardness of water for water supply source management. CNA studies groundwater in Riviera Maya where the tourist industry has been developed rapidly and many injection wells of wastewater exist.	A system to integrate data and activities carried out by various institutions should be established.
102	• CNA intends to create new regulations or modify existing regulations on wastewater management in order to make them suitable to specific geological conditions, i.e. limestone terrain, of the Yucatan Peninsula. • Hotels are large water consumers and wastewater dischargers. Wastewater treatment facilities in hotels are not necessarily sufficient.	It should be considered necessity of specific regulation on wastewater management with purpose to protect groundwater.
103	• It has been established as CAPA's policy to be a leading organization in the water supply and wastewater sector based on the quality of its service and implementation of the best technical, commercial, and administrative processes. It is also intended to attain operational, economic, and financial self-sufficiency with the purpose to contribute to the development of the State. • The document called "Manual de Organización y Procedimientos" was elaborated by a consultant firm contracted by CAPA. If it is implemented and applied, it could result in an improvement of efficiency in general. • CAPA has numerous data and this makes it possible to implement an evaluation indicator system. For this purpose, the consultantship proposed a General Evaluation System which includes infrastructure and coverage indicators, income and operative and commercial efficiencies.	CAPA is likely to be on the right track. It is recommendable to implement what they have planned.
11	Othon P Blanco	
111	• BOD generation and discharge to the environment in Othon P Blanco are the highest of the three municipalities. • Only Chetumal has a population that makes up about 60% of the total population of the municipality. • CAPA has constructed about 8,800 connection pits that connect house drainage to the sewers. However, it is estimated that about 1,500 houses actually have a connection.	Connection of house drainage to the sewers should be urgently promoted in Chetumal
112	• Although there exists no operating sewerage system in the rural area at present, CAPA has begun to introduce a system. However, there is concern that the same problem of connection to	Appropriate technology for rural and semi-urban areas should be established to reduce the pollution load from the

No.	Assessment	Key Problems
	house drainage as in Chetumal will appear. A countermeasure to solve this problem is expected. • Design parameters of the system are based on literature, not based on actual operation. Therefore, it is necessary to obtain the parameters through actual operation and to establish an operation manner. • The sewage system mentioned above targets communities that have certain population density. Alternatives for smaller communities should be considered.	areas
113	• The water supply and sewer services in Othon P. Blanco Municipality have resulted in financial deficits during the past three years. • The low rate of micro-metering restricts the potential application of progressive water rates. • Resources are scarce by definition. Being realistic, it will likely be more and more difficult to depend on higher levels of government to finance all necessary services. • To persuade service users to pay their share of service costs, it is easier when service users are relatively satisfied with the service. • Fortunately, the CAPA head office has plans to complete installation of water meters (micro-metering) within the next two years.	The financial status of water supply and sewer services in Othon P Blanco conducted by CAPA should be improved. This could be achieved through improvement of the water supply service; application of existing water rates through micro-metering, reduction in unaccounted for water, and improvement in water quality. These efforts should be monitored through selected performance indicators.
114	• In the Municipality of Othon P Blanco, environment education is given separately by a number of agencies such as SEDUMA, CAPA, the Municipality of Othon P. Blanco and NGOs. • There are few programs directed specifically at wastewater management with the objective of preserving the environment. Society as a whole can barely grasp the magnitude of environmental sanitation problems; as a result, limited participation from the population in wastewater management and modest public awareness on environmental issues has been observed.	Various organizations, SEMARNAT, SEDUMA, CAPA, the Municipality, NGO, etc., should join efforts and work together as a team to disseminate knowledge through concrete practices with the participation of the community starting with schoolchildren and communities in general.
12	Felipe C Puerto	
121	• An off-site system is operating in an area of Felipe C Puerto City, which targets only 567 residents. This leads to sewerage service coverage of 3% for the city's population and 1% for the total municipal population. • A sewage treatment plant in Felipe C Puerto City has a capacity of 5 liters/sec (432m3/day). However, actual inflow is 1.34 liters/sec (116 m3/day) or 27% of the rated capacity.	Wastewater in the city of FCP should be collected up to the rated capacity of the existing treatment plant and the sewerage system should be expanded.
122	• There exists no operating sewerage system in the rural area at present. As the population of communities having between 100 and 2,500 residents makes up more than 50% of the total population of the municipality, certain adequate measures should be taken to improve the situation.	Appropriate technology for rural and semi-urban areas should be established to reduce the pollution load from the areas.
123	The water supply service in Felipe Carrillo Puerto Municipality has not paid for itself during the past three years. • The low rate of micro-metering restricts the potential application of progressive water rates. • Resources are scarce by definition. Being realistic, it will likely be more and more difficult to depend on the higher levels of government to finance all necessary services. • To persuade service users to pay their share of service costs, it is easier when service users are relatively satisfied with the service. • Fortunately, the CAPA head office has plans to complete installation of water meters (micro-metering) within the next two years.	The financial status of water supply and sewer services conducted by CAPA should be improved. This could be achieved through improvement of the water supply service; application of existing water rates through micro-metering, reduction in unaccounted for water, and improvement in water quality. These efforts should be monitored through selected performance indicators.

No.	Assessment	Key Problems
124	• Latrine programs have been carried out in the past in some communities. However, due to adaptation problems and inadequate management and maintenance of the latrines, outdoor defecation is still practiced. Infection and contamination due to outdoor defecation and inappropriately located latrines, as well as animals in the urban areas are the main causes of gastrointestinal diseases.	Appropriate use of latrines in the rural area should be disseminated.
13	Solidaridad	
131	• Only Playa del Carmen has a population that makes up about 68% of total population of the municipality. • In Playa del Carmen, actual inflow almost reaches the rated capacity of the plant and expansion and/or construction of a sewage treatment plant is urgent. In order to cope with this situation, CAPA has a plan to construct a plant with a capacity of 360 liters/sec (31,110 m^3/day).	A new treatment plant should be constructed and operated to cope with increasing demand.
132	• There exists no operating sewerage system in the rural area at present. However, CAPA will begin to introduce a sewerage system in the rural area and get to work on a small scale collective sewage treatment facility and a sewer system in Puerto Aventuras and Akumal in Riviera Maya. • Design parameters of the system are based on literature, not based on actual operation. Therefore, it is necessary to obtain the parameters through actual operation and to establish an operation manner. • The sewage system mentioned above targets communities with a certain population density. Alternatives for smaller communities should be considered.	Appropriate technology for rural and semi-urban areas should be established to reduce the pollution load from the areas.
133	• The water supply and sewer service in Solidaridad Municipality showed positive financial results during the past three years. • The financial sufficiency of water supply and sewer services in Solidaridad Municipality may be attributable to a relatively high micro-metering rate of 56%, as well as to the 132 hotels identified in the area. • Financial self-sufficiency should not lead to complacency, as the situation can change quickly. The present favourable situation is the time to establish the mechanism to monitor and improve the service on a permanent basis. • Solidaridad Municipality will further benefit from the CAPA head office plans to complete installation of water meters (micro-metering) within the next 2 years.	The good financial status should be sustained through improvement of the application of existing water rates, expansion of micro-metering, careful watch on unaccounted for water, and constant improvement of water quality. These efforts should be monitored through selected performance indicators.

2.3.2 Solid Waste Management

The table below presents an assessment of the present situation and key problems in the field of solid waste management.

Table 13: Assessment and Key Problems in Solid Waste Management

No.	Assessment	Key Problems
20	State Level	
201	• New and various requirements in SWM have arisen along with economic development such as collection services for the growing population, sanitary landfilling and recycling; however, the municipalities do not have sufficient capacity to meet the requirements. • There is a framework where the state government through SEDUMA supports the municipalities, although it cannot be said that it functions well. • The new requirements need large finance. The municipalities can only access the financial resources through the state government.	The framework where the state government and the municipalities collaborate on SWM should be encouraged in order to cope with the new requirements.
202	• The municipalities have problems in final disposal. SEDUMA carries out projects for constructing new sanitary landfills in Chetumal, Felipe C Puerto and Tulum to cope with this situation. • The project in Chetumal is preferable for the municipality. However, it may be difficult to realize the other projects. Felipe C Puerto has pointed out high operational costs of the landfill, for which the municipality could not afford. An important aquifer may exist around the project site in Tulum. • None of the projects considers improvement of the current operation manner, closure or remediation of existing and abandoned dumping sites. They are important issues to realize sanitary landfilling in the study area, as it is very difficult to jump up from the bottom to the top at once technically and financially.	Final disposal in the municipalities should be improved. The projects conducted by SEDUMA for new landfills construction in Chetumal, Felipe C Puerto and Tulum, shall proceed. However, they may need to take into consideration respective conditions of municipalities, especially Felipe C Puerto and Solidaridad. The current manner of the disposal operation should be improved. Closure and remediation of existing and abandoned dumping sites should be planned and implemented.
21	Othon P Blanco	
211	• The waste collection works are well carried out; however, there are some threats that may cause a deterioration of the current situation, i.e. the unbalanced collection route design gives too big a workload on collection vehicles and does not allow them to receive appropriate maintenance, and the long duration to obtain spare parts keeps the collection vehicles out of service and money is lost. • The final disposal amount at the site of Calderitas recorded by the municipality, about 9,000 tons of waste per month (300 tons/day), is far beyond the estimated disposal waste amount, 120 tons/day. Knowing the correct disposal amount is fundamental not only for planning the operation schedule but also for controlling operation costs. The waste amount should be recorded correctly. • Income from the solid waste service in Othon P Blanco Municipality covered only 8% of service costs in 2002. Even if the solid waste service continues within the municipal system, justification to secure or increase its budget can be more convincing if specific cost figures are used. Therefore, careful record-keeping of all service activities becomes essential to translate them into cost figures. The records will permit preparation of performance indicators of a diverse nature, operational-commercial-financial, which can be constantly monitored as a way to improve efficiency and effectiveness of the solid waste service. The expected end result will be improved finances of the solid waste management service.	The management capability of the municipality should be strengthened by careful record-keeping and the introduction of indicators in order to provide stable, effective and efficient SWM services.
212	• The disposal site in Calderitas presents serious sanitary and environmental risks, including the proliferation of insects and animals, fire, leachate, etc.	The existing disposal site in Calderitas should be improved.

No.	Assessment	Key Problems
213	• There exist open dumpsites around small towns such as Bacalar. Although the degree of adverse sanitary and environmental impacts is not yet significant compared with the dumpsite in Calderitas, it may become considerable along with development in the future.	Sound solid waste management including an appropriate final disposal system should be established in small towns.
214	• The municipality shows an interest in composting. Recycling activities including composting are a good method of encouraging resource conservation. However, they should be implemented based on financial feasibility to sustain their operation.	Introduction of composting should be considered chiefly from a viewpoint of financial feasibility.
215	• In addition to the existing problems in solid waste management, new problems will arise in Costa Maya where large-scale development of tourism is expected in the near future.	A solid waste management system in COSTA MAYA should be established with participation of the tourism sector in order to cope with demands derived from its development.
216	• In the Municipality of Othon P Blanco, environment education is given separately by a number of agencies such as SEDUMA, CAPA, the Municipality of Othon P Blanco and NGOs. However, there are few programs directed specifically at solid waste management. Society as a whole can barely grasp the magnitude of environmental sanitation problems. Modest public awareness on environmental issues has been observed.	The organizations (SEMARNAT, SEDUMA, CAPA, the Municipality, NGOs, etc.) should join efforts and work together as a team to disseminate knowledge through concrete practices with the participation of the community starting with schoolchildren and communities in general.
22	Felipe C Puerto	
221	• The waste collection service is only provided to the city of Felipe C Puerto. Fifty percent of the residents of the city are covered by the service. This is quite a low service coverage for a city. The low service coverage reflects what clandestine waste dumping can be found in many places of the city. • The poor status of collection vehicles makes it difficult to provide proper waste collection services.	The collection service coverage in the city of Chetumal should be improved.
222	• Municipal records say that about 30 tons of waste is collected and disposed of every day. However, the estimated collection and disposal waste amount is around 10 tons/day. This misunderstanding may lead to improper planning and operation. The correct waste amount should be recorded. • The issue is the financial deficit of solid waste management services. Felipe Carrillo Puerto Municipality is provided with the service free of charge. No solid waste service charges have been established up to the present. Even if the solid waste service continues within the municipal system, justification to secure or increase its budget can be more convincing if cost figures are used. Therefore, careful record-keeping of all service activities becomes essential to translate them into cost figures. The records will permit preparation of performance indicators of a diverse nature, operational-commercial-financial, which can be constantly monitored as a way to improve efficiency and effectiveness of the solid waste service. The expected end result will be improved finances of the solid waste management service.	The management capability of the municipality should be strengthened by careful record-keeping and the introduction of indicators in order to provide stable, effective and efficient SWM services.
223	• The current disposal site is an uncontrolled open dump. It causes several problems such as fire, odor, proliferation of insects and animals, air pollution, groundwater contamination, etc.	The current dump site should be improved immediately, taking into consideration lack of capability of the municipality.
224	• Hospital waste is collected separately from the ordinary waste collection service. However, it is disposed of with the ordinary waste. In order to minimize the spread of diseases, the hospital waste should be carefully and separately disposed of.	Hospital waste should be carefully and separately disposed of.

No.	Assessment	Key Problems
225	• There are few environmental education activities on solid waste management developed in Felipe Carrillo Puerto. In many areas in the periphery of the city of Felipe Carrillo Puerto, materials such as plastic bags and plastic bottles are seen scattered in the streets and open areas. Modest public awareness on environmental issues is one of causes of the situation.	Public awareness on environmental issues should be encouraged.
23	Solidaridad	
231	• There are two abandoned dump sites in the municipality, which have awful sanitary and environment conditions.	The two abandoned dump sites should be closed properly and immediately.
232	• In the municipality, several recycling activities have been carried out. This should be appreciated. However, some of them reportedly failed due to lack of finance.	Financial feasibility should be taken into account for sustaining recycling activities.
233	• New solid waste service charges were established in January 2003, which appear to be comprehensive enough to cover the different types of service users; however, there may have been unforeseen administrative obstacles in the application of these user charges during the initial stage. Perhaps service users are not familiar with these user charges, despite being published in an Official Gazette, and are therefore reluctant to pay.	Income should be improved by facilitating the application of service charges established in January 2003.
234	• The Municipality of Solidaridad has carried out a series of activities including environmental education, training and events related to solid waste management with the participation of schools and a private company. Most of the activities were developed in Playa del Carmen and in the coastal areas of Riviera Maya where no big solid waste problems are observed. However, in some towns scattered waste is observed mainly in open lands. This situation indicates that in spite of the effort deployed by the municipality, community participation is still required.	Community participation in SWM should be encouraged in small towns.

2.3.3 Groundwater Management

The table below presents an assessment of the situation and key problems in the field of groundwater management.

Table 14: Assessment and Key Problems in Groundwater Management

No.	Assessment	Key Problems
301	• A well inventory of the Study Area is kept on the computer of CNA. However, the design of registered wells and geologic log at the time of construction are not submitted and stored in the inventory. These data are important as a basis for construction of groundwater management tools, such as a hydro-geological map, cross sections and computer groundwater models. Particularly important are those of the injection wells.	Well design and geologic log data at the time of construction should be kept and maintained.
302	• Although the inventory has the concession water amount of the well, the actual amount of extraction and injection is not recorded. At least once a year, the users should report the actual amount as well as its water quality.	The actual extracted and injected water amount should be recorded.
303	• CNA should conduct a regular inspection on the actual amount of water extracted and injected in the selected wells and their water quality at least once a year. • Groundwater monitoring wells have been constructed recently in the area of Cancun-Tulum. Water levels and water quality are regularly checked manually at a 6 months interval. It is not necessary to install automatic water level and quality recorders for all the wells at present. However, several selected wells should be monitored automatically.	Inspection and monitoring system on water quality of wells should be established.
304	• Many injection wells have already been operated in the Study Area. However, an injection standard has not been established.	A standard for injection wells should be established and enforced.

3 Formulation of Master Plan

3.1 Planning Frameworks

3.1.1 Future Developments

"*Programa Estatal de Desarrollo Urbano del Estado de Quintana Roo* (PEDU)" was officially published in "*Periódico Oficial del Gobierno del Estado de Quintana Roo*" on 22 April 2002. This program develops a scenario where overdevelopment in the north of the state is to be limited by POETs (*Programa de Ordenamiento Ecológico*) covering the region, and the south is to grow with a balance between development and environment conservation, such as low impact tourism, according to POETs covering the area. The program estimates how communities are to develop in the future. In this Study, the program is considered as a kind of superior plan.

3.1.2 Future Population

a. Residential Population

The forecasted future population is shown in the table below.

Table 15: Population Forecast

Municipality	2003	2005	2010	2015
OTHON P BLANCO	228,683	269,647	358,299	415,189
FELIPE CARRILLO PUERTO	63,616	66,149	70,661	73,901
SOLIDARIDAD	142,666	204,049	311,429	403,704
Total	434,965	539,845	740,389	892,794

b. Number of Tourists

The forecasted number of tourists is shown in the table below.

Table 16: Number of Tourists (Forecast)

Year	2003	2005	2010	2015
Costa Maya	80,468	217,000	221,000	225,000
Playa del Carmen	916,396	1,061,244	1,389,659	1,669,924
Aventuras – Akumal	637,791	732,149	873,206	960,403
Tulum	122,838	146,078	215,273	300,318
Total	1,757,493	2,156,471	2,699,138	3,155,645

3.1.3 Future Wastewater Amount and Quality

a. Wastewater Generation Rate

Wastewater generation rate is defined based on a manual of CNA[2]. The manual recommends employing 75% of the design water supply rate as the wastewater generation rate for planning of sewerage facilities. It also recommends the water supply rate depending on climate.

In planning the Master Plan, 230 liters/person/day is considered as the water supply rate as the Study Area belongs to a "Hot climate." Therefore, 173 liters/person/day of the wastewater generation rate is obtained as follows.

$$q = 230(liter / person / day) \times 75\% = 173(liter / person / day)$$

b. Wastewater Amount

Table 17 shows the wastewater generation amount in the future obtained from the wastewater generation rate and future population forecast.

Table 17: Summary of Wastewater Generation Amount

Unit: m^3/day

MUNICIPALITY	2003	2005	2010	2015
OTHON P. BLANCO	39,813.7	47,326.7	62,676.2	72,529.8
FELIPE CARRILLO PUERTO	11,005.3	11,444.0	12,223.9	12,784.9
SOLIDARIDAD	29,920.0	41,358.4	61,614.6	78,991.5
Total	80,739.0	100,129.1	136,514.7	164,306.2

c. Future Wastewater Quality

The manual of CNA also defines pollutant load rates. With the pollutant load rates and the wastewater generation rate, wastewater quality is assumed as shown in the table below.

Table 18: Pollutant Load Rate

Item	Pollutant Load Rate (g/person/day)	Water Quality (mg/liter)
BOD	54	312
COD	110	636
SS	52	300
T-N	8	46
T-P	4.60	27

Source: Manual de Agua Potable, Alcantarillado y Saneamiento, Ver3.0, 2001 CNA II-3.-4.2

[2] Manual de Agua Potable, Alcantarillado y Saneamiento, Ver 3.0, 2001 CNA

3.1.4 Future Waste Amount and Composition

a. Waste Generation Rate

a.1 Households Waste

Generation rates of household waste are set as shown in the table below.

Table 19: Household Waste Generation Rate

Municipality	Waste generation rate (g/person/day)
OTHON P. BLANCO	970
FELIPE CARRILLO PUERTO	802
SOLIDARIDAD	970

a.2 Non-household Waste

A rate of 601.0 g/day/EAP(economic activity population) is employed in the planning as the non-household waste generation rate.

a.3 Waste Generation Rate per Tourist

The same waste generation rate as that of households is employed for tourists.

b. Waste Composition

Future waste composition is estimated as shown in the table below.

Table 20: Waste Composition

Composition	Portion %
Paper	14.08
Kitchen waste	18.74
Textile	13.52
Grass & wood (garden waste)	17.19
Plastic	5.93
Rubber & leather	7.31
Metal	4.19
Glasses	8.67
Soil, stone, ceramic	7.06
Others	3.32
Total	100.00

c. Bulk Density

A bulk density of 0.169 at the generation point is employed in this planning.

d. Future Waste Amount

Table 21 shows an estimation of waste generation amounts in the future.

Table 21: Waste Generation Amount in the Future

Category	Year	Othon P Blanco	Felipe C Puerto	Solidaridad	Total
Household (ton/day)	2003	221.83	51.01	138.39	411.22
	2005	261.56	53.05	197.93	512.54
	2010	347.55	56.67	302.09	706.31
	2015	402.74	59.27	391.59	853.60
Non-household (ton/day)	2003	42.20	10.60	25.90	78.70
	2005	46.01	11.10	34.20	91.31
	2010	59.44	12.40	55.10	126.94
	2015	72.33	13.40	73.80	159.53
Tourist (ton/day)	2003	1.50	-	29.40	30.90
	2005	3.80	-	33.90	37.70
	2010	4.00	-	43.40	47.40
	2015	4.00	-	51.40	55.40
Total (ton/day)	2003	265.52	61.61	193.69	520.82
	2005	311.37	64.15	266.03	641.55
	2010	410.99	69.07	400.59	880.65
	2015	479.06	72.67	516.79	1,068.52

3.2 Threats in the Future

On the basis of understanding the present situation of environmental sanitation, it is confirmed that if the situation is left as it is and the development of tourism proceeds, the groundwater, which is the only source of water supply and has links between other aquatic environments, will face the threats of pollution and depletion. Therefore, it will be a significant factor in hampering sustainable development of the study area in the future as shown in Figure 4.

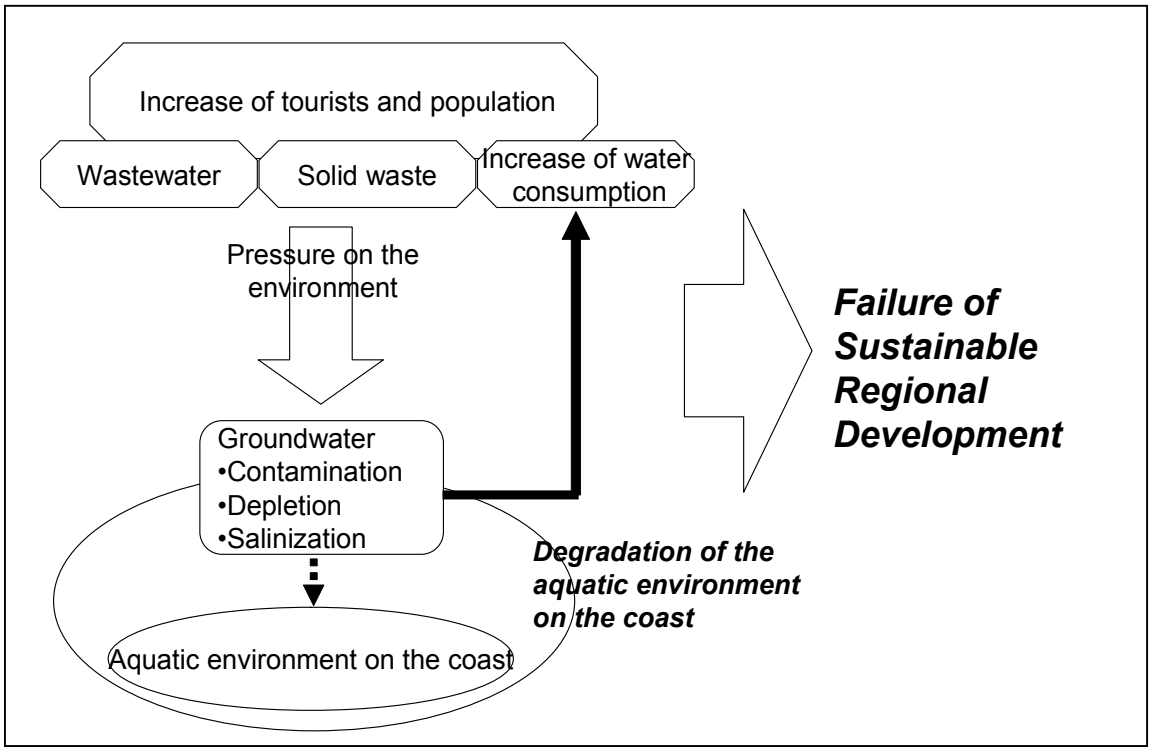


Figure 4: Groundwater and Sustainable Development

If no new measures are taken in the WWM and the SWM in the future, the amount of BOD discharged into the environment will increase from about 13 thousand tons in 2003 to about 26 thousand tons in 2015 as shown in Table 22. The BOD concentration in the groundwater is estimated to increase up to 4.9 mg/liter in 2015.

The question is what degree of pollution is a BOD concentration of 4.9 mg/liter. As there are no environmental standards for public water bodies in Mexico, the standards in Japan are taken up as a reference. A BOD concentration of 4.9 mg/liter is categorized in Class B, being very close to Class C (See Table 24 and Table 25). Class C is defined as a waste body that requires sophisticated purification to be used as a water supply.

Consequently, it was found that the groundwater would be so severely contaminated as to deteriorate the coastal aquatic environment, if no measures were taken in environmental sanitation management, or WWM and SWM.

Table 22: BOD Discharge Amount to the Environment

Unit: ton/year

Item	2003	2005	2010	2015
Wastewater				
OTHON P. BLANCO	4,397.1	5,227.5	6,922.2	8,010.5
FELIPE CARRILLO PUERTO	1,250.4	1,299.3	1,388.4	1,451.8
SOLIDARIDAD	1,446.7	1,999.7	2,979.2	3,819.3
Total	**7,094.2**	**8,526.5**	**11,289.8**	**13,281.6**
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	7,522.9	8,892.5	11,759.9	13,649.7
FELIPE CARRILLO PUERTO	1,975.9	2,054.0	2,201.4	2,307.3
SOLIDARIDAD	3,726.7	5,130.7	7,694.5	9,902.6
Total	**13,225.5**	**16,077.2**	**21,655.8**	**25,859.6**

Table 23: Estimated BOD Concentration of Groundwater

Unit: mg/litre

Wastewater	2003	2005	2010	2015
From wastewater filed				
OTHON P. BLANCO	2.4	2.8	3.7	4.3
FELIPE CARRILLO PUERTO	0.5	0.5	0.6	0.6
SOLIDARIDAD	1.6	2.2	3.3	4.3
Total	**1.4**	**1.6**	**2.2**	**2.5**
From solid waste filed				
OTHON P. BLANCO	1.7	2	2.6	3
FELIPE CARRILLO PUERTO	0.3	0.3	0.3	0.3
SOLIDARIDAD	2.6	3.5	5.3	6.8
Total	**1.2**	**1.4**	**2**	**2.4**
Overall				
OTHON P. BLANCO	4.0	4.8	6.3	7.3
FELIPE CARRILLO PUERTO	0.8	0.8	0.9	0.9
SOLIDARIDAD	4.2	5.7	8.6	11.1
Total	**2.5**	**3.1**	**4.1**	**4.9**

Table 24: Environmental Standards for Public Water Bodies (Rivers) in Japan

Class	Water usage	pH	BOD mg/liter	SS mg/liter	DO mg/liter	Total coliform MPN/100ml
AA	• Water supply class 1 • Conservation natural environment • Usages list in A-E	6.5 to 8.5	1 or less	25 or less	7.5 or more	50 or less
A	• Water supply class 2 • Fisher class 1 • Usages list in B-E	6.5 to 8.5	2 or less	25 or less	7.5 or more	1,000 or less
B	• Water supply class 3 • Fisher class 2 • Usages list in C-E	6.5 to 8.5	3 or less	25 or less	5 or more	5,000 or less
C	• Fisher class 3 • Industrial water class 1 • Usages list in D-E	6.5 to 8.5	5 or less	50 or less	5 or more	-
D	• Industrial water class 2 • Conservation natural environment • Usages list in E	6.5 to 8.5	8 or less	100 or less	2 or more	-
E	• Industrial water class 3 • Conservation of the environment	6.0 to 8.5	10 or less	Floating matter such as garbage should be observed	2 or more	-

Source: Water Environment in Japan, Ministry of Environment in Japan

Table 25: Definitions of Water Usage to Environmental Standard of Public Water Body (River) in Japan

Item	Definitions
Conservation natural environment	Conservation of natural environment for natural sightseeing purposes (e.g. Natural park, world natural heritage, etc)
Water supply class 1	Water source for drinkable water production by low level water purification (e.g. sand filter, etc.)
Water supply class 2	Water source for drinkable water production by normal level water purification (e.g. chemical settling and sand filter, etc.)
Water supply class 3	Water source for drinkable water production by advanced level water purification (e.g. chemical settling and sand filter with activated carbon absorption, etc.)
Fisher class 1	Highly oligotrophic water body
Fisher class 2	Oligotrophic water body
Fisher class 2	Intermediate between eutrophic and oligotrophic water body
Industrial water class 1	Water source for industrial water production by normal level water purification (e.g. simple settling, etc.)
Industrial water class 2	Water source for industrial water production by advanced level water purification (e.g. chemical settling, etc.)
Industrial water class 3	Water source for industrial water production by special level water purification
Conservation of the environment	No sickening for living environment

3.3 Selection of Optimum Technical System

3.3.1 Consideration of Principal Objective

The 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,

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

Meanwhile, it has so far been understood that the pollution load originating from the WWM and SWM sectors on groundwater is the most significant environmental impact due to the geological characteristics of the Study Area. Therefore, the preservation of groundwater from the pollution load should be focused on, 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 the pollution load originating 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 originate from domestic activities and BOD is the most common indicator to evaluate the pollution load caused by domestic activities. The BOD amount is closely related to other pollutants such as coliform, nitrogen and phosphorus. Therefore, control of the BOD amount leads to controlling other pollutants.

As mentioned previously, the environmental standards in Japan for public water bodies defines Class AA for natural environment conservation, of which the BOD concentration is 1 mg/liter and below. It is proposed to refer to this standard to preserve the coastal aquatic environment in the Study Area. The proposal is as follows.

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

The proposed upper limits of the BOD discharge amount are 3,132.3 tons/year for the WWM sector and 2,104.7 tons/year for the SWM sector.

Table 26: 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

3.3.2 Selection of an Optimum Technical System in Wastewater Management

Setting up ***"BOD discharge amount originated from wastewater is to be less than 3,100 ton/year by 2015"*** as the minimum requirement, various treatment level and treatment methods were considered.

Consequently, treatment levels and treatment methods shown in the tables below have been selected taking into account various sizes of communities in the Study Area.

Table 27: Selected Wastewater Treatment Level

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 28: Selected Wastewater 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

3.3.3 Selection of an Optimum Technical System in Solid Waste Management

Setting ***"the BOD discharge amount originating from solid waste to be less than 2,100 tons/year by 2015"*** as the minimum requirement, some technical scenarios were examined.

Consequently, the technical system shown in the table below was selected based on mutual agreement between the Mexican Counterpart and the Study Team.

Table 29: Selected SWM Technical System

Technical System	Scenario 4
1. Source Reduction	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

3.4 The Master Plan

3.4.1 Basic Concept

3.4.1.1 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

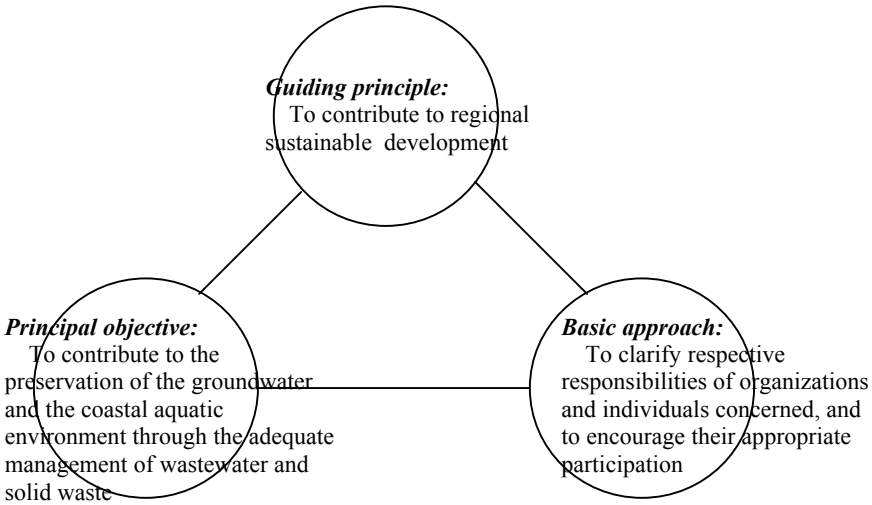
To contribute to regional sustainable development of the Yucatan Peninsula

b. Principal Objective

To preserve the groundwater and the coastal aquatic environment in southern Quintana Roo State, or the 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 Environmental Sanitation Management



3.4.1.2 Target Value of the Master Plan

The target value of the principal objective of the Master Plan is as follows:

The BOD discharge amount originating from wastewater and solid waste is to be less than 5,200 tons/year by 2015, aiming at controlling the BOD concentration of groundwater at 1.0 mg/liter and below.

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

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

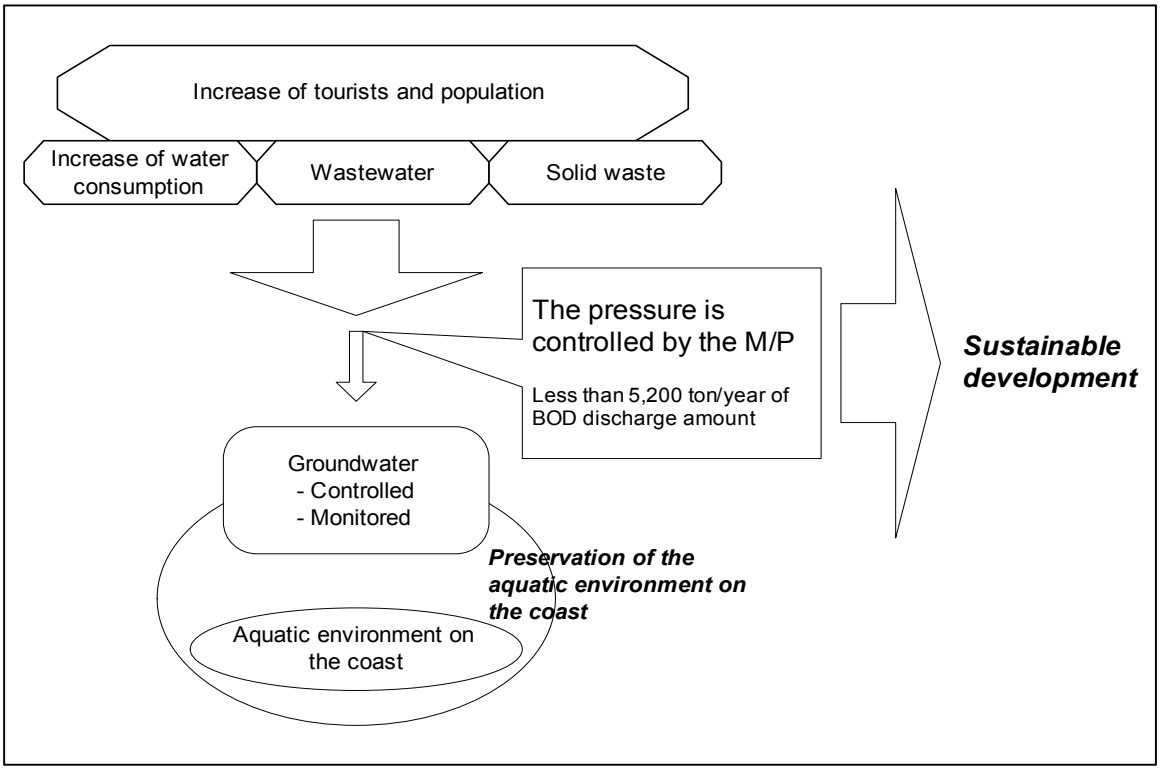


Figure 5: Target Value of the Master Plan

3.4.2 Wastewater Management Master Plan

3.4.2.1 Objectives, Target Values and Target Year

a. Principal Objective and Target Value

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

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

The target value is as follows;

The BOD discharge amount originating from wastewater is to be around 3,100 tons/year by 2015.

b. Particular Objectives and Target Values

The master plan formulated should aim at achieving the principal objective, as well as at accomplishing the following particular objective inherent to wastewater management.

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

In order to accomplish the objective, target values regarding sewer service coverage and treated water quality as shown in Table 30 and Table 31 have been set.

Table 30: Target 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 31: 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 the master plan is set as: ***Year 2015***

3.4.2.2 Proposed Measures

a. Wastewater Treatment Method

The treatment methods shown in Table 32 are proposed to achieve the treatment levels set in Table 31.

Table 32: 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

b. Sludge Management Plan

Excess sludge will be generated in large quantities in the future along with the expansion of wastewater treatment, and measures to cope with the excess sludge need to be taken. Table 33 shows the amount of excess sludge to be disposed of, with a water content of 85%.

Table 33: Required Excess Sludge Disposal Amount

Unit: m^3/year

	OTHON P. BLANCO				FELIPE CARRILLO PUERTO			SOLIDARIDAD			
Year	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

Disposal measures of excess sludge are landfilling, desiccation and incineration. Desiccation and incineration require a 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.

3.4.2.3 Cost Estimation

The cost of the Master Plan is estimated as follows.

Table 34: Overall Cost of the Master Plan

unit: million pesos

Item	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
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 C 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

Table 35: Master Plan Cost in Othón P. Blanco

unit: million pesos

Item	Level	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Sewer line														
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
Treatment facilities														
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	215.68	0	81.431	134.25	81.431	0	0	0	0	0	0	512.789
	total	0	254.24	6.221	127.24	137.44	129.25	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 & maintenance	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	262.58	16.422	142.17	153.62	146.92	29.383	41.319	42.607	38.436	45.466	56.853	981.388
Sludge management														
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
Overall														
Sewer line		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
Treatment facilities		5.612	262.58	16.422	142.17	153.62	146.92	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	5.38	5.798	6.138	6.545	7.046	50.66
Overall total		7.382	276.59	60.32	186.68	193.61	199.55	66.678	98.409	102.77	91.251	109.21	128.43	1,520.88

Table 36: Master Plan Cost in Felipe C Puerto

unit: million pesos

Item	Level	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Sewer line														
Construction	Level 1	0	0	0	0	0	0	5.444	11.974	7.827	9.188	9.476	8.605	52.514
	Level 2	0	0	0	0	0	0	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	25.191
	Level 4	0	0	0	0	0	0	0	0	0	0	0	0	0
	total	1.584	3.219	2.274	2.248	2.274	2.274	9.329	14.263	11.726	12.38	12.613	10.379	84.563
Design & supervision	Level 1	0	0	0	0	0	0.163	0.359	0.235	0.276	0.284	0.258	0	1.575
	Level 2	0	0	0	0	0	0.049	0	0.049	0.028	0.026	0.053	0	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	0	0.706
	Level 4	0	0	0	0	0	0	0	0	0	0	0	0	0
	total	0.097	0.068	0.067	0.068	0.068	0.279	0.427	0.352	0.371	0.378	0.311	0	2.486
Operation & maintenance	Level 1	0	0	0	0	0	0	0.273	0.872	1.263	1.722	2.195	2.626	8.951
	Level 2	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0	0	0	0	0
	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
Treatment facilities														
Construction	Level 1	0	0	0	0	0	0	4.689	10.311	6.74	7.913	8.16	7.41	45.223
	Level 2	0	0	0	0	0	0	5.69	0.053	5.65	3.283	2.999	6.168	23.843
	Level 3	0	13.574	0	0	13.574	0	0	13.574	0	0	0	0	40.722
	Level 4	0	0	0	0	0	0	0	0	0	0	0	0	0
	total	0	13.574	0	0	13.574	0	10.379	23.938	12.39	11.196	11.159	13.578	109.788
Design & supervision	Level 1	0	0	0	0	0	0.141	0.309	0.202	0.237	0.245	0.222	0	1.356
	Level 2	0	0	0	0	0	0.171	0.002	0.17	0.098	0.09	0.185	0	0.716
	Level 3	0.204	0.204	0	0.204	0.204	0	0.204	0.204	0	0	0	0	1.224
	Level 4	0	0	0	0	0	0	0	0	0	0	0	0	0
	total	0.204	0.204	0	0.204	0.204	0.312	0.515	0.576	0.335	0.335	0.407	0	3.296
Operation & maintenance	Level 1	0	0	0	0	0	0	0.235	0.751	1.088	1.483	1.89	2.261	7.708
	Level 2	0	0	0	0	0	0	0.285	0.287	0.57	0.734	0.883	1.192	3.951
	Level 3	0.113	0.3	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	0	0	0	0	0	0	0	0	0	0	0	0
	total	0.113	0.3	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
Sludge management														
Disposal cost	Level 1	0	0	0	0	0	0	0.034	0.111	0.161	0.219	0.279	0.334	1.138
	Level 2	0	0	0	0	0	0	0.081	0.081	0.161	0.208	0.25	0.338	1.119
	Level 3	0.012	0.043	0.077	0.111	0.144	0.178	0.212	0.246	0.28	0.314	0.348	0.381	2.346
	Level 4	0	0	0	0	0	0	0	0	0	0	0	0	0
	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
Overall														
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 37: Master Plan Cost in Solidaridad

unit: million pesos

Item	Level	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Sewer line														
Construction	Level 1	0	0	0	0	0	0	3.395	3.358	3.016	3.085	2.954	3.878	19.686
	Level 2	0	0	0	0	0	0	0	0.867	0.045	0.045	0.708	0.594	2.259
	Level 3	0	11.438	11.438	11.438	11.438	11.438	4.174	4.174	4.174	4.174	4.174	0	78.06
	Level 4	9.38	20.291	20.383	20.383	18.498	22.176	9.186	9.186	9.186	9.186	9.186	0	157.041
	total	9.38	31.729	31.821	31.821	29.936	33.614	16.755	17.585	16.421	16.49	17.022	4.472	257.046
Design & supervision	Level 1	0	0	0	0	0	0.102	0.101	0.09	0.093	0.089	0.116	0	0.591
	Level 2	0	0	0	0	0	0	0.026	0.001	0.001	0.021	0.018	0	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	0	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	0	4.43
	total	0.951	0.954	0.954	0.898	1.008	0.504	0.529	0.493	0.496	0.512	0.134	0	7.433
Operation & maintenance	Level 1	0	0	0.05	0.052	0.053	0.055	0.216	0.374	0.516	0.661	0.801	0.984	3.762
	Level 2	0	0	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	0	0.572	1.144	1.716	2.287	2.859	3.068	3.277	3.486	3.694	3.903	26.006
	Level 4	3.63	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	3.63	4.099	5.755	7.35	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	38.53	40.069	39.889	44.563	29.573	31.225	30.876	31.776	32.765	20.954	390.963
Treatment facilities														
Construction	Level 1	0	0	0	0	0	0	2.8	2.767	2.487	2.543	2.435	3.198	16.23
	Level 2	0	0	0	0	0	0	0	3.301	0.172	0.171	2.696	2.262	8.602
	Level 3	0	38.734	0	38.734	0	38.734	0	0	0	0	0	0	116.202
	Level 4	138.94	98.931	0	237.87	0	98.931	138.94	0	0	0	0	0	713.598
	total	138.94	137.67	0	276.6	0	137.67	141.74	6.068	2.659	2.714	5.131	5.46	854.632
Design & supervision	Level 1	0	0	0	0	0	0.084	0.083	0.075	0.076	0.073	0.096	0	0.487
	Level 2	0	0	0	0	0	0	0.099	0.005	0.005	0.081	0.068	0	0.258
	Level 3	0.581	0.581	0.581	0.581	0.581	0.581	0	0	0	0	0	0	3.486
	Level 4	3.568	1.484	3.568	3.568	1.484	3.568	2.084	0	0	0	0	0	19.324
	total	4.149	2.065	4.149	4.149	2.065	4.233	2.266	0.08	0.081	0.154	0.164	0	23.555
Operation & maintenance	Level 1	0	0	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	0	0.071	0.08	0.09	0.098	0.108	0.231	0.238	0.244	0.345	0.43	1.935
	Level 3	0	0	1.24	1.717	2.077	2.377	2.639	2.726	2.809	2.888	2.966	3.041	24.48
	Level 4	6.47	7.506	9.443	11.841	13.777	15.157	16.783	17.461	18.132	18.796	19.455	20.11	174.931
	total	6.47	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		149.55	147.24	14.944	294.43	18.053	159.58	163.71	26.874	24.344	25.341	28.722	29.853	1,082.64
Sludge management														
Disposal cost	Level 1	0.007	0.007	0.007	0.007	0.007	0.007	0.029	0.051	0.07	0.089	0.108	0.133	0.522
	Level 2	0.018	0.021	0.024	0.028	0.031	0.034	0.037	0.08	0.082	0.084	0.12	0.149	0.708
	Level 3	0	0	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	5.78	6.043	6.305	6.568	55.51
	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
Overall														
Sewer line		13.961	36.782	38.53	40.069	39.889	44.563	29.573	31.225	30.876	31.776	32.765	20.954	390.963
Treatment facilities		149.55	147.24	14.944	294.43	18.053	159.58	163.71	26.874	24.344	25.341	28.722	29.853	1,082.64
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		165.71	186.52	56.711	338.48	62.655	209.53	199.49	64.701	62.171	64.418	69.171	58.874	1,538.43

3.4.2.4 Financial Analysis and Financial Plan

a. Financial Analysis

a.1 Income and Cost

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 tourist 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.

According to CAPA, income per cubic meter of wastewater treatment is 1.42 pesos. Service charges from wastewater can be obtained multiplying the income per cubic meter by wastewater generation.

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% or 95% of the gross income of water supply. According to CAPA, income of water supply per cubic meter is 7.11 pesos.

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

An 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 the Wastewater Master Plan.

Table 38: 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

a.2 Financial Balance of Wastewater Master Plan

The 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 is equivalent to saying that the projected number of tourists differed greatly among the

municipalities. The large inflow of tourists in Solidaridad Municipality not only made the financial balance positive in the Municipality, but as the resulting surplus was sufficient to cover the financial deficits that were estimated to occur in Othon P. Blanco and Felipe Carrillo Puerto, it also turned a financial surplus for the Wastewater Master Plan in the whole Study Area., as shown in the following Table.

Table 39: 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 tourist industry in the cost of Wastewater Master Plan.

a.3 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 to its financial viability using the following indices: the financial internal rate of return (FIRR), the 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 40: 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

b. Financial Plan

As 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 a surplus is estimated between 2010 and 2015. Felipe Carrillo Puerto, on the other hand, would need these funds up to 2014.

As already mentioned, the additional funds required in OPB and FCP could be covered with the surplus estimated to occur in Solidaridad, where 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 tables below.

Table 41: 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 42: 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 43: 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 44: 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

3.4.2.5 Implementation Plan

The order of implementation of works should be decided while taking into account cost-effectiveness. Table 45 shows the cost per ton of BOD removal. According to the table, it is found that the implementation of the works in Solidaridad is the most cost-effective, followed by Othon P Blanco and Felipe C Puerto, and from the aspect of treatment level, Level 4 is the most cost-effective, followed by Level 3, Level 2 and Level 1. Table 46, Table 47, Table 48 and Table 49 show the achievement ratio of the works in respective municipalities and in treatment levels that are set based on the order of cost-effectiveness.

Table 45: Unit Investment Cost of BOD Removal (2004 to 2015)

Level	Total investment (million pesos)	BOD removal 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 46: 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%

Table 47: 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%

Table 48: 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%

Table 49: 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%

3.4.3 Solid Waste Management Master Plan

3.4.3.1 Objectives, Target Values and Target Years

a. Principal Objectives and Target 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

The target value is as follows;

The BOD discharge amount originating from solid waste is to be less than 2,100 tons/year by 2015.

b. Particular Objectives and Target Values

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

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

The table below shows target values of the particular objectives by municipality.

Table 50: Target Values of the SWM Master Plan (by Municipality)

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: 75% (61%) OPB: 72% (57%) FCP: 29% (18%) SOL: 88% (82%)		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

The target values are also set by urban groups. Table 51 shows the urban groups and the communities belonging to them. Table 52 shows target values set for the respective urban groups. Table 53 shows components of waste minimization.

Table 51: 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 52: 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 53: 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 as follows:

Master Plan: Year 2015

Strategic actions to achieve the objectives should be, in practice, introduced step by step 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)***

3.4.3.2 Strategies

The following eight points are strategies to accomplish the objectives.

1. ***Focusing on the urban area***
2. ***Development of SWM systems accommodating to communities of various size***
3. ***Introduction and promotion of waste minimization***
4. ***Financial self-sufficiency***
5. ***Cooperation among the three government levels***
6. ***Development of a 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 the population concentrates in a small number of communities. Only 24 urban communities have 2,500 and more persons, and these communities are estimated to have 85% of the total population in the target year of 2015.

Meanwhile, people in rural villages discharge a small amount of waste and there is space to dispose of it. Therefore, the demand for solid waste services 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 communities of various size

Even urban communities have populations of various size so it is inappropriate to apply the same SWM system to all of them. That is, communities with a small population cannot afford and do not require a 100% collection rate and sophisticated sanitary landfill.

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

3. Introduction and promotion of waste minimization

The waste amount generated per person in the study area is not so different from that 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.

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

4. Financial self-sufficiency

Most of the 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. As a result, there is a risk that SWM may fall into disarray if the state or the federal government changes their funding policy of municipal budgets, despite recognizing that 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. Consequently, 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 are recently becoming various and sophisticated such as sanitary landfilling, waste minimization, public-private partnership, hazardous waste management, etc. They will compound further in the future. As a result, it is impossible for municipalities to cope with them by themselves. 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 a 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 builders between the governments and the citizens. In order for them to appropriately participate in SWM, a 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 the other strategies strengthen their capacity. However, they should not be carried out individually. They should be integrated. The executing bodies should

accumulate experience and knowledge. Otherwise, they will not be 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. Also, the number of tourists has increased. However, public services have not yet been developed in the area. The solid waste service is carried out on a small scale by some village people. As such a system will not be able to cope with future development, a SWM system shall be established to protect the beautiful nature in the area.

3.4.3.3 Proposed Measures

a. Proposed Measures

The table below shows the proposed measures corresponding to the respective strategies.

Table 54: Strategies and Proposed Measures

Strategies	Proposed Measures
1. Focusing on the urban area	11. Focusing on the urban area
2. SWM systems accommodating to communities of various size	21. Flexible arrangement of collection rate 22. Flexible arrangement of final disposal manner
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 an information system for the integral management
6. Development of a 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 establishing a firm SWM system

b. Burden Sharing of the Proposed Measures

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

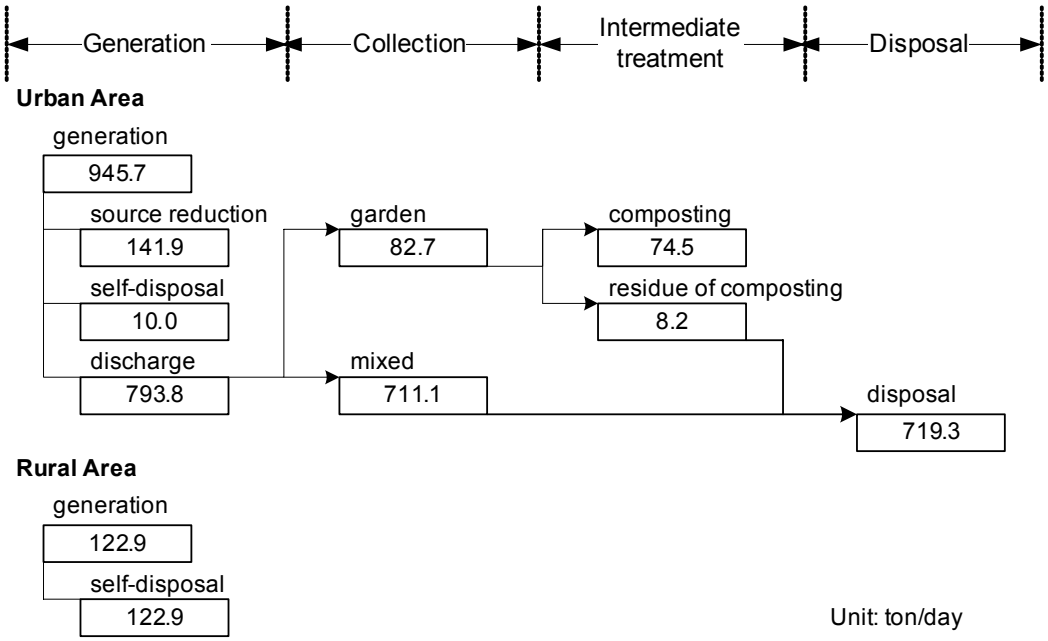
Table 55: Burden Sharing of the Proposed Measures

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 manner			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		
81. Establishment of an organizational and institutional framework 82. Introduction of culture of waste minimization 83. Preparation of establishing of a firm SWM system		S	R	P	P

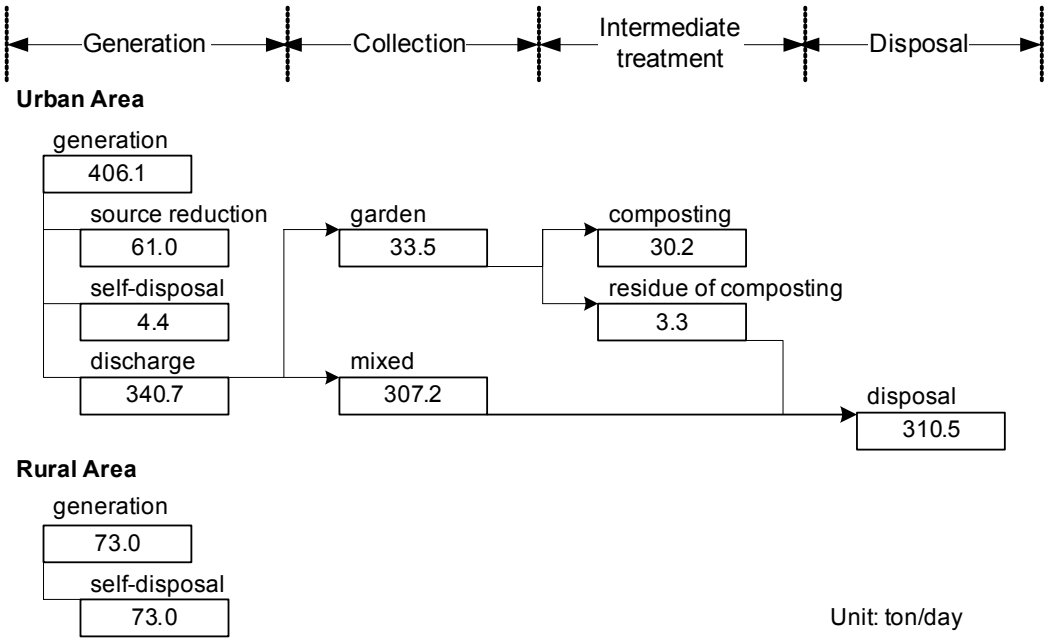
3.4.3.4 Waste Stream

This section describes waste streams of the Master Plan.

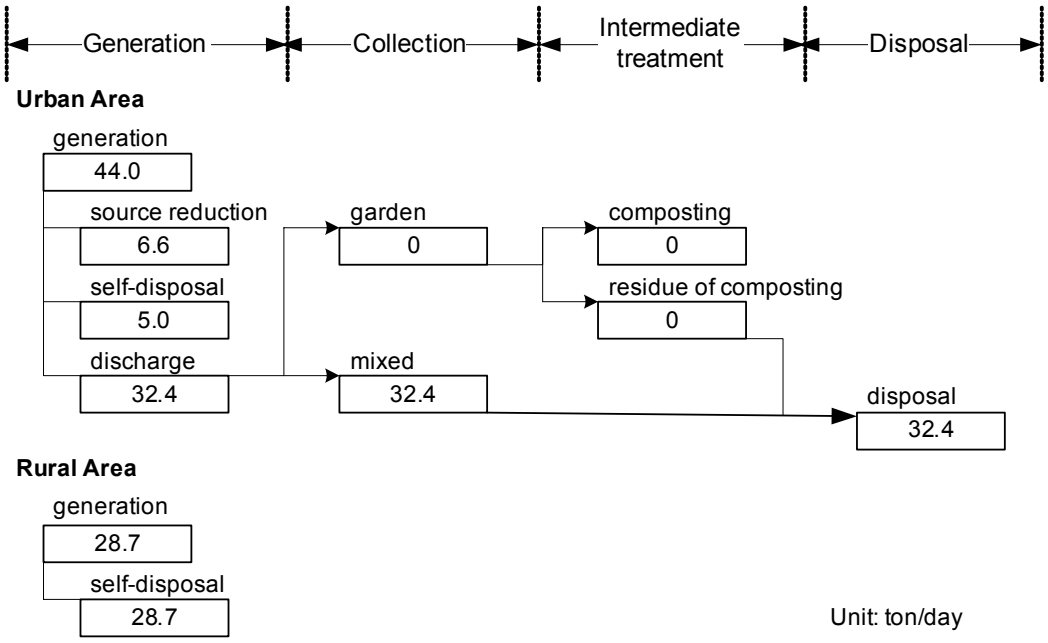
a. Whole Study Area in Year 2015



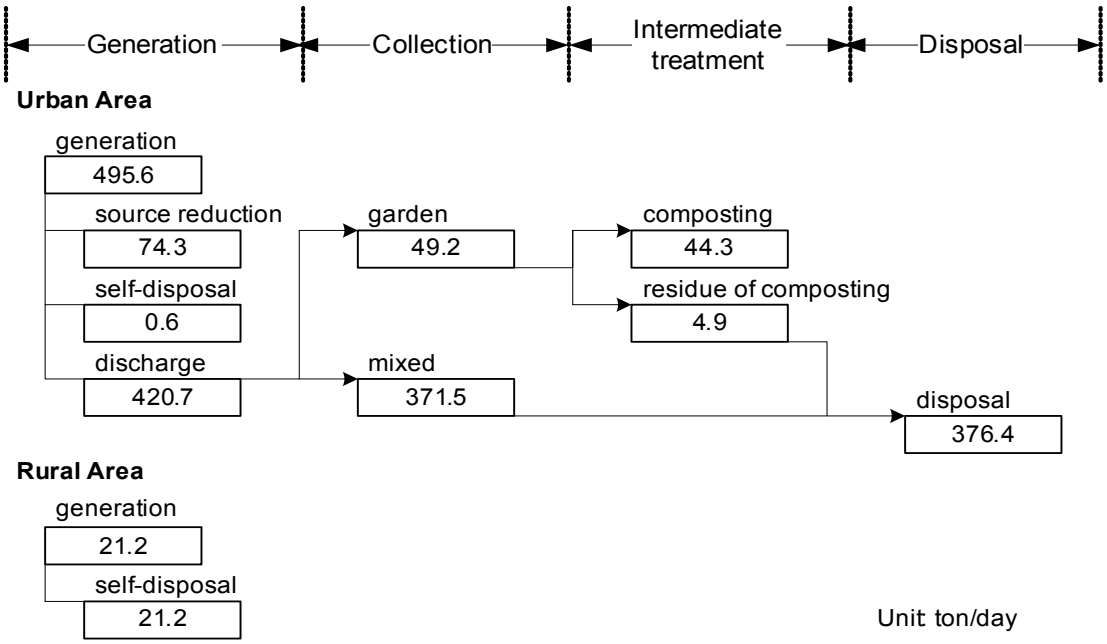
b. Othon P Blanco in Year 2015



c. Felipe C Puerto in Year 2015



d. Solidaridad in Year 2015



3.4.3.5 Cost Estimation

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

Table 56: Cost of the SWM Master Plan (Whole Study Area)

Unit: 1,000 pesos

Item	Short				Middle				Long				Total
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Source reduction	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 57: Cost of the SWM Master Plan (Othon P Blanco)

Unit: 1,000 pesos

Item	Short				Middle				Long				Total
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Source reduction	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 58: Cost of the Master Plan (Felipe C Puerto)

Unit: 1,000 pesos

Item	Short				Middle				Long				Total
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Source reduction	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 59: Cost of the Master Plan

Unit: 1,000 pesos

Item	Short				Middle				Long				Total
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Source reduction	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

3.4.3.6 Financial Analysis

a. Scenarios

For the purpose of financial analyses, three basic scenarios were set 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: 30 Pesos for households, 100 Pesos for businesses

Scenario 2: 40 Pesos for households, 150 Pesos for businesses

Scenario 3: 50 Pesos for households, 200 Pesos for businesses

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%.

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%).

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%.

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%.

c. Financial Self-sufficiency

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. Therefore, 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. In addition, the SWM service will be much improved when compared with the case “without the Master Plan”.

3.4.3.7 The Solid Waste Management Master Plan

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

Table 60: The SWM Master Plan (Whole Study Area)

Item	unit	Present	Short				Middle				Long				
		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	10.9	17.5	25	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	
discharge	ton/day	319.9	341.2	427.9	494.6	576	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	711.1	
garden waste	ton/day	0	0	0	4.9	10.7	17.3	24.9	33.2	41.9	51	60.9	71.4	82.7	
3) Disposal															
disposal	ton/day	319.9	341.2	427.9	490.3	566.4	590.8	627	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	
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												
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 per month for business firms.

Table 61: The SWM Master Plan (Othon P Blnaco)

Item	unit	Present	Short				Middle				Long				
		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	268.5	287	306	325.1	344.2	356.3	368.7	380.9	393.6	406.1	
sorce reduction	ton/day	0	0	5	8	11.5	18.4	22.8	27.6	32	44.3	49.4	55	61	
self-disposal	ton/day	58.3	77	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	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	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	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	
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												
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 per month for business firms.

Table 62: The SWM Master Plan (Felipe C Puerto)

Item	unit	Present	Short				Middle				Long				
		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	
sorce reduction	ton/day	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	5.2	5.1	5	5	5	
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	
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	
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												
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 per month for business firms.

Table 63: The SWM Master Plan (Solidaridad)

Item	unit	Present	Short				Middle				Long				
		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	426.7	449.4	472.3	495.6	
sorce reduction	ton/day	0	0	5.1	8.3	12	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	14.4	0.8	0.8	0.8	0.8	0.6	0.6	0.6	0.6	0.6	
discharge	ton/day	159	176.6	220	253.1	288	306.9	328.6	350.2	367	374.9	390.4	405.6	420.7	
2) Collection															
mixed waste	ton/day	159	176.6	220	250.4	282	297.2	314.5	331.3	342.9	345.3	354.7	363.4	371.5	
garden waste	ton/day	0	0	0	2.7	6	9.7	14.1	18.9	24.1	29.6	35.7	42.2	49.2	
3) Disposal															
disposal	ton/day	159	176.6	220	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	
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												
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)															
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 per month for business firms.

3.4.3.8 Implementation Plan

The following tables show how to implement the Master Plan in Phases.

Table 64: 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 65: 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 66: 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	-	-

3.4.4 Evaluation of the Master Plan

3.4.4.1 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 the Yucatan Peninsula. The Master Plan aims at preventing 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 human health in the Study Area. These are assumed as benefits to be brought about by implementation of the Master Plan.

For analytical purposes in this economic evaluation, the 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).

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 67: 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 food 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*

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.

The economic evaluation of this Study conservatively estimates the adverse effects of water contamination/environmental degradation on tourism in the case “without the Master Plan”, by defining the adverse effect as a 1%/year decrease with respect to the forecasted increase rate after 2006, and then a 10% decrease in 2015.

The difference in revenues between the cases “with the Master Plan” and “without the Master Plan” is considered as the benefit. As the table below shows, the cumulative benefit by 2015 is calculated as 10,529 Million Pesos.

Net Present Value (NPV), Benefit Cost Ratio (B/C), and Internal Rate of Return (IRR) were calculated from the streams of Costs and Benefits. The results were, as shown in the Table below, NPV = 2,545 Million Pesos, B/C ratio = 2.06, and IRR = 39.00%.

Table 68: 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%

In addition, two cases were set for a sensitivity analysis, i.e. a 0.5%/year decrease (Case 1) and a 1.5%/year decrease (Case 3) from the forecasted increase rate of tourists after 2006. The results of the sensitivity analysis were NPV = 68 Million Pesos, B/C = 1.03 and IRR = 10.87% in Case 1; and NPV = 5,020 Million Pesos, B/C = 3.09, and IRR = 50.68% in Case 3.

Table 69: Results 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

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 70: 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	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 the negative image caused by environmental degradation. Quantitative economic evaluation resulted in NPV=2,545 Million Pesos, B/C=2.06, and IRR=39.00%
2	**Preservation of biodiversity:** to avoid loss of resources that could be utilized for food 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 preserving this biodiversity.
3	**Protection of the water source for drinking water:** to avoid the 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 the Yucatan Peninsula than the national average. The economic loss caused by this intestinal sickness absenteeism is significant. The M/P contributes to avoiding this loss.

3.4.4.2 Overall Evaluation

The proposed Master Plan will preserve the groundwater and the coastal aquatic environment in the Study Area. Contamination and deterioration of them will induce a reduction in tourism revenue, an increase in medical cost, loss of employment opportunity and loss of biodiversity, which will be enormous economic losses compared to the cost of the Master Plan. Therefore, 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 into financial deficit. The Wastewater Management Master Plan will be financially viable, when considering the three municipalities as a unit.

A fee for solid waste services 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 protecting the health of residents and tourists, as it will preserve the groundwater, which is the only drinking water source in the Study Area. The Master Plan will also contribute to conserving the worldwide unique ecosystem to a large extent.

CAPA, which is in charge of wastewater management in the Study Area, has the 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 that the Master Plan is technically viable and it is expected for those organizations to further 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 sustainable development of the Study Area in the future.

3.5 Recommendations on Groundwater Management

The Study focuses on the sectors of Wastewater Management (WWM) and Solid Waste Management (SWM) according to the Scope of Work agreed by both the Mexican Side and the Japanese side. However, it is understood that Groundwater Management (GWM) is of great importance as it is closely related to WWM and SWM due to the geologic characteristic of the Study Area. Therefore, this chapter gives general recommendations on GWM.

3.5.1 Risk Assessment and Goal Setting

Management of the groundwater basin implies a program of development and utilization of subsurface water for some stated purpose, usually of a social or economic nature. In general, the desired goal is to obtain the maximum quantity of water to meet predetermined quality requirements at least cost.

Considering vulnerable characteristics of aquifers and the growing water demand in tourism in the Yucatan Peninsula, the groundwater situation will progressively become critical in the future. Risks based on assessment of the current situation and goals set are summarized in the following statements.

Risk 01: *Saltwater intrusion or "Upconing" may occur due to the overdraft of groundwater.*

Risk 02: *Groundwater contamination may occur due to wastewater, animal waste, fertilizer pesticides, septic tanks and so on.*

Goal 1: *To control groundwater extraction based on evaluation of "the perennial yield".*

Goal 2: *To protect aquifers from contamination caused by domestic, industrial, agricultural sources and so on.*

3.5.2 Strategies

The proposed strategies for achieving the goals are as follows.

Strategy 1: *Establishment of groundwater database*

Strategy 2: *Construction of monitoring network*

Strategy 3: *Establishment of standards on the injection well design, construction and operation and maintenance*

3.5.3 Improvement Measures

The proposed improvement measures corresponding to the strategies are shown in the table below.

Table 71: Proposed Improvement Measures on Groundwater Management

Strategies	Contents (Proposed Improvement Measures)
Establishment of Groundwater Database	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 Standards 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, experience 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 standard O&M method based on the monitoring • administrative and technical guidance by CNA

4 Model Projects

Nine Model Projects were carried out during the Study aiming at the following four points.

- Evaluate feasibility of measures listed in the Master Plan
- Launch implementation of the Master Plan
- Encourage the executing agency to establish ownership for the Master Plan
- Encourage establishment of the required system and acquisition of necessary capabilities to implement the Master plan.

The figure below shows the locations of the projects' sites.

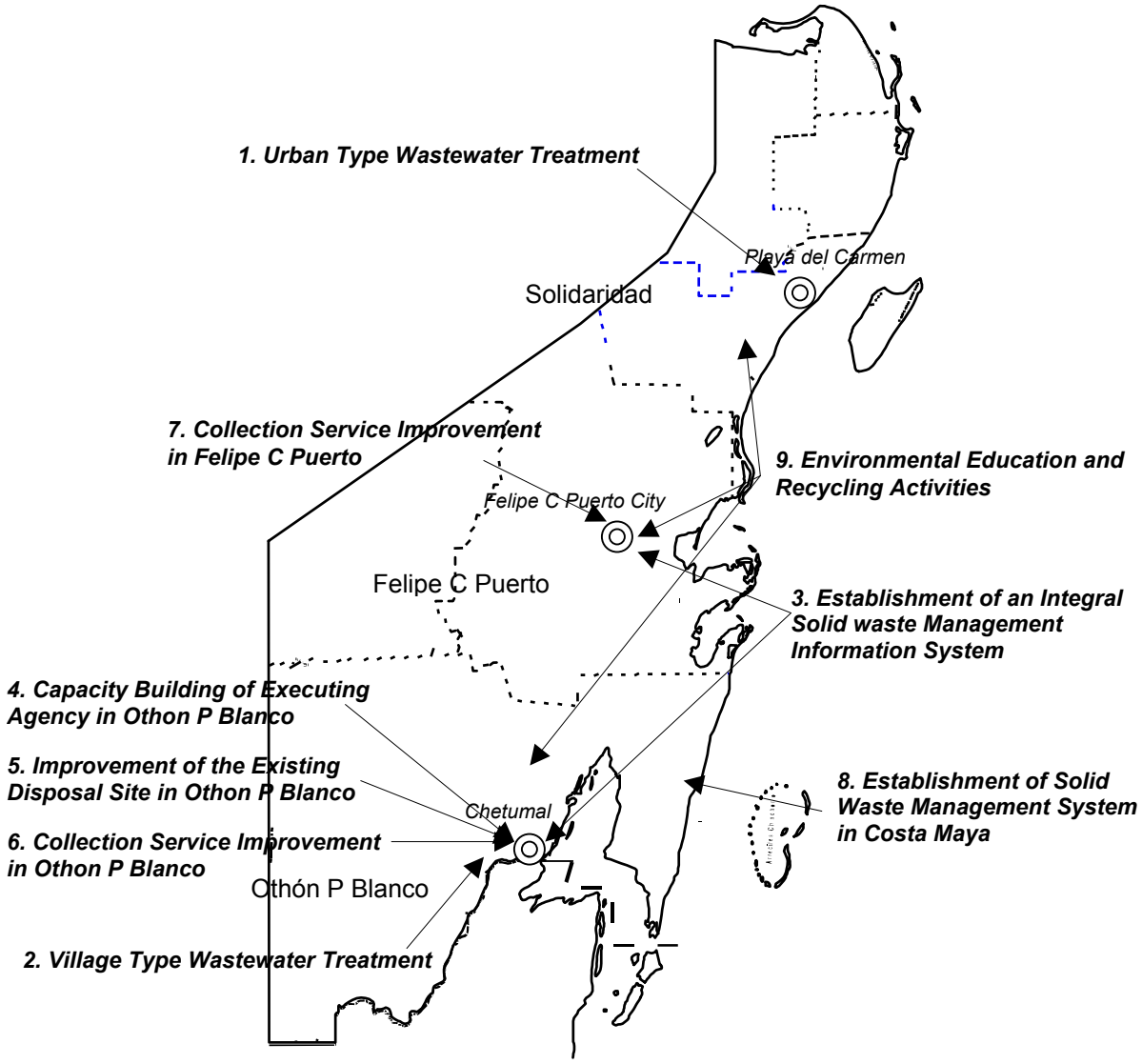


Figure 6: Location Map of the Model Projects

4.1 Urban Type Wastewater Treatment

4.1.1 Outline

Playa del Carmen in Solidaridad Municipality was the project site. In this Model Project, the following works were conducted.

- Geophysical survey (electromagnetic survey)
- Construction of monitoring wells
- Water quality analysis
- Groundwater simulation

Conclusion and recommendations induced from the results of the works above are described below.

4.1.2 Conclusion

a. Distribution and Characteristics of Limestone Aquifer

- The underground geology of the study area can be geophysically divided into three resistivity layers, i.e. U1, U2 and U3, from the top to the bottom of 200m depth. These resistivity layers are widely distributed in the survey area.
- The U1 layer was distributed from the ground surface to a depth of 20～25m. This layer is composed of reef limestone and calcareous sandstone. It is abundant in fractures and cavities and becomes a freshwater aquifer.
- The U2 layer is composed of limestone of abundant fractures and cavities caused by high karst development. The resistivity of the layer is less than 4 Ωm. The fractures and cavities are filled with seawater and the layer forms a seawater aquifer. The thickness of the layer is approximately 50m.
- The U3 layer is composed of limestone or muddy limestone showing 4～100 Ωm of resistivity. The facies of the low resitivity layer (4～25 Ωm) varies place to place and consists of an alternation of hard and fractured limestone. The high resistivity layer (more than 25 Ωm) is not well developed in karst and is composed of hard muddy limestone. This high resistivity layer is distributed at a depth from 60 to 110m in the study area. The borehole drilled at the wastewater treatment plant (WTP) encountered this layer at a depth of 62 m (Boring P4). This layer is compact and hard. It composes impermeable or semi-permeable hydrogeologic basement in the survey area.
- The groundwater level of the boring sites ranges from 4 to 8m below ground surface. The thickness of the freshwater is about 20 m, but it increases more than 40 m in the

inland area according to the geophysical survey. The seawater exists under the freshwater widely in the inland area.

- According to the dilution tests, the estimated range of the permeability coefficient in the U1 and U2 layers is 1.1 to 22.0 cm/sec.

b. Behavior of Wastewater Plume

- The CNA injection well inventory shows that the number of injection wells in Solidaridad province is 184 on a notification basis. The daily injection volume runs up to 73,051 m^3, which is 397 m^3/day per well on average.
- Treated wastewater is being injected into the injection well in the CAPA WTP in Playa del Carmen at a rate of 3,880 m^3 per day (45 l/s). In addition to this well, another injection well is utilized for injecting untreated wastewater which exceeds the capacity of the WTP.
- Almost all injection wells in the study area have their well screens in the U2 layer (seawater aquifer) as well as the WTP considering geologic conditions. There exists no significant impermeable layer between the U2 layer and the overlying U1 layer （freshwater aquifer）. Thereby it is inferred that the injected wastewater migrates upward to the freshwater aquifer.
- According to the density dependent flow model, the wastewater plume injected in the seawater aquifer migrates upward and affects the freshwater in the case of the 100 m depth injection well.

c. Water Quality and Contamination

- Comparing the water quality of the monitoring wells with WHO guideline values for drinking water, Cl, Na and TDS exceed the guideline in all the wells. A high concentration of NH_4 was detected at the monitoring wells in the WTP. These wells were contaminated by the injection well located just upstream of the monitoring site. The monitoring well in Colonia Ejidal, which is not covered by the sewer system, shows a high concentration of NH_4 indicating man-made contamination. A high concentration of SO_4 was also found at the monitoring wells in the WTP.
- Contamination of trichloroethylene and heavy minerals was not detected.

4.1.3 Recommendations

- Groundwater contamination in the freshwater aquifer is in progress in the coastal urban areas due to wastewater injection. Since groundwater is finally discharged to the coast,

the seawater environment may be contaminated in the future. In order to reduce the pollution load in the water environment, an injection norm should be established and injection should be controlled adequately.

- Wastewater should be injected into a formation below the lowermost formation consisting of a muddy, hard and dense layer, which is thought to be a confining layer and impervious or semi-pervious. The injection zone, on the contrary, must be sufficiently permeable, porous, and thick to accept injected wastewater at the proposed injection rate without requiring excessive pressure. Ideally, the injection zone should be homogeneous.

- In order to select an appropriate injection zone, a regional geological survey should be conducted. The survey should consist of the following items.

  1) Data Collection, Arrangement and Hydrogeological Mapping

  2) Geophysical Survey: to explore resistivity structure and fresh water-saline water interface in each urban area.

  3) Exploratory Borehole Drilling and Logging: to investigate drilling velocity, resistivity, spontaneous potential of the formations, and temperature and electric conductivity of groundwater, etc. The target drilling depth is 400m.

- The injection well should be designed and constructed so that it does not allow any fluid to escape the injection string or any fluid to migrate into the borehole to shallow fresh water aquifers.

- The system of reporting on and monitoring the operation and management of the injection well as well as the norm on the injection zone, well structure, injection rate and quality of injected water, etc. should be established.

4.2 Village Type Wastewater Treatment

4.2.1 Outline

Although CAPA had operated sewage systems for large cities such as Chetumal and Playa del Carmen, it did not have a system for emerging small communities. Meanwhile, even in cities where a sewage system has been installed, connection of household effluent to the public sewer has not become widespread due to reasons such as economic burden and existing septic tanks.

The above-mentioned has led to a situation where the large investment cannot bring about an effect and the groundwater is continuously contaminated. In order to solve those problems, a

Model Project, "the Village Type Wastewater Treatment," was planned and carried out in Subteniente Lopez, Chetumal in the Municipality of Othon P Blanco.

The wastewater treatment facility and sewer pipes in Subteniente Lopez were constructed by CAPA. This model project was to support CAPA's project so that CAPA would gain experience in order to expand such a village type wastewater treatment system to other emerging communities. The planned components of the project were as follows.

- Diagnosis of performance of the new treatment plant
- Preparation of a manual on operation and maintenance of the treatment plant
- Training of CAPA's personnel regarding operation and maintenance of the treatment plant
- Establishment a fund for economically assisting the residents to connect their domestic wastewater to the public sewer
- Environmental education to the residents for promoting the connection

4.2.2 Outcomes

- Through this Model Project, 99 houses were connected to the public sewer. In order to promote the connection, an explanation to the residents was made along with environmental education; in addition, a fund to economically help them has been established in the structure of CAPA.

- Meanwhile, a manual for operation and maintenance of a new small scale sewage system was prepared. With the manual, instruction on operation and maintenance as well as designing and construction was conducted to CAPA personnel. CAPA has obtained technical knowledge on those issues.

- Construction of the sewage system, which was CAPA's jurisdiction, was delayed. As a result, activities of operation adjustment on biological treatment process, which was initially planned, could not be conducted.

4.2.3 Conclusion and Recommendation

Due to the big delay in construction of the sewage system, some of the activities that were initially planned were not conducted. However, CAPA now appears to be capacitated toward solving problems. It is expected that CAPA will expand the project following the M/P over the Study Area, utilizing this experience.

a. In-house Connection Works

The CAPA is now at the stage of utilizing the asset provided by JICA, effectively practicing the methods of contract agreement acknowledged from the Model Project. It leads to the suggestion that the in-house Connection Work will be processed not only within the target

area of the Model Project but in a wider study area for the purpose of improvement of the sewage system.

The in-house connection plan was designed by CAPA in this model project. However, there were some disagreements between CAPA's plan and the reality, causing problems at the time of construction. The problems can be solved by promoting more dialogue with the residents and at the same time, establishing a new section which is in charge of the contract agreement of in-house connection and design/construction all together within CAPA.

b. Treatment Facility

It was impossible for the Study Team to conduct the performance evaluation of the treatment plant due to the big delay in construction of the sewage system within the jurisdiction of CAPA. The Study Team strongly recommends that CAPA execute the monitoring according to the manual prepared by the Study Team, and go on to the performance evaluation and design review of the plant, if necessary.

In order to avoid a delay in construction work, several considerations or measures should be made concerning not only the ability of construction workers, but also the types and method of survey prior to design and construction; how to reflect the results from site survey into design and construction planning; and cost estimates based on construction planning and site inspection after contract. They can be improved through the PDCI (Plan, Do, Check, Improvement) cycle by repetitive practice.

4.3 Establishment of an Integral Solid Waste Management Information System

4.3.1 Outline

The new General Law for the Preservation and Management of Waste establishes the implementation of an Information System for the Integral Management of Solid Waste (SIGIR), whose main purpose would be the creation of a mechanism of coordination and information among the three government levels, on the subjects of sharing responsibility, prevention of the generation, valorization and integral management of solid waste.

The Model Project aims to cooperate in the setting-up of the Information System forecasted in the General Law; likewise, it intends to use this system as an instrument which may continue tracking the development of the Master Plan.

4.3.2 Outcomes

- SIGIR (Integral Solid Waste Management Information System) has been established in SEDUMA and in the municipalities of Othon P. Blanco and Felipe Carrillo Puerto.
- Personnel of the three institutions were trained in processing and registering information and the system is used as an instrument of consultation and coordination of activities among the three organizations.
- SEDUMA is going to place a window in its web page concerning SIGIR
- The information processed will be sent to the National System of Environmental Information and Natural Resources. Regrettably, this System is not yet in operation; in coordination with the Mexican C/P it was agreed to process the information and to send it to the SEMARNAT office in Quintana Roo.
- It has been agreed with the C/P that implementation of the Master Plan will be promoted through SIGIR. This activity will start with the official appropriation of the Master Plan by the Mexican authorities.
- SIGIR will be the instrument to be used in monitoring of the implementation of the Master Plan.
- Other organizations of the three government levels have manifested their interest in participating in SIGIR, i.e. FONATUR, BANOBRAS, CAPA, CNA, and other municipalities in the state.

4.3.3 Conclusions and Recommendations

a. Conclusions

- The establishment of SIGIR responds to a precept of the General Law and to an evident need of creating more synergy among the three government levels for taking care of the integral management of solid waste in the scope of their respective competences.
- The organizations linked through the net agree on the importance of SIGIR as a mechanism of information and coordination among them.
- SIGIR is an ideal instrument which informs the public and which achieves general participation on the subject of shared responsibility, prevention of the generation, valorization and integral management of solid waste.

b. Recommendations

- Assign on a permanent basis an operator for SIGIR in each participant organization.
- Routinely prepare and send to the National System of Environmental Information and Natural Resources, the information foreseen in the General Law. The Department of SEMARNAT in Quintana Roo will receive and register such information while the National System is activated.
- The moment the program of implementation of the Master Plan is prepared, its monitoring will start.
- SIGIR should incorporate other organizations of the three government levels, especially the other municipalities of Quintana Roo state, on the subject of solid waste management.
- SIGIR will be able to link all organizations that will be in charge of implementation of the Master Plan on the subject of wastewater management, especially the protection of the aquifer and the aquatic environment in general.
- SIGIR may be an ideal instrument for starting the structure 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 execution (2004-2015).

4.4 Capacity Building of Executing Agency in Othon P. Blanco

4.4.1 Outline

The SWM in OPB has faced financial imbalance. In general, financial imbalance can result from low income, high cost, or both. The income side of the financial problem is likely to have a political solution, since a recent Federal Law (Ley General para la Prevención y Gestión Integral de los Residuos) passed on 8 October 2003 established as an obligation for all users of the SWM service to pay user charges. In accordance with this new Federal Law, the Study Team prepared a municipal regulation on SWM in the Study Area, and when this regulation is passed by one or all three of the Municipalities in the Study Area, all users of the SWM service – including households – in a Municipality will have an obligation to pay the corresponding user charges. As a result, if SWM user charges are set at the appropriate levels and updated periodically, income improvement can be expected from the proper application and enforcement of the proposed municipal regulation on SWM.

Thus, the Study Team considered that improved understanding of the SWM cost by the OPB municipal government officers would have to be given a higher priority, taking into account the following facts: (1) lack of cost accounting specific to SWM; (2) cost estimation of SWM requiring special requests to the Accounting Section, rather than being a routine operation; (3) cost estimation based on the tracking down of appropriate accounts of the government budgeting system; (4) difficulty in monitoring cost performance of SWM activities over time due to the shortage of quantified indicators (for example, cost per ton of solid waste collection over time); and (5) the lack of cost performance indicators by SWM activity resulting in difficulty to focus and guide improvement measures.

This Model Project aimed at establishing a manner of calculation and control of the cost of solid waste management in a routine way by introducing the software, COSEPRE.

4.4.2 Outcomes

- A mechanism has been established to collect the necessary data which are handled by other municipal offices. Communication channels have been opened and cooperation has improved noticeably during implementation of the Model Project.
- The collected data frequently require prior processing for input into the software, and for this purpose, appropriate tables and forms have been prepared.
- The above mentioned data processing requires some criteria, sometimes based on accounting, other times based on reality, and these criteria have been transmitted to the municipal officers appointed for implementation of the Model Project.

4.4.3 Conclusion and Recommendation

a. Conclusion

- Awareness has been instilled in the concerned municipal officers about the need to approach the SWM service on the basis of its specific cost and revenues.
- The recommended COSEPRE software is being usefully applied in the Urban Development Office of Othon P. Blanco Municipality.
- Channels of communication and cooperation have been established among the different offices within the municipal government.
- The results obtained with the software are being subject to analysis for practical application in the improvement of SWM services.

b. Recommendation

- Use of the COSEPRE software should be expanded to other municipal offices, specifically Accounting and Finance, and the interested municipal employees should be given the chance to learn and use the software.
- The data collection system for the COSEPRE software should be continuously improved according to the accumulation of experience by the operators of the software.
- The results obtained should be discussed among those municipal officers responsible for SWM and those from Finance, Accounting, Human Resources, Urban Development and Education. A clear understanding of the objectives that are sought with the application of the COSEPRE software can improve the cooperation needed among the different municipal offices.
- Constant improvement should be sought in the cooperation and exchange of information among the diverse municipal offices.
- The software "Costos de MRS" was written using Microsoft Access, and should be improved and modified in order to adapt it to the particular needs of the municipality according to the accumulation of experience and the needs that may arise.

4.5 Improvement of the Existing Disposal Site in Othon P Blanco

4.5.1 Outline

All the solid wastes generated in Chetumal city are currently disposed of in Calderitas Dump Site. The wastes placed at this site were scattered around the area, and those wastes were exposed to the atmosphere. As a result, the water from rainfall penetrated into the wastes, causing leachate. The leachate from wastes is polluted water which easily contaminates groundwater.

Furthermore, the site did not have any facility to weigh the incoming solid wastes. Lack of basic data, such as the weight of wastes, made it difficult to evaluate the current condition and to achieve successful solid waste management.

This model project was formed to solve these problems with full collaboration of the specialists among the JICA study team and the C/P. The planned components of the project were as follows.

- Improvement of the existing disposal site by constructing dikes, compacting waste, covering waste with soil and installing gas removal pipes
- Technology transfer of proper landfilling with an operation manual

- Introduction of an incoming waste weighing system with installation of a weighbridge

4.5.2 Outcomes

The following are major outcomes.

- The leachate generation amount has been reduced by good waste compaction and cover soil.
- Accessibility on the site has been improved by the construction of a perimeter road.
- The incoming waste amount is known by utilization of the weighbridge.
- The number of flies and birds on the improved site has been drastically reduced.

4.5.3 Conclusion and Recommendation

a. Conclusion

This project seems to have been completed successfully. The difference of the outcomes between the improved landfilling and previous dumping is easily discovered within the site. Through this Model Project, the operational staff has acquired skills and knowledge regarding proper landfilling and its importance has been instilled in the persons concerned of the municipality and other institutions.

The amount of wastes was assumed to be 100 tons/day in weight, or 200 m^3/day in volume after compaction. However, the actual amount of wastes was 162 tons/day or 324 m^3/day in average, which is a bit larger than estimated. The result indicates that the disposal site will be full before the estimated life time of 5.1 years.

The model project has been successful within the term of the project. However, in order to continue the landfill operation after its handover, adequate budget from the municipality is necessary.

b. Recommendation

For the purpose of utilizing as much of the capacity of the landfill as possible, more frequent operation of waste compaction should be encouraged. Some action should be taken immediately so that disposal machineries are kept up with their daily loads. Besides, an inspection and maintenance plan is an important component of machinery operation.

The municipality has strengthened its capability to operate the disposal site properly by means of implementing the model project. This is an indication that the municipality is technically prepared to operate sanitary landfills. Therefore, this is probably the best time to

consider taking another run at the suspended project for construction of a new sanitary landfill in the area adjacent to the existing disposal site.

4.6 Collection Service Improvement in Othón P. Blanco

4.6.1 Outline

In general terms, it can be stated that the collection service under the Head Office of Municipal Public Services is effective, since it collects most of the wastes generated in the covered area; on the other hand, it lacks efficiency given the inadequate exploitation of resources, which consequently has an impact upon the costs of the service.

The inefficiency was largely caused by lack of planning and design of the service. This situation greatly adds to the costs of the service and curtails the possibilities of raising the service coverage due to lack of budget.

In order to revert to the status quo, a project oriented at improvement of the current collection service is deemed convenient so as to achieve a level of efficiency that allows, in the short term, considerable cost reduction and enhanced quality; as well as reinforcement of the system's organization so that waste management can be integrally outlined and a better allocation of resources can be achieved, which in turn will contribute to expanding coverage towards outer locations.

The planned components of this Model Project were as follows.

- Preparation of a manual for planning and designing of collection routes
- Technical transfer for planning and designing of collection routes with the manual
- Establishment of a method for gathering and recording waste collection data

4.6.2 Outcomes

- Through the optimization of the routes, the total time of operation of a truck was reduced by 11%; the hours paid to operative personnel were reduced by 11%; the total tons collected per hour was increased by an average of 3% and a maximum of 10%; the tons collected per assistant was increased by 8% at maximum and 3% on average. These results reflect a reduction in the direct costs of the service.

- The Direction of Municipal Public Services incorporated within its administrative and operational process the use of the "route sheet" for gathering information in all the collection routes. Two calculation books were designed and put into operation in excel format. These books allow the recording of information gathered in the route sheet, the consolidation of information per route and vehicle, the estimation of resources used

(manpower, vehicle) and estimation of quality indicators. These instruments are used for the whole service.

- The application of quality indicators for all the routes came into operation; goal values were established for each one of them and a table of priorities was designed for the optimization of the routes.
- The D.M.P.S. decided to elaborate a monthly report which details the operation of the collection service, including an analysis of its efficiency. The purpose is to evaluate the service, to have the necessary antecedents in order to effect the changes and to elaborate budgets.
- A manual for improvement of the collection service has been prepared. In addition, an instruction manual for the recording of data and the use of the calculus book was elaborated. Personnel were trained on the use of both manuals.
- Coordination between the municipality and small localities was fortified. Coordination meetings were carried out among the organizations involved and the Technical Unit was created. The localities are operating the route sheet, performing the monitoring of the routes and sending the information to the D.M.P.S. The D.M.P.S. is giving technical support to the localities for optimization of the service.

4.6.3 Conclusions and recommendations

a. Conclusions

The Model Project has shown a possibility to considerably improve the service through a rational plan of collection, which will permit not only increasing the efficiency and quality of the service but also achieving an adequate level of competitiveness and attaining important reductions of costs.

During the development of the experience, a set of problems became apparent; these problems affect the quality and efficiency of the service and are not related to its design but to parallel activities that drivers and collectors perform. These problems should be eliminated in the optimization of the routes in order to achieve effective results.

Besides increasing the efficiency of the service, its quality has also been improved, carrying out optimum collection according to established collection days and timetables. After the service is performed, no scattered waste is observed on the streets. These achievements have been possible due to the constant participation of all personnel that took part in the model project, and those who put into practice the knowledge obtained through the training program. The adequate diagramming and daily control of the parameters monitored by part of

the technical personnel, allowed making the necessary adjustments in the routes. The constant supervision of the routes assured the execution of the journeys and hence the coverage of the service. Finally, the correct execution of the route and the lifting and loading of waste strongly influenced the increase in efficiency and effectiveness of the service.

The D.M.P.S. has agreed on the importance of optimizing the service and on the need of formulating in the short term a type of charge for the cleaning service, which will allow its sustainability. The city halls are interested in improving and controlling the collection service and are able to cooperate with the D.M.P.S. in order to achieve the objective.

b. Recommendations

With the purpose of increasing the efficiency of personnel, it is recommended to modify the system of payment. This may be carried out because the new system of controlling the routes makes it possible to know the hours that were effectively worked.

It is recommended to eliminate the allocation of a fixed amount of fuel per vehicle, which avoids any type of control over the resource. Nowadays there are variations of over 20% of consumption for the same vehicle, which strongly impacts the costs of the service.

It is recommended to perform more supervision in the area of routes in order to assure execution of the journeys.

It is recommended to carry out the collection of household waste separately from vegetable waste (especially pruning waste) in order to improve the efficiency of collection and avoid damage to the compactor equipment.

It is recommended to acquire new trucks that can replace small trucks and dumping trucks, due to their low efficiency and because they are not suitable for the service that is currently performed.

4.7 Collection Service Improvement in Felipe Carrillo Puerto

4.7.1 Outline

The municipality of Felipe Carrillo Puerto had low collection service coverage for municipal wastes (household, commercial, institutional, and so on). The reason behind this low coverage is related to the scarce budget available to the municipality for these activities, ranging from 10 to 12% of the total budget, which resulted in the poor condition of the collection vehicles and a lack of planning of the service.

It was evident that planning of the collection service did not exist and auditing of the service and information surveying were not carried out properly. This situation could be reverted if a

program aimed at improvement of the collection service was implemented. The proposed model project aimed at such improvement through the following phases:

- Designing of the collection service with technical criteria,
- Implementation of routes as per the proposed layout
- Preparation of a Plan to expand coverage
- Preparation of a manual that will constitute the basic tool to extend the experience to other locations

4.7.2 Outcomes

- The new collection service was put into operation in Felipe Carrillo Puerto; the design of the service was based on basic criteria, which allowed the optimum use of the resources available.

- The number of users served by the new collection service is higher than 16.000 inhabitants, which represents an increment of 78% in coverage in the city of F.C.P.

- The Direction of Municipal Public Services incorporated within its administrative and operational processes the use of the Route Sheet that allows gathering field information of the services. A computer schedule was put into operation for the registering and management of data obtained through the route sheet and a schedule for the consolidation of information and the estimation of indicators.

- The use of indicators was enforced, setting specific goal values for each one, and evaluating the routes each month. The necessary correction was carried out. The municipality decided to incorporate into the Direction of Municipal Public Services a technician in charge of the computer management and processing of field information, the elaboration of monthly reports and the evaluation of routes through the use of indicators.

- The number of hours worked per month was reduced as well as the number of journeys.

- Personnel of the D.M.P.S. are trained for carrying out the design of the collection service, making possible to extend the experience to other areas of the city or communities.

- A procedures manual was elaborated for design of the collection service and optimization of the collection routes. An instruction manual for the recording of data and the use of the calculus schedule was also elaborated. Technical personnel were trained on the use of both manuals.

4.7.3 Conclusions and recommendations

a. Conclusions

- Authorities of the municipality have agreed that the adequate management of waste will allow improving the living conditions of the community, reducing gastrointestinal diseases and minimizing negative impacts on the aquatic environment.
- Implementation of the model project has generated a culture of waste management, both in the community as well as in the D.M.P.S. The community is aware of the importance of the adequate management of wastes and is able to collaborate with activities carried out by the municipality on this subject.
- With the new system adopted by the D.M.P.S., the City Council is ready to examine a tariff for the service, in order to obtain the income required for carrying out the replacement of equipment and increasing the coverage to other communities.
- The adequate design and control of the service has shown the municipality that this is an efficient mechanism through which the coverage may be increased.

b. Recommendations

- It is important to study in a technical way and to enforce in the short term a tariff to charge for the service. A proper alternative is to at first charge the commercial sector and over generators, and later charge the community. In the latter case, the revenue may be associated to the application of a subsidy directed exclusively to the lower income sector.
- To approve and to apply in the short term a Regulation for the Rendering of the Public Service of Integral Management of Urban Solid Waste.
- To purchase two trucks with compacting capability and to improve the mechanical status of the current trucks.
- To improve the operation of the final disposal place. It is crucial that together with the improvement and increment of the coverage of the collection service, the final disposal place be improved.
- The current conditions of operation represent a serious risk to the environment. In this respect, it is recommended that the municipality designate on regular basis equipment for the accommodation of wastes in order to minimize the area contaminated with wastes and the generation of fires.

4.8 Establishment of Solid Waste Management System in Costa Maya

4.8.1 Outline

Costa Maya is located in the southern part of Quintana Roo State, and touristic development is considered the way to achieve economic growth of the area.

The Costa Maya development project pretends to promote low impact tourism and tourism of low density with an exclusive destiny. It will be specifically directed to small groups who will visit reserves, beaches, reefs, archeological places and hotels built in harmony with nature. In other words, the tourism development plan pretends to promote sustainable development

The Model Project was oriented to the development of a minimization culture. This initial step has opened a door to shared responsibility, prevention of the generation, valorization and integral management of solid waste foreseen in the new General Law for the Prevention and Integral Management of Waste (Federation's Official Magazine, October 08, 2003).

The planned components of the Model Project were as follows.

- Formulation of an institutional framework for solid waste management
- Introduction of waste minimization culture such as recycling and composting
- Improvement of the existing dumping site

4.8.2 Outcomes

- The "Commission for the Management of Solid Waste in Mahahual (CSWM)" consisting of local residents has been created. The municipality of Othon P Blanco has acknowledged it and the "Community Regulation for the Collection, Management and Final Disposal of Solid Waste in Mahahual."

- The municipality has decided to structure an administrative unit in charge of the development of Costa Maya.

- On the main avenue, five stations of waste separation were installed. Tourists make use of the infrastructure of separate discharge.

- Two composters were installed for a group of restaurants in order to start a program of management of organic waste. The experience did not achieve a positive result due to the high moisture content of the wastes. Meanwhile, in the Tele High school a composter was constructed in order to receive the waste of restaurants. The experience

has been successful. Students plan to install a school orchard using all the compost that has been produced.

- ECOCE Company has started its negotiations with the CSWM in order to collect all PET containers.
- A manual landfill has been constructed. The municipality will be in charge of the operation.
- The municipality has started the procedures with FONATUR in order to obtain funds for the construction of a sanitary landfill that will provide services to all of Costa Maya.
- The municipality has started to charge stores and the enterprise which owns the cruisers' harbour (Puerto Costa Maya) for solid waste management services. A rate/fee structure is in preparation, which may assure the financial sustainability of the system.

4.8.3 Conclusions and Recommendations

a. Conclusions

- The strategy and the measures proposed in the M/P are being executed.
- The community of Mahahual is incorporating the practice of minimization in the management of their solid waste.
- The authorities of the three government levels have agreed on the importance of waste minimization for effective protection of the aquatic environment against the impact of solid waste in Costa Maya.
- The information and coordination among the three government levels is still weak.

b. Recommendations

- Implementation of the Master Plan must be considered as an objective of the public policies of the three government levels. The regulations established in the "General Law for the Prevention and Integral Management of Urban Solid Waste" should be applied. The municipal authorities should consider the approval of the project "Regulation for the Rendering of the Public Service of Integral Management of Urban Solid Waste." These are the basic elements to establish a sound solid waste management in Costa Maya.
- The municipality of Othon P. Blanco should incorporate the recommendations of the M/P in the revision of the Mahahual Urban Development Program" and structure an

administrative unit which assumes the responsibility of the management of solid waste in Costa Maya.

- Officially recognize and support the Commission for the Management of Solid Waste in Mahahual and apply the "Community Regulation for the Collection, Management and Final Disposal of Solid Waste in Mahahual".
- Support the initiative of FONATUR for financing the new landfill and the transfer stations in Costa Maya.
- Encourage the private sector to participate in activities for the minimization of solid waste by taking ECOCE as an example.
- Structure and apply equitable and fair fees that permit to assist the cost of the rendering of the service of solid waste management.

4.9 Environmental Education and Recycling Activities

4.9.1 Outline

There is a Law of Ecological Balance and Environmental Protection of the State of Quintana Roo, which includes several articles related to environmental education. There are many institutions which are working with environmental education programs. However, there is no coordination among them; therefore, environmental education is not effective nor does it provide a practical dimension focused on the problem of appropriate solid waste and wastewater management. Also, recycling activities are not promoted at the government level (state and municipal). Such activities are mainly practiced informally by the private sector.

Under these circumstances, this Model Project aimed at providing an education program that can make children be acquainted with the importance of resource conservation and recycling through harmonized coordination of different institutions. The planned components of the Model Project were as follows.

- Formulation of an environmental education program
- Preparation of educational materials such as a video, texts and posters
- Training for the counterpart personnel and school teachers regarding implementation of the environmental education program
- Holding environmental education classes in primary schools
- Introduction of recycling activities in primary schools

4.9.2 Outcomes

- A working team integrated by SEDUMA, OPB and CAPA personnel has been formulated, and a commitment of this team to follow the environmental education model project and recycling activities has been made.
- Personnel of the C/P (OPB, FCP, CAPA and SEDUMA) were trained in environmental education through work sessions and workshops. The trained personnel, in turn, trained elementary school teachers to carry out experimental classes with students. Then, experimental classes on environmental education in schools were implemented.
- Recycling activities took place in elementary schools. The private sector (recycling company) participated in the paper recycling activities.

4.9.3 Conclusions and Recommendations

a. Conclusions

- The strategy and proposal measures regarding environmental education in the P/M are on-going.
- With the implementation of the Model Project of Environmental Education and Recycling Activities, the C/P formed a working team where the institutions can share their experiences and enrich the actions and impact of the project in the State.
- The working team (Executing Unit of Environmental Education) has carried out the short term program of environmental education activities (training workshops for teachers, experimental classes and other activities related) successfully.
- The school community has been incorporating waste minimization practices through paper recycling activities.
- Coordination among private companies, schools and institutions is still weak.

b. Recommendations

- To conform and consolidate in a permanent form the Executing Unit where SEDUMA acts as a coordinating organism.
- To implement a monitoring system for the environmental education program and recycling activities.
- To incorporate in a permanent way the Ministry of Education in the Executing Unit.
- To promote and institutionalize recycling activities at the state level.

- To obtain incentives and finances to reinforce the environmental education activities with the participation and support of the private sector.

5 Conclusion and Recommendations

5.1 Conclusion

5.1.1 Conservation of Coastal Aquatic Environment

a. What is the Coastal Aquatic Environment?

The karst topography of the Yucatan Peninsula, which is permeable and soluble, formulates a unique coastal aquatic environment composed of reefs, lagoons, mangrove forests, caves and cenotes. There is no river on the surface in the Study Area except Rio Hondo, which runs on the border between Mexico and Belize. Rain percolates and streams under the ground, and then flows out to the coastal area. Namely, the groundwater directly connects with the coastal aquatic environment and nurtures this rich environment. Therefore, it is reasonable to comprehend that the coastal aquatic environment includes the groundwater in the Study Area.

b. Value of the Coastal Aquatic Environment

In the State of Quintana Roo, the above mentioned coastal aquatic environment stretches from Cancun to Costa Maya. The coastal aquatic environment is important as a tourism resource and a habitat of various creatures. In addition, the groundwater is indispensable for human life as the unique water supply resource.

The tourism industry is not only important for the State of Quintana Roo, but also for the Country of Mexico. The foreign currency earning by the tourism industry ranks third following one by oil and by workers in foreign countries. In 2000, the tourism industry earned 8,300 million dollars. One third of the amount came from the State of Quintana Roo. In addition, tourism creates job opportunities so it is also important for the regional economy.

The unique coastal aquatic environment provides habitats for various animals and plants. About 670 species of animals and 1,500 species of plants inhabit the State including endangered species such as manatees, jaguars and green turtles.

c. Threats to the Coastal Aquatic Environment

As mentioned above, the coastal aquatic environment faces various threats caused by the rapid urbanization being brought along with the development of tourism. The threats can be divided into direct environmental disruption, such as housing land development, road construction, and construction of hotels, and indirect environmental disruption, such as over exploitation of groundwater for water supply and groundwater contamination caused by inappropriate disposal of wastewater and solid waste.

Regarding the direct environmental disruption, POET (Programa de Ordenamiento Ecologico Territorial), which is a zoning ordinance, works as an effective tool. In the Study Area, the three areas of Costa Maya, Sian Ka'an Biosphere and Corridor Cancun - Tulum are regulated by POETs. In addition, a new POET is under preparation targeting the Bacalar area.

Meanwhile, measures by the state and the municipalities have not caught up with problems of water supply, wastewater treatment and solid waste disposal brought by the rapid increase of population and tourists. It is feared that the indirect environmental disruption is rapidly and seriously developed.

The objective of the Study was to formulate the Environmental Sanitation Management Master Plan aiming at preserving the coastal aquatic environment along the coast of Quintana Roo State in the Yucatan Peninsula, which was to cope with the indirect environmental disruption.

5.1.2 Preservation of Groundwater

a. Threats to the Groundwater

The groundwater nurtures the coastal aquatic environment which is important as a resource for tourism and a habitat for various animals and plants, and is a unique source for drinking water in the Yucatan Peninsula.

The fresh water layer in the peninsula is thin due to the intrusion of sea water. In areas close to the coastal line, groundwater becomes saline water under 5 or 10 m from the surface. Most of the extraction wells for water supply are located in the interior about 20 or 30 km from the coastal line where the fresh water is developed to the depth of around 50 m or more; however, over exploitation may cause local salinization.

It is considered that the most serious threat to the groundwater is domestic wastewater from houses and hotels. Sewerage coverage rates in the Study Area are very low such as 16% in Othon P Blanco, 1% in Felipe C Puerto and 5% in Solidaridad. Even in areas covered by the sewerage system, residents hesitate to connect their in-house drainages to the public sewer due to economical reasons. Furthermore, because of an absence of rivers on the surface, treated wastewater from sewage plants is discharged into the saline water layer under the ground, and then contaminates the groundwater.

Waste collection works in urban communities in Othon P Blanco and Solidaridad have been relatively well done. However, disposal of waste is inadequate, which causes a large amount of leachate and contaminates the groundwater.

The service industry focusing on tourism is the most important industry in the Study Area. The manufacturing industry has not yet been developed and agriculture is not widespread. Therefore, it is assumed that domestic wastewater and solid waste from houses and the service industry, namely from residents and tourists, are principal sources of pollution to the groundwater. The Study estimated that 60 % of the pollution load originates from domestic wastewater and 40 % from solid waste.

b. What will happen in the future?

A rapid increase in population and tourists is forecasted in the Study Area. The forecasted population in 2015 is 893,000, which is twofold of the estimated population of 435,000 in 2003. Meanwhile, the 1,757,000 tourists in 2003 are estimated to become 3,156,000 in 2015.

If no new measures are taken in the sectors of wastewater and solid waste, it is predicted that the groundwater will be contaminated to a level of 4.9 mg/liter of BOD due to the pollution load originating in the sectors. This level of contamination is categorized as Class C in the environmental standard for river water in Japan, which means the groundwater will not be suitable as a source for drinking water. Furthermore, it will deteriorate the coastal aquatic environment such as cenotes, caves and reefs.

Such environmental deterioration will bring about loss of attraction as a tourist resort, loss of biodiversity and health hazards. It is estimated that foreign currency earnings by tourism until 2015 will be 10,529 million pesos below the original forecast.

It is concluded that the pollution load originating from wastewater and solid waste will contaminate the groundwater; which will lead to deterioration of the coastal aquatic environment; consequently, a sustainable development of the Study Area will be hampered.

5.1.3 The Master Plan

a. Basic Concept

The proposed Master Plan sets “to contribute to regional sustainable development of the Yucatan Peninsula” as the guiding principle, “to preserve the groundwater and the coastal aquatic environment in southern Quintana Roo State through the adequate management of wastewater and solid waste” as the principal objective, and “to clarify respective responsibilities of the public sector, the private sector, the residents and the tourists, and to encourage their appropriate participation in Environmental Sanitation Management” as the basic approach.

As the target values of the Master Plan, it is proposed that the BOD discharge amount originating from wastewater and solid waste is to be less than 5,200 tons/year by 2015,

aiming at controlling the BOD concentration of the groundwater at 1.0 mg/liter and below; less than 3,100 tons/year from wastewater, and less than 2,100 tons/year from solid waste.

b. The Wastewater Management Master Plan

In order to achieve the target mentioned above, the Wastewater Management Master Plan proposes various treatment levels taking into account the characteristic of the population distribution in the Study Area; a higher treatment level (more reduction of pollution load) for larger populations and a lower treatment level for smaller populations. The reduced pollution load amount per cost is greater in a larger facility. Thus, the Master Plan proposes to prioritize projects in larger communities taking into account cost-effectiveness. The responsible institution is CAPA (Commission of Potable Water and Sewerage).

The total cost of the Master Plan is 3,300 million pesos until 2015. The results of the financial analysis say that the current tariff can basically cover the total cost when considering the Study Area as a unit; however, the tariff cannot cover the cost in Othon P Blanco and Felipe C Puerto when considering the municipalities individually.

c. The Solid Waste Management Master Plan

The Solid Waste Management Master Plan targets urban communities that will have a population of more than 25,000 in 2015, taking into consideration the relationship between community size and the demand for solid waste services. It also proposes higher waste collection rates and a more sophisticated waste disposal manner for larger communities. In addition, waste minimization is proposed, as it leads to reduction of the pollution load and conservation of resources. Responsible authorities are the municipal governments, and SEDUMA will guide and support them.

The total cost of the Master Plan is 1,178 million pesos by year 2015. However, the incremental cost is only 441 million pesos as the solid waste service is currently provided. The financial analysis says that in order to cover the total cost of 1,178 million pesos, it is necessary to charge residents from 40 to 50 pesos/month/house and business entities from 150 to 200 pesos/month/entity. Then, financial self-sufficiency can be achieved.

d. Benefits

The expected benefits, which the Master Plan will bring about, are 1) keeping of attraction to tourists, 2) preservation of biodiversity and 3) protection of the water source for drinking water. A quantitative economic evaluation was carried out targeting the first benefit. As a result, EIRR (Economic Internal Rate of Return) was 39.0%, NPV (Net Present Value) was

2,545 million pesos and B/C (Benefit – Cost Ratio) was 2.06. Therefore, it is concluded that the Master Plan is economically feasible.

5.1.4 Model Projects

An investigation on hydrogeological conditions and some measures listed in the Master Plan were carried out as Model Projects.

Urban Type Wastewater Treatment carried out at Playa del Carmen in Solidaridad clarified that the current manner of treated wastewater injection is not appropriate in view of the hydrogeological conditions of the site and there is room for improvement. In addition, ammonia was found in the groundwater, which indicates that the groundwater was artificially contaminated.

Residents are responsible for connection of in-house drainage to the public sewer. However, financial burden for the connection and lack of knowledge about environmental conservation discouraged the residents from doing so. Consequently, although CAPA constructed the public sewers, the actual sewerage coverage was not increased. To cope with this problem, Village Type Wastewater Treatment established a fund to ease the financial burden and provided explanations to residents along with environmental education. As a result, the connection was promoted.

Establishment of an Integral Solid Waste Management Information System formulated a framework where SEDUMA and the municipalities exchange information on Solid Waste Management; the former is an institution of the state government and the latter are responsible for provision of solid waste services. The system is also to respond to a requirement of a new federal law, “General Law for the Preservation and Management of Waste.” In regard to this Model Project, it is proposed to establish an Executive Unit in SEDUMA for promoting and supervising implementation of the Master Plan and to enact a new municipal ordinance of Solid Waste Management based on the Master Plan.

Capacity Building of Executing Agency in Othon P Blanco aimed at establishing a manner of controlling solid waste service costs. This Model Project was carried out in collaboration with two other Model Projects, i.e. Improvement of the Existing Disposal Site and Collection Improvement. Namely, technical data obtained from these Model Projects were combined with cost data; then, the results of analysis of the combined data were sent back for improvement of the disposal site operation and the collection works. Accordingly, the Model Project is to strengthen a core capability of Integral Solid Waste Management. Information on cost was dispersed over several sections of the municipal government so it was difficult to gather information at the beginning. However, communication channels among the sections

were established and awareness of improvement among the municipal personnel was boosted through the Model Project.

Through Improvement of the Existing Disposal Site in Othon P Blanco, dispersed waste over the disposal site was gathered in a certain area, compacted and covered with soil, which improved sanitary conditions; and an access road was constructed which significantly improved workability of the site. In addition, the amount of waste brought to the site was determined due to installation of a weighbridge. Information on waste amount is one of the most important information in Solid Waste Management. The average amount of waste disposed of during the Model Project was 160 tons/day.

Collection Service Improvement was carried out in Othon P Blanco and Felipe C Puerto. Through the Model Project, a method for planning collection routes, recording operation data and evaluating the data was established. As a result, a reduction in the operation time of collection vehicles and an increase in the collected waste amount per crew were confirmed in Othon P Blanco. Those data indicate a possibility of cost reduction. In Felipe C Puerto, the Model Project increased the collection coverage up to 80% from 50 % before the Model Project.

In the Model Project of Establishment of Solid Waste Management System in Costa Maya, several stations for separate collection were installed aiming at waste minimization; the stations were managed by a newly established committee on Solid Waste Management in a local community; and negotiation with traders regarding collected PET bottles and cans got started. Namely, a new Solid Waste Management System has begun to work.

Environmental Education and Recycling Activities prepared educational materials such as a video and texts, established a method of environmental education using the materials, and realized a paper recycling activity. These activities are carried out and expanded by the Mexican counterpart themselves.

5.2 Recommendations

5.2.1 Recommendations for implementation of the Master Plan

a. The Wastewater Management Master Plan

1. Improvement of Sewerage Coverage

- In the development of sewerage systems in urban communities, priority shall be given to those that are cost effective in view of reducing the pollution load and those communities that generate a large amount of the pollution load.
- The manual and experience acquired through the Model Project of Village Type Wastewater Management shall be utilized for the construction and operation of sewerage systems in small communities in the future.
- CAPA shall be after required investment cost for development of sewerage system in coordination with CNA.

2. Promotion of In-house Drainage Connection

- CAPA shall formulate a project team for promoting the in-house drainage connection. The team shall be composed of personnel from various sections such as planning, construction, operation and maintenance, and community relations.
- The promotion shall be conducted not only in areas where sewerage system exists, but also in areas where construction of a sewerage system is planned. The promotion shall be carried out beforehand, e.g., before or at an early stage of construction works.
- In order to ease the financial burden on residents, the fund established in the Model Project of Village Type Wastewater Treatment shall be expanded and further utilized.
- In order to raise residents' awareness on environmental conservation, explanations to residents shall be combined with environmental education.

3. Income Improvement and Cost Reduction

- The tariff of sewerage service, which is currently set as 20% of the water supply charge, shall be raised according to expansion of the sewerage service.
- Installment of micrometers shall be promoted and fee collection rate shall be improved.
- Indirect cost that currently occupies about 50% of the total cost shall be reduced.

b. The Solid Waste Management Master Plan

1. Improvement of waste collection coverage

- Improvement of collection works shall be continued based on the manuals prepared and the experience acquired through the Model Project of Collection Service Improvement.
- Capacity reserved in the improvement shall be utilized for expansion of collection coverage.

2. Implementation of Proper Waste Disposal

- The existing disposal sites shall be improved referring to the manual and the experience acquired through the Model Project of Improvement of the Existing Disposal Site in Othon P Blanco.
- The current disposal operation shall be moved to a sanitary landfill in Chetumal, Riviera Maya and Costa Maya according to schedule set in the Master Plan.
- Othon P Blanco Municipality shall be after the required investment cost for construction of a sanitary landfill in Costa Maya in coordination with FONATUR.

3. Promotion of Waste Minimization

- The Model Project of Environmental Education and Recycling Activities shall be continued and expanded in coordination with the Ministry of Education and other institutions concerned.
- Paper recycling that was launched in the Model Project shall be expanded.
- Recycling of PET shall be promoted in coordination with ECOSE.
- Pruning waste composting shall be started in the near future.

4. Actions towards Financial Self-sufficiency

- Fee collection of solid waste services shall be considered and implemented as soon as possible.
- A system to charge tourists for solid waste services shall be considered as soon as possible.

5. Strengthening of Institutional System

- An Executive Unit that is to be in charge of guidance and support of Solid Waste Management shall be established in SEDUMA.
- The municipalities shall consider the proposed ordinance regarding Solid Waste Management.

5.2.2 Recommendations for Groundwater Preservation

1. Establishment of a Groundwater Monitoring System

- CNA shall establish a monitoring system that is capable of comprehending groundwater status quantitatively.
- The monitoring results shall be utilized for proper implementation of the Master Plan, e.g., if monitoring results say that contamination of the groundwater is serious in a certain area, a recommendation of prioritizing construction of sewerage in the area can be induced.

2. Improvement and strengthening of Institutional System

- In order to make it possible that evaluation of monitoring results leads to necessary actions to protect the groundwater, the current institutional system shall be improved and strengthened, e.g., if quality of the groundwater is regulated quantitatively, results of monitoring can be evaluated according to the regulation and then actions can be taken immediately such as further studies or guidance.
- CNA shall begin to establish regulations on the injection well considering the results of the Model Project of Urban Type Wastewater Management.

5.2.3 Recommendations for Conservation of the Coastal Aquatic Environment

1. Water Quality Monitoring in Nearshore Waters

- The relationship between the quality of the groundwater and of the seawater shall be studied in coordination with monitoring conducted by the Navy in nearshore waters.
- The Navy's monitoring works shall be diagnosed and evaluated. If necessary, measures shall be taken for improvement of the monitoring system.

2. Promotion of Cooperation with Projects and/or Institutions Concerned

- Information shall be interchanged among related projects such as Mesoamerican Coastal Reef Conservation, and possible coordination shall be after.
- Information shall be interchanged among institutions dealing with environmental conservation such as University of Quintana Roo, ITCH (Instituto Tecnologico de Chetumal) and ECOSUR (El Colegio de la Frontera Sur).

In conclusion, the Study Team would like to express it appreciation to the organizations and individuals in both Mexico and Japan having participated in or cooperated with this Study. We expect that what we have done together will lead to sustainable development of the Study Area, the State of Quintana Roo and the Yucatan Peninsula.