C.1.4 Solid Waste Management

C.1.4.1 Overview of the Solid Waste Management

Through the political constitution of the United Mexican States, the municipalities have the obligation to render basic public services (primary and essential ones), within which the cleaning, collection, haulage, treatment and final disposal of wastes are specifically mentioned. On the other hand, at a federal level, the General Law of Ecological Balance and Environment Protection states in Chapter II, article 8th (section IV) on the competences of the municipalities, "the enforcement of juridical provisions in regards to the prevention and control of effects on the environment arising from the generation, haulage, storage, handling, treatment and final disposal of industrial solid not regarded as hazardous …" and (section IX) "Preservation and restoring of the ecological balance and protection to the environment within population centers will be sought, with respect to the effects stemming from the sewerage and cleaning services, markets, main markets, cemeteries, slaughterhouses, traffic and local transports …". Additionally, in Chapter IV article 137, the municipality has the power to authorize the collection, storage, haulage, reuse, treatment and final disposal services of municipal solid wastes as per its local laws on that matter and as per the Mexican Official Standards".

In the same manner, at a state level, the General Law of Ecological Balance and Environment Protection of the state of Quintana Roo outlines the municipality's competences as to the management of solid wastes, specifically in Chapter II article 6 (section IV), which reads: "…The regulation of juridical provisions relative to the prevention and control of effects on the environment due to the generation, haulage, storage, handling, treatment and final disposal of household wastes, as well as the enforcement of the same as to non-hazardous industrial wastes ". On the other hand, Chapter IX article 167, with mention to the public services, states the following: "The municipalities will set out the juridical and administrative provisions to protect the environment within population centers, as per their constitutional, legal and regulatory powers, with respect to the negative effects on the environment arising from the operation of potable water, sewerage and cleaning services, markets, main markets, slaughterhouses, cemeteries, streets, urban parks and gardens, traffic and municipal transportation and municipal doghouses, and the same will be observed by the municipalities and particulars whom have been granted the provisioning of some of the services above". On the other hand, the Organic Municipal Law of the State of Quintana Roo, in Section V of the same, establishes what public services are under the responsibility of the municipality and regulates their development. The same document also states that the municipalities can be divided into city halls, districts and sub-districts, and the functions of the city halls will be to

manage and improve the quality of public services, with specific mention to the cleaning service.

At a municipal level, the Police and Good Government Edict for the municipality of Othón P. Blanco, in chapter V, article 208, sets forth that the cleaning and collection service is a public interest and will be provided by the City Hall through the Direction Office of Municipal Public Services. Additionally, the same chapter therein defines the types of wastes regarded in the service, the conditioning and storage and discharging of the wastes by the users, collection method for bulky waste, management of garden waste, responsibilities by the dwellers in regards to urban cleansing (sweeping and discharge by households, businesses, and so on), operational cleaning programs, sanctions and final disposal method, among others. A Cleaning Code also exists; however, it is not enforced.

Currently the Direction Office of Municipal Public Services directly runs the collection, haulage, final disposal and sweeping operations, with service to the city of Chetumal and the locations of Subteniente López, Xul-Ha, Huay-Pix, Raudales, Laguna Guerrero and Luis Echeverría; in other locations such as Bacalar, Nicolás Bravo, Calderitas, Javier Rojo Gómez, Alvaro Obregón, etc., the service is provided independently from the Direction Office by the city halls or districts and with their own funds by providing vehicles and payment to the staff employed for the service. In the remaining locations no service is being rendered and generators deal with their own wastes by burning the same. Within the municipality there is a single private service that serves the location of Mahahual, which includes the collection, haulage, cleaning of beaches, sweeping and final disposal, due to the tourism activity developing within the area.

The Direction Office of Municipal Public has a Department of Urban Image within its flowchart, which is in charge of operating the collection, haulage, sweeping and final disposal services of municipal solid wastes. The service is aimed mainly at the city of Chetumal, an only once a week are wastes collected at the locations of Subteniente López, Xul-Ha, Huay-Pix, Raudales, Laguna Guerrero and Luis Echeverría.

The wastes collected correspond to household, commercial, pruning and junk waste. The discharge system within the city varies, with predominance of supermarket plastic and small plastic containers for household wastes; in the case of businesses, the same are generally stored in bulk and in drums in front of the commercial stalls.

The collection service is provided seven days of the week with three shifts: morning, afternoon and night shift. The collection frequency will vary depending on the sector, with a daily frequency for downtown area and three times a week for the rest of the city. The collection method is door-to-door.

The service is designed to serve the entire city with a total of 31 collection routes, employing 17 vehicles with diverse capacity and type; additionally, it has an additional 10 vehicles to carry out special operations and the collection in other locations. It is important to mention that most of the vehicles are in poor conditions, some of them with longevity of up to 15 years.

A control of the trips and the tonnage collected and introduced to the final disposal site is carried out, which is determined as per the nominal capacity of the vehicle. Throughout 2002, according to this log a total of 71,540 tons of household wastes, 18,250 tons of commercial wastes, 19,710 tons of prunings and garden waste and 449 tons of junk were collected.

On an annual basis, the Direction Office carries out two operations with the purpose of picking up junk and bulky waste to prevent the proliferation of mosquitoes and other sanitary vectors.

The total of workers regarded in the collection service adds up to 150 people; most of them work seven days a week, thus, several extra time is paid if it is considered that the working week is of five days.

Regardless of the fact that the collection service is contemplating the frequencies and established routes, there are sectors in the city that are not clean, mainly due to the fact that the collection schedules are not attended as a consequence of the poor mechanical status of the vehicles and because the users do not take out their wastes when the collection truck passes by.

The sweeping service is provided only in the city of Chetumal, with a coverage ratio of 50% of the city; it is mechanical and covers the main avenues, the Bahia boulevard and some secondary streets. Manual sweeping is carried out from Monday to Sunday in a single shift from 04:00 through 11:00. As of this year, two mechanical brand new sweepers have been incorporated into the service, which service Boulevard and main avenues between 04:00 and 14:00.

Sweeping wastes are carried to gathering points, where they are later collected by vehicles devoted exclusively to such activity and disposed of in the municipal dumpsite.

The total of workers regarded in the service totals de 75 people, who generate several extra time as the collection workers, as they work seven days a week.

All the wastes collected are disposed of in a dumping site located in Calderitas, approximately 15 Km. of the city. During its first stage, this disposal site performed as a sanitary landfill; however, due to budget issues and a poor operation it became an open

dumping site that currently poses serious environmental risks, such as the proliferation of sanitary vectors because the wastes are not covered and not arranged in concentrated areas, presence and infiltration of leachate and fires.

The dumpsite has an area of 15 hectares and above 85% of the same has been utilized and, according to estimates by the Direction Office of Municipal Public Services, its useful life would not surpass two years.

There is a staff at the dumping site that records all the vehicles coming in, regardless where they come from; there is also a D-9 bulldozer and a D-6 bulldozer. However, only the D-6 is in operative conditions and spreads and compacts the wastes. The inappropriate mechanical conditions of the same do not allow their continued operation, and thus the construction of waste cells cannot be maintained. The staff assigned for the dumpsite includes two arrangers, two people in charge of registering and controlling the entrance of vehicles and three guards.

Due to the environmental and sanitary problem posed by the dumpsite, the Secretaryship of Urban Development and Environment (SEDUMA) has planned the construction of a sanitary landfill next to the current dumpsite, which currently under review of the Environmental Impact Manifest.

The Direction Office of Municipal Public Services has no control over the costs of the service, and all of the input, pieces of equipment, personnel, and so on, are provided by the Municipal Clerkship Office. The latter situation has an impact on development of the service, since the resources available are unknown and a programmed maintenance of the vehicles is impossible. Also, their renewal is not contemplated, which in turn affects the coverage and quality of the same and higher costs of the service.

With respect to charges for the service, only the commercial sector pays at the Municipality's Treasury when they have to renew the stall's business permit.

C.1.4.2 Waste Stream

a. Actual Situation

The establishment of a waste flow for the municipality of Othón P. Banco currently is not possible as the needed background for it is unavailable.

Most of the locations conduct the burning of the wastes at the generation spots, because the collection and haulage service is not rendered at the same or the frequency is inadequate.

At those locations where the service is provided continuously, a proper record of the collected wastes is not maintained nor the means exists quantify them, as by means of a scale.

In the case of the service operated by the Direction Office of Municipal Public Services, the control of wastes is incipient, and despite of the fact that a control of the wastes entering the dumping site is maintained, the latter is based only on the number of trips made by each truck and a tonnage is assigned according to the capacity of the compaction devices or dumping devices of the trucks, and in the case of some of the compaction trucks this fact is totally inaccurate, because most of them are old and the efficiency of the compaction system is quite low.

As to the composition of the wastes, yet surveys have been conducted, the same are aimed at specific locations; therefore, the latter should not be representative of the entire municipality.

It is evident that in order to improve the management of the solid wastes it is necessary be aware of the amount of wastes being generated and their composition; thus, a system is deemed convenient for the city of Chetumal and main locations that quantifies the amount of wastes, but taking into consideration that most of the same are burned and that the better the services are upgraded with a better coverage, more of the wastes will be incorporated into the service.

b. Estimation

As explained so far, insufficient data cannot make it possible to prepare a waste stream that schematizes waste amount of generation, collection, recycling, clandestine dumping, etc. over the municipality. However, waste collection amount and disposal amount could be estimated based on information obtained.

Population of the city of Chetumal was about 120,000 in year 2000. Information obtained says that: about 90% of the residents are covered with the collection service; waste generation amount is 0.97 kg/person/day[4], about 29 ton/day of waste is generated from commercial activities besides residents. Furthermore, all waste generated is not necessarily collected, certain amount of waste is recycled, scattered, etc. Then, suppose 90% of the waste generated is collected.

Consequently, the information and assumptions bring that about 120 ton/day of waste is collected and disposed of; (120,000 x 90% x 0.97 kg/person/day +29 ton/day) x 90%.

[4] PROYECTO EJECUTIVO DEL RELLENO SANITARIO DE LA CIUDAD DE CHETUMAL, MUNICIPIO DE OTHÓN P. BLANCO, QUINTANA ROO, December 2001

C.1.4.3 Technical System

a. Overview of the Organization of the Service

The management of municipal solid wastes is carried out through the General Direction of Municipal Public Services, which operates the service directly and has the following organization:

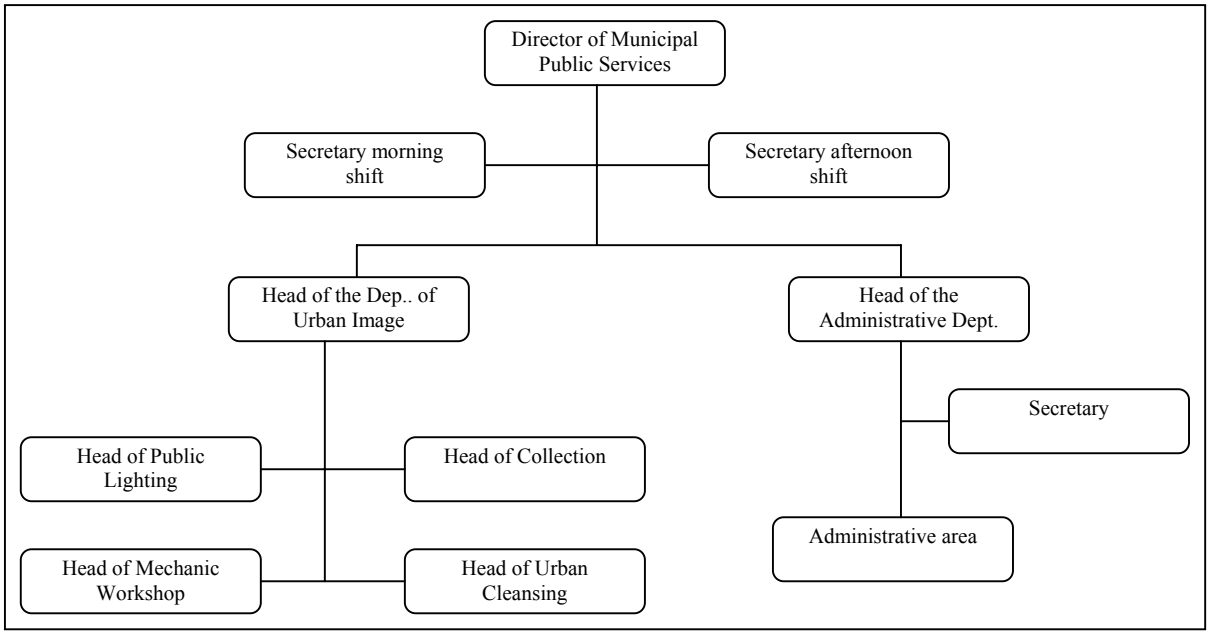


Figure C-12: Flowchart of the Direction Office of Municipal Public Services

Such office currently has total 397 workers assigned to diverse areas as follows:

- Office Director 1
- Direction staff 2
- Head of the Urban Image Department 1
- Head of the Administrative Dept. 1
- Public Lighting 27
- Urban Cleansing Area 209
- Mechanic workshop 13
- Collection Area 114
- Administrative Area 29

The collection area has the following flowchart:

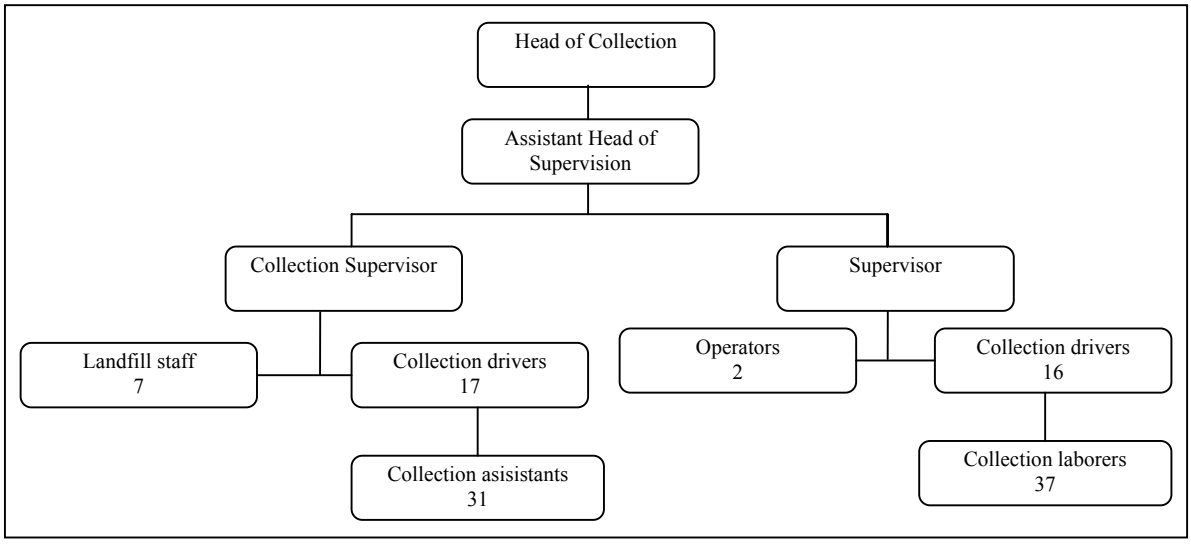


Figure C-13: Flowchart of the Collection Area

The sweeping service within the urban cleansing area has the following structure:

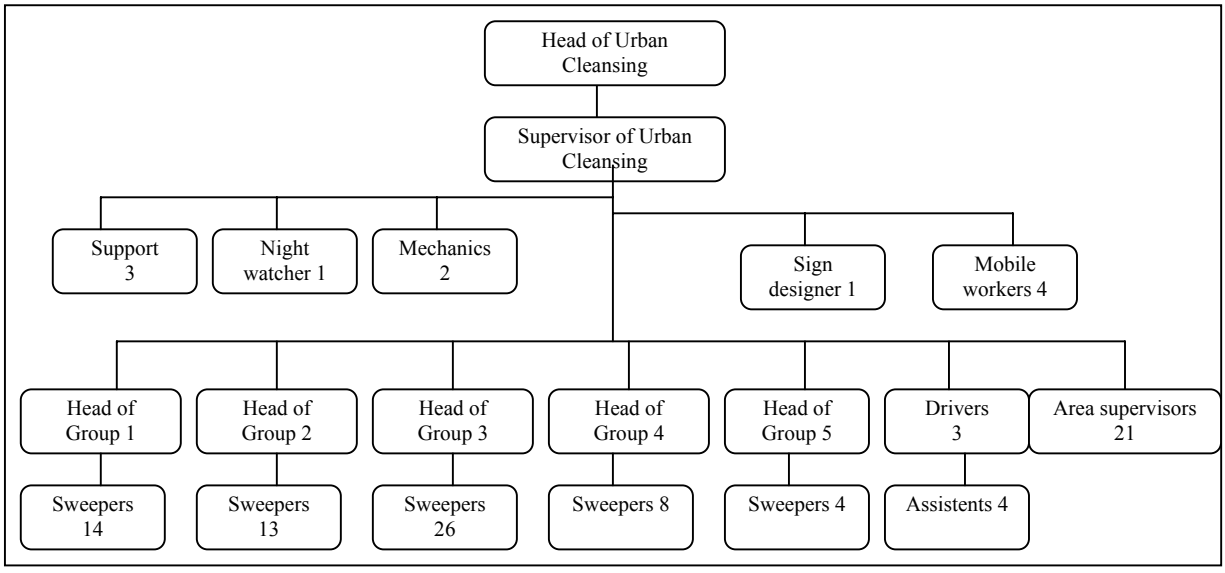


Figure C-14: Flowchart of the Sweeping Service

b. Discharge and Storage System

Currently the conditioning of household solid wastes is made in plastic bags deposited in front of the dwellings, on the curbs and they are later picked up by the collection staff. Also, low capacity plastic or metallic containers are used in a lower proportion.

In the case of commercial wastes, they are stored in 200 liter drums; however, it is a common practice by businesses, which generate important amounts of packaging, that said are

discharged in bulk on public thoroughfare. Schools and institutions discharge their wastes in 200-liter metallic drums provided by the municipality.

There is an important amount of users that take their wastes out after the collection truck passes by; and thus the same remain on the streets and are scattered by dogs. The latter situation calls for a reinforcement of the service and the sectors are re-collected again.

The use of 200-liter metallic containers represents an important issue as far as their collection is concerned, as they are filled to the top and therefore hinders their unloading in the collection truck, and this situation is worse because construction debris are also disposed.

c. Collection and Haulage Service

The collection and haulage service operated by the Department of Urban Image of the Direction Office of Municipal Public Services is provided at the city of Chetumal, with 90% coverage of population, as well as to the locations of Subteniente López, Xul-Ha, Huay-Pix, Raudales, Laguna Guerrero and Luis Echeverría. The following figure shows the sectors being serviced.

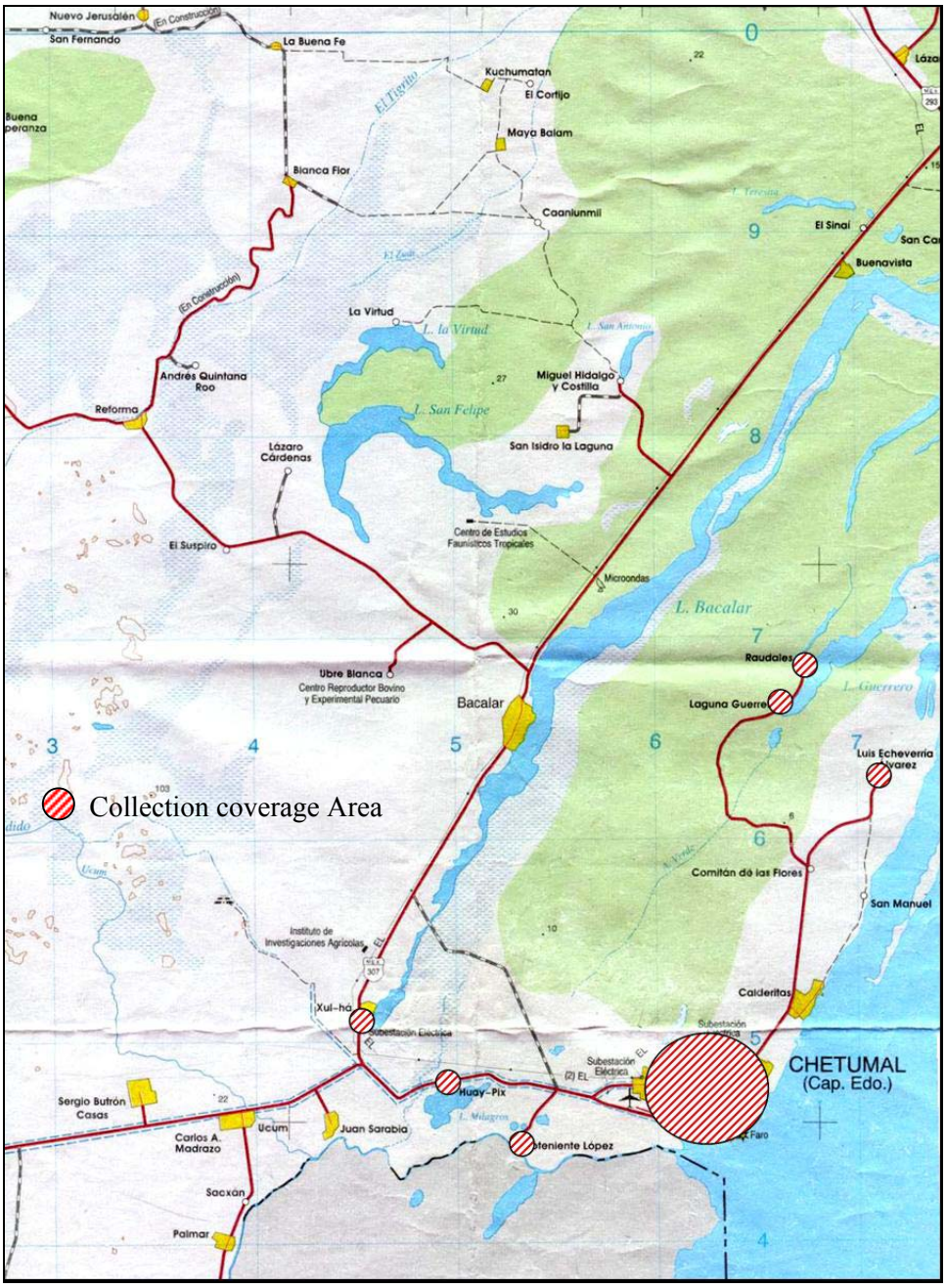


Figure C-15: Locations Covered with the Collection Service

The service provided by the Direction Office includes the collection and haulage of household, commercial and institutional wastes; sweeping of Chetumal's downtown, collection of containers installed at the bay's peripheries and the disposal of the same in a dumpsite located at Calderitas.

The collection method is door-to-door in all the dwelling areas. For the business sector, the system is mixed, door-to-door or at gathering points where drums are placed. The trucks are not equipped with lifting forks or similar devices that allow the loading of the metallic receptacles; therefore, this labor is quite hard for the collection staff.

So that the communities take out their wastes at the moment of the collection stage, the municipality has implemented several steps such as the distribution of fliers with information on the service, alarms when the collection truck passes by with the help of a hand bell or music. However, none of these measures have proven effective.

The collection service is designed based on a 7-day per week service with three shifts: morning, afternoon and night service, with the following schedules:

- Morning 06:00 through 14:00
- Afternoon 12:00 through 20:00
- Night 22:00 through 06:00

In general terms the service is provided on the morning and afternoon shifts; on the nocturnal shift only one route is attended, with a touring of the main avenues and the collection of sweeping wastes.

On every shift, the collection vehicles serve a specific route and allocates the corresponding staff: one driver and two collection assistants, which work on average 8 hours per day.

42% of the trucks work seven days a week and the rest Monday through Saturday. When the service is provided on the weekends, several extra time is necessary, as the normal working week lasts from Monday through Friday and the service does not contemplate several working shifts that cover the whole week and prevent the use of extra time.

The number of trips per collection route is variable, depending on the type of vehicle employed. In the case of compaction trucks they make two trips; cylindrical compaction trucks make three and dump trucks make 4. Every month a fleet of approximately 24 trucks is operating that work an average of 24 days per month. The average tons collected per month in total sum 9,162, which includes 65% of household wastes, 16.6% of commercial wastes, 18% pruning and garden wastes and 0,4% junk waste.

c.1 Analysis of the Collection routes

In order to render the collection service, the Direction Office has subdivided the service in the city of Chetumal in three areas known as “Sector 1”, “Sector 2” and “Sector 3”, as observed in the following figure.

Each of these areas was subdivided into sub-sectors that represent each a collection route.

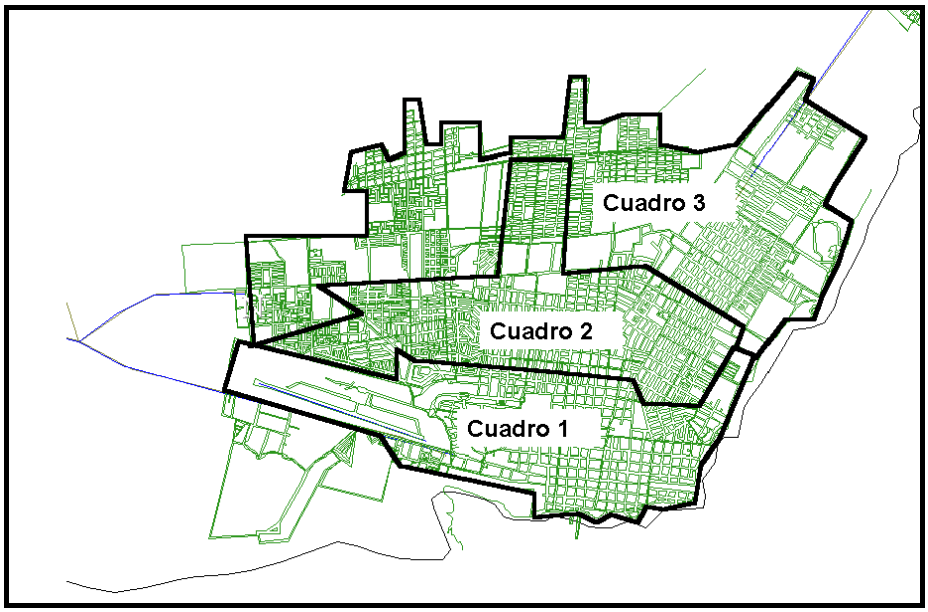


Figure C-16: Collection Sectors

There is a total of 31 collection routes with the following features.

Table C-17: Collection Routes

Area of Service	Route No.	Truck assigned	Shift	Days of service
Sector 1	1	208	Morning	Monday through Sunday
	2	207	Morning	Monday through Sunday
	3	160	Morning	Monday through Sunday
	4	158	Morning	Monday through Sunday
	29	028	Morning	Monday through Sunday
Sector 2	5	024	Morning	Monday-Wednesday-Friday
	6	118	Morning	Monday-Wednesday-Friday
	7	036	Morning	Monday-Wednesday-Friday
	8	096	Morning	Monday-Wednesday-Friday
	9	026	Morning	Monday-Wednesday-Friday
	10	097	Morning	Monday-Wednesday-Friday
	11	159	Morning	Monday-Wednesday-Friday
	12	157	Morning	Monday-Wednesday-Friday
	13	027	Morning	Monday-Wednesday-Friday
	14	209	Morning	Monday-Wednesday-Friday
Sector 3	15	209	Morning	Tuesday-Thursday-Saturday
	16	036	Afternoon	Tuesday-Thursday-Saturday
	17	156	Morning	Tuesday-Thursday-Saturday
	18	157	Morning	Tuesday-Thursday-Saturday
	19	096	Morning	Tuesday-Thursday-Saturday
	20	027	Morning	Tuesday-Thursday-Saturday
	21	156	Morning	Monday-Wednesday-Friday
	22	159	Morning	Tuesday-Thursday-Saturday
	23	026	Morning	Tuesday-Thursday-Saturday
	24	156	Afternoon	Tuesday-Thursday-Saturday
	25	024	Morning	Tuesday-Thursday-Saturday
	26	097	Morning	Tuesday-Thursday-Saturday
	27	118	Morning	Tuesday-Thursday-Saturday
	28	036	Morning	Tuesday-Thursday-Saturday
	30	110	Morning	Monday through Sunday
	31	027	Afternoon	Tuesday-Thursday-Saturday

There is a total of 6 routes of service, Monday through Saturday on the morning shift; the remaining routes are provided the service three times a week, 22 of them on the morning shift and only 3 on the afternoon shift.

The collection on the night shift covers only one route with the main avenues of the city, and the trip can be modified in function of the needs. This route has a daily collection Monday through Sunday.

The total of trucks employed is 17 that belong to the municipality. Additionally, the Direction Office of Municipal Public Services has ten more trucks of diverse types to provide the collection service at the locations of Subteniente López, Xul-Ha, Huay-Pix, Raudales, Laguna Guerrero and Luis Echeverría once per week. However, in some occasions and as per request by the community, the frequency increases to twice or thrice a week. Despite of the increase in frequency, the generators of these locations usually burn down their wastes, an so the wastes collected basically comprise cans, glass, junk and plastic.

Out of the designing of the collection service, it can be concluded that said has not been performed efficiently, as the logical thing to do would be a balance between the morning and night routes, which would actually reduce the number of trucks per shift. Under the current scheduling, the total of three-days-per-week routes adds up to 25, out of which 22 are conducted on the morning shift, 11 from Monday through Friday and 11 from Tuesday through Saturday. Therefore, every morning a total of 17 trucks must be running, including the daily frequency vehicles. If it is considered that only three afternoon shifts are available, one on Mondays, Wednesdays and Fridays and tow on Tuesdays, Thursdays and Saturdays, operations could be run with 6 routes on the morning shift Monday, Wednesday and Friday and 7 afternoon routes on Tuesdays, Thursdays and Saturdays. In this manner, a minimum of four trucks would be available for the collection service in the other locations, thus shrinking the amount of dump trucks.

Surveillance of the service is conducted by the supervisors, who go on field to verify the compliance with the routes and the adequate collection of the wastes. Simultaneously, a control of the trucks entering the dumpsite is maintained, their entrance and departure times are recorded, truck number, type of wastes and verification that the vehicles are fully loaded. With this data, the total number of trips per truck is controlled and fuel consumption per route. The tonnage collected is then calculated according to the number of trips, considering the nominal capacity of each vehicle.

In addition to these controls, the Direction Office does not have quality and efficiency indicators of the service, which would allow the improvement of the routes. A great interest by the servicemen to run the service smoothly is observed, However, it is necessary to

reinforce service planning by redesigning the entire service, specially the collection routes, with the incorporation of technical control indicators for efficiency and costs. In tandem with the aforesaid, it is necessary to implement a budget system that includes all the investments required to sustain and increase the current coverage of the service.

c.2 Amount of Wastes Collected

As above mentioned, the amount of waste collected is determined based on the number of trips and the nominal load capacity of compaction devices or the dumping device on dump trucks, as a scale system is unavailable.

According to the entrance control at the final disposal site, in year 2002 the total of wastes collected added up to 109,949 tons, out of which 71,540 tons belong to household wastes, 18,250 to commercial wastes, 19,710 to pruning and garden waste and 449 tons to junk waste. The following figure displays a detail of the monthly entrance log to the dumpsite.

Table C-18: Waste Entrance Control Log to the Dumping Site

CONTROL DE VIAJES DE BASURA.																																
MES : ENERO 2002																																
No.ECON.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total Viajes	Capac.	Toneladas
108	0	5	3	3	4	0	5	6	3	5	3	3	0	5	2	3	3	3	3	0	6	3	5	6	5	5	0	5	3	6	0	103	3	309
29	0	7	4	4	3	0	5	3	5	4	4	0	0	3	3	5	1	4	3	0	2	5	7	6	1	0	0	0	0	0	0	79	3	237
30	0	4	3	3	0	0	4	3	3	3	2	0	0	3	3	3	2	2	1	0	5	7	3	2	2	0	0	3	4	3	0	68	3	204
33	0	2	4	2	2	0	2	2	4	2	2	2	0	2	2	2	2	2	2	0	2	2	2	2	2	2	0	2	2	2	0	54	3	162
110	0	4	5	3	3	0	4	3	3	3	3	3	0	3	3	3	3	3	1	0	3	3	3	3	3	5	0	5	5	3	0	83	3	249
154	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	12
157	2	4	2	4	3	2	4	2	4	4	4	3	0	4	4	4	4	4	3	2	2	4	4	4	4	3	2	3	4	4	0	97	6	582
160	0	3	2	3	3	0	4	4	3	2	1	2	0	4	4	2	3	4	3	2	3	4	0	0	0	0	0	0	2	4	0	62	6	372
158	0	3	4	3	2	0	3	4	2	4	4	4	1	4	4	4	4	4	2	0	7	4	3	4	4	3	1	4	4	4	0	94	6	564
37	0	2	2	2	1	0	2	2	2	2	2	2	0	2	2	2	2	2	2	0	2	2	2	2	2	2	0	2	2	2	0	49	6	294
96	0	3	2	2	2	0	2	1	1	1	0	0	0	3	2	2	2	2	3	0	2	2	2	2	2	2	0	1	3	2	0	46	6	276
155	0	3	3	2	2	0	2	3	2	2	4	3	1	2	2	2	3	2	3	0	3	3	3	2	3	3	0	5	3	3	0	69	6	414
118	0	3	3	2	2	0	2	1	3	1	2	2	0	3	2	1	2	2	2	0	3	2	2	2	2	2	0	3	3	2	0	54	6	324
97	0	4	5	4	4	0	2	2	2	2	4	2	0	4	4	3	4	4	4	0	4	4	4	4	3	2	0	4	4	3	0	86	6	516
21	0	0	2	2	0	0	0	0	0	0	0	0	0	2	2	2	2	2	0	0	0	0	0	0	0	0	0	2	2	0	0	18	6	108
98	0	1	2	2	2	0	2	2	2	2	2	2	0	2	2	2	2	2	2	0	2	2	2	2	2	2	0	2	4	2	0	51	6	306
109	0	5	3	5	2	0	3	2	3	3	3	2	0	3	3	3	3	3	2	0	4	3	5	5	4	4	0	6	2	2	0	83	6	498
36	0	3	4	3	3	2	4	4	4	4	3	4	1	4	4	4	4	4	4	2	4	3	3	4	4	3	1	0	0	1	0	88	6	528
27	1	2	1	3	2	1	4	3	2	4	2	3	0	3	3	3	2	3	2	0	3	3	3	3	3	3	0	3	4	3	0	72	6	432
24	0	3	3	2	2	0	2	2	2	2	2	2	0	2	1	2	2	0	0	0	0	0	0	1	4	2	0	3	3	4	0	46	6	276
156	0	2	4	3	2	2	4	3	3	2	2	2	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34	6	204
26	0	2	3	2	3	0	0	1	3	3	3	3	0	0	0	2	3	2	3	1	1	4	4	4	2	2	0	4	2	2	0	59	6	354
159	0	3	3	3	3	0	3	3	4	4	3	3	0	3	4	3	4	4	4	0	4	5	4	4	4	3	1	3	2	4	0	88	6	528
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	2	3	2	0	0	0	0	0	0	12	3	36
120	0	0	0	0	1	0	2	2	2	2	2	2	0	0	0	0	0	0	1	0	2	2	2	2	2	1	0	0	0	2	0	27	3	81
86	0	3	0	2	3	0	0	0	2	0	0	3	0	2	0	0	1	3	2	0	1	0	0	0	0	0	0	0	2	0	0	24	6	144
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
63	2	0	0	0	3	1	0	0	0	0	0	2	1	0	0	0	0	0	1	1	0	0	0	0	0	2	1	0	0	0	0	14	3	42
121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
TOTALES	5	71	67	64	57	8	65	58	66	61	57	54	6	65	57	57	58	61	53	8	65	72	65	67	60	51	6	60	60	58	0	1562		8052

c.3 Collection Vehicles

The collection service is carried out with 27 trucks, out of which 20 are furnished with compaction devices and, 1 flat truck, 2 mini size flat pickups, 1 large pick up and 3 dump

trucks. Most of the compaction trucks are old, some of them 15 years old, and only three trucks if this year 2003. In general terms, the mechanical conditions of the same is poor and they constantly demand corrective maintenance.

Maintenance and repair of the trucks is conducted by the mechanical workshop; the duties are carried out by five mechanics, one automotive electrician, 1 welder, 1 assistant welder and one tire mender.

All the input required for the repairs are requested to the Municipal Clerkship, which supplies the requisitions in a minimum of two weeks and maximum a month.

For the provisioning of fuel, two supplying centers are available where fuel reservoirs are loaded with the prior consent by the Municipal Clerkship staff that oversees the filling at that place. A control of fuel consumption is conducted by comparing the number of trips per truck to verify the yield.

The costs related to the operation of a collection truck adds up to $18,875 pesos per month, which includes repairs, fuel, driver, collection and mechanical labor.

In case of mechanical failures by the vehicles or increase in the volume of wastes, the Direction Office supports on the Union of Dump Truck Workers to lease dump trucks that will replace the wrecked trucks.

c.4 Special Collection Services

Constant cleaning operations take place at several points of the city, specially unoccupied land lots where wastes are dumped without control and become small dumpsites. These operations are conducted on Saturdays and Sundays with the help of dump trucks.

Two operations are carried out per year for the collection of bulky and junk waste, in order to prevent the proliferation of mosquitoes that carry diseases. The entire Direction Office of Municipal Public Services takes part in these operations, city hall personnel, unions, boy scout, students, and so on. This operation is broadcasted to the entire community through diverse mass media, so that people take out their wastes and support the campaign.

c.5 Collection and Haulage Service in other Locations

As above mentioned, Como the Direction Office of Municipal Public Services does not render the service throughout the territory of Othón P. Blanco. At the locations with a higher population concentration, the service is provided through the City Halls or districts, such as Bacalar, Nicolás Bravo, Calderitas, Alvaro Obregón, Javier Rojo Gómez, and so on. The following figure displays the above locations.

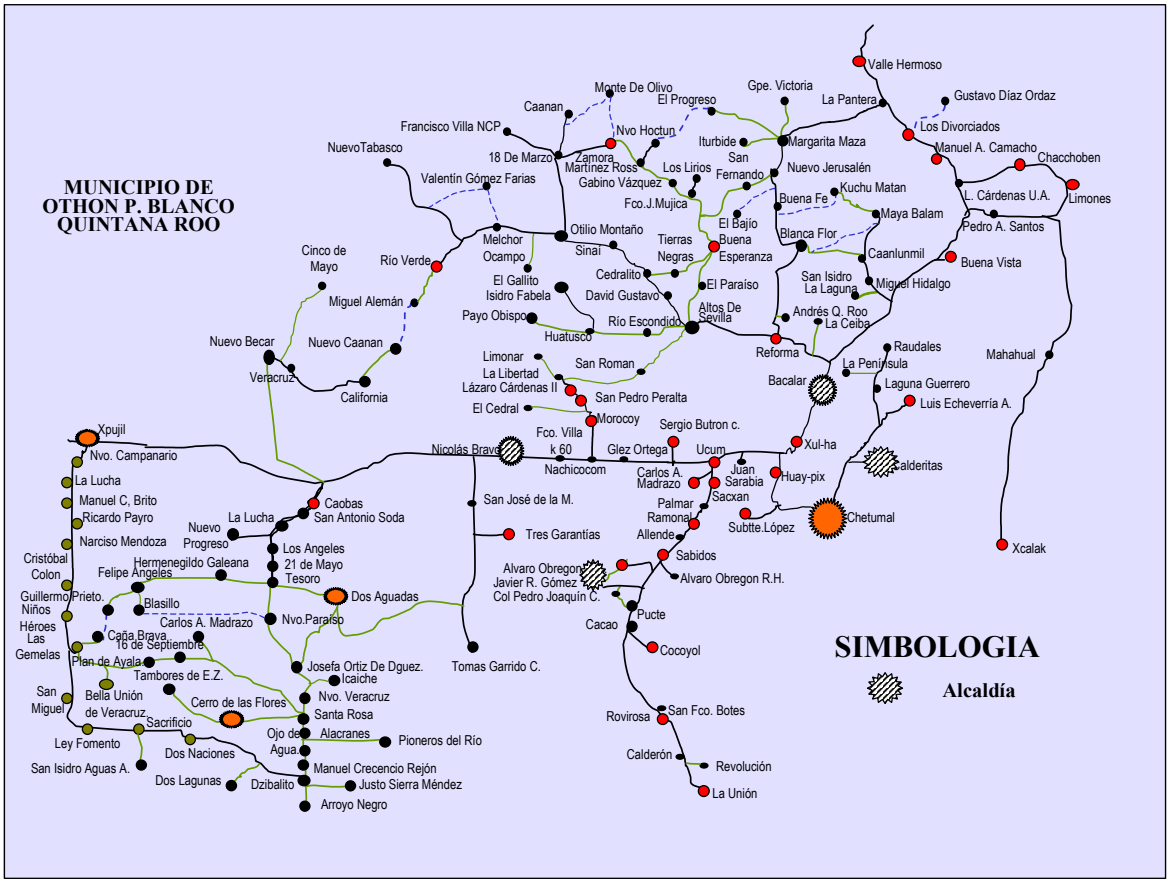


Figure C-17: Locations with Collection Service Operated by the City Halls

Each of the city halls has developed a collection service aimed at the needs of the community and to its available resources. In the case of Bacalar, the City Hall has two trucks to conduct the service and haulage services: one of these trucks is equipped with a compaction device and was delivered by the Municipality to the City Hall on March of the current year, whereas the other is a dump truck provided by the municipality as well. The household solid waste collection service is provided on Mondays, Wednesdays and Fridays from 06:00 through 19:00 with the compaction truck. The crew assigned includes a driver and three assistants, which are paid by the municipality as well. The dump truck works on Tuesdays, Thursdays, Saturdays and Sundays for the collection of junk, construction waste and pruning and garden waste from 06:00 through 19:00. Previously only wastes were collected for those generators that paid for the service with a charge of $20 per month for dwellings and $50 for businesses; as of the moment the municipality provided the truck to the city hall, the service is provided to the community regardless of the payment.

The collected wastes are deposited in an open dumpsite located 7 Km. north of the village.

In Nicolás Bravo, the collection service is carried out with a Ford 1978 pickup, with a capacity of 750 kg. The service is provided on Mondays, Wednesdays and Fridays from 06:00 through 14:00; in case the route is not completely covered, it is finished on the next day. The crew costs (a driver and two collectors) are covered by the municipality. Fuel, repairs and purchase of tires are covered by the City Hall, which obtains the funds from the license charge to allow the functioning of peddling trade. Once a year two operations to get rid of junk are carried out where the community is requested to have some vehicle available to collect these wastes. The wastes collected are disposed of in a dumping site at the outskirts of the village.

At the location of Javier Rojo Gómez, the collection is conducted with a 7 m^3 dump truck provided by the municipality to the village's city hall. The service is provided Monday through Saturday from 08:00 through 13:00. The village is composed by three neighborhoods and as of this year two are being rendered the collection service and the users still have not accustomed to the system, reason why the volume of wastes is still quite low. The operating costs of the service are absorbed by the city hall, which obtains the funds from contributions from the union of sugar industries and traders. The wastes are disposed of in an open dumpsite located next to one of the neighborhoods, in front of dwellings.

In all these locations most of the wastes are burned and most of the wastes that reach the dumping site are glass, cans, junks and plastics.

All the dumpsites are in poor sanitary conditions, which pose a great environmental risk and a center of diseases.

In the remaining locations of the municipality wastes are burned, and an important amount of plastic containers are observed on the streets and close to the dwellings.

d. Sweeping service

The collection service is directly operated by the Direction Office of Municipal Public Services as well through the Urban Cleansing dept. The service is provided exclusively in the city of Chetumal and involves manual and mechanical sweeping.

d.1 Manual Sweeping

The manual sweeping system is organized in workgroups that serve the city's main avenues and in the assignation of fixed sweeping locations, covering around 50% of the city.

The service is provided on a single shift Monday through Friday from 04:00 through 11:00; however, in most of the cases the beginning time of the service is modified due to issues stemming from the parking of vehicles on the streets, and in these case since the sweepers

have streets assigned the working day finishes once the entire sector is swept. On the other hand, regardless of the fact that the works are scheduled Monday through Friday, An important number of the workers work seven days of the week, with the normal service rendered on Saturdays and conducting operations or re-cleaning of several locations of the city on Sundays. This situation greatly increases the costs of the service, since extra time has to be paid plus a Sunday premium according to the law.

In order to conduct the job, the sweepers have a broom, a rake, a collecting pan, a 200-liter drum on top of a small wheel cart. For the collection of the wastes the department has four vehicles exclusively devoted to these duties: a flat bed truck with a 3-ton banister, two pickup trucks with a wooden frame on the back and a simple pickup truck.

The sweeping service includes sweeping, scraping, scavenging, clearing and collection of wastes. The sweeping service does not include the maintenance of serviced areas.

The sweeping service considers five workgroups, each of them with a boss and a number of staff as follows.

- Group 1 14 sweepers
- Group 2 13 sweepers
- Group 3 26 sweepers
- Group 4 8 sweepers
- Group Av. Héroes 4 sweepers

Each sweeper has assigned his/her sweeping routes that mark the streets or avenues to be swept and the beginning an ending points. In general terms, sweeper serves a single route throughout the days of the week; however, in some cases the service is not provided on a daily basis and the sweeper will have to cover more than one route per week, depending on the working day.

On Wednesdays most of the sweepers are drawn from their normal routes to conduct cleaning, scraping, painting of curbs and collection of wastes at specific places defined by the department.

Wastes produced by the sweeping activity are carried to gathering points where they are collected by the vehicles of Urban Cleansing and by the collection truck that performs the night service.

The sweeping service per fixed spot is designed to serve a specific area, be it a park, market or warehouse. The days of service and the schedules are the same as those of the workgroup sweeping, and the service is also provided on the weekends, although it is not regarded like that for the scheduling. The total of sweeping workers for this modality is 21.

The manual sweeping performance ranges between 2,5 to 3,5 Km/day/worker. The sweeping service design serves a total of 633 Km. of avenues, streets and gardens.

d.2 Mechanical sweeping

Early this year, the municipality acquired two Karcher mechanical sweepers model KMRASSOD, with which they provide the service to the Boulevard and the main avenues according to their needs.

The service is provided Monday through Saturday from 04:00 through 14:00.

To date no route design has been implemented for the mechanical sweeping, right now a stage to record the performance and fuel consumption is underway to proceed to the design of the same.

To date the mechanical sweeping service covers a total of 175 Km. of avenues.

e. Final Disposal

All the waste collected by the Direction Office of Municipal Public Services are transported and disposed of in a dumpsite at the location of Calderitas. The wastes of Calderitas and from collection by particulars are disposed of therein as well.

The site has an area of 15 ha. and started operations in 1992 as a sanitary landfill; however, as of two years and due to budget issues the operations was conducted inadequately and wastes were no longer compacted nor covered, and thus became an open dumping site.

The works initially constructed are now wrecked or in poor conditions, such as the scale. Most of the land is covered with wastes and in some sectors the thickness reaches several meters and in other just a few centimeters. All the areas present uncovered wastes, as there is no covering material available within or close to the site. No deposits for the accumulation of leachate exist, therefore the latter are not perceived and it is assumed they infiltrated into the subsoil. No airshafts for venting biogas exist either that might eventually generate, as decomposition of the wastes is conducted aerobically. The access road and the surrounding ones present a severe accumulation of waste and in broad extensions.

The dumping site represents a severe sanitary and environmental risk. It poses a sanitary risk because it allows the proliferation of birds, insects and other animals that could easily transmit serious diseases to the population. It is an environmental risk because fires have already generated at this place (natural causes and/or intentional) that have been terribly difficult to handle and that have lasted for months, therefore altering the quality of air and since wastes are in the open the generation of leachate increases; also, due to the

characteristics of the soil, this leachate can quickly infiltrate and there is a considerable possibility that they reach the groundwater and pollute the same.

Around 85% of the surface is covered with wastes and, should the operation trend continue, the useful life of the site will not go beyond two years.

Currently the dumpsite receives wastes between 06:00 and 20:00 in the case of particulars and 24 hours a day for the municipality. All the vehicles entering the site, be it particulars or municipal, are recorded on control sheets where the entrance hour and exit of the same is registered, the name of the driver, the vehicle plate and the type of wastes.

Within the site there is personnel that directs the trucks to the unload area; however, this action is not always conducted. In order to compact and distribute the wastes two Caterpillar bulldozers model D-9 and D-6 are available, yet in poor conditions; in fact, the D-9 is non operational. The working schedule of these machines goes from 06:00 through 20:00, but this schedule is not fulfilled all the time; therefore, the construction of waste cells of accumulation of the residues to minimize the covered area is impossible. No scheduling or works aimed at the obtaining of material to cover the wastes exists; therefore the current situation will prevail.

There are scavengers within the site devoted to the recovery of some items such as cans, glass, junk, aluminum and copper, and in order to facilitate this job they burn the wastes.

A total of seven people work at the dumpsite: 2 arrangers of the wastes, 2 entrance controllers and three 3 guards.

The following pictures display the conditions of the dumping site.

Figure C-18: Status Quo of Chetumal Dumpsite

With regards to other locations, all of the same have open dumping sites with areas ranging from 1 to 5 ha. In these sites, the wastes are scattered with several thickness not beyond 1.5 m, and frequently the wastes are burned down at the site to increase their useful life and some

recovery duties of items also exist. None of the dumpsites have a closing door, entrance control or a guard post, or coverage of the wastes or machinery to do the same.

The inappropriate final disposal of solid wastes throughout the territory of Othón P. Blanco poses the most serious danger for the management of the wastes, as each dumpsite poses a potential risk for contamination of air and groundwater, and therefore they are in need of attention and short-term solutions.

f. Maintenance of Vehicles

f.1 Characteristics of the Vehicles

The Department of Municipal Public Services possess 22 vehicles for carrying out the service of collection and also holds an equipment for operating the dumping site in Calderitas. The characteristics of the vehicles and the equipments are detailed in the following table:

Table C-19: Background of the Collection Service Vehicles

Internal no.	Type	Brand	Issue no.	Capacity Ton	Status
024	Compactor	DINA-551	1993	6	Regular
026	Compactor	DINA-551	1993	6	Good
027	Compactor	DINA-551	1993	6	Good
028	Dumping truck	DINA-551	1993	7	Good
029	Dumping truck	DINA-551	1993	7	Good
036	Compactor	DODGE-600	1993	6	Regular
037	Compactor	DODGE -600	1993	6	Garage
096	Comp. cylinder	FORD	1995	8	Good
097	Comp. cylinder	FORD	1995	8	Good
098	Comp. cylinder	FORD	1995	8	Good
108	Small truck	FORD-350	1997	3	Good
109	Small truck	FORD-350	1997	3	Regular
110	Compactor	FORD-F35	1997	6	Good
118	Comp. cylinder	FORD	1984	8	Garage
156	Compactor	M. BENZ FL70	2000	6	Good
157	Compactor	M. BENZ FL70	2000	6	Good
158	Compactor	M. BENZ FL70	2000	6	Good
159	Compactor	M. BENZ FL70	2000	6	Good
160	Compactor	M. BENZ FL70	2000	6	Garage
207	Compactor	INTERNATIONAL	2003	6	Good
208	Compactor	INTERNATIONAL	2003	6	Good
209	Compactor	INTERNATIONAL	2003	6	Good
	Bulldozer	CATERPILLAR D-5	1988	-----	Good

f.2 Organizational Structure of the Maintenance Area

The Department of Municipal Public Services has a Garage Area for the maintenance of vehicles, which depends directly from the Department of Public Image, as can be appreciated in the following organization chart:

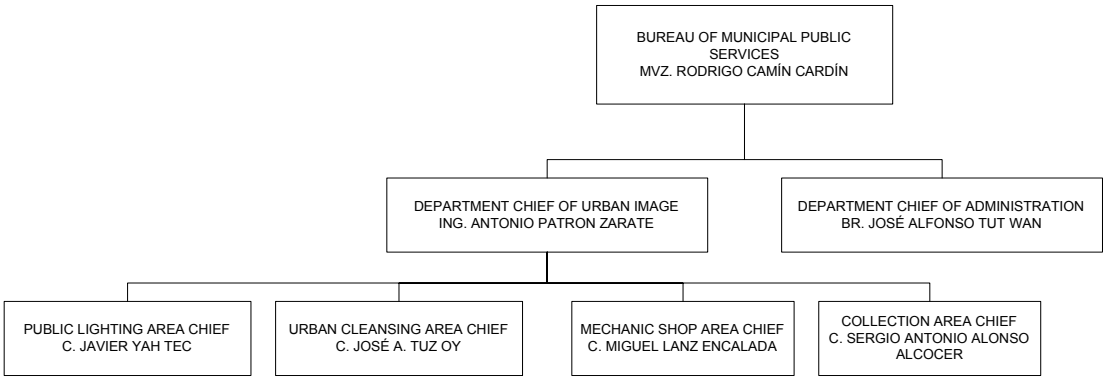


Figure C-19: Flowchart of the Maintenance Area

On the other hand, the Garage Area has the following structure:

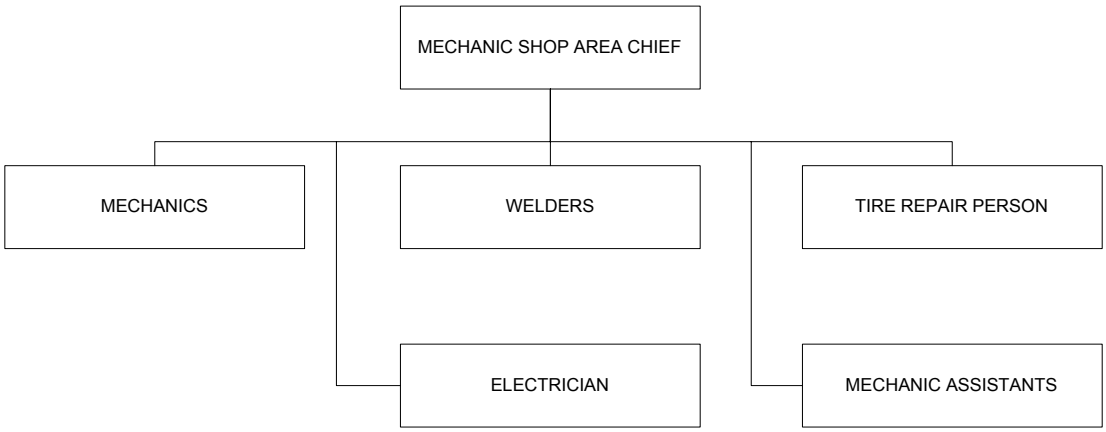


Figure C-20: Flowchart of the Garage Area

The total staff working in the garage is 13 people: 1 head of area, 5 mechanics, 3 welders, 2 tire-workers, 1 electrician and 1 mechanic assistant. The responsibilities of personnel are defined by their position.

f.3 Responsibilities

Staff of the garage works only one shift, starting from 07:00 to 16:00 hours. Additionally, every day two mechanics are denominated for the shift and in case of any damages that the vehicles may have, they are contacted in their homes for the reparation of the vehicles.

The responsibilities of the Garage Area are:

Objective: To repair and to maintain in good conditions all the vehicles of the Department of Municipal Public Services and all official units of the Municipality of Othon P. Blanco.

Among the functions developed by the head of the Garage Area are:

Continuous functions:

- To revise all vehicular units and bulldozers of the municipal dumping site
- To supervise the departure of the waste collection trucks.
- To design the daily activities of subordinated workers.
- To carry out supervision travels on the corresponding sectors in order to check that the unities do not suffer any damages.
- To demand spare parts to the Department of Urban Image once the mechanical and/or electrical damage has been revised. The head of the garage area has to fill in a spare parts' format and has to gather all the signatures of the people involved.
- To demand work tools to the person in charge of the warehouse.
- To supervise the cleanliness of the Garage Area.
- To elaborate daily reports of the work carried out.
- To supervise the activities carried out by mechanics, welders and tire-workers.
- To carry out the general reparation of vehicles assigned to the Department.

Periodical functions:

- To supervise the cleaning work of the Garage Area.
- To develop meetings with personnel in order to comment any problems related to their work and to look for proper solutions.
- To support welders in the elaboration of street lighting and the reparation of metallic sets in any park that requires amends.

Occasional functions:

- To support the Ministry of Health with vehicles and personnel in the campaigns of junks' removal.
- To support the Department of Municipal Public Services in general cleaning activities (also called Ant Operation).
- To repair official units of the Municipality of Othon P. Blanco

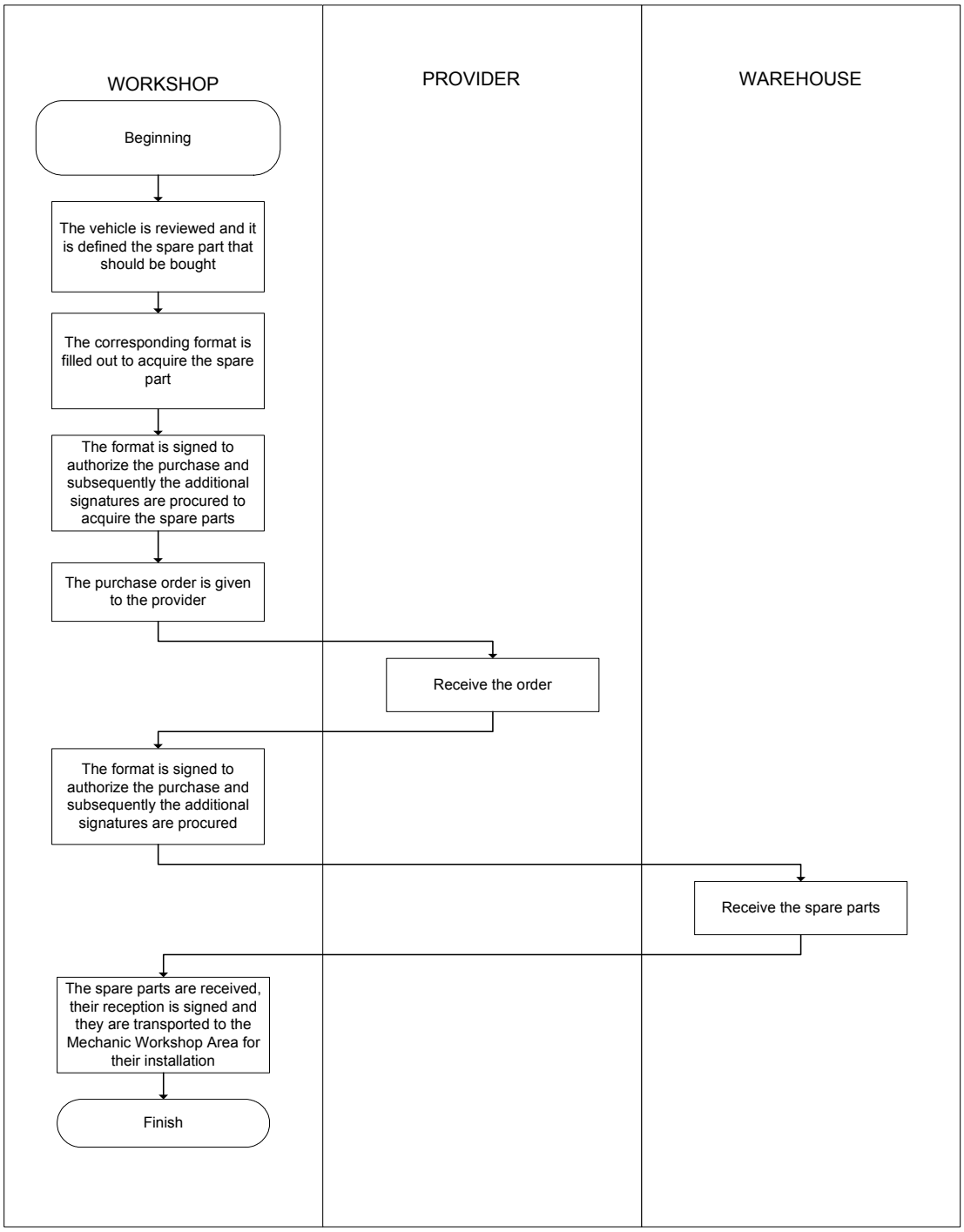
f.4 Operational Procedure

In case of damages in vehicles, the procedure to follow is:

- The Mechanic Chief is informed that a truck has had damages.
- The Mechanic Chief allocates a mechanic in order to look for the vehicle and to repair it.
- In case that the damage can not be solved in situ, the vehicle is transported to the garage where is analyzed whether the reparation may be done in the garage or if specialists have to be called (generally the agents of the vehicle's brand are located in Merida).
- In case that the damage can be repaired in the garage, the mechanic demands for the spare parts and when he has them, he proceeds with the reparation of the vehicle. The mechanism for the acquisition of spare parts is shown in Figure 3.
- If the damage is bigger, the specialists are informed and they go to the garage and perform the reparation of the vehicle. Later they send the invoice to the Department of Municipal Public Services, which also sends it and all its background to the Office of

Budgetary Control which depends on the Municipal Treasury. This is in order to schedule the payment for the service.

- Every 5 or 6 days, in order to schedule the payments, the Department gives to the Office of Budgetary Control all invoices corresponding to the purchase of spare parts.



f.5 Facilities for Carrying Out the Maintenance Works

The facilities of the mechanic garage are located within the building of the Department of Municipal Public Services.

The garage area has equipment and tools to perform all the works, among them there are other equipments such as a working table, welders, compressors, press, drills, engines with brush, battery chargers, etc. In addition, the General Warehouse also has some tools that may be required for the development of the reparation works, but the mechanic has to demand them in order to obtain them. In this case, any tool required from the warehouse must be demanded through a voucher that should be signed by the person who receives the tool or equipment.

f.6 Storage of spare parts

Any input required for the preventive and reparative maintenance of vehicles and machinery belonging to the Department of Municipal Public Services is managed by the General Warehouse, area that depends from the Department of Administration of the former Department.

The General Warehouse manages the following materials:

- Tools, equipments, inputs and spare parts for the maintenance of the vehicles and equipments of the Department of Municipal Public Services.
- Material for street lighting.
- Material, tools and equipment for the Area of Urban Image.
- Cleaning articles for the Department and Stationery offices.

For the preventive maintenance of vehicles and machinery, the Warehouse holds a stock of the following inputs:

Input	Amount
Hydraulic oil	800 L
SAE 50 oil	400 L
SAE 40 oil	400 L
Antifreeze	12 GAL
Brake fluid	48 units of 350 cc.
Distilled water	24 L
Filters (combustible, air, oil)	6 of each type
Patches of different types	100 approx. of each type

The required spare parts go directly to the Warehouse, where an entry record is developed; later on such spare parts are delivered to the mechanic. However, before delivering them, a voucher is elaborated in order to register the unity where the part will be used and the

mechanic to whom it is delivered. Finally, the mechanic has to sign the voucher registering in this way the acquirement of the spare part.

Every material, input, tool, equipment, etc. that is used in the Department goes first to the General Warehouse where they are registered. Later, they are distributed. All outputs are performed through the voucher that the receptors and warehouse' staff sign.

Weekly, the General Warehouse makes an inventory of all materials that have been received and distributed, identifying at the same time the person who received the material, the vehicle in which it was used and the voucher number through which the delivery was made. In addition, the inventory indicates the existence of material in the warehouse and the inputs that need to be restored.

f.7 Comments

On the one hand, the vehicle and machinery's maintenance system of the Collection Service is well structured. An Organization Manual and a Procedure Manual define the activities, procedures, elaboration of reports, communication processes, formats to use, responsibilities, organizational structure, etc. On the other hand, the reparation of damaged vehicles is relatively fast, commonly in 24 to 48 hours, depending on the nature of the damage. Bigger damages generally demand more time, depending directly on the existence of spare parts in the local commerce or in the time availability of experts and representatives of the vehicles' brands.

C.1.4.4 Review of State Plans

The state of Quintana Roo, aware of the inappropriate operating conditions of the final disposal sites and the risks for the environment and the tourism activity, has drafted a plan along with the Secretaryship of Urban Development and Environment (SEDUMA) to construct sanitary landfills in the short term that will replace the principal open dumpsites.

Within the projects regarded by the Seduma the construction of a sanitary landfill that allows the closure of the Calderitas dumping site is contemplated.

The plan includes three stages to follow:

The first stage corresponds to the executive project draft, whose purpose is to select a site to develop the works as per environmental and economic technical criteria. The latter criteria that apply to these type of projects are set out in the Mexican Official Standard NOM-083-ECOL-1996, which establishes the conditions to be met by the sites to be devoted to the final disposal of municipal solid wastes, outlining the geological, hydrological, hydro geological, territorial arrangement and other legal restrictions.

Once the site is selected and within the same executive project, the corresponding project related to the compliance with the Mexican Official Standard NOM-084-ECOL-1997 is developed, which outlines the specific design of the sanitary landfill, its pollution control works and operation of the same for the proper functioning of the landfill and the establishment of an environmental on-site monitoring program.

After the executive project is ready, the second stage corresponds to the elaboration of the Environmental Impact Manifest, with the purpose of presenting the same before the competent authorities for their review and obtaining of the environmental permits to continue with the third stage; i.e., the construction of the landfill.

To date, the project for the municipality of Othón P. Blanco has the Executive Project and the Environmental Impact Manifest under the evaluation stage, an activity under the jurisdiction of Seduma. Both the executive project and the Environmental Impact Manifest have been elaborated by private companies that were awarded the same through tenders. The executive project was made by the Colegio de Ingenieros Geólogos de México A.C. and the Manifest was made by Planeación Estrategias y Control Ambiental S.A. de C.V.

For the selection of the site the locations of Calderita, next to the current disposal site; Camino Comitán Guerrero, located south in Km. 3.2 between Comitán de las Flores and Laguna Guerrero, Ejido laguna Guerrero; and the abandoned highway between Chetumal and Bacalar, northeast of the same at 6.5 Km. of the crossroad between the Chetumal Cancún highway and the common lands of Subteniente López.

The selected site was Calderita for the following reasons:

- Closeness to the generation site
- Adequate road infrastructure
- Within the area of ecological conservation that will prevent human settlements around the site
- Awareness by the community, as they are not reluctant to the current dumpsite
- The possibility of cleaning the current site becomes more feasible
- Protection of the Calderita zone and tourism development by improving the sanitary and environmental conditions of the location.

It is important to mention that the three surveyed places do not meet the hydro geological demands due to their closeness to the aquifer and to the geology of the area; so the project will have to include engineering works to protect the same.

The sanitary landfill project will have an area of 15 ha. and will be designed for a useful life of 12 years, to be built in three stages and with a volume capacity of 1,203,304 m^3, including coverage. The filling method will be an area type, because the groundwater level is located 4.4 m below, therefore the project will not include *in situ* coverage material and will need its

transportation from other places. Three possible strata are regarded to extract the material and they are located between 4.2 and 12.7 Km.

The complementary works include the scale facilities, administrative offices, dressing rooms, vigilance booth, restrooms, access and waiting areas, roads, area for the maneuvering of vehicles, rainwater drainage system, outer fencing, buffering zone, signals, electricity and lighting, shed and landscape project.

Waterproofing of the bottom landfill with the following components is contemplated:

- 30 cm clay layer compacted at a 90% from Proctor (embankment)
- Geomembrane layer coated with clay of 60 mil thick (1.5 mm)
- Geotextile layer
- Drainage layer to extract leachate with 30 cm thick

A leachate collection system is considered to be formed by installed drainages at the bottom of the cells, which will carry the liquids to a skip pit and where they will be pumped to an evaporation lagoon, which will be waterproofed and with a depth of 60 centimeters, and from there liquids will be pumped again to irrigate the cells.

Biogas will be handled through passive control systems, specifically airshafts with a distance of 50 m between each other and the later burning of the biogas.

A monitoring program is contemplated that includes:

- Biogas monitoring
- Monitoring of leachate
- Monitoring of groundwater
- Monitoring of airborne particles
- Noise monitoring

The use of a track tractor, a back digger, a dump truck, a flat vibrating roller and an tanker truck are considered. The staff will be composed by 11 people.

Regarding the negative impacts generated by the project and outlined in the Environmental Impact Manifest are the following:

- Leveling, hatchet-blowing and cleaning of the land
- Drawing and leveling of the access road and internal authorities
- Vehicle traffic in access roads
- Haulage of wastes
- Extraction of coverage material.

The main positive impacts are the following:

- Placement of vegetal layer after the closure of the site
- Placement of final layer cover after the closure
- Maintenance of final cover after the closure

Once the assessment of the Environmental Impact manifest concludes, a call for tenders will be published for the construction of works. Once these works have materialized, the operation of the landfill will kick off under the responsibility of the municipality.

The solution planned by the Seduma to get rid of the current dumpsite in Calderitas has a highly beneficial impact for the community and the environment; however, there is an important risk throughout the process that has not been quite regarded.

The highest risk throughout the process is that the sanitary landfill project has not been linked with the cleaning and closure of the current dumping site. Linking both projects will:

Improve the sanitary and environmental conditions of the place, minimizing the contamination risks posed today by the dumpsite and that are not resolved by constructing a new landfill. On the contrary, if the current conditions prevail, it is possible that given the closeness between the same the project work goes out of control in the short term because no physical barriers exist to stop the current sanitary and environmental conditions from damaging the planned site; for instance, the presence of vectors and infiltration of leachate. Additionally, modification of the existing operational practices at the dumpsite is necessary, a thing that seems hard if no prior preparation exists.

To ensure the execution of cleaning and closure projects by programming both works in tandem, so when the operation of the sanitary landfill begins the dumpsite will have notoriously improved its operations, thus allowing a smooth transition between both projects.

Connection of works such as rainwater and leachate management between both projects should be done; otherwise a negative impact will reverberate in the operation of the sanitary landfill and even paralyze the works.

The cleaning and closure project will contemplate the arrangement of most of the wastes already scattered by the formation of cells to be covered with natural soils; it will also consider works for the management of liquids, gas and rainwater. All the latter activities will be related with an appropriate personnel training to execute the same, which will allow them to acquire the experience correctly run the new landfill and thus ensure the sustainability of the same.

Cleaning and closure of the current dumping site will allow a new availability of land for the disposal of wastes, gaining additional time to begin the habilitation works for the new landfill and more time to make investments.

During the recovery of the dumpsite it will be necessary to have adequate machinery and pieces of equipment which can be latter employed for the operation of the sanitary landfill, trimming down costs.

By linking both projects an integral recovery program will be available, with a closure project that will include a landscape project to expand to the new project. The latter will have an important impact on the community, who will stop perceiving the management of wastes as an endless problem.

C.1.4.5 Organizational Structure

Within the organizational structure of the Municipality there are two offices with functions related with the solid waste management: Urban Development and Ecology Bureau, which sets the municipal policy on environmental matters, urban development, and establishes and verifies the norms and procedures; and the Bureau of Municipal Public Services, which directly provides the solid waste management service through the Department of Urban Image.

This department directly provides the service of collection, transport, sweeping and final disposal, mainly in the city of Chetumal. It provides partial service in the localities of Subteniente López, Xul-Ha, Huay-Pix, Raudales, Laguma Guerrero and Luis Echevarría, with a weekly collection service.

Services in the localities of Bacalar, Nicolás Bravo, Calderitas, Javier Rojo Gómez and Alvaro Obregón, are in charge of their respective town or delegation offices and the Municipality supports them with vehicles and payment of salaries of the assigned personnel.

The locality of Mahahual has a private service, which is paid for by local residents and tourism related businesses.

Communities without service, mainly in rural areas, burn their solid waste.

Othon P. Blanco Municipality has assigned 114 persons to the Collection Area and 209 to Urban Cleansing (Sweeping).

C.1.4.6 Financial System

Section 2.3.5.2 described the municipal taxes and fees. “Service fees” are charged by municipalities for diverse services, including solid waste services.

In Othon P. Blanco Municipality, the monthly service fees for the collection, transport, treatment and final disposal of solid waste applicable in fiscal year 2003 was approved by the Municipal Council on December 5, 2002, and made official by its publication in the Official

Gazette on March 20, 2003. The solid waste service fees are being applied to business firms in Chetumal, Calderitas, Bacalar and Costa Maya. The service fees consist of a listing of 80 business types, further classified into 218 categories, to which 12 tariff levels are applied. Most business firms are applied the monthly 50 Pesos fee, but the range of fees starts at 30 Pesos and goes up to 1,200 Pesos per month. The lowest 30 Pesos fee is applied to small grocery shops, while the highest 1,200 Pesos fee is applied to supermarkets. Other solid waste service monthly fees are:

60 Pesos: liquor selling shops, ice maker, bakery
75 Pesos: propane gas shops
80 Pesos: guest house, discos, night clubs
90 Pesos: food distributor, lumber shops
150 Pesos: dance halls
200 Pesos: hotels with up to 10 rooms
250 Pesos: banks
300 Pesos: hospitals, hotels with up to 30 rooms
400 Pesos: schools (kindergarten, elementary, secondary), hotels with up to 50 rooms
500 Pesos: hotels with more than 50 rooms, soft drink bottling

Business firms that fall out of the listing of business types mentioned above will be applied a fee ranging between 50 Pesos and 800 Pesos per month, depending on the nature of the business and its size.

Solid waste service fees are charged only to commercial firms, but the awareness of these firms to comply with payments appears to be low. License to operate commercial firms needs to be renewed during the first months of every year, the firms being required to be up-to-date on payment of taxes and fees, and this requirement appears to be the major reason for commercial firms to pay the solid waste service fee during the first three months of the year.

In the case of Othon P. Blanco Municipality, income from solid waste service fees covers only a minimum part of the cost of providing the service. In 2001, income from solid waste service amounted to 1.37 Million Pesos (95% Chetumal and 5% Bacalar), while the cost of the service was estimated at 16.91 Million Pesos. This means that the income from solid waste service fee covered only 8% of the service cost. As the municipal budget in 2001 was 202 Million Pesos, expenditures on solid waste disposal required around 8% of the municipal budget.

Solid waste generation in Othon P. Blanco Municipality is reported as 170 ton per day, or 62,000 ton per year. At a total service cost of 16.91 Million Pesos in 2001, the cost per ton could be estimated to be around 270 Pesos, or about USD27, which may be more appropriate to be interpreted as the cost of solid waste collection service. CEPIS (Centro Panamericano

de Ingeniería Sanitaria y Ciencias del Ambiente) indicated the acceptable range of solid waste collection cost per ton to be USD25-40 in 2001.

C.1.4.7 Accounting System

Section 2.3.5.1 on Public Finance presented the income and expenditures of Othon P. Blanco Municipality, showing the different accounts used to describe the items in the municipal income and expenditures. The accounts are common to government offices. It is a government accounting. The overall income and expenditures table does not allow identification of the source of each income or expenditures, as they are grouped under broad headings like "Fee income" or "Personnel expenses".

It is possible however to estimate the income and expenditures of solid waste service, as was already done by the Municipality at the request of the Study Team. This required special efforts, determining the corresponding income and cost figures according to the appropriate account numbers, a process that may be open to the introduction of errors.

It can be seen that the accounting at present is geared to the management and control of the budget, which is understandable for a government office. However, as a provider of services, it would be extremely useful if the Municipality could determine the cost and income of a given service. Keeping these income and expenditures data separately for each service will permit the calculation of performance indicators for the service. The performance indicators are essential to implement a continuous monitoring system, a necessary step to improve the efficiency and effectiveness of the service.

C.1.4.8 Social Aspect

Social aspects affected by the solid waste management are the following.

Social Aspect	Consideration
Coverage of the collection service	90% in the city of Chetumal. Weekly collection in neighboring communities.
Solid waste disposal according to norms	100% of solid waste is disposed of without compliance with the official Mexican norms.
Conservation of health	Important incidence of diseases related with an inadequate management of solid waste: intestinal infection, dengue fever, typhoid fever, helminthiases.
Drinking Water Quality	Preliminary calculation of leachate intrusion in the aquifer was estimated to correspond to a pollutant load of 1830 ton of BOD per year

C.1.4.9 Environmental Education

The Secretariat of Urban Development and Environment (SEDUMA) through the Office of Environmental Contamination Prevention and Control carried out a program of environmental education with the objective of strengthening awareness in students, the respect and protection of the environment and conservation of the biodiversity. This program

has the goal of sensitizing students of primary schools, regarding the conservation of the living environment. The activities were carried out mostly in primary schools located at the riverside of Rio Hondo with the purpose of participating actively inside an institutional promotion work group for the environmental culture. In the activities were projected audio visual regarding the harmful effects generated by the solid waste and the different types of pollutants in the aquatic, air and terrestrial ecosystems, and showing of didactic material regarding the importance reef system roles in the marine life, etc. For the period 2003-2004 the Office intends to continue the activities of environmental education in the northern areas (along the highway towards Felipe Carrillo Puerto and on the Costa Maya).

The Municipality of Othon P. Blanco through its Urban Development and Ecology Office, is carrying out environmental education programs for kindergarten and primary schools, through a series of characters called "Recicloso", "Tlacuachino" and "Manatin", each one of them presents a specific function regarding environmental management.

The first character represented by a bear forms "the club of Recicloso and their friends" and it is a project focused on environmental nature activities for kindergarten children and primary schools, specifically focused on use an management of organic and inorganic wastes, and reforestation with the participation of "Recicloso" as the main actor during the project. The project objective is to implement a program of “formal” type Education and Environmental Communication with issues and activities related to the appropriate domestic waste management, as well as to induce for reforestation and care of plants in its own school, through the central character of "Recicloso" as motivational outstanding for kinder and primary schoolchildren.

An ONG “Friends of the Manatee” (a civil association) submitted a proposal to the Secretariat of Education and Culture on the importance of "Area Subject for the to Sanctuary Ecological Conservation of the Manatee" to implement a support program in formal education for care and improvement of the environment. This program is focused on basic and middle level grades, and through of didactic activities and spreading of the information it is possible to transmit the knowledge, values and the respect to the ecological issues and how to manage the ecosystems that conforms the sanctuary of manatee, as well as learning of rational and sustainable use of natural resources of the living environment.

C.2 Felipe C. Puerto

C.2.1 Water Quality Monitoring

As mentioned in the section of Othon P. Blanco, water quality monitoring is periodically carried out by the navy targeting the coastal water of Yucatan Peninsula and Gulf of Mexico and by CAPA targeting well water.

The monitoring carried out by the navy has purpose to check eutrophication of water and appropriateness for notation. Meanwhile, CAPA checks its appropriateness as a source of water supply.

C.2.1.1 Monitoring Result of CAPA

Table C-20 shows monitoring items and Table C-21 presents monitoring results from 2000 to 2002. The results do not show contamination.

Table C-20: Monitoring Item of CAPA Source Well

pH	Chlorine (mg/litter)
Water temp.	Total hardness (mg/litter)
Air temp.	Hardness Ca(mg/litter)
EC (µsiems/cm)	Hardness Mg(mg/litter)
Color (u PT-Co)	Sodium (mg/litter)
Odor	Bicarbonate (mg/litter)
Turbidity (UTN)	Sulphate (mg/litter)
Alkalinity phenolphthalein (mg/litter)	Calcium (mg/litter)
Total alkalinity (mg/litter)	Magnesium (mg/litter)
	Total dissolved solid (mg/litter)

Table C-21: Monitoring Results of CAPA's Well

Name of well	Item	Year			
		2000	2001	2002	Average
Chum on	pH	7.3		7.3	7.3
	Water emp.	26.4		24.6	25.5
	EC(μsiems/cm)	1,310		1,034	1,172
	Turbidity(UTN)	2.5		2.5	2.5
	Total alkalinity(mg/litter)			280.0	280.0
	Chlorine(mg/litter)	275.2		99.8	187.5
	Total hardness(mg/litter)	978.3	836.6	512.5	775.8
	Sulphate(mg/litter)			54.6	54.6
	Calcium(mg/litter)			85.0	85.0
	Magnesium(mg/litter)			24.3	24.3
	Total dissolved solid(mg/litter)			681.2	681.2
Chunhuas	pH	7.4		7.4	7.4
	Water emp.	26.1		25.6	25.9
	EC(μsiems/cm)	1,280		1,190	1,235
	Turbidity(UTN)	2.5		2.5	2.5
	Total alkalinity(mg/litter)			195.2	195.2
	Chlorine(mg/litter)	301.5		275.1	288.3
	Total hardness(mg/litter)	861.3	942.9	657.0	820.4
	Sulphate(mg/litter)			354.6	354.6
	Calcium(mg/litter)			176.0	176.0
	Magnesium(mg/litter)			48.6	48.6
	Total dissolved solid(mg/litter)			737.8	737.8
Emiliano Zapata	pH	7.4		7.9	7.7
	Water emp.	26.8		26.1	26.5
	EC(μsiems/cm)	1,150		2,130	1,640
	Turbidity(UTN)	3.0		2.5	2.8
	Total alkalinity(mg/litter)			960.0	960.0
	Chlorine(mg/litter)	399.7		318.3	359.0
	Total hardness(mg/litter)	703.6	890.0	837.5	810.4
	Sulphate(mg/litter)			145.6	145.6
	Calcium(mg/litter)			210.0	210.0
	Magnesium(mg/litter)			75.9	75.9
	Total dissolved solid(mg/litter)			1,999.2	1,999.2

C.2.2 Groundwater Management

C.2.2.1 Hydrogeologic Conditions

Municipality of Felipe Carrillo Puerto is located on the plain, which is composed of Miocene-Pliocene carbonate rocks. In the western part of the municipality, however, Eocene carbonate rocks are distributed. In the eastern part, there is a large area of tidal zone, which is covered by recent deposits. Groundwater exists in these carbonate rocks. According to INEGI (2002), elevation of groundwater table ranges from 1 m to 10 m above mean sea level.

C.2.2.2 Extraction and Injection Wells

a. Extraction

Number of registered production wells in Felipe C. Puerto is 449 according to CNA. Of the 449 wells, agricultural wells make up 75% (336 wells) and public wells 16.5% (74 wells) (Refer to Table 2-1, Chapter 2.2.1.5). Number of wells for service sector is only four (4) wells. CAPA Felipe C. Peuerto presently has 4 wells for its urban water supply. These wells were constructed in 1987. The well diameter is 12 inches and the depth is 26 to 30 m. A maximum total capacity of the wells is 244 LPS. Table C-22 shows parameters of CAPA wells. These wells are located in the town area.

Table C-22: Parameters of Production Wells of CAPA in Felipe C. Puerto

Well No.	Well Depth (m)	Discharge (LPS)	SWL (m)	DWL (m)
1	26	72	13	13
2	30	56	18	18
3	30	80	18	18
4	30	36	8	8
Total	-	244	-	-

SWL:Static Water Level DWL:Dynamic Water Level
Source: CAPA Felipe C. Puerto

b. Injection

An injection well is being operated by CAPA (Figure C-21). In addition, according to CNA, twenty (20) injection wells are registered. Most of them are utilized for livestock waste water injection.

A waste water treatment is being operated for FRANCISCO VILLAGE, which is located between the street 57 and 59 of the town. This village has 114 houses. The plant was designed to treat 5 LPS of waste water, which only covers 2.0% of Felipe C. Puerto. The treated water is injected into the CAPA injection well.

The depth and the screen position of the CAPA injection well is unknown. According to CAPA, an average injection rate is 3 LPS. A field test conducted by the Study Team shows the following water quality:

PH 7.50
Electric Conductivity 1490 micro S/cm
Temperature 29.5 ° C

Figure C-21: Injection Well in CAPA Felipe C. Puerto

C.2.2.3 Present Status of Monitoring

CNA has not yet constructed monitoring wells in this area. CAPA is conducting water analysis of the production wells at six (6) months interval. Table C-23 shows the result of monitoring.

Table C-23: Results of Water Quality Analysis in CAPA Wells*

No.	PH	T (℃)	EC (microS/cm)	Chloride (mg/l)	Hardness (mg/l)
1	7.40	26.4	1,110	113.6	377
2	7.44	26.4	1,990	128.7	421
3	7.41	26.4	2,440	166.7	725
4	7.20	26.2	1,680	128.4	376

T: Temperature EC: Electric Conductivity * Date: 27th, 28th December, 2000
Bacteria test is also conducted, however, CAPA Felipe C. Puerto has no laboratory at present.

C.2.3 Wastewater Management

C.2.3.1 Overview of Wastewater Management

a. Present Situation

Sewer system is hardly working in Felipe C. Puerto. Only 140 houses developed by the private sector in urban area are covered by the system.

Table C-24: Outline of Sewer System in Felipe Carrillo Puerto

Item			State of Quintana Roo	Felipe Carrillo Puerto
1. Basic item				
Area of administrative boundary (km2)			50,843	13,806
Population of administrative boundary			1,233,490	65,861
Service projected area (km2)			76.02	0.02
Water production amount (1,000 m3/year)			112,737.78	6,223.25
Effective (billing)water supply amount (1,000m3/year)			45,700.42	1,405.47
Water supply population			1,171,816	57,220
Unit water supply amount (l/day/person)			263.58	297.97
Effective Unit water supply amount (l/day/person)			106.84	66.39
Sewage generation rate for planning (l/person/day)			75% of water supply amount*	
Unit sewage pollution load (g/person/day)		BOD	54	54
		S S	52	52
2. Service projected and present served population for wastewater management				
	Sewer system(off-site)	Plan	372,994	567
		Actual	370,955	567
	On-site system	Plan	0	0
		Actual	0	0
	Latrine system	Plan	0	0
		Actual	Not available	Not available
	No-system	Plan		56,653
		Actual	800,861	56,653
3. Off site sewer system				
	Responsible authority		C.A.P.A.	
	Construction		C.A.PA.	
	O & M		ORG. OPER.	
	Service area (km2)		62.38	0.02
	Service population		370,955	567
	Number of connections		90,698	114
	Service coverage rate (population)		30.07	2.88
	Length of pipe line		1’088,376	6,804
	Number of pump station		-	0
	STP intake amount (lps)		1,251.83	1.34
	Sewage production per capita		291.6	204.2
	Sewage treatment plant (STP)			
	Number of STP		16	1
	Treatment method		Activated sludge	Activated sludge
	Treatment Capacity		1,432	5
	Annual average intake amount			
	Intake waste quality (Jan. to June/2003)		BOD: COD: S S:	100.80 249.99 68.33
	Treated water quality (Jan. to June/2003)		BOD: COD: S S:	2.15 12.64 6.00

Source : CAPA July 2003

Table C-25: Service Coverage of Sewer System in 2000

Item	Municipality	Population	Service coverage		
			Water supply	Sewer line	Sewage treatment capacity
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%
State total		720,567	95%	57%	73%

Source: CAPA Plan Estratégico APAS 2001-2025

b. Plan

CAPA prepared a strategic plan[5] of wastewater management for the whole Quintana Roo State in 2001. Table C-26 and Table C-27 show implementation and investment plans for Felipe C. Puerto respectively from the strategic plan.

Table C-26: Phased Implementation Plan in Urban Area of Felipe Carrillo Puerto

Item	2001 to 2005	2006 to 2010	2011 to 2025	Total
Water supply amount (litter/sec)	15	10	21	46
Sewer system (ha)	109	39	86	234
Sewage treatment amount (litter/sec)	114	8	17	139
Acc. sewage treatment amount (litter/sec)	114	122	139	-

Table C-27: Investment Plan for Felipe Carrillo Puerto Urban Area (Million pesos)

Item	2001 to 2005	2006 to 2010	2011 to 2025	Total
Water supply	42.2	5.2	11.1	58.5
Sewer line	85.0	6.0	14.0	105.0
Sewage treatment	16.0	2.0	3.0	21.0
Land acquisition	1.0	0.0	1.0	2.0
Total	144.2	13.2	29.1	186.5

C.2.3.2 Outline of Sewer System

As it mentioned above, the off-site sewer system has hardly been developed in Felipe C. Puerto, except the 140 houses. A sewage treatment plant for the 140 houses treats 1.34 liter/sec (116 m^3/day) of wastewater. As for on-site system, septic tank dominates.

Table C-28 shows outline of the sewage treatment plant for the 140 houses.

Table C-28: Outline of Felipe Carrillo Puerto Sewage Treatment Plant

Item	Parameter
Actual treatment amount	1.34litter/sec (116 m3/day)
Intake water quality	BOD:101mg/litter, COD:250mg/litter, SS:68 mg/litter
Treated water quality	BOD:2.2mg/litter, COD: 13mg/litter, SS: 6 mg/litter
Treatment method	Activated sludge method

Source: CAPA

C.2.3.3 Sewerage and Pollutant Sources

Table C-29 shows wastewater discharge amount with respect to each source in Quintana Roo State in 2001. Discharge amount from Service such as hotels is distinguishing due to the active tourism. It occupies more than 70% of the whole discharge amount. Meanwhile, discharge amount from industry such as manufacturing, mining, etc. is very small. It makes up only 1.48%.

Table C-29: Wastewater Discharge Amount to Federal Control Water Body in 2001

Source	Wastewater Discharge amount (m3/year)	Ratio
Domestic	378,100	0.44%
Industry	1,271,600	1.48%
Service	62,439,000	72.83%
Urban public	21,536,100	25.12%
Others	106,000	0.12%
Total	85,730,800	100.00%

Source : ANUARIO ESTADÍCO Quinntana Roo edición 2002/INEGI

No data of wastewater discharge amount in respective municipalities are available. However, working population data by municipality is obtainable as shown in Table C-30. Checking figures of Felipe C. Puerto, working population in Industry/Manufacturing is small like other municipalities. Consequently, residents and tourists are considered as principal pollutant sources.

[5] PLAN ESTRATÉGICO DE LOS SERVICIOS AGUA POTABLE, ALCANTRILLADO Y SANEAMIENTO 2001-2035, CAPA

Table C-30: Distribution of Working Population

Code	Category	Quintana Roo	BENITO JUÁREZ	COZUMEL	FELIPE CARRILLO PUERTO	ISLA MUJERES	JOSÉ MARÍA MORELOS	LÁZARO CÁRDENAS	OTHÓN P. BLANCO	SOLIDARIDA
11	Agriculture, livestock, forestry, fishery and hunting	10.5%	1.0%	2.0%	49.8%	12.0%	57.2%	49.5%	19.7%	5.5%
21	Mining	0.2%	0.1%	0.1%	0.3%	0.2%	0.1%	0.5%	0.3%	0.4%
22	Electric and water	0.5%	0.4%	0.6%	0.3%	0.7%	0.3%	0.5%	0.7%	0.3%
23	Construction	8.4%	8.6%	9.7%	6.3%	4.6%	6.0%	6.3%	7.1%	12.4%
31	Industry/Manufacturing	7.1%	7.2%	6.1%	5.3%	4.3%	4.8%	7.1%	8.6%	6.0%
43	Commercial	16.8%	19.4%	21.3%	8.8%	18.5%	6.6%	8.7%	13.9%	14.0%
48	Transport, postal and warehousing	5.8%	7.3%	6.5%	2.0%	8.0%	2.7%	3.7%	3.7%	4.2%
51	Mass communication media	0.9%	1.0%	0.8%	0.5%	0.5%	0.2%	0.4%	0.9%	0.5%
52	Financial and insurance service	0.7%	0.9%	0.5%	0.1%	0.3%	0.0%	0.2%	0.6%	0.4%
53	Real estate	0.9%	1.2%	1.6%	0.0%	1.5%	0.0%	0.1%	0.3%	1.2%
54	Academic service	1.9%	2.4%	2.0%	0.6%	1.2%	0.4%	0.4%	1.6%	1.1%
55	Service for commercial acuity	3.0%	4.3%	2.6%	0.5%	1.9%	0.3%	0.6%	1.4%	2.1%
61	Education service	4.6%	3.5%	3.5%	8.2%	3.4%	6.1%	4.9%	7.5%	1.8%
62	Social welfare and health	2.4%	2.2%	2.4%	1.6%	2.0%	1.2%	1.2%	3.9%	1.0%
71	amusement service	1.7%	1.7%	3.6%	0.6%	3.1%	0.2%	0.3%	0.7%	3.8%
72	Hotel and restaurant	18.3%	23.4%	21.3%	4.4%	21.3%	3.0%	4.1%	5.5%	33.5%
81	Other service exc. Government	8.7%	9.5%	8.8%	5.0%	5.9%	5.9%	4.3%	9.4%	6.9%
93	Government activity	5.3%	3.4%	4.6%	3.9%	8.9%	3.5%	5.5%	11.7%	2.7%
	Not specify	2.2%	2.3%	2.0%	1.6%	1.7%	1.6%	1.9%	2.3%	2.3%
	Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source : based on Tabulados Básicos QUINTANA ROO XII Censo General de Población y Vivienda 2000 / INEGI

Table C-31 shows BOD generation amount with considering that residents and tourists are principal pollutant sources and supposing that BOD pollutant load unit is 54 g/person/day[6].

Table C-31: Estimated BOD Generation Amount

	Population		BOD generation amount (ton/year)		
	Settlement	Tourist(Person/year)	Settlement	Tourist	Total
Cozumel	62,078	455,621	1,223.565	24.604	1,248.169
Felipe Carrillo Puerto	61,703		1,216.158		1,216.158
Isla Mujeres	14,911	141,785	293.896	7.656	301.552
Othón P. Blanco	230,718	205,216	4,547.448	11.082	4,558.530
Benito Juárez	438,872	2,987,841	8,650.163	161.343	8,811.506
José María Morelos	31,668		624.176		624.176
Lázaro Cárdenas	20,891		411.758		411.758
Solidaridad	86,863	1,504,052	1,712.078	81.219	1,793.297
Quintana Roo state	947,704	5,294,515	18,679.242	285.904	18,965.146

6

PROYECTO EJECUTIVO PARA EL ALCANTARILLADO SANITARIO Y TRATAMIENTO DE AGUAS RESIDUALES DE LAS LOCALIDADES DE XCALAK, HUAY-PIX, XUL-HÁ Y SUBTENIENTE LÓPEZ EN EL MUNICIPIO DE OTHÓN P. BLANCO, QUINTANA ROO / CAPA

Meanwhile, treated wastewater amount was 42,368m^3/year[7] in 2002. Supposing that BOD concentration of inflow is 101 mg/liter and one of outflow is 2.2 mg/liter, this leads 4.19 ton/year of BOD removal amount by wastewater treatment. This BOD removal amount makes up only 0.2% of the total BOD generation amount. The rest, 99.8% of the generation amount, is discharged to the environment without treatment.

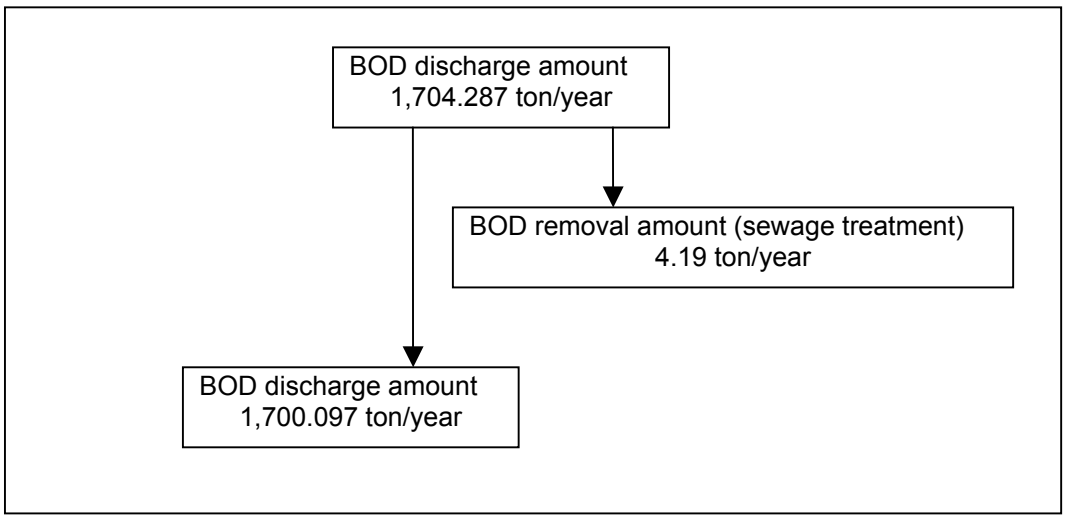


Figure C-22: BOD Balance in Felipe C. Puerto Municipality

C.2.3.4 Organizational Structure

The Operating System of Felipe Carrillo Puerto manages the subsystems of: Carrillo Puerto, Señor, Tihosuco, Chunchuhub and Chan Santa Cruz.

The organizational structure of the Felipe Carrillo System is the same as that of Othon P. Blanco System.

C.2.3.5 Financial System

CAPA provides water supply service in Felipe Carrillo Puerto Municipality, where the number of water supply connections in 2001 was 10,852 or 12.4% of the State total. Households comprised the overwhelming majority of customers with 10,309 connections or 95.0%, followed by 2.66 % of commercial firms, 2.29% of General Services, 0.02% of industrial firms, and 0.04% of hotels. Service coverage was estimated at 87% water supply and 1% sewer service.

As already described in Section 4.1.3.7, CAPA water rates are set by customer category, being composed of a base monthly rate depending on volume (cubic meter per month), and

[7] CFAPA

an excess consumption rate that is priced as Pesos per cubic meter consumed. The excess consumption rate increases with consumption, as it corresponds to a progressive rate.

In Felipe Carrillo Puerto Municipality, income from water supply between 2000 and 2002 accounted for 85% or more of total income, while income from waste water service was zero. Fines can be applied when a bill is not paid for two months or longer, and water supply can be cut off in the case of non-payment. Accordingly, re-connection charges are foreseen as an income source when the water supply service is restored.

The water production volume in 2001 was 6.631 Million cubic meters, and the budgeted expenditures were 11.48 Million Pesos, giving an average cost of 1.73 Pesos per cubic meter of water produced in Felipe Carrillo Puerto Municipality.

C.2.3.6 Accounting System

CAPA is a decentralized public institution of mixed nature, that is, State and Municipal, with own assets. As a public institution, accounting is needed for budget management and control, but CAPA also generates financial statements as Balance Sheet and Income Statement (Profit and Loss) for the institution as a whole.

However, it is more difficult to come up with financial statements for each water supply system. Then, a comparison was made between the income and the expenditures of each system. On the income side, data were available as budget income and as actual income, while on the expenditures side only the budget was available, as shown in the following table.

Table C-32: Balance of CAPA Felipe Carrillo Puerto System (Million Pesos)

INCOME & EXPEND.	Year 2000		Year 2001		Year 2002	
	Budget	Actual	Budget	Actual	Budget	Actual
INCOME						
Water supply	1.07	1.50	1.85	1.97	2.47	2.74
On-time	1.00	0.35	1.71	0.83	1.10	1.32
Late	0.07	1.15	0.14	1.14	1.37	1.42
Sewer system	0.00	0.00	0.00	0.00	0.00	0.00
On-time	0.00	0.00	0.00	0.00	0.00	0.00
Late	0.00	0.00	0.00	0.00	0.00	0.00
Connection fee	0.03	0.19	0.08	0.10	0.14	0.05
Re-connection fee	0.00	0.00	0.01	0.00	0.00	0.00
LPS (liter per second)	0.01	0.00	0.00	0.00	0.00	0.00
Updating	0.00	0.00	0.00	0.00	0.00	0.00
Surcharges	0.00	0.00	0.00	0.00	0.00	0.00
Fines	0.00	0.00	0.00	0.02	0.00	0.00
Implementation	0.00	0.00	0.00	0.00	0.00	0.00
Other Incomes	0.00	0.02	0.01	0.03	0.05	0.02
Value added tax	0.00	0.02	0.00	0.05	0.00	0.06
Total	1.12	1.74	1.95	2.17	2.67	2.87
EXPENDITURES						
Personnel	2.57		3.78		4.41	
Materials & supplies	1.64		2.07		2.01	
General Services	3.45		3.46		3.53	
Aid, subsidy & transfer	0.04		0.10		0.09	
Goods (furniture, equip.)	0.00		0.63		0.00	
Public works	0.00		1.38		0.44	
Contingent expenses	0.00		0.00		0.26	
Public debt	0.00		0.06			
Total Expenditures	7.70		11.48		10.74	
BALANCE	-6.59		-9.53		-8.07	

Source: CAPA

The above table indicates that the balance of income and expenditures was negative in Felipe Carrillo Puerto Municipality between the years 2000 and 2002. Actual income covered 22.6% of budgeted expenses in the year 2000, 18.9% in 2001 and 26.7% in 2002.

C.2.3.7 Social Aspect

Social aspects and considerations are presented in the following.

Social Aspect	Consideration
Coverage of the sewer service	At the municipal level it is 1%
% of houses with infiltration ditches/cesspool (septic fosas)	At the municipal level 33% of surveyed houses use infiltration ditches/cesspool (septic fosas); the remaining 65% of houses do not have any system to dispose of domestic waste; high incidence of open defecation.
Conservation of health	The incidence of intestinal infections in the State is 6178.9 per 100,000 inhabitants (1224 cases over the national average). High incidence of helminthiases.
Drinking Water Quality	The use of bottled water is expanding in the city of Felipe Carrillo Puerto. People in the rural areas of the Municipality drink the water supplied by the CAPA rural system.
Aquatic areas for recreation	The coastal area is free of contamination (Sian Ka´an Biosphere Reserve)
Family income and expenditures	Economic activity is related with commerce and government service in the city of Felipe Carrillo Puerto; while agriculture prevails in the rural area. Fluctuation in tourism activities in the State is important, but does not determine family income.

C.2.3.8 Environmental Education

The State Commission for Potable Water and Sewerage (CAPA) implemented a program "Friendly School - Green House" with the objective to improve and raise the life quality of families in needs through simple and appropriate technologies to the region, through school lectures and chats, chats with parents, lecture on sanitation and reforestation, maintenance of physical and sanitary conditions of water supply and control of the quality of water, among others. Also CAPA through the "Clean Water" Program, carries out within the communities visited (Señor, Canzepchen, Kampocolche Nuevo, Chanchen Comandante, Tixcacal Guardia), actions focused on control of water quality to reduce the risks of transmission of gastrointestinal diseases.

With the purpose of reinforcing the institutional initiative in the implementation process of the work program, CAPA was supported by the National Water Commission (CNA), the Mobile Net Promoters of Family Development of the State and by leaders of the community. The lectures to the community were focused on the promotion of the importance, care and use of water as issues related to the health.

C.2.4 Solid Waste Management

C.2.4.1 Overview of Solid Waste Management

The municipality of Felipe Carrillo Puerto sets up and conducts its municipal solid waste management services through the Direction Office of Municipal Public Services, who renders the collection, haulage, final disposal and sweeping activities directly and exclusively to the municipality's capital town of Felipe Carrillo Puerto; the other towns are not rendered with the service.

From a juridical perspective, the municipality possesses the Regulation on Garbage Cleaning and Collection, which sets out the grounds basis for the organization, surveillance and functioning of the municipality's public cleaning service. This regulation also states that a cleaning commission will be created with the participation of the neighborhood association heads, neighborhood councils, mass media and bodies or institutions standing for sectors of the city. Said commission will be chaired by the Director of Municipal Public Services. Likewise, it is stated that the Direction Office is entitled launching awareness programs to improve the city cleanliness, to determine the location of final disposal sites, to industrialize and trade wastes by itself, in decentralized manner or grant its concession pursuant to the Law, to establish collection schedules and routes, and so on; the Regulation also points out the obligations by the users and the fines to be enforced in case of penalties. This regulation, yet currently in force, is not complied with, except in parts of Felipe Carrillo Puerto.

As above mentioned, the service is conducted exclusively at the municipality's capital city; other towns such service is not provided and wastes are disposed of by burning them at the points of generation. In several of these towns the accumulation of wastes, such as plastic bottles, is perceivable; the accumulation of wastes on the roads and unoccupied lots is also important.

The service provided by the Direction Office is inceptive and thus reflects serious deficiencies, as a consequence of the lack of resources and service planning. Funds come mainly off the municipality's pockets, and the service is not charged to any of the users whatsoever.

The collected wastes include household, commercial, institutional and medical residues. The management of medical wastes is worth mentioning, as the service collects all the wastes generated at health institutions, including pathogenic organic wastes, which are latter disposed of at the town's dumping site, posing a serious risk to health.

The service is rendered at a total of 11 neighborhoods that add up to 50% of town inhabitants, and therefore a 23% coverage of the entire population.

The collection frequency is on a daily basis for downtown and medical wastes and three times a week for the rest of the city. Several of the neighborhoods covered have some their streets unattended, because of their faulty status.

Collection is carried out in two shifts; 6:00 through 13:00 and 14:00 through 18:00, Monday to; Saturdays and Sundays have only one shift from 06:00 to 11:00. The service is provided with two, 11 m^3 dump trucks plus a 4 m^3 high platform pickup; each of them with a crew formed by the driver and three collection workers. Given the number and capacity of the trucks, not the entirety of the wastes are collected at the serviced zone, and so wastes remain on the streets and are scattered by dogs; thus spoiling the city image. Sometimes wastes are disposed of at illegal dumping sites illegally by the generators.

In general terms, the morning shift trucks travel twice to the dumping site, and only two of them do so in the afternoon shift. The bad status of the trucks, along with the lack of resources, cause them to be non-operational for a long time, meanwhile the service is not rendered or downtown areas are attended only.

Most of the times the wastes are stored in bags or drums provided installed by the municipality at concurred places such as town squares, market places or tourism spots. The Users do not always hand over their wastes when the collection truck passes, and they remain on the streets. The collection method is door-to-door; however, at those sectors where trucks are unable to enter, wastes are carried to gathering points where no structure exists to contain them.

Three times a year an operation is conducted to clean up and collect the wastes at the locations of Señor, Laguna Kana, Tihosuco, Polyuc, Chumhuhub and Tepic; the wastes collected are mainly of bulky and junk type.

The wastes generated at markets are collected by a truck owned by the merchants, who pay for that system.

Two private entities provide the household collection service; they serve several residencies who cash out between $5 and $10 pesos every time wastes are collected. This service is not programmed however and it responds only to the needs of its users.

According to estimates by the Direction Office, roughly 1,000 ton/month are collected; this figure has been determined in function of the truck's capacity and the number of trips; however, a great uncertainty remains over the values, as no control exists to establish whether the trucks are fully loaded or not when they get to the dumping site, the type of wastes are not classified and since they are no compaction trucks, big differences in weight prevail due to the density of the wastes.

The annual cost of the collection and haulage service adds up to $1,200,000 Pesos, including the operation of the vehicles and labor.

The sweeping service is carried out exclusively at downtown areas and on the main access roads, of a manual nature and executed by fifteen people.

Sweeping is conducted only in one shift from 06:00 to 13:00, Monday through Friday, and 6.5 Km of avenues per day are serviced and around 3 tons per day are collected.

Wastes from the sweeping activity are gathered in a cart that is picked up by the collection truck; when the truck is the carts are carried to the city hall to unload the wastes in the following collection shift.

All the wastes collected are transported to an open dumping site, located 6 Km away from the city at one side of the federal highway that joins the town with Cancun.

At this site, wastes are disposed of with no control whatsoever, and the wastes are scattered all over the place; no accumulation of liquid percolation is perceived, which probably seeped and evaporated. There is an important amount of birds, mosquitoes and flies.

No staff exists at the dumping site; therefore no control exists over residues coming in; no infrastructure exists either and the site is open for any type of waste to be discharged.

This dumping site has undergone through several fires that affect the highway, since the smoke hinders the drivers' visibility, with fatal accidents that have taken place. Most of these fires are provoked in order to minimize the volume of the wastes and thus generate additional space to unload additional wastes.

The only work carried out by the Direction Office at the dumping site is the arrangement of the wastes, an activity executed every six months and that responds to the need of incrementing the available disposal space.

Currently the Direction Office of Municipal Public Services is planning to move the dumping site to a location owned by it, located in Km 137+000 of the federal highway between Carrillo Puerto-Valladolid, which will allow the reduction of costs, as the current land is a rental.

The new piece of land is located 10 Km away from the city, with a greater area than the current dumpsite and has a tree-buffering zone that lowers the visual impact of the activity.

C.2.4.2 Waste Stream

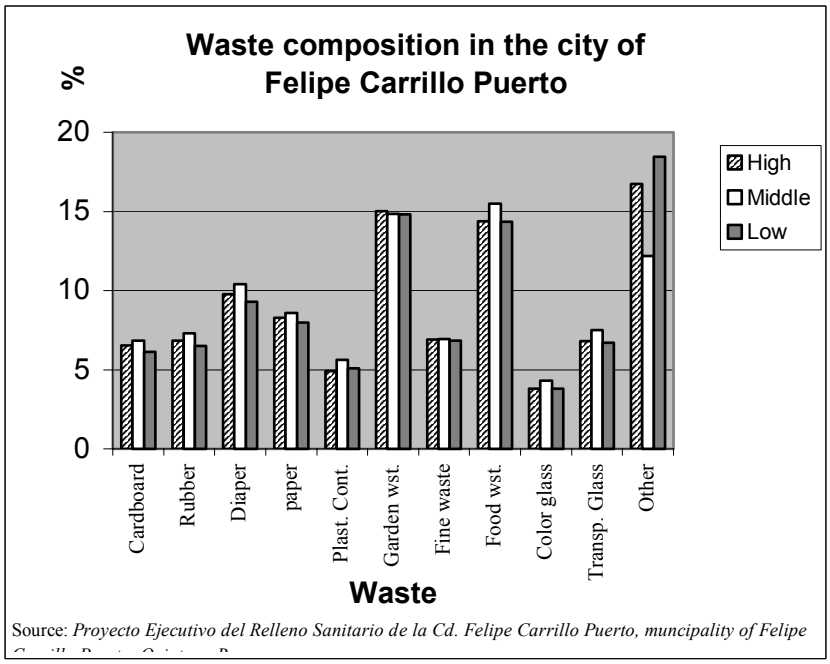
a. Actual Situation

Considering that solid waste management in the municipality of Felipe Carrillo Puerto is conducted in a rudimentary level, its coverage reaches only 23% of the population total and that part of these wastes are burned, it is impossible to find a background for establishing a waste flow.

Currently, a single study on the amount and composition of the wastes has been carried out and belongs to the executive project for a sanitary landfill, developed by the Secretaryship of Urban Development and Environment. The study compiled information exclusively of the city, which accounts for 45% of population total; therefore, this information cannot be employed for the entire municipality, especially when most of the locations have a Mayan population with other habits.

The study was carried out pursuant to the regulations in force and the results obtained were as follows.

- Generation per head for the high-income level is 0.84 kg/person/days; for the middle income sector is 0.75 kg/person/day and for the lower income sector 0.833 kg/person/day. No measurements were made for commercial and institutional sectors.
- Regarding the composition, it was determined only for the household sector and the following figure displays the results obtained.



Source: *Proyecto Ejecutivo del Relleno Sanitario de la Cd. Felipe Carrillo Puerto, muncipality of Felipe*

Figure C-23: Results of the Waste Composition Study

b. Estimation

As explained so far, insufficient data cannot make it possible to prepare a waste stream that schematizes waste amount of generation, collection, recycling, clandestine dumping, etc. over the municipality. However, waste collection amount and disposal amount could be estimated based on information obtained.

Population of the city of Felipe C. Puerto was about 18,500 in year 2000. Information obtained says that: about 50% of the residents are covered with the collection service; waste generation amount is 0.8 kg/person/day according to the waste generation rates above. No information on waste from commercial activities exists. Then, suppose that about 3 ton/day of waste is generated due to its population sizes. Furthermore, all waste generated is not necessarily collected, certain amount of waste is recycled, scattered, etc. Then, suppose 90% of the waste generated is collected.

Consequently, the information and assumptions bring that about 9 ton/day of waste is collected and disposed of; (18,500 x 50% x 0.8 kg/person/day +3 ton/day) x 90%.

C.2.4.3 Technical System

a. Introduction

In order to provide the collection, haulage, sweeping and final disposal, the direction Office of Municipal Public Services has the following organizational structure:

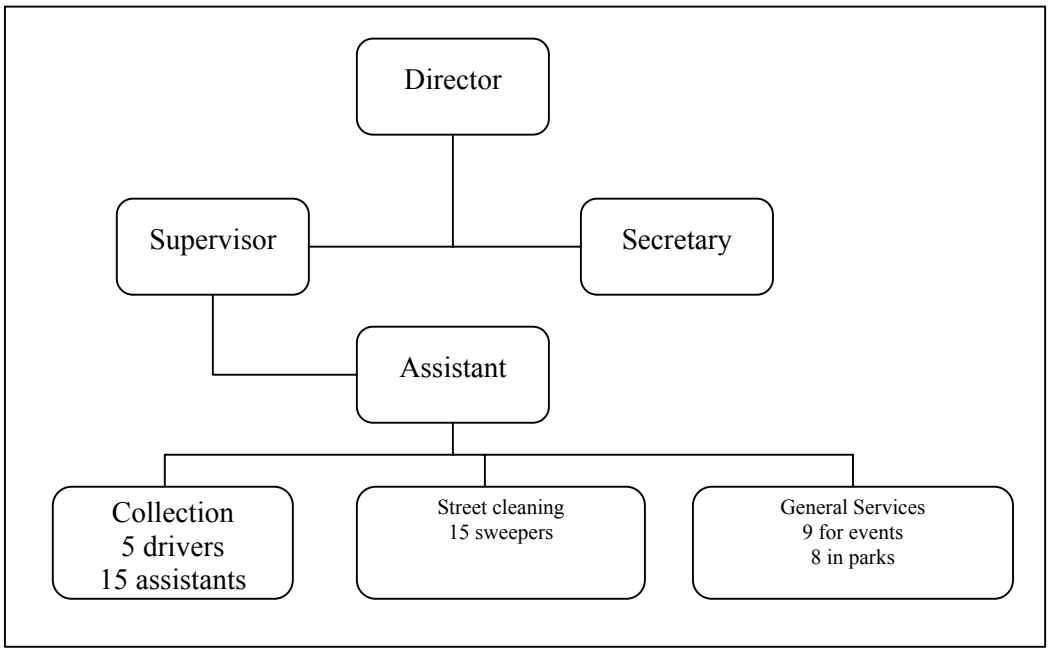


Figure C-24: Flowchart of the Direction Office of Municipal Public Services

Among the functions developed by the Office is the design of the collection and haulage service, through the establishment of routes and schedules to collect, industrialize and commercialize the wastes, by itself or in a decentralized manner or grant its concession, to determine the places where public dumping sites will be located, to inform on the penalties by the users, etc.

Currently, the Direction Office conducts the service only in the city of Felipe Carrillo Puerto, and no other places are served. The management system responds basically to the city needs, and no planning exists thereof, due to the scarce funds available to the city hall.

b. Discharge and Storage System

Discharging of the solid wastes in made in supermarket bags, which are dropped in front of the curbs or in small baskets to be picked up later by the collection staff. Low-capacity plastic, wooden or metallic containers are also used, but in a lower proportion.

In the commercial sector, wastes are stored in plastic bags or in 200-liter drums where they mix in bulk. In the case of packaging material, they are discharged in front of the stalls with no conditioning whatsoever. The institutional and school wastes are stored in 200-liter drums.

Organic medical and pathogenic wastes are discharged in special plastic bags, totally sealed.

Additionally, the municipality has installed a total of 50 plastic containers and 50, 200-liter drums in tourist zones, parks, squares, commercial areas and areas with high concentration of people. In spite of it, the community is used to throw their wastes anywhere and great quantities of wastes are found on public thoroughfare, a fact mostly particular in the city as users do not take their wastes out when are the collection truck passes by, as shown in the figure below.

Figure C-25: Accumulation of Wastes on Public Roads

On the other hand, in the case of the drums on public thoroughfare, all types of wastes are deposited, including construction debris, which thus hinders their collection.

c. Collection and Haulage Service

The collection and haulage service is executed exclusively in the town Felipe Carrillo Puerto, with service to the neighborhoods of Plan de Ayala, Leona Vicario, Lázaro Cárdenas, Rafael Melgar, Cecilio Chi, Javier Rojo Gómez, Juan Vega, Centro (downtown) and Jesús Martínez Ross, and encompassing the area as follows:

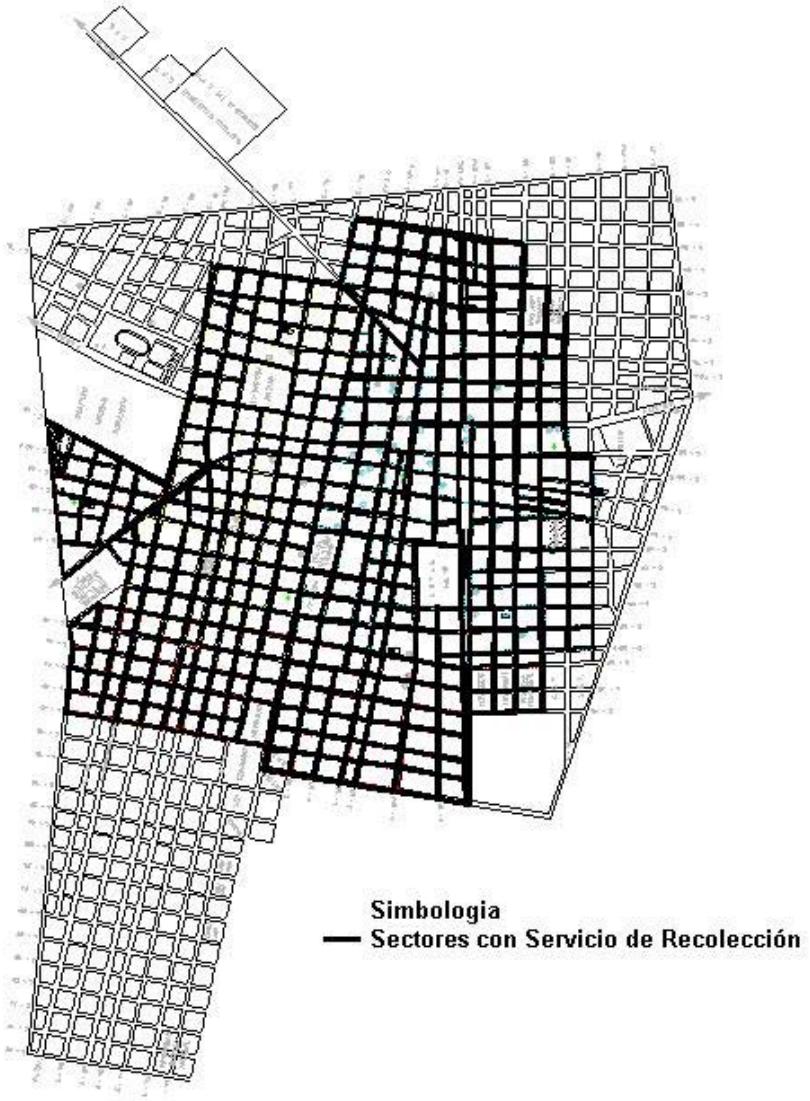


Figure C-26: Area Coverage of the Collection Service

The collection service includes household, commercial, institutional and medical wastes. Within medical wastes, organic and pathologic wastes are regarded.

The collection method is door-to-door and the truck announces its arrival with a hand bell.

The collection service is executed Monday through Sunday as per the following timetable:

Days of Service	Schedule
Monday through Friday	06:00 to 13:00
	14:00 to 18:00
Saturday and Sunday	06:00 to 11:00

In downtown area, the collection is conducted twice a day Monday through Friday, with a day and an afternoon shift and servicing the whole area; on Saturdays and Sundays the service is in the day only. Medical wastes are also collected on a daily basis but in the morning shift exclusively.

The closest neighborhoods to downtown are Juan B. Vega, Javier Rojo Gómez, Cecilio Chi, Leona Vicario and Jesús Martínez Ross, and they are served three times a week, specially the avenues abutting with the downtown area, in some occasions the service is provided in both shifts.

In the case of the remaining neighborhoods farther away from downtown, such as Mario Villanueva, Plan de Ayala, Francisco May, Rafael Melgar and Lázaro Cárdenas, collection is carried out two or three times a week in a single shift but in parts of them only, due to the faulty conditions of the streets.

It can be said that the service aims at keeping downtown area plus the main avenues of the city clean, particularly those connecting with other cities. The trucks begin the service at a fixed spot and start picking up the wastes until they reach their capacity, and they head towards the dumping site to unload the wastes; return to the city and continue with the service. Their job is done when the entire area has been served or when the workday is over.

The service is executed with two Ford trucks dated 1998 with an 11 m^3 capacity dump trucks, and serves downtown area and the rest of the neighborhoods but excluding their peripheral zone. These trucks work Monday through Friday and in both two shifts. Saturdays and Sundays they also collect wastes from hospitals and/or health centers.

Medical wastes and the wastes from the neighborhoods' peripheral zones are collected with a 4 m^3 capacity high platform pickup that works Monday through Friday in the morning shift only.

Given the years of service and the working conditions of the trucks, their status is precarious, and therefore require of repairing maintenance very often, and the Direction Office is devoid of the necessary funds to do so; the reason why these trucks can be off-service for several days. Currently, the municipality is making arrangements to acquire two new dump trucks.

The Direction Office has a depot to park and provide maintenance to the trucks, with a space devoted to junk and abandoned or wrecked vehicles. The figure shows a detail of such facility.

The personnel devoted to the service includes 5 drivers and 15 collection workers, and divided into crews (1 driver and three collectors) per truck and per collection schedule; i.e., two crews for the dump truck in the morning shift and two more crews on the same trucks but in the afternoon shift and one crew for the platform pickup.

Figure C-27: Depot for Parking and Maintenance of the Trucks

The collection service for the city's market was taken over by the merchants themselves, given the irregularity of the service provided by the Direction Office; for such purpose they acquired a dump truck with a capacity of 3 Tons, which is used for the collection service on a daily basis. The number of trips to the dumping site depends on the amount of wastes generated; wastes are collected in it and once it reaches its capacity, these are carried to the dumpsite.

Within the city there also exist one or two particulars with small flat bed trucks and implemented with a banister that offer the particular collection service. These vehicles travel around the different streets in the city, especially during the morning and collect wastes of houses or businesses that are prone to disbursing between $5 to $10 pesos per discharge. Some generators employ this service continuously, while others do so when the municipal service does not collect their wastes, be it because it was simply not rendered or because they did not take their wastes on time.

The Direction Office only has a control of the trips made by each truck and oversees onsite the development of the service by means of the supervisor.

By reviewing the background and analyzing the waste collection and haulage service, we can say that said is carried out with minimal programming; it is far from covering the collection

needs, even at the coverage area, and, if not improved in the short run, it will render unmanageable with the obvious issues implied, affecting the population's health, the sanitary conditions and the development of tourism.

c.1 Quantity of Wastes Collected

Based on the number of trips performed by each truck and considering an average tonnage for each truck, the Direction Office has outlined the amount of wastes collected.

Dump trucks make five trips Monday through Friday to the final disposal site, three in the morning shift and two in the afternoon; on Saturdays and Sundays the number of trips comes down to dos. The platform pickup makes two trips every day, Monday through Friday.

The municipality regards a capacity of 5 ton/trip for the dump truck and 2 ton/trip for the platform pickup; steep values if it is considered that the wastes are not compacted and for household wastes, their density should range around 200 Kg/m^3. According to the criterion utilized by the Direction Office, the expected density of the wastes in the dump truck is of 450 kg/m^3 and 500 Kg/m^3 for the platform pickup, therefore, a total of 310 tons should be collected every week with a production per head of 3 Kg./person/day.

If the amount of 200 Kg/m^3 is employed, the weekly generation would sum 135.6 tons and a per head production of 1,3 Kg/person/day. Therefore, a per-head generation of 1 kg/person/day can be expected from household wastes if it is considered that commercial, institutional, medical, sweeping garden wastes and the residues from a floating population are also part of the wastes collected. The above value would match those data estimated in the city's waste generation and composition study, conducted within the Executive Project for a Sanitary Landfill by the SEDUMA and that calculates a per capita production of 0.75 to 0.84 Kg/person/day.

c.2 Special Collection Services.

The Direction Office of Municipal Public Services holds a cleaning operative at the locations of Laguna Kana, Tihosuco, Chunhuhub Tepic and Poliuc three times a year.

These operations has the purpose of collecting bulk waste and junk within the above locations and prevent the proliferation of mosquitoes that carry diseases, such as dengue. The Office takes all of its staff and vehicles to the area to be served, and the works are carried out along with the community.

In some opportunities and as per the request by some of the city halls, an additional operation can be performed, as long as the resources are available.

d. Sweeping Services

The sweeping service is operated by the Direction Office of Municipal Public Services and in covers downtown area and main avenues. The following figure displays the service area.

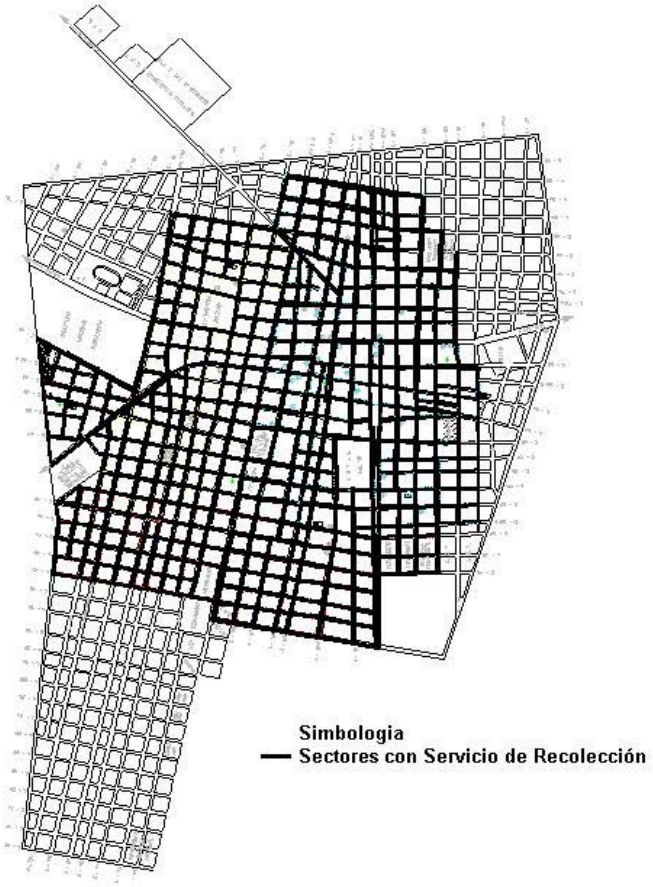


Figure C-28: Sweeping Service Area

Sweeping service is conducted manually and performed by a total of 15 people, and each one of them is assigned to the same streets every day, Monday through Friday.

The hour of attention starts at 06:00 until 13:00, but this schedule is not respected all the time and several times the service starts before and ends up when the worker has cleaned all of his corresponding section.

In order to execute the service, each sweeper is provided with a broom, a shovel and a cart to collect the wastes, when the latter reach their capacity, they are carried to gathering points where they are collected by the dump trucks. In case the truck has already passed, the carts are taken to the city hall where the trucks of the afternoon shift collect them. The daily yield per sweeper is roughly 1,000 m.

The appropriate execution of the services is overseen by two supervisors, who verify that the service has been conducted in each of the streets assigned. No service quality levels or indicators are available.

According to the background data handled by the Office, roughly 3 tons of wastes are daily collected from the sweeping activity with an annual cost of the service of $432,000 pesos.

e. Final Disposal

All the wastes collected by the Direction Office of Municipal Public Services, by the market and particulars are disposed of in an open dumping site, located 6 Km away from the city, at one side of the federal highway between Felipe Carrillo Puerto and Cancún.

This dumpsite has no works or infrastructure whatsoever or staff that records the entrance or number of trips.

The wastes are placed without an arrangement and cover most of the land, and in some cases in very thin layers. No leachate accumulation is observed, but it is almost certain that they seeped into the ground due to the permeability of the soil. There are several birds, mosquitoes and flies.

The dumpsite conditions can be observed in the following pictures.

Figure C-29: Felipe Carrillo Puerto Dumpsite

The dumpsite is open 24 hours a day and, due to the lack of control, fires have occurred in several occasions, most of them provoked by the scavengers that intend to recover such items

as cans, glass, copper, and so on. These fires last for months and affect the surrounding areas, specially the highway to Cancun, since the smoke hinders the drivers' visibility, with fatal accidents that have taken place.

The Direction Office visits the place twice a year with machinery to rearrange the wastes and free some areas to continue with the disposal of wastes. Some of the fires are provoked to shrink the waste volume and maximize the site's useful life.

Currently, the Direction Office of Municipal Public Services is planning to move the dumping site to a location owned by it, 10 Km away from the city at one side of the highway between Carrillo Puerto-Valladolid, which will allow the reduction of costs, as the current land is a rental. The Office's intention is to create a new dumping site, with no planned protection or control of the environment, which they justify based on the lack of resources that prevent them to develop a different final disposal method.

The other locations in the municipality also get rid of their wastes at dumping sites, which are generally located where construction material has been extracted (*sascab*), such places have unhealthy conditions and are severe air pollution spots due to the burning of the wastes, as well as water contamination places due to the infiltration of percolated liquids.

f. Maintenance of Vehicles

The Department of Municipal Public Services has five vehicles for performing the collection service; four trucks for collection and a van for the inspection of the service. The characteristics of the vehicles are:

Type	Brand	Model	Issue no.	Capacity
Compactor	Chevrolet	Cheyenne	1998	3 ton
Dump truck	Ford	F 450	1999	8 ton/
Dump truck	Ford	F 450	1999	8 ton/
Cargo bars truck	Chevrolet	3.500	1993	3 ton/
Van	Nissan	750	1997	

All vehicles are in very bad conditions as can be seen in the following pictures:

COMPACTOR
Chevrolet Cheyenne

COMPACTOR
Chevrolet Cheyenne

DUMP TRUCK
Ford F450 XL Super Duty

DUMP TRUCK
Ford F 450 XL Super Duty

CARGO BARS TRUCK
Chevrolet 3500

Nissan 750 VAN

Vehicles are parked in the municipal parking place.

For the dumping site there is a Caterpillar bulldozer, model D-5, which is property of the Department of Public Works. This machine goes to the landfill every two or three months in order to accommodate all wastes.

The Department of Municipal Public Services does not have proper infrastructure to carry out the preventive and/or reparative maintenance of their vehicles. Therefore, in case of damages or failures, all vehicles are sent to reparation to external garages.

The procedure to follow in case of damages in the vehicles is the following:

- The Department of Municipal Public Services reports in writing to the Administrative Office about damages in vehicles and possible causes (see following figure).
- The Administrative Office sends personnel in order to evaluate the damages of the vehicle and it also assigns the garage where the damages will be repaired.
- The Administrative Office sends a letter to the garage, which is also sent to the supplier altogether with the vehicle, in order to start the reparation works.
- Once the works have been done, the garage informs the Administrative Office, who at the same time informs the Department of Municipal Public Services in order to withdraw the vehicle.

In case of minor damages such as the damage of a tire, the truck is sent directly to one of the garages assigned by the Administrative Office. In this case, the Department pays directly for the works and later it issues a query with the corresponding invoice in order for the Administrative Office to reintegrate the money.

Generally the administrative procedure for starting with the reparation of a vehicle is fast, however, the process may be delayed because in many cases the garage has excessive amounts of work or because more time is needed for the acquisition of the spare parts.

GOBIERNO DEL ESTADO DE QUINTANA ROO
MUNICIPIO DE FELIPE CARRILLO PUERTO
H. AYUNTAMIENTO 2002 – 2005
OFICIALIA MAYOR

REQUISICIÓN DE MATERIALES

FOLIO: _____

C. OFICIAL MAYOR
P R E S E N T E .

FECHA: _____ _____ _____
AÑO MES DIA

POR ESTE CONDUCTO ME PERMITO SOLICITAR LOS SIGUIENTES MATERIALES, EQUIPOS Y/O SERVICIOS PARA EL CORRECTO DESEMPEÑO DE LAS FUNCIONES DE ESTA DEPENDENCIA A MI CARGO:

CANTIDAD	DESCRIPCIÓN	OBSERVACIONES

AREA SOLICITANTE COTIZO RECIBI LO SOLICITADO

JEFE DE REC. MATERIALES

Application Order for the Reparation of Vehicles

C.2.4.4 Review of State Plans

The state of Quintana Roo is developing, in coordination with the Secretaryship of Urban Development and Environment, a strategy devoted to improving the disposal of household solid wastes within their municipalities; for the above, the SEDUMA has entrusted the elaboration of an Executive Project for a Sanitary Landfill and the Environmental Impact Manifest for a sanitary landfill that replaces the current dumpsite of the city of Felipe Carrillo Puerto.

Currently the project is under the evaluation of the Environmental Impact Manifest; once it is concluded, the SEDUMA is considering the construction to be later run by the municipality.

The selected site to develop the project has a surface of 12.7 hectares and it is found in a land lot known as Rancho Raymundo, in Km 10.5 of the federal highway No. 184 between 184 Felipe Carrillo Puerto – Chunhuas, on its Southside.

The project's life is estimated in 10 years and will allow the disposal of 200,000 tons approximately.

The project is contemplating the following infrastructure works: control booth, scale booth, administrative office, freight shed, external fencing, potable water main, electricity, sewage network, inner roads, protection drainage, leachate gathering network, drying lagoon, signals, skip pits, and so on.

Water proofing of the landfill bottom is projected with the following layers:

- Two layers of sascab, 20 cm thick
- Two layers of geomembrane, 60 mils thick (1.5mm)
- Two layers of geotextile material
- Drainage layer to extract leachate
- Granulated layer over the drainage layer.

The collection system of seepage will include drainages with gathering pipeline, located over the bottom waterproofing system. The liquids collected will be carried to two waterproofed drying lagoons, which will accumulate 11,335 m^3.

The construction of airshafts for biogas, which will be located within the waste cells and equidistant with a range of 50 m, is considered.

The project also contemplates the development of a monitoring program throughout all of the landfill stages; this program regards biogas, leachate, groundwater, air quality and noise monitoring. This program also contemplates the construction of nine monitoring wells distributed upstream and downstream of the sanitary landfill and will allow the surveillance of the groundwater quality and determine whether there is a leachate migration.

The type of landfill to be developed will be superficial, and minimum earthwork is contemplated due to the depth of the aquifer. The covering material will be obtained from the excavations onsite, but since it will not be enough it will be externally loaned from a place located 30 Km away.

For the landfill operations an Angledozer, type D-3, tractor D-5, a tank truck to carry water, a tank truck for leachate haulage, and a 7m^3 dump truck will be considered. Regarding the personnel, an on-site engineer, a secretary, two field foremen, a guard, three tractor drivers, three general assistants, a weighmaster, a night watcher and two persons to arrange will be employed.

The project takes into account the termination and post-termination of the site.

Regarding the impact, the Environmental Impact Manifest concludes the following:

- The sanitary landfill of the city of Felipe Carrillo Puerto carries nine significantly adverse impacts, 8 during the operation stage and one during the site preparation stage, on the aquifer, soil and human health environmental traits. In attention to this circumstance, the enforcement of preventive and mitigation steps will be required to allow the project to fit the natural environment where it will be conducted.

- In its different stages, the development of the project will cause 36, non-significant adverse impacts, which will arise either during the preparation, construction and operation of the site. Out of the 36 foreseen non-significant impacts, the enforcement of measures to prevent them is feasible; for the remaining (9), it is deemed that the traits of the impacted elements: vegetation, topography and soil, were modified in such a manner that the possibility to restore their original conditions is none.

- Significant beneficial impacts will present basically during the construction stage on the soil, air and water. The latter is due to the fact that the construction of the infrastructure, to avoid or minimize environmental impacts stemming from the project, is deemed as important to avoid contaminant processes.

- It is worth mentioning that two beneficial impacts were highlighted during the operation stage of the project; such activities refer to the monitoring wells for biogas and leachate, which will allow the proper functioning of the proposed technology.

The projected sanitary landfill, although it represents a solution for the management of solid wastes for the city of Felipe Carrillo Puerto, in reality it does not fit for budgetary purposes of the municipality or to the amount of wastes generated. Some of the works are over-dimensioned, as well as the operational activities. For instance, it can be said that a total of 15 workers are regarded, but currently no more than 12 trips per day to the dumpsite take place; and if compaction trucks will be employed, the number would reduce to less than half that amount, and the same happens with the machinery.

A sanitary landfill project for this city will only be feasible as long as there is availability of resources and, given the municipality does not charge for the service, for now it seems impossible to raise the budget allocated to the management of solid wastes. This criterion should be borne in mind, not only for final disposal but for the entire planning of the service; it also has to be considered that roughly 23% of the population is covered by the service.

One of the alternatives at this time that could be developed for the disposal of solid wastes is a semi-mechanized sanitary landfill with aquifer protection through the landfill's bottom waterproofing and the extraction of leachate, which would be stored at a gathering lagoon. The operation of it would be manual, which would in turn allow the arrangement of the wastes and configuration of cells, with coverage works conducted once a week or every 15 days, using one dump truck to bring the covering material and a front loader to load the material and spread it over the waste cells.

The above costs of this operational system would be absorbed by the municipality, and even further if a special charge for the service is implemented, which would ensure the continuity of the service.

Right now, it is important that a strong link between the City Hall and the SEDUMA be established, so that they can face the solid waste management issue in tandem, not only in regards to final disposal, but to the services as a whole. Therefore, they will make a planning of the same with short-term and long term goals, thus avoiding the collapse of the system.

C.2.4.5 Organizational Structure

The organizational structure of the Municipality assumes responsibility for the solid waste management through the Bureau of Municipal Public Service. This Bureau is in charge of collection, transport, sweeping and final disposal of solid waste.

A great weakness is observed in the service, which is provided only in the city of Felipe Carrillo Puerto with a coverage of 50% of the population; the service is provided in the following neighborhoods of the city: Plan de Ayala, Leona Vicario, Lázaro Cárdenas, Rafael Melgar, Cecilio Chi, Javier Rojo Gómez, Juan Vega, Centro and Jesús Martínez Ross. Cleansing operations are carried out three times a year in the localities of Señor, Laguna Kana, Tihosuco, Polyuc, Chunhuhub and Tepic.

The assigned personnel consist of 5 drivers and 15 workers in the collection service, and 15 in sweeping.

C.2.4.6 Financial System

Section 2.3.5.2 described the municipal taxes and fees. "Service fees" are charged by municipalities for diverse services, including solid waste services. In the case of Felipe Carrillo Puerto Municipality, solid waste service is at present provided free of charge. However, recognition is growing that some service fee needs to be charged as fixed monthly tariff for households and for commercial firms.

In 2002, the cost of solid waste service was estimated at 1.16Million Pesos. As the municipal expenditures in 200 amounted to 86.6 Million Pesos in 2002, expenditures on solid waste disposal accounted for 1.3% of municipal expenditures in Felipe Carrillo Puerto.

Solid waste generation in Felipe Carrillo Puerto Municipality is reported as 40 ton per day, or 14,600 ton per year. At a total service cost of 1.16 Million Pesos, the cost per ton comes up to be around 80 Pesos, or about USD8, which may be more appropriate to be interpreted as the cost of solid waste collection service. However, a quick calculation during one meeting indicated that the reported collection of 40 ton per day was more likely 20 ton per day, which upon consideration of the coverage of the solid waste collection service would more likely be 12 ton per day. In this case, the solid waste collection cost would be around 265 Pesos per ton, or USD26 per ton. CEPIS (Centro Panamericano de Ingenieria Sanitaria y Ciencias del Ambiente) indicated the acceptable range of solid waste collection cost per ton to be USD25-40 in 2001.

C.2.4.7 Accounting System

Section 2.4.5.1 on Public Finance presented the income and expenditures of Felipe Carrillo Puerto Municipality, showing the different accounts used to describe the items in the municipal income and expenditures. The accounts are common to government offices. It is a government accounting. The overall income and expenditures table does not allow identification of the source of each income or expenditures, as they are grouped under broad headings like “Fee income” or “Personnel expenses”.

It is possible however to estimate the income and expenditures of solid waste service, as was already done by the Municipality at the request of the Study Team. This required special efforts, determining the corresponding income and cost figures according to the appropriate account numbers, a process that may be open to the introduction of errors.

It can be seen that the accounting at present is geared to the management and control of the budget, which is understandable for a government office. However, as a provider of services, it would be extremely useful if the Municipality could determine the cost and income of a given service. Keeping these income and expenditures data separately for each service will permit the calculation of performance indicators for the service. The performance indicators are essential to implement a continuous monitoring system, a necessary step to improve the efficiency and effectiveness of the service.

C.2.4.8 Social Aspect

Social aspects and considerations are presented below.

Social Aspect	Consideration
Collection Service Coverage	50% in the city of Felipe Carrillo Puerto. Burning of solid waste is a common practice in rural areas.
Solid waste disposal according to norms	100% of solid waste is disposed of without compliance with the official Mexican norms.
Conservation of health	Important incidence of diseases related with an inadequate management of solid waste: intestinal infection, dengue fever, typhoid fever, helminthiases.
Drinking Water Quality	Preliminary calculation of leachate intrusion in the aquifer was estimated to correspond to a pollutant load of 488.1 ton of BOD per year

C.2.4.9 Environmental Education

Environmental protection activities were carried out in the municipality of Felipe Carrillo Puerto through an Environmental Education Program to promote the Biodiversity and Management of the Sian Ka'an Biosphere Reserve by an NGO in coordination with the Ministry of Education and Culture among schoolchildren. This program consisted of guided visits to observe the flora and fauna of the region. The Municipality of Felipe Carrillo Puerto, in coordination with SEMARNAT, also distributed trees for planting to primary and secondary schools with the objective of protecting the environment. However, regarding solid waste management there are no environmental education programs with the exception of cleansing programs implemented by the municipality itself.

C.3 Solidaridad

C.3.1 Water Quality and Monitoring Conditions

As mentioned in the section of Othon P. Blanco, water quality monitoring is periodically carried out by the navy targeting the coastal water of Yucatan Peninsula and Gulf of Mexico and by CAPA targeting well water.

The monitoring carried out by the navy has purpose to check eutrophication of water and appropriateness for notation. Meanwhile, CAPA checks its appropriateness as a source of water supply.

CNA carried out a study on available quantity of water and its quality targeting wells and cenotes to meet with increasing demand. Results of the study recommended preservation of water resources and establishment of water quality monitoring network.

C.3.1.1 Water Quality of Water Supply Sources

CAPA carries out monitoring of water resources in Solidaridad as well as in Othon P. Blanco and Felipe C. Puerto. Meanwhile, CNA studied water quality of 30 resources such as wells and cenotes in 2001. The following are the result of the study.

Table C-33: Water Quality of Water Supply Sources

ID	Date	Site	Water Temp.	pH	BOD (mg/litter)	COD (mg/litter)	Colif. Tot.	N-org .(mg/litter)	N-amon. (mg/litter)	NO_2 (mg/litter)	NO_3 (mg/litter)	T-N (mg/litter)
1	16-Oct-01	Cenote Chemuyil	27.8	7.0	2.0	10.3	0	1.44	0.05	0.04	0.60	2.13
2	16-Oct-01	Noria en Tulum	28.8	7.2	2.0	1.0	460	1.15	0.05	0.03	0.80	2.03
3	16-Oct-01	Cenote Calimba	26.6	7.3	2.0	1.0	75	0.57	0.28	0.03	0.40	1.28
4	16-Oct-01	Pozo en Tulum	28.0	7.3	4.2	20.0	9	0.86	0.28	0.04	0.80	1.98
5	16-Oct-01	Pozo en Casa Cenote	27.6	7.2	2.0	83.9	240	1.15	1.73	0.05	0.90	3.83
6	16-Oct-01	Pozo en Akumal	25.3	7.2	2.0	1.0	240	0.57	0.05	0.01	0.50	1.13
7	16-Oct-01	Pozo en el basurero de Akumal	26.8	7.7	3.0	24.6	139	1.15	0.05	0.04	0.60	1.84
8	16-Oct-01	Cenote en banco de materiales	27.2	7.3	2.0	1.0	1,100	0.86	0.05	0.03	0.50	1.44
9	16-Oct-01	Cenote un hueco en Cd. Chemuyil	27.5	7.3	4.0	8.0	1,100	0.57	0.05	0.02	0.30	0.94
10	16-Oct-01	Pozo del Restaurant La Esperanza	27.7	7.6	2.0	1.0	240	0.86	0.86	0.01	0.50	2.23
11	16-Oct-01	Cenote en Cueva de Murcielagos	26.0	7.0	2.0	53.0	460	2.01	0.05	0.04	0.70	2.80
12	16-Oct-01	Cenote Dos ojos	26.4	7.0	2.0	86.3	240	0.57	0.05	0.02	0.50	1.14
13	16-Oct-01	Cenote Azul	26.3	7.1	2.0	451.9	240	0.57	0.05	0.01	0.40	1.03
14	16-Oct-01	Cenote Cristalino	26.2	7.3	2.0	83.9	240	0.57	0.05	0.02	0.50	1.14

ID	Date	Site	Water Temp.	pH	BOD (mg/litter)	COD (mg/litter)	Colif. Tot.	N-org .(mg/litter)	N-amon. (mg/litter)	NO_2 (mg/litter)	NO_3 (mg/litter)	T-N (mg/litter)
15	16-Oct-01	Cenote del parque infantil Pto. Aventuras	26.9	7.1	2.0	288.1	75	0.86	0.28	0.04	0.70	1.88
16	16-Oct-01	Cenote en la playa Playa del Carmen	25.6	7.0	2.0	266.7	93	1.44	0.05	0.04	0.80	2.33
17	16-Oct-01	Cenote cercano a Xcaret	25.6	7.2	2.0	36.4	240	0.86	0.57	0.03	0.70	2.16
18	16-Oct-01	Cenote en el antiguo camino a Xcaret	25.9	7.0	2.0	57.8	93	0.57	0.05	0.02	0.50	1.14
19	16-Oct-01	Pozo de CAPA en Puerto Aventuras	26.6	7.2	2.0	212.1	43	0.87	0.05	0.02	0.60	1.54
20	16-Oct-01	Cenote al final brecha Pto. Aventuras	25.8	7.0	2.0	76.8	75	0.86	0.28	0.04	0.70	1.88
21	16-Oct-01	Cenote en el vivero de Pto. Aventuras	26.1	7.0	2.0	1.0	240	0.57	0.57	0.03	0.04	1.21
22	16-Oct-01	Pozo en Cabañas Paamul	27.4	7.3	2.0	1.0	460	0.86	0.28	0.04	0.70	1.88
23	16-Oct-01	Noria en Xcaret	26.9	7.1	2.0	91.0	240	0.86	0.28	0.04	0.80	1.98
24	16-Oct-01	Cenote en Cavernas Chaaktún	25.5	7.1	2.0	57.8	23	0.57	0.28	0.03	0.40	1.28
25	16-Oct-01	Pozo en Hotel Capitán Laffite	25.5	6.9	2.0	57.8	23	0.86	0.28	0.04	0.70	1.88
26	16-Oct-01	Pozo en Playa del Carmen	27.2	6.8	2.0	24.6	23	0.57	0.05	0.01	0.40	1.03
27	16-Oct-01	Cenote en la Granja Sacbé	25.8	7.1	2.0	8.0	23	1.44	0.05	0.05	0.90	2.44
28	16-Oct-01	Sitios de muestreo	27.1	6.8	2.0	1.0	23	0.28	0.05	0.01	0.20	0.54
29	16-Oct-01	Pozo en Rancho Grande	26.4	7.6	2.4	31.4	460	1.44	0.05	0.05	0.90	2.44
30	16-Oct-01	Pozo en Rancho San Luís	26.5	7.6	2.0	1.0	460	1.44	0.05	0.04	0.80	2.33

Source : Estudio de Calidad del Agua en el Corredor Turístico Cancún – Tulum, Riviera Maya, Quintana Roo, CNA, Envirotech Tecnologías Ambientales, S.A. de C.V., Dec. 2001

Among the measured values above, correlation between COD and T-N, which are indicators of organic pollution, was analyzed as shown in the following figures. If the data are analyzed all together, it does not imply correlation between COD and T-N as shown in Figure C-30. However, if data having more than 2 mg/liter of BOD are picked up, COD and T-N of the data shows possibility of correlating each other as shown in Figure C-31, where value of R2 showing degree of correlation is 0.92. This correlation is found in domestic wastewater consisting of mainly organic pollutants. Therefore, the four points where the data were obtained might have a possibility of contamination by domestic wastewater.

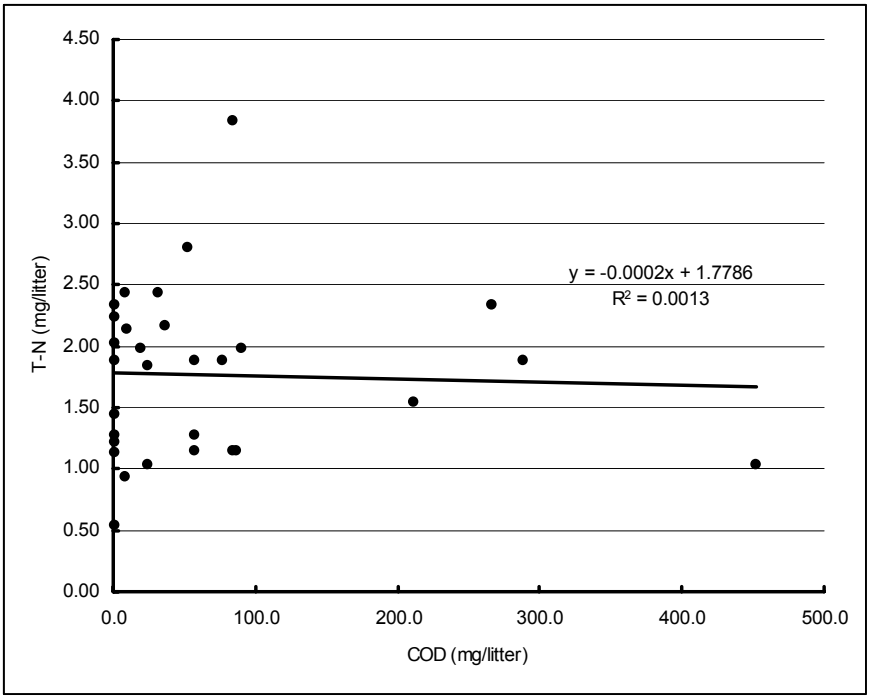


Figure C-30: Relation Between with COD and T-N (whole sample)

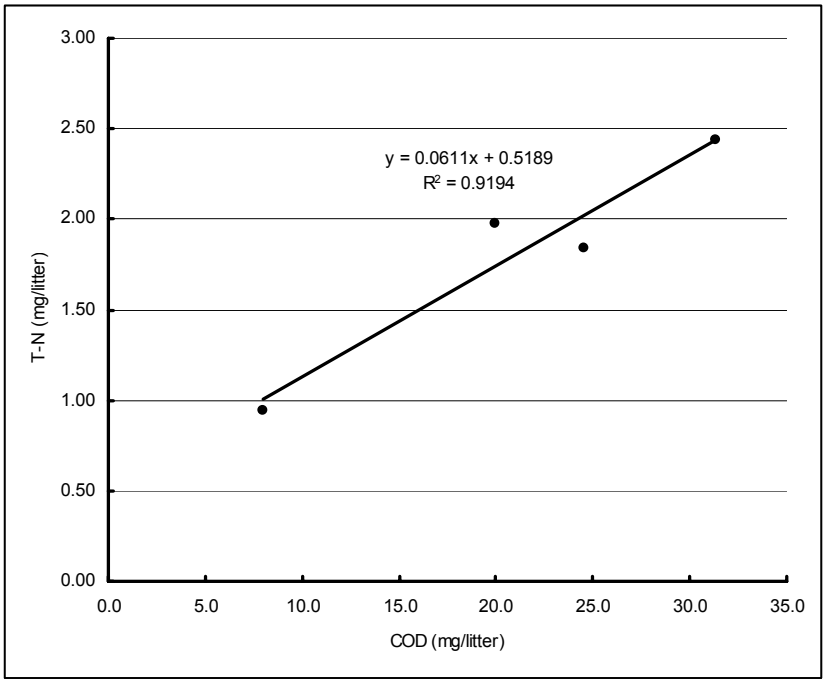


Figure C-31: Relation Between with COD and T-N (BOD more than 2 mg/litter)

C.3.2 Groundwater Management

C.3.2.1 Hydrogeologic Conditions

Municipality of Solidaridad is located on the plain, which is composed of carbonate rocks of Miocene to Pliocene ages. Pleistocene sediments are distributed mainly in the coastal area. These carbonate rocks constitutes aquifers. Sinkholes (*Cenote*) are distributed in many places in the municipality. In the underground, there are many cavities. Some of them are estimated to connect directly to the sea. Water level is merely less than 5 m above mean sea level. According to CNA borehole data drilled at the coastal area of Akumal, fresh water exists up to the depth of about 20 m. Brackish water exist in between 20 to 25 m. Below 25 m, groundwater becomes seawater.

C.3.2.2 Extraction and Injection Wells

a. Extraction

Number of registered production well is 222. The production wells for service sector make up 58% (129) of the total number. On the other hand, public and agricultural wells are less than other two municipalities due to smaller municipality area and population in Solidaridad. Number of well is 29 for public and 35 for agriculture, respectively.

CAPA has 15 production wells in Playa Del Carmen for the town water supply. These wells are located in the area of within 15 km from the coast. Table C-34 shows pumping capacity of the well field. Depth of the well is 25 to 30 m with 12 inches casing, which is equipped with the deep well turbine pump. CAPA is considering augmentation of water production by construction of new deep wells in near future because of increasing demand of water supply in the town.

Table C-34: Pumping Capacity of CAPA Playa Del Carmen Well Filed

Well Number	Capacity (LPS)	Actual Pumping Rate (LPS)	Status
1	25	27.00	In operation
2	25	24.50	In operation
3	25	40.00	In operation
4	25	34.30	In operation
5	25	21.00	In operation
6	25	29.80	In operation
7	25	25.80	In operation
8	25	25.80	In operation
9	25	25.80	In operation
10	25	25.80	In operation
11	25	32.40	In operation
12	25	-	stock
13	25	30.30	In operation
14	25	-	stock
15	25	-	stock
Total	375	342.50	-

Source: CAPA

b. Injection

CAPA Playa Del Carmen has two injection wells in its sewage disposal plant. In other times, one injection well has been operating for 15 years. However, this well was abandoned after new injection well was constructed 5 years ago. One backup well is also installed in the plant. Depth of the injection well is 120 m. Casing diameter is 12 inches, however, the screen position is unknown (Figure C-31). Injection rate is 45 LPS. This amount is a total of treated wastewater in the plant.

In addition to this injection well, Playa Del Carmen has another sewage disposal plant in *PLAYADEL* resort golf course. This plant has a capacity of 80 LPS. An injection well of 65 m depth is installed, however, it is operated mainly in rainy season. In most of the seasons, treated water is discharged to lagoon or irrigated for golf course.

Meanwhile, according to CNA, number of injection wells registered in Solidaridad runs up 184 wells (Refer to Table 2-1, Chapter 2.2.1.5). This figure is a largest among three (3) municipalities in the study area. Particularly, injection wells for service sector make up 92% (169 wells) of the total. These injection wells are densely located in the coastal town areas of Solidaridad.

Figure C-32: Injection Well in the Treatment Plant of CAPA in Playa Del Carmen

C.3.2.3 Present Status of Monitoring

According to CAPA , Playa Del Carmen has two monitoring wells. However, their locations and parameters of the wells have not been identified at this progress report time. As presented in Chapter 2.2.1.5, there are thirty (30) monitoring wells installed recently by CNA. Therefore, water levels and quality could be monitored not only in the town of Playa Del Carmen, but also other towns in the coastal area of Solidaridad.

The following table shows several parameters of water quality monitoring in 14 production wells in CAPA Playa Del Carmen.

Table C-35: Results of Water Quality Analysis in the Production Wells

Parameters/Well No.	1	2	4	5	6	7	8	9	10	11	12	13	14
EC (micros/cm)	1,018	150	1000	1,000	800	900	1,000	900	850	900	900	1,000	1,000
pH	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
Hardness (mg/l)	302	250	300	300	230	248	235	295	280	210	200	240	200
Nitrate (mg/l)	0.62	0.58	0.52	0.75	0.6	1.0	0.9	0.6	0.65	0.6	0.65	0.62	0.6
Sulfate (mg/l)	35	42	38	43	40	51	55	55	55	60	42	40	36
Chloride (mg/l)	250	280	300	305	200	200	200	210	210	230	250	265	300

EC: Electric Conductivity Date of Analysis: 14th of May, 2002
Source: CAPA

The permissible concentration of chloride is 250 mg/l according to Mexican standard. Several wells slightly exceed the standard.

C.3.3 Wastewater Management

C.3.3.1 Overview of Wastewater Management

a. Present Situation

Playa del Carmen which is the capital city of Solidaridad is only covered by a sewer system in the municipality. No sewer system is found in rural area. Table C-36 shows outline of sewer system in the municipality.

Table C-36: Outline of Sewer System in Solidaridad

Item		State of Quintana Roo	Solidaridad
1. Basic item			
Area of administrative boundary (km2)		50,843	4,419
Population of administrative boundary		1,233,490	111,533
Service projected area (km2)		76.02	13.24
Water production amount (1,000 m3/year)		112,737.78	12,406.35
Effective(billing) water supply amount (1,000 m3/year)		45,700.42	3,946.38
Water supply population		1,171,816	105,600
Unit water supply amount (litter/day/person)		263.58	321.88
Effective Unit water supply amount (l/day/person)		106.84	102.39
Sewage generation rate for panning (litter/person/day)		75% of water supply amount	
Unit sewage pollution load (g/person/day)	BOD	54	54
	S S	52	52
2. Service projected and present served population for wastewater management			
Sewer system(off-site)	Plan	372,994	37,091
	Actual	370,955	6,655
On-site system	Plan	0	1,767(year2002)
	Actual	0	0
Latrine system	Plan	0	0
	Actual	not available	not available
No-system	Plan		5,006
	Actual	800,861	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	8.23
Service population		370,955	6,655
Number of connections		90,698	1,770
Service coverage rate (population)		30.07	25.59
Length of pipe line		1'088,376	79,860
Number of pump station		-	3
STP intake amount (litter/sec)		1,251.83	64.21
Annual average intake amount (m3/year)		39,477,711	2,024,927
Number of sewage treatment plant		16	3
Treatment method		Activated sludge	Activated sludge
Treatment Capacity (litter/sec)		1,432	65
Annual average intake amount			
Intake waste quality (Jan. to June/2003)		BOD: COD: S S:	322.89 507.27 455.00
Treated water quality (Jan. to June/2003)		BOD: COD: S S:	11.18 55.19 19.00

source: CAPA July 2003

Table C-37: Service Coverage of Sewer System in 2000

Item	Municipality	Population	Service coverage		
			Water supply	Sewer line	Sewage treatment capacity
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

Playa del Carmen adjoins Benito Juarez Municipality that has a large scale tourist city, Cancun. Under influence of the tourism development in Cancun, Playa del Carmen itself attracts a lot of tourists and is growing rapidly. Annual population increase of the city shows high rate, 12%.

According to CAPA's Plan Estratégico APAS 2001-2025, sewer service coverage in Playa del Carmen is to be about 15% in 2000 at sewage treatment capacity. Meanwhile, CNA's investigation in 2002 shows that 8,569 residents are covered by the system. This is equivalent to 21.9 % of sewer service coverage at population base.

Business establishments such as commercials, industrials and hotels that are not covered by the sewer system chiefly apply septic tank treatment system. Table C-38 shows areas not having the sewer system and Table C-39 presents wastewater disposal method in such areas. As the last table shows, method of sink hole is largely applied, then, it is considered to be one of causes contaminating groundwater.

Table C-38: Without Sewer Service Area

Name of colony	Population a/	Nos. of household
Ejidal	15,220	3,805
Luis Donaldo Colosio	25,280	5,056
Nicte-Ha	4,330	866
Casco Antiguo	864	216
Total	45,694	9,943

SOURCE : EVALUACIÓN SOCIAL DEL PLAN PARCIAL DE ALCANTARILLADO SANITARIO Y SANEAMIENTO DE LA CIUDAD DE PLAYA DEL CARMEN, CAPA SEPTENBER 2002

Table C-39: Breakdown of Wastewater Disposal Method in Without Sewer Service Area

Wastewater disposal method	Ratio
Septic tank	24%
Sink hole	72%
Latrine	2%
No system	2%

SOURCE : EVALUACIÓN SOCIAL DEL PLAN PARCIAL DE ALCANTARILLADO SANITARIO Y SANEAMIENTO DE LA CIUDAD DE PLAYA DEL CARMEN, CAPA SEPTENBER 2002

Both combined and separate sewer systems were found in the same sewage system. During rain season, inflow often exceeded capacity of sewage treatment plant and quality of outflow became exacerbated. In order to cope with this issue, CAPA expanded its capacity from 33 liter/sec to 66 liter/sec.

b. Plan

CAPA prepared a strategic plan[8] of wastewater management for the whole Quintana Roo State in 2001. Table C-40 and Table C-41 show implementation and investment plans for Solidaridad respectively from the strategic plan.

Table C-40: Phased Implementation Plan in Urban Area of Solidaridad

	2001 to 2005	2006 to 2010	2011 to 2025	Total
Water supply amount (litter/sec)	707	501	1,445	2,653
Sewer system (ha)	1,240	837	2,396	4,473
Sewage treatment amount (litter/sec)	543	339	911	1,793
Acc. sewage treatment amount (litter/sec)	543	882	1,793	-

Source: CAPA Plan Estratégico APAS 2001-2025,

Table C-41: Investment Plan for Solidaridad Urban Area (Million pesos)

	2001 to 2005	2006 to 2010	2011 to 2025	Total
Water supply	280.5	180.0	516.5	977.0
Sewer line	191.0	134.0	383.0	708.0
Sewage treatment	119.0	68.0	182.0	369.0
Land acquisition	35.0	25.0	72.0	132.0
Total	625.5	407.0	1,153.5	2,186.0

Source: CAPA Plan Estratégico APAS 2001-2025,

[8] PLAN ESTRATÉGICO DE LOS SERVICIOS AGUA POTABLE, ALCANTRILLADO Y SANEAMIENTO 2001-2035, CAPA

C.3.3.2 Outline of Sewer System

Only Playa del Carmen that is growing by tourism development is covered with off-site sewer system in Solidaridad Municipality. Table C-42 shows outline of the sewer system in Playa del Carmen.

Table C-42: Outline of the Playa del Carmen Sewer System

Year	Service population	Water supply amount for household (litter/sec)	Total water supply amount (litter/sec)*	Wastewater generation amount (litter/sec)*	Wastewater collection amount (litter/sec)*
2000	8,569	88.34	204.09	56.98	46.79
2002	15,121	103.33	242.68	117.11	101.67
2005	28,264	139.77	299.80	159.89	141.49
2010	52,436	178.44	365.19	232.41	232.41
2015	67,032	204.27	414.47	292.15	292.15
2020	76,733	229.20	460.08	331.57	331.57

* : include total user (household, commercial, industries, hotels and general service)
source : EVALUACIÓN SOCIOECONÓMICA PROYECTO DE REHABILITACIÓN DE LA PLANTA DE TRATAMIENTO DE AGU RESIDUALES DE PLAYA DEL CARMEN, SOLIDARIDAD, QUINTANA ROO, MAYO DE 2002/ CNA

a. Sewer Line

The sewer system covers areas where 62% of residents live such as Playacar and Calica. In the covered areas, both combined and separate sewer systems are found. The combined system covers Gonzalo Guerrero, Residencial Quintas del Carmen, Zazil-Há and some coastal areas. Figure C-33 shows areas covered with the sewer system.

Table C-43: Number of Combined Sewer System User

Category of discharger	Number
Household	7,873
Trade	1,671
Industries	6
Hotels	126
General service	62

Sauce : EVALUACIÓN SOCIOECONÓMICA PROYECTO DE REHABILITACIÓN DE LA PLANTA DE TRATAMIENTO DE AGU RESIDUALES DE PLAYA DEL CARMEN, SOLIDARIDAD, QUINTANA ROO, MAYO DE 2002/ CNA

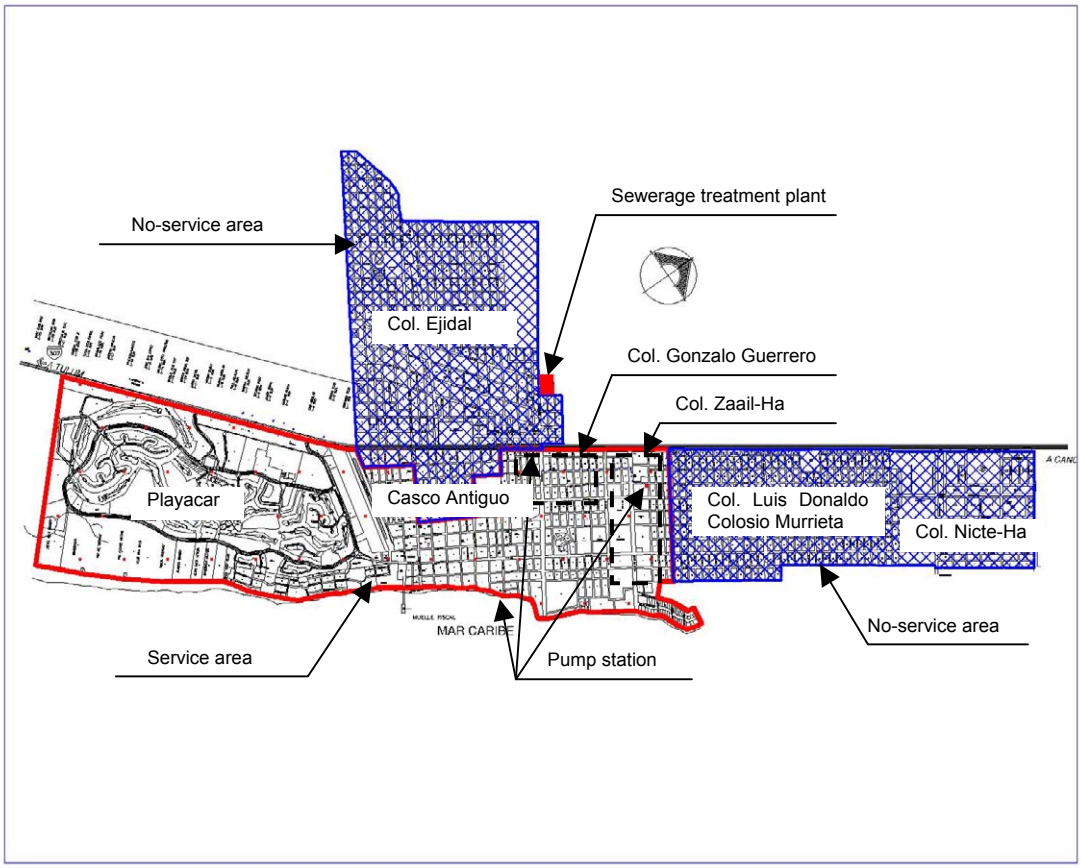


Figure C-33: Sewer Service Area

Public sewage treatment plant is located in northwest of the city. Meanwhile, there is a privates sewage treatment plant in Playacar. There are three pump stations in the city due to its flatness.

Table C-44: Outline of Pump Station

Name	Pump capacity
Playero	110 HP
Zazil-Ha	30 HP
Constituyentes	50 HP

Sauce : EVALUACIÓN SOCIOECONÓMICA PROYECTO DE REHABILITACIÓN DE LA PLANTA DE TRATAMIENTO DE AGU RESIDUALES DE PLAYA DEL CARMEN, SOLIDARIDAD, QUINTANA ROO, MAYO DE 2002/ CNA

b. Sewage Treatment

Table C-45 shows quality of inflow and effluent of the sewage treatment plant before expansion of the capacity. The plant has a capacity of 66 liter/sec at present and the quality is improved.

Table C-45: Treated Water Quality (Before rehabilitation)

Item	Oct. 2000 (CNA)	Oct. 2001 (CAPA)	
		Inflow	Effluent
BOD (mg/litter)	115.91	171.44	38.63
COD (mg/litter)	293.23	425.74	250.08
SS (mg/litter)	86	113.33	207.5

Sauce : EVALUACIÓN SOCIOECONÓMICA PROYECTO DE REHABILITACIÓN DE LA PLANTA DE TRATAMIENTO DE AGU RESIDUALES DE PLAYA DEL CARMEN, SOLIDARIDAD, QUINTANA ROO, MAYO DE 2002/ CNA

Actual inflow to the sewage treatment plant is 64.21 liter/sec for its capacity of 66 liter/sec (5,702 m3/day). Although the effluent quality has been improved by the expansion, the actual inflow becomes close to the limit of the capacity. CAPA has a plan to construct a new treatment plant having capacity of 400 liter/sec in order to cope with rapid increase of the wastewater amount. Effluent from the plant is discharged to underground at a depth of 140 m through injection well. Table C-46 shows outline of the sewage treatment plant.

Table C-46: Outline of Playa del Carmen Sewage Treatment Plant

Item	Parameter
Treatment capacity	65 liter/sec (5,616 m3/day)
Actual treatment amount	64.21 liter/sec (5,547 m3/day)
Intake water quality	BOD:323 mg/liter, COD:507 mg/liter, SS:455 mg/liter
Treated water quality	BOD:11.2 mg/liter, COD:55mg/liter, SS:19 mg/liter
Treatment method	Activated sludge method

Source: CAPA

C.3.3.3 On-site System

CAPA is constructing collective on-site sewerage system in 4 communities having population less than 2,500. Table C-47 presents outline of the collective on-site sewerage system.

Table C-47: Outline of Collective On-site System

Municipality	Location	Projected population	Treatment capacity	Treated water quality
LAZARO CARDENAS	Holbox	1,633 (year 2022)	1.88 litter/sec (162.4m3/day)	BOD:30 (mg/litter) SS: 30 (mg/litter)
SOLIDARIDAD	Puerto Aventuras	1,048 (year 2022)	1.20 litter/sec (103.7 m3/day)	BOD:30 (mg/litter) SS: 30 (mg/litter)
	Akumal	2,078 (year 2022)	2.39 litter/sec (206.5 m3/day)	BOD:30 (mg/litter) SS: 30 (mg/litter)
OTHON P. BLANCO	Subteninte Lopez	2,320 (year 2022)	2.66 litter/sec (229.8 m3/day)	BOD:30 (mg/litter) SS: 30 (mg/litter)

Source : CAPA/CONSORICO DE INGENIERIA MEXICANA, S.A. DE C.V.

In Solidaridad Municipality, the system is under construction in Puerto Aventuras and Akumal that are located in Riviera Maya that undergoes rapid tourism development. Septic tank + filtration is applied as treatment method.

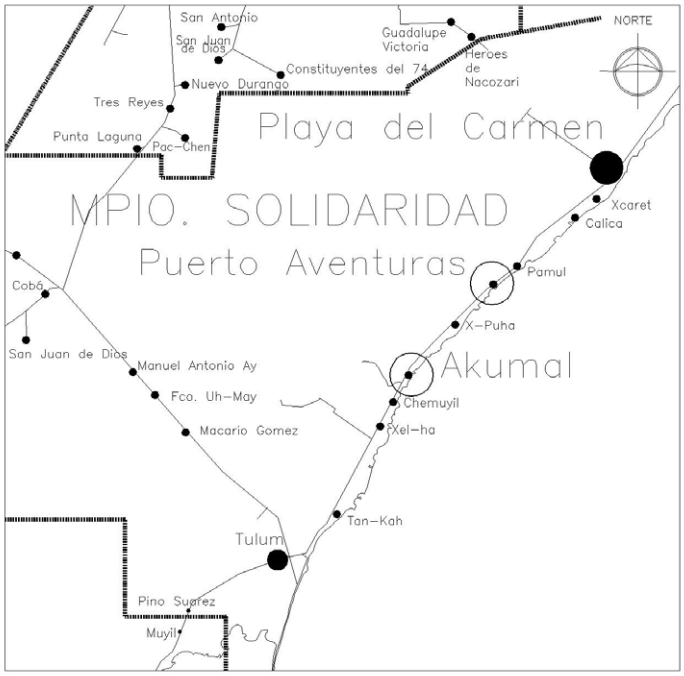


Figure C-34: Location Map of Puerto Aventuras and Akumal

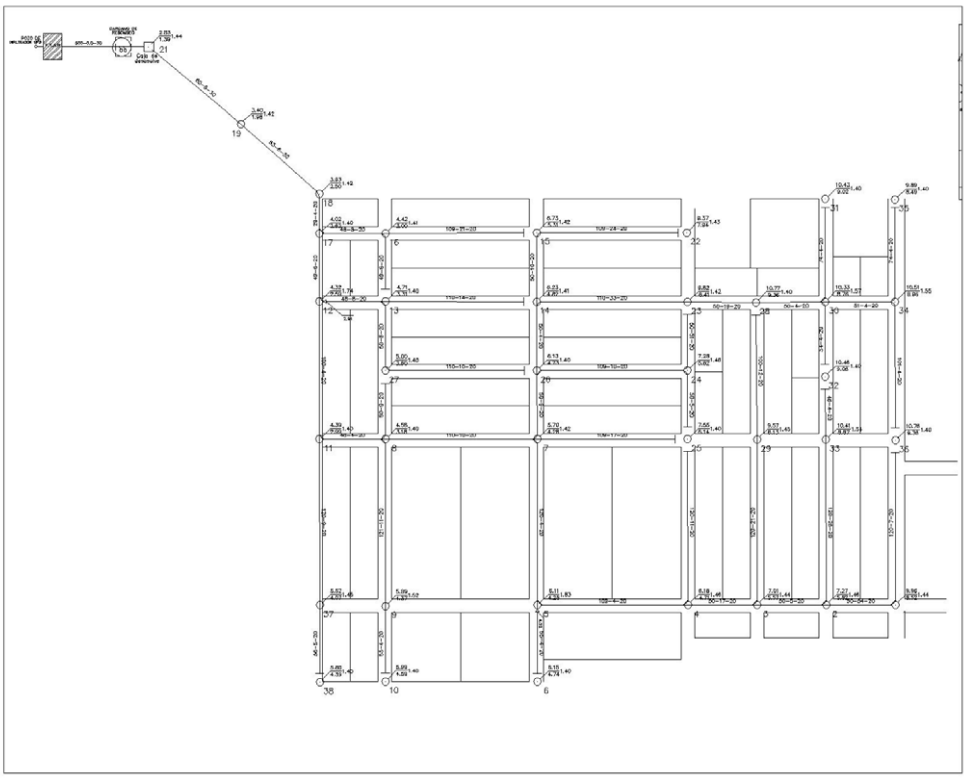


Figure C-35: Sewer Network of Puerto Aventuras

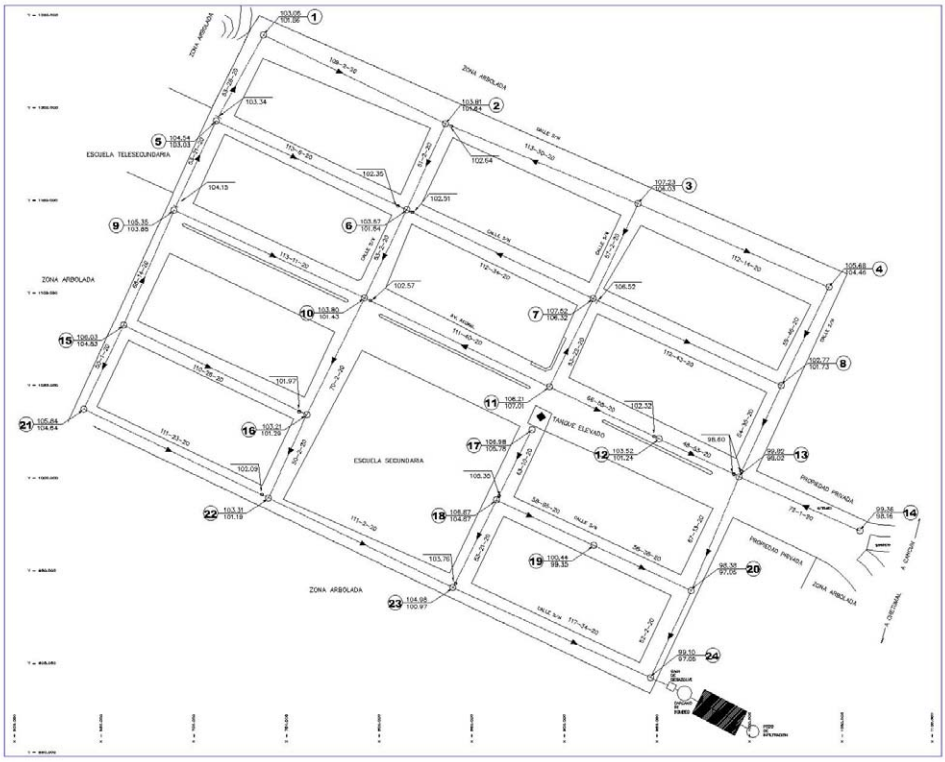


Figure C-36: Sewer Network of Akumal

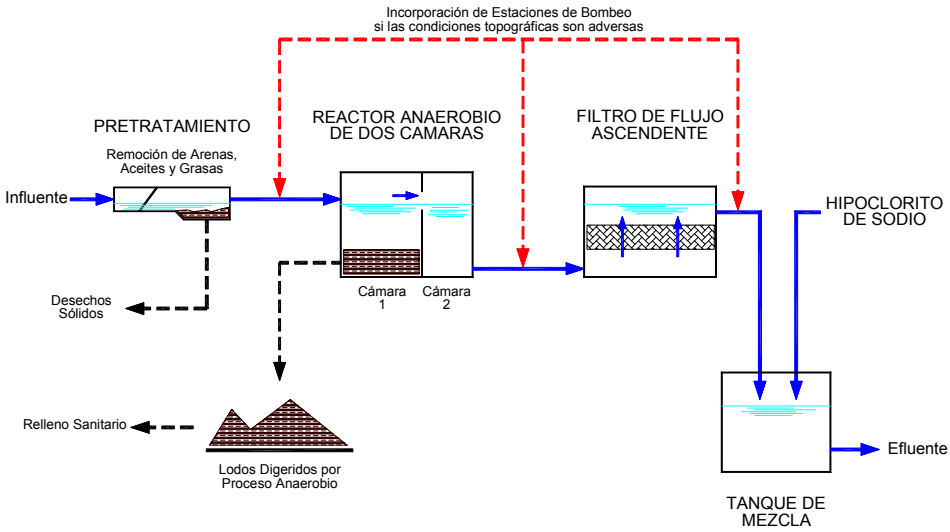


Figure C-37: Flow Sheet of On-site Collective Treatment System

C.3.3.4 Sewerage and Pollutant Sources

Table C-48 shows wastewater discharge amount with respect to each source in Quintana Roo State in 2001. Discharge amount from Service such as hotels is distinguishing due to the active tourism. It occupies more than 70% of the whole discharge amount. Meanwhile,

discharge amount from industry such as manufacturing, mining, etc. is very small. It makes up only 1.48%.

Table C-48: Wastewater Discharge Amount to Federal Control Water Body in 2001

Source	Wastewater Discharge amount (m3/year)	Ratio
Domestic	378,100	0.44%
Industry	1,271,600	1.48%
Service	62,439,000	72.83%
Urban public	21,536,100	25.12%
Others	106,000	0.12%
Total	85,730,800	100.00%

Source : ANUARIO ESTADÍCO Quinntana Roo edición 2002/INEGI

No data of wastewater discharge amount in respective municipalities are available. However, working population data by municipality is obtainable as shown in Table C-49. Checking figures of Solidaridad, working population in Industry/Manufacturing is small like other municipalities. Consequently, residents and tourists are considered as principal pollutant sources.

Table C-49: Distribution of Working Population

Code	Category	Quintana Roo	BENITO JUÁREZ	COZUMEL	FELIPE CARRILLO PUERTO	ISLA MUJERES	JOSÉ MARÍA MORELOS	LÁZARO CÁRDENAS	OTHÓN P. BLANCO	SOLIDARIDA
11	Agriculture, livestock, forestry, fishery and hunting	10.5%	1.0%	2.0%	49.8%	12.0%	57.2%	49.5%	19.7%	5.5%
21	Mining	0.2%	0.1%	0.1%	0.3%	0.2%	0.1%	0.5%	0.3%	0.4%
22	Electric and water	0.5%	0.4%	0.6%	0.3%	0.7%	0.3%	0.5%	0.7%	0.3%
23	Construction	8.4%	8.6%	9.7%	6.3%	4.6%	6.0%	6.3%	7.1%	12.4%
31	Industry/Manufacturing	7.1%	7.2%	6.1%	5.3%	4.3%	4.8%	7.1%	8.6%	6.0%
43	Commercial	16.8%	19.4%	21.3%	8.8%	18.5%	6.6%	8.7%	13.9%	14.0%
48	Transport, postal and warehousing	5.8%	7.3%	6.5%	2.0%	8.0%	2.7%	3.7%	3.7%	4.2%
51	Mass communication media	0.9%	1.0%	0.8%	0.5%	0.5%	0.2%	0.4%	0.9%	0.5%
52	Financial and insurance service	0.7%	0.9%	0.5%	0.1%	0.3%	0.0%	0.2%	0.6%	0.4%
53	Real estate	0.9%	1.2%	1.6%	0.0%	1.5%	0.0%	0.1%	0.3%	1.2%
54	Academic service	1.9%	2.4%	2.0%	0.6%	1.2%	0.4%	0.4%	1.6%	1.1%
55	Service for commercial acuity	3.0%	4.3%	2.6%	0.5%	1.9%	0.3%	0.6%	1.4%	2.1%
61	Education service	4.6%	3.5%	3.5%	8.2%	3.4%	6.1%	4.9%	7.5%	1.8%
62	Social welfare and health	2.4%	2.2%	2.4%	1.6%	2.0%	1.2%	1.2%	3.9%	1.0%
71	amusement service	1.7%	1.7%	3.6%	0.6%	3.1%	0.2%	0.3%	0.7%	3.8%
72	Hotel and restaurant	18.3%	23.4%	21.3%	4.4%	21.3%	3.0%	4.1%	5.5%	33.5%
81	Other service exc. Government	8.7%	9.5%	8.8%	5.0%	5.9%	5.9%	4.3%	9.4%	6.9%
93	Government activity	5.3%	3.4%	4.6%	3.9%	8.9%	3.5%	5.5%	11.7%	2.7%
	Not specify	2.2%	2.3%	2.0%	1.6%	1.7%	1.6%	1.9%	2.3%	2.3%
	Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source : based on Tabulados Básicos QUINTANA ROO XII Censo General de Población y Vivienda 2000 / INEGI

Table C-50 shows BOD generation amount with considering that residents and tourists are principal pollutant sources and supposing that BOD pollutant load unit is 54 g/person/day[9].

Table C-50: Estimated BOD Generation Amount

	Population		BOD generation amount (ton/year)		
	Settlement	Tourist(Person/year)	Settlement	Tourist	Total
Cozumel	62,078	455,621	1,223.565	24.604	1,248.169
Felipe Carrillo Puerto	61,703		1,216.158		1,216.158
Isla Mujeres	14,911	141,785	293.896	7.656	301.552
Othón P. Blanco	230,718	205,216	4,547.448	11.082	4,558.530
Benito Juárez	438,872	2,987,841	8,650.163	161.343	8,811.506
José María Morelos	31,668		624.176		624.176
Lázaro Cárdenas	20,891		411.758		411.758
Solidaridad	86,863	1,504,052	1,712.078	81.219	1,793.297
Quintana Roo state	947,704	5,294,515	18,679.242	285.904	18,965.146

Meanwhile, treated wastewater amount was 12,025,128m^3/year[10] in 2002. Supposing that BOD concentration of inflow is 323 mg/liter and one of outflow is 11.2 mg/liter, this leads 631.43 ton/year of BOD removal amount by wastewater treatment. This BOD removal amount makes up only 35% of the total BOD generation amount. The rest, 65% of the generation amount, is discharged to the environment without treatment.

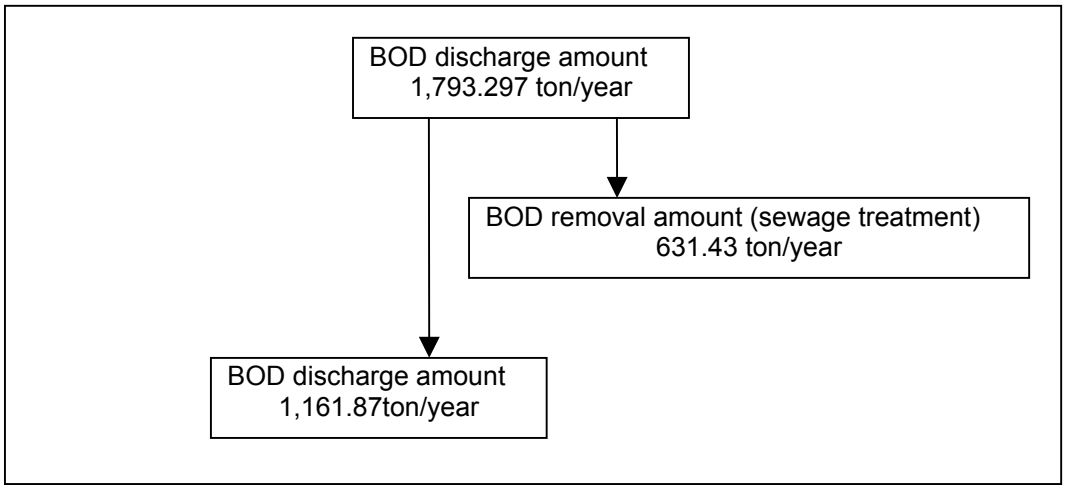


Figure C-38: BOD Balance in Solidaridad Municipality

9

PROYECTO EJECUTIVO PARA EL ALCANTARILLADO SANITARIO Y TRATAMIENTO DE AGUAS RESIDUALES DE LAS LOCALIDADES DE XCALAK, HUAY-PIX, XUL-HÁ Y SUBTENIENTE LÓPEZ EN EL MUNICIPIO DE OTHÓN P. BLANCO, QUINTANA ROO / CAPA

10 CAPA

C.3.3.5 Organizational Structure

The Operating System of Solidaridad manages the subsystems of Playa del Carmen, Tulum and Riviera Maya.

The organizational structure is the same as that of the Othon P. Blanco Operating System.

C.3.3.6 Financial System

CAPA provides water supply and sewer services in Solidaridad Municipality, where the number of water supply connections in 2001 was 6,491 or 7.4% of the State total. Households comprised the majority of customers with 4,864 connections or 75%, followed by 21 % of commercial firms, 2% of General Services, 2% of hotels and 0.1 % of industrial firms. Service coverage was estimated at 43% water supply and 15% sewer service.

As already described in Section 4.1.3.7, CAPA water rates are set by customer category, being composed of a base monthly rate depending on volume (cubic meter per month), and an excess consumption rate that is priced as Pesos per cubic meter consumed. The excess consumption rate increases with consumption, as it corresponds to a progressive rate.

In Solidaridad Municipality, income from water supply between 2000 and 2002 accounted for 60% or more of total income, while income from waste water service comprised 2-4% of total income. Fines can be applied when a bill is not paid for two months or longer, and water supply can be cut off in the case of non-payment. Accordingly, re-connection charges are foreseen as an income source when the water supply service is restored.

The water production volume in 2001 was 9.956 Million cubic meters, and the budgeted expenditures were 31.19 Million Pesos, giving an average cost of 3.13 Pesos per cubic meter of water produced in Solidaridad Municipality.

C.3.3.7 Accounting System

CAPA is a decentralized public institution of mixed nature, that is, State and Municipal, with own assets. As a public institution, accounting is needed for budget management and control, but CAPA also generates financial statements as Balance Sheet and Income Statement (Profit and Loss) for the institution as a whole.

However, it is more difficult to come up with financial statements for each water supply system. Then, a comparison was made between the income and the expenditures of each system. On the income side, data were available as budget income and as actual income, while on the expenditures side only the budget was available, as shown in the following table.

Table C-51: Balance of CAPA Solidaridad System (Million Pesos)

	Year 2000		Year 2001		Year 2002	
	Budget	Actual	Budget	Actual	Budget	Actual
INCOME						
Water supply	47.80	44.26	51.23	48.88	83.91	51.60
On-time	38.09	34.07	37.77	36.32	62.34	40.02
Late	9.71	10.19	13.46	12.56	21.57	11.58
Sewer system	1.46	1.24	1.18	2.76	2.28	2.02
On-time	1.25	0.90	0.97	2.52	1.87	1.37
Late	0.21	0.34	0.21	0.24	0.41	0.65
Connection fee	1.08	2.04	0.55	0.38	2.87	4.55
Re-connection fee	0.25	0.31	0.00	0.69	0.72	0.38
LPS (liter per second)	7.37	2.88	11.28	8.17	3.09	14.87
Updating	0.00	0.00	0.00	0.00	0.00	0.00
Surcharges	0.00	0.00	0.00	0.00	0.00	0.00
Fines	0.00	0.66	0.00	0.01	0.00	0.00
Implementation	0.00	0.00	0.00	0.00	0.00	0.00
Other Incomes	1.46	3.05	5.48	3.01	5.33	2.62
Value added tax	0.00	5.02	0.00	6.10	0.00	6.64
Total	59.42	59.46	69.72	70.00	98.20	82.68
EXPENDITURES						
Personnel	4.51		9.96		10.64	
Materials & supplies	3.24		3.37		2.88	
General Services	3.60		8.75		8.14	
Aid, subsidy & transfer	0.00		0.00		0.00	
Goods (furniture, equip.)	0.48		1.83		0.15	
Public works	5.33		7.10		1.20	
Contingent expenses	0.00		0.00		0.63	
Public debt	0.00		0.18		0.00	
Total Expenditures	17.16		31.19		23.64	
BALANCE	42.26		38.53		74.56	

Source: CAPA

The above table indicates that the balance of income and expenditures was positive in CAPA Solidaridad Municipality between the years 2000 and 2002. Actual income covered 140% of budgeted expenses in the year 2000, 182% in 2001 and 111% in 2002.

C.3.3.8 Social Aspect

Social aspects and considerations are presented below.

Social Aspect	Consideration
Coverage of the sewer service	At the municipal level it is 15%
% of houses with infiltration ditch/cesspool (septic fosas)	At the municipal level it is 63% of surveyed houses
Conservation of health	The incidence of intestinal infections in the State is 6178.9 per 100,000 inhabitants (1224 cases over the national average).
Drinking Water Quality	The taste is somewhat salty. Population in general use bottled water.
Aquatic environment for recreation	The aquifer flowing out and in the coastal area receives important discharges of water from septic fosas and injection wells of effluent from the wastewater treatment plant (Playa del Carmen).
Family income and expenditures	The inadequate management of wastewater is leading to an environmental degradation (aquifer and coastal waters) and the family income can be affected by a contraction in tourism. Expenditures on medical care and bottled water go up.

C.3.3.9 Environmental Education

The State Commission for Potable Water and Sewerage (CAPA) implemented a program "Friendly School - Green House" with the objective to improve and raise the life quality of families in needs through simple and appropriate technologies to the region, through school lectures and chats, chats with parents, lecture on sanitation and reforestation, maintenance of physical and sanitary conditions of water supply and control of the quality of water, among others. Also CAPA through the "Clean Water" Program, carries out within the communities visited (Hondzonot, Yaxche, Chanchen Palmar, San Silverio, Yalchen, all located at western sector of the municipality), actions focused on control of water quality to reduce the risks of transmission of gastrointestinal diseases.

With the purpose of reinforcing the institutional initiative in the implementation process of the work program, CAPA was supported by the National Water Commission (CNA), the Promoters of Mobile Net for Family Development of the State and by leaders of the community. The lectures to the community were focused on the promotion of water importance, care and use as issues related to the health.

C.3.4 Solid Waste Management

C.3.4.1 Overview of the Solid Waste Management

The municipality of Solidaridad, whose capital city is Playa del Carmen, records the greatest population growth rate in the country as a consequence of the strong development of tourism its is undergoing; thus, the above situation directly impacts on the generation of household wastes, especially Playa del Carmen, Tulúm and the rest of the tourism locations at the Mayan Riviera.

In order to arrange and develop the management of municipal solid wastes, the city hall has two legal instruments. The first one is the *"Code on the Municipal Public Administration of Solidaridad"*, issued on March 15th, 2001, whose purpose is to regulate the municipality's public administrative structure and functioning, as well as to set out the powers and duties of entities and units within its structure. This code establishes that the Direction Office of Municipal Public Services is obligated to administer, operate and supervise the rendering of municipal public services, be it directly or through a grantee. In case the service is franchised, it will verify and oversee the rendering of such obligations by the grantee with quality, efficiency, on time and form. In addition to the collection, haulage, treatment and final disposal service of the wastes, the Direction Office of Municipal Public Services also has the obligation to provide public lighting, public roads and thoroughfare, public cleansing and green areas. It is also obligated to program and estimation of the required resources, works and property for the smooth functioning of the municipal public works and services.

The second instrument is *"Code on the Provision of the Public Collection, Haulage, Treatment and Final Disposal Service of Solid Wastes in the Municipality of Solidaridad",* issued on June 30th 1999, which sets forth the basic rules for the provision of the disposal, collection and treatment service of garbage or solid wastes generated at the municipality's population centers. This code enunciates the competencies, normative and operative authorities, the citizens' obligations, prohibitions and restrictions, the service's structure and operation, payment of fees, sanctions, and so on. The operational authorities that are liked with the operation of the waste collection and cleaning service are within the Direction Office of Municipal Public Services, the Assistant Office of Environmental Sanitation and the Direction Office of Municipal Ecology.

Currently the collection, haulage and final disposal service is carried out by a private company (Servicios Ambientales Urbanos S.A. de C.V.), who began operations in June 2002, servicing the city of Playa del Carmen. As of January 2003, the locations of Chemuyil, Puerto Aventuras, Akumal and Tulúm are incorporated into the service, where the locations of Coba, Manuel Antonio Hay, Francisco Uh May and Macario Gómez are provided with the special

service (rendered once a week). The collected wastes are unloaded at a final disposal site located around 13 Km. away from Playa del Carmen.

The service contract between the City Hall and the company "Servicios Ambientales Urbanos S.A. de C.V," will be in force until April 2004 and includes the collection, haulage, final disposal, sweeping and cleaning services. The dumping site calculates a total of 3,000 tons/month with a cost of $ 1,472,900 pesos plus Value-Added Tax; however, currently the service picks up and unloads around 4,000 tons/month.

The collection service is provided Monday through Friday, spanning morning and night shifts and with diverse collection frequencies, depending on the sector, ranging from once a week to a daily basis. The main collection method is door-to-door, and in some instances gathering points exist.

In general terms, the locations served seem quite neat, both in front of the houses and on streets and roads and public spots; however, some unoccupied land lots adjacent to the houses are perceived, with some concentrations of aged wastes.

The sweeping service is provided in the night and exclusively at the urban zone of Playa del Carmen, with the help of a mechanical sweeper that keeps the avenues and streets clean. On the other hand, in Playa del Carmen's downtown, 30 stainless steel containers have been installed with three compartments to separate the wastes.

In hotels and tourism centers, the management of the wastes is conducted by the Direction Office of Municipal Services through the franchised company and it serves around 50% of the area; the rest of the works is handled by the generators of wastes, who hire small private companies.

In remote locations no collection or haulage service of the wastes is offered; therefore, the community has to burn down the wastes at their premises' backyards. These locations have a population below 500 people.

The total of persons being served sums roughly 113,156 out of 133,634 people; i.e., the service coverage hovers around 85%.

Three open air dumpsites exist within the area being serviced by the Direction Office of Municipal Services: the first one is located 8 Km. away from Tulúm, on one side of the Tulúm-Coba federal highway; the second one is located in Akumal; and the third one is 13 Km. north of Playa del Carmen. Out of these three dumping sites, only the place located in Playa del Carmen is running and is in charge of the franchised company, which not only conducts the final disposal of the wastes collected but is also running a cleaning program of

the site. Prior to the beginning of the program, this dumpsite posed serious environmental risks; the lack of covering material was ripe for the proliferation of flies, mosquitoes, rodents and birds and allowed the burning of the wastes by the scavengers, in order to facilitate the extraction of recoverable material. The constant combustion of wastes generated lots of smoke that reached the highway and even the city of Playa del Carmen, if the winding conditions were appropriate. Currently, the dumpsite is running in a controlled manner, arranging and compacting the wastes, with daily coverage, a single shift and installing a gas venting system.

The total of wastes disposed of between June of 2002 and May 2003 totals 77,708 tons, out of which 70% accounts for the wastes collected by the franchised company and 30% for the residues collected by particulars.

The other dumpsites do not have a sanitation program. In the case of the Tulúm dumping site, it is used in emergency situations and no closing system exists to prevent the unloading of the wastes. The Akumal dumpsite is fenced to prevent the access; however, around its perimeter and in front of the highway there is an important accumulation of wastes, mainly bulk waste. In both dumpsites wastes are scattered throughout the land; deep waste deposits are not perceived or concentrations of seepage, which leads to think that such liquid has percolated. No surveys or monitoring that demonstrate the contamination of the aquifer by percolated liquids exist to date; nevertheless, in July of this year an environmental and urban geo-reference will take off that will include variables, water status in water bodies. In relation with biogas, no background exists that leads to conclude about its existence; however, since part of the wastes have been burned and combustion continues for long periods in spite of the humidity of the wastes, it is believed that biogas is behind such circumstance.

In order to strengthen the solid waste management service, the Direction Office of Municipal Public Services and the Direction Office of the Environment, in coordination with other entities such as NGOs and the private sector, are developing the Integral Municipal Solid Waste Management Program, which includes a general diagnosis on the status of the same and pilot projects such as the waste classification, minimization and recycling. On the other hand, the 2002 – 2005 Municipal Development Plan sets out the promotion of the recycling culture and segregation of wastes as the action items within the municipal residues.

At a state level, the Secretaryship of Urban Development and Environment has fostered the construction of a sanitary landfill for Tulúm, whose Environmental Impact Manifest is under review.

C.3.4.2 Waste Stream

a. Actual Situation

Currently not enough background is available for the establishment of a waste flow. Although an entrance log to the dumping site is maintained, it only registers the number of trips and the collection area the trip comes from; i.e., Playa del Carmen, Riviera Maya or particular.

The trips assigned to the Playa del Carmen area include the collection routes encompassing Playa del Carmen, Akumal, Chemuyil and Puerto Aventuras. The latter routes are designed to simultaneously pick up household, commercial, tourism and institutional solid wastes; the serviced routes to micro size dumpsites and wastes stemming from streets, pruned trees and gardens. In the Mayan Riviera area, the wastes collected from hotels, restaurants, tourism centers and small neighborhoods within that area are regarded. Finally, the trips conducted by particulars include the wastes from any other collection service provided by small companies within the municipality, and the waste flow is not classified.

The above characterization does not offer enough data to estimate the volume of wastes generated by household and commercial areas, lodging, restaurants and institutions, street sweeping, cleaning of green areas, junk, bulk waste, and so on.

To the above it has to be taken into consideration that, although a collection program is available that covers an important extension, the burning of wastes still prevails at most of the generation sites.

To date, no surveys have been conducted that account for the amount and composition of the wastes within the municipality of. Some research exists in this regards and whose information is disclosed below; however, the data is aimed at specific locations or generators. Therefore, complementing this above with studies on all the generators and statistically validating such data is necessary.

Regarding the composition studies above mentioned, they have been carried out in some hotels and at the location of Tulúm; the results obtained are disclosed in the following figures:

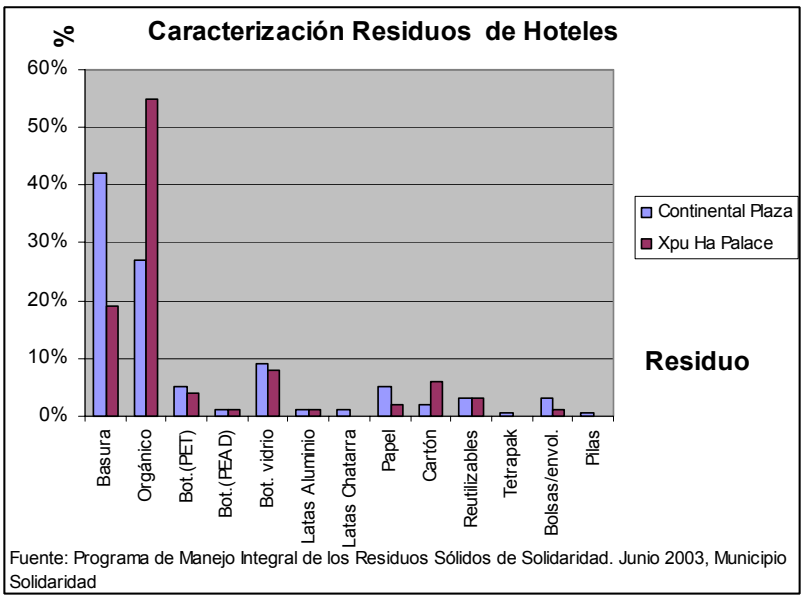


Figure C-39: Composition of Wastes in Hotels

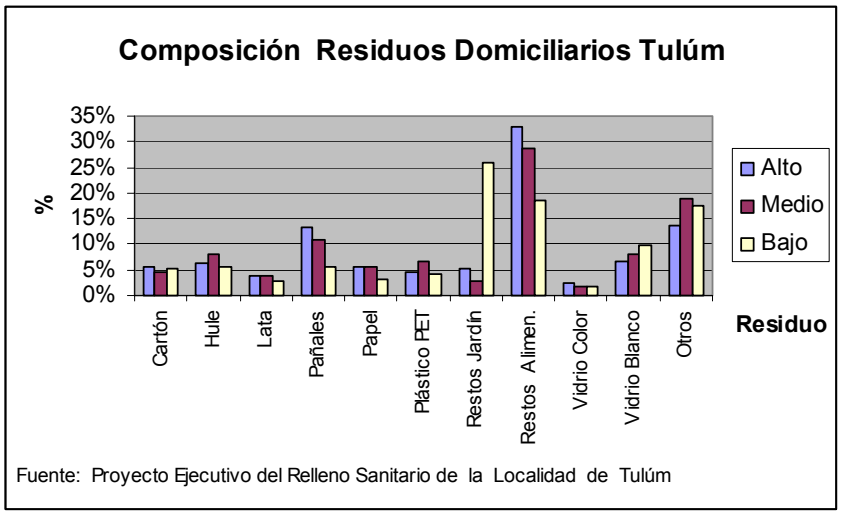


Figure C-40: Composition of Household Wastes in Tulúm

Based on this background it can be said that the household and tourism sectors present similar components, being the organic matter (food and garden leftovers) the most widely present: around 30 and 40% in household wastes and between 25 and 55% in hotel wastes. The second component is represented by papers and cardboard with a figure of 11% approximately for household and a slight lower amount for hotels. The remaining constituents of importance are plastics and glass; diapers are also an important item within the household wastes.

b. Estimation

As explained so far, insufficient data cannot make it possible to prepare a waste stream that schematizes waste amount of generation, collection, recycling, clandestine dumping, etc. over

the municipality. However, waste collection amount and disposal amount could be estimated based on information obtained.

The information says that about 113,000 residents are covered with the collection service. According to waste generation amount data of Chetumal and Felipe C. Puerto, it can suppose that of Solidaridad is 0.9 kg/person/day. Furthermore, all waste generated is not necessarily collected, certain amount of waste is recycled, scattered, etc. Then, suppose 90% of the waste generated is collected. It can be said that waste collection/disposal amount generated by residents would be 90 ton/day; 113,000 x 0.9 kg/person/day x 90%. Meanwhile, 4,000 ton/month of waste is collected and disposed of according to the contractor. This is equivalent to 130 ton/day of waste. Considering the waste generated from hotels and other commercial activities, this 130 ton/day of waste may not be far from actual amount.

C.3.4.3 Technical System

a. Introduction

As mentioned above, the Direction Office of Municipal Public Services handles all the operational activities in relation with the management of municipal solid wastes, be it through their direct execution or franchising the service to third parties. The Direction Office of Municipal Ecology works in tandem with the latter office, and it is in charge of developing programs or projects for the integral management of solid wastes, as well as of environmental education duties.

The Direction Office of Municipal Public Services is organized as follows:

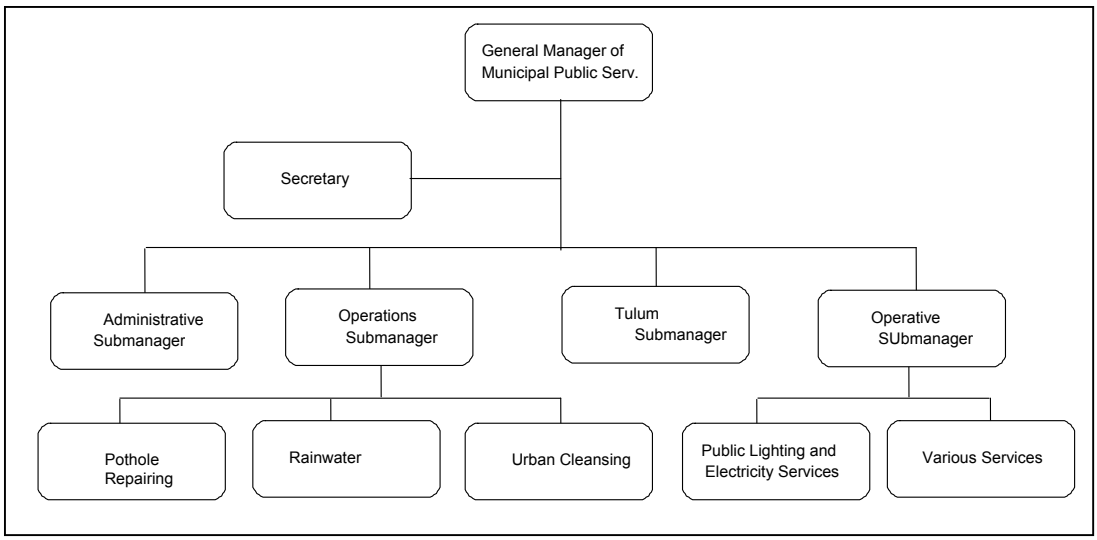


Figure C-41: Flowchart of the Direction Office of Municipal Public Services

The Direction Office is in charge, among other obligations, of the establishment, upgrading and management of the municipal public services, especially the provisioning of potable

water and sewerage, public cleansing, collection and treatment of wastes and provisioning of locations devoted to the disposal of wastes and residues; conservation of the municipal road system; maintenance, improvement and supervision of the public lighting system; vigilance and control of garden issues in squares, gardens, parks and avenues, overseeing their preservation, ornamentation and maintenance.

As of June 1st, 2002, the collection, haulage, final disposal and sweeping services are hired by the City Hall with the company Servicios Ambientales Urbanos S.A. de C.V., rendering the service in the first place to Playa del Carmen. Later on, and dated January 26th, 2003, the contract is attached an addendum and through which the municipality gratuitously loans the company with three collection units to provide the service at the hotel zone of the Mayan Riviera; the villages of Chemuyil, Puerto Aventuras, Akumal and Tulúm and a special service to the locations of Coba, Manuel Antonio Hay, Francisco Uh May and Macario Gómez. The contract will be in force until April 9th, 2004.

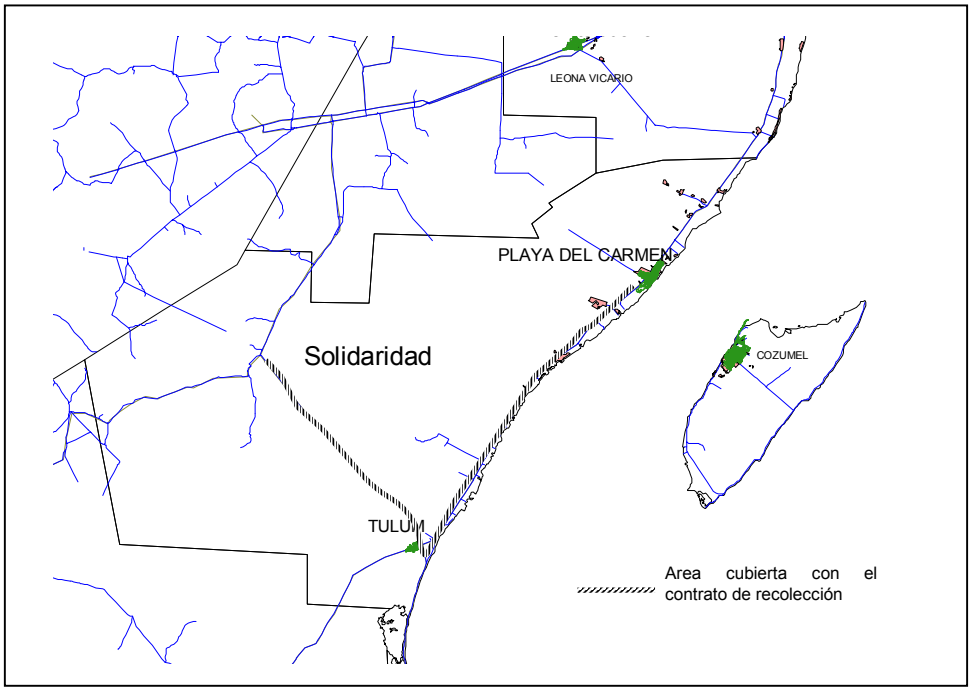


Figure C-42: Area Regarded within the Contract

The contract entered between the company Servicios Ambientales Urbanos S.A. de C.V. and the City Hall outlines as the grantee's responsibilities, in addition to the collection, haulage and final disposal of the wastes generated at the locations above referred, the provisioning of a total of 5,600, 120-liter polyethylene containers to be handed over to the users; the cleansing of micro-dumpsites, mechanical sweeping of streets and restoring and re-operation of Playa del Carmen's municipal dumping site.

The municipality pays the grantee for the collection, haulage, final disposal, sweeping and restoring of the dumpsite on a monthly basis, a total of $ 1,472,900 pesos plus value-added tax.

b. Waste Storage System

Currently the conditioning of household solid wastes in the city of Playa del Carmen varies according to the sector; in the case of the neighborhood of Ejido, discharging of the wastes is by means of plastic bags from supermarkets or businesses, and bags devoted specifically for wastes are used in a lower proportion. In some land lots 120-liter plastic containers were delivered for the storage of wastes; however, most of the times they are not employed for such purpose. In the Colosio neighborhood, wastes are discharged in supermarket bags or business, and the use of waste bags specifically devoted for such purpose is scarce. A suitable use of the containers is observed at the land lots where said containers were installed. The rest of the city has the same type of storage and a proper usage of the same is perceived, and the users wash them as well.

At the location of Chemuyil, each house has a 120 liter container where users store their wastes. In peak days, the capacity of these containers is insufficient to that purpose, and thus an accumulation of wastes is observed on the sidewalks by the time of the collection works; additionally, six gathering points have been created and where five, 200 liter metallic drums have been installed, and they are marked in order to identify the type of waste to be disposed of in them (organic or inorganic waste). Both the containers and drums have a jumbo sized waste bag.

At the location of Puerto Aventura, wastes are deposited in 120-liter containers, and their number and capacity is sufficient to serve the demand, except during peak days when wastes pile up and they are found on the curbs when the collection truck passes by. In this village, the 120-liter containers are protected with jumbo-sized waste bags. When supermarket or commerce bags are used to discharge the wastes, said are placed in an elevated place to prevent their tearing by dogs. Only the elementary school of the village has three, 200-liter drums where wastes are disposed of in bulk.

At the location of Akumal, wastes are deposited in 120-liter containers. However, problems arise during the peak days, as their capacity is insufficient, and therefore part of the wastes pile up on the sidewalks. Storage in jumbo-sized bags also exists, as well as supermarket or commerce bags that are placed in an elevated place to prevent their tearing by dogs. In the case of the elementary and junior high school, they have a 120-liter container and a 200-liter drum where wastes are disposed of in bulk.

In Tulúm, wastes are discharged basically in jumbo-sized waste bags or in supermarket and commerce bags. The 120-liter containers provided by the municipality are insufficient; only the main avenue has a sufficient amount of them and they are complemented with 200-liter drums during peak days. In the neighborhoods, wastes are stored in several manners: 120-liter containers, other plastic containers of several sizes, jumbo-sized bags and supermarket or commerce bags. In the case of the Villa Tulúm, a gathering center that comprises an area with four walls and a door is available, which is closed to keep the wastes protected. In Villa Huracanes there is a gathering center that is not fenced in or walled, which allows the wastes to be exposed and become scattered. In Tulúm's hotel zone, wastes are stored in jumbo-sized bags. In this zone there are gathering centers located in front of the hotels and on the side of the main road; these gathering centers have a floor area with four wooden walls.

At the location of Coba the wastes are mainly discharged in jumbo-sized bags, and in supermarket/commerce bags or flour sacks in a minor proportion. The 120-liter containers provided by the municipality are scarce. Available at police stations, ruins, health centers and elementary school there are 200-liter drums (two per location), where wastes are discharged in bulk.

At the locations of Manuel Antonio Uh May, Francisco Uh May and Macario Gómez, the wastes from commercial stalls are stored mainly in jumbo-sized bags, in supermarket/commerce bags or flour sacks. The rest of the locations are handled with 200-liter drums and 120-liter containers in a lower proportion.

In general terms, all the locations have an appropriate storage system, with no accumulation of wastes on curbs, except during peak days and around the area of the container.

c. Collection and Haulage System

The collection and haulage system renders the service to the cities of Playa del Carmen, Tulúm and the locations of Chemuyil, Puerto Aventuras, Akumal, Coba, Manuel Antonio Uh May, Francisco Uh May and Macario Gómez. The collected wastes include household, commercial and institutional wastes and the residues from the hotels in the zone.

Regarding the total amount of wastes collected, the following table displays the waste input in the disposal site, a record that is kept by the franchised company.

Table C-52: Amount of Collected Wastes

Unit: ton

Year	Month	Playa del Carmen	Mayan Riviera
2002	June	3,949	
	July	3,984	
	August	3,472	
	September	3,836	
	October	3,966	
	November	3,677	
	December	3,837	
2003	January	4,000	267
	February	3,540	1,736
	March	4,186	1,868
	April	4,230	1,987
	May	3,931	1,909
	Global	46,608	7,767

The collection system employed depends on the features of the serviced locations: door-to-door, at gathering points or main avenues. A detail of the collection service per location is shown next.

The collection in the neighborhoods of Ejidos and Colosio that belong to Playa del Carmen is conducted on main streets and avenues only, and this is due to the faulty conditions of the same. In the remaining neighborhoods and sectors of the city, the collection method is door-to-door.

At the locations of Chemuyil, Puerto Aventura, Tulúm and Coba, wastes are collected door-to-door and at the existing gathering points in the case of Chemuyil and Tulúm.

At the locations of Manuel Antonio Hay, Francisco Uh May and Macario Gómez, wastes are collected on the road and on the first block closer to the highway; however, the rest of the streets are not serviced due to the scarce concentration of dwellings, and so their inhabitants carry their wastes to the collection site.

The collection service is conducted in two shifts: a morning shift from 07:00 through 15:00 and a night shift from 19: 00 through 01:00 am. The collection frequency depends on the location and/or service area. The following table displays the current schedule of the collection service and the figure shows the routes in the city of Playa del Carmen.

Table C-53: Schedule of the Collection Service

Sector	# Route	Morning 07:00-15:00 hr.							Night 19:00-03:00 hr.						
		L	M	M	J	V	S	D	L	M	M	J	V	S	D
Downtown 1	1	x		x		x									
Downtown 2	2								x	x	X	x	x	x	x
Downtown 3	3								x	x	X	x	x	x	x
Permanent	4	x	x	x	x	x	x								
Colosio 1	5	x		x		x									
Colosio 2	6	x		x		x									
Ejido 1	7		x		x		x								
Ejido 2	8		x		x		x								
Area Nueva	9		x		x		x								
Tourism zone	10								x	x	x	x	x	x	x
Hotels	11								x	x	x	x	x	x	x
Micro-dumpsites	12	x	x	x	x	x	x								
Solidaridad sectors	13		x		x		x								
Tulúm residential zone	14		x		x		x								
Hotel and ruins zones of Tulum	15	x		x		x									
Populated sectors	16							x							

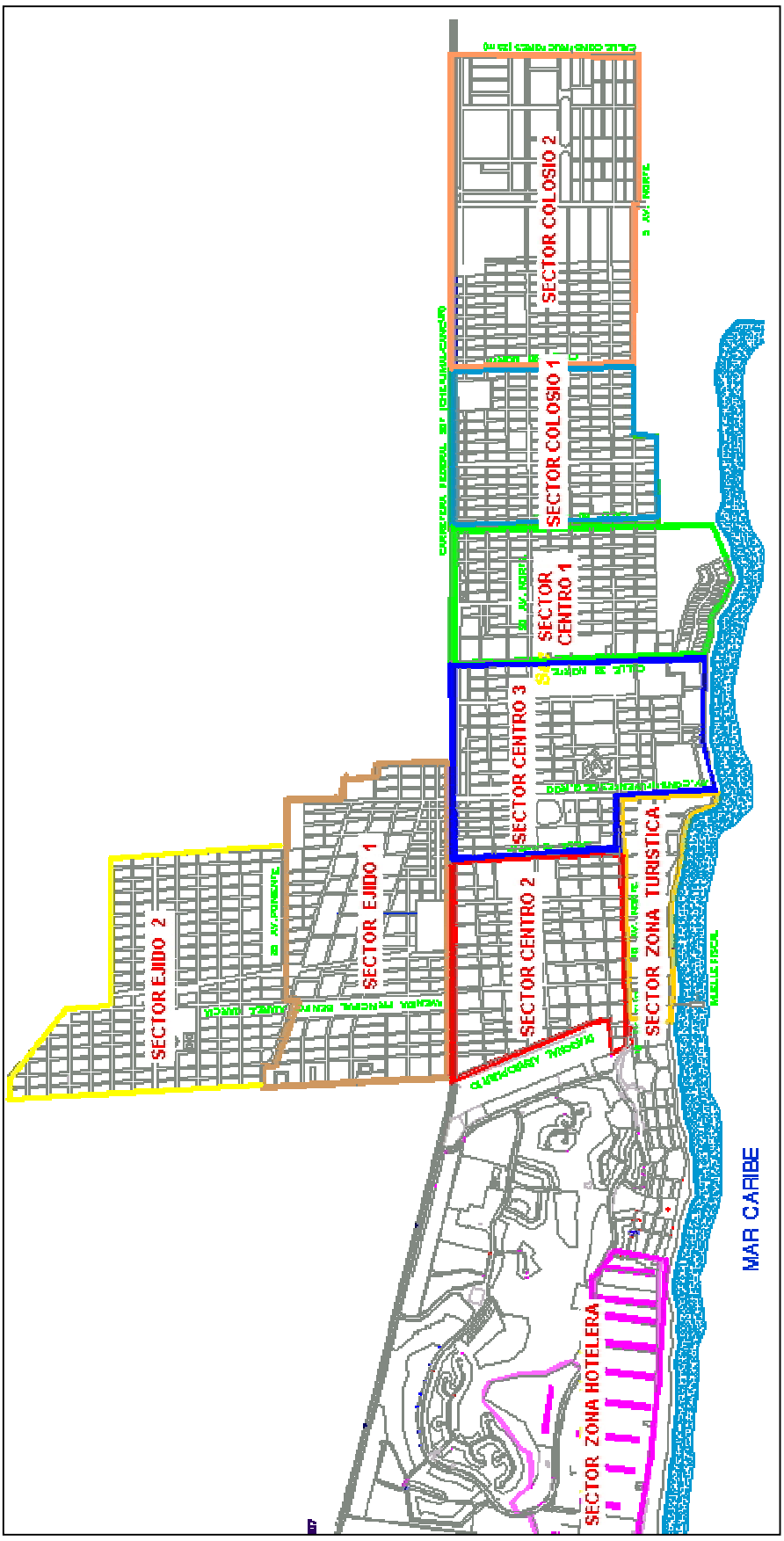


Figure C-43: Collection Routes of Playa del Carmen

A total of 12 routes for the day shift and four night shifts exist. Route N°1 through N°9 serve the sectors and neighborhoods of Playa del Carmen, whereas route N°13 provides the service at locations of Playa del Carmen and after 12:00 it serves the villages of Akumal, Chemuyil and Puerto Aventuras; route N°14 covers the residential zone of Tulúm; route N°16 provides the service to the locations of Antonio May, Macario Gómez, Francisco Uh May and Coba; route N°12 includes the collection of wastes disposed of at micro-dumpsites or small garbage dumps. The hotel and tourism zone is covered by routes N°10, N°11 and N°15, and it includes the following sites or hotels.

Table C-54: Hotels and Tourism Sites Covered by the Collection Service

Place		Location at the Federal Highway (307 Km.)
Southern zone		
	Spa Palace	271
	Aventuras Palace	271
	Xpuha Palace	265
	Kantenah Paladium	261
	Colonial Paladium	261
	El Dorado	262
	Flamenco Xcaret	281
	Lápiz	269
	Akumal Beach	254
	Bathing resort of DIF	251
	Bahía de Puntas Solimante Hotel	245
Northern zone		
	Los Corales restaurant	296
	Ikal del Mar	296
	Los Pinos restaurant	296
	Qualton Club Riviera Maya	296
	Playa Xcalacocos	296
	Paradise Point Resort	296
	Bahía Xcalacocos	296
	Capitán Lafite	285
	Cabañas de Kailum	298
	Club El Mandarín	269
	Tres Ríos	301
	Apasco concrete company	304
	Playa Paraíso (households)	309
	Carrousel Village Hotel	309
	Ibersotar Playa Paraíso	309
	Mayan Palace	309

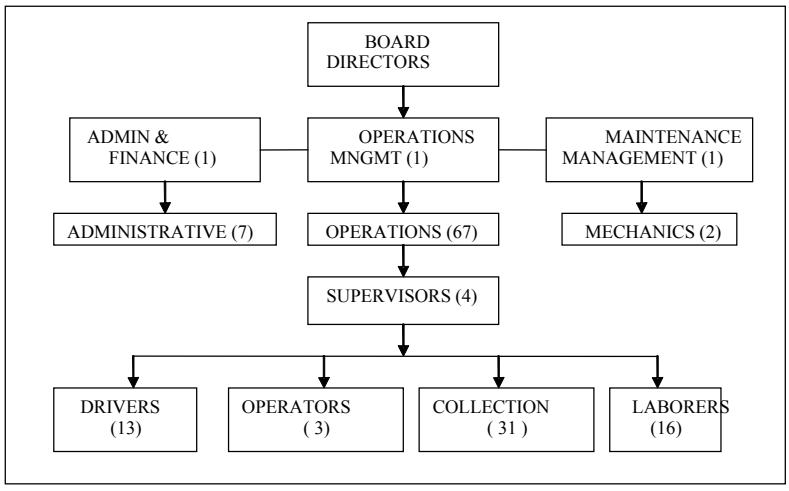
Each collection truck makes an average of two trips per route on a normal working day, in both shifts. On peak days, the number of trips totals three. The dump truck makes from three to five trips on a normal day and up to six on peak days, and it is also employed for the collection at micro-dumpsites.

In order to develop the collection and haulage activities, the franchised company has the following infrastructure.

Table C-55: List of Vehicles Employed for the Service

Own vehicles:		
Amount	Type	Description
02	Collection truck	International year 2002, DT 4300, long chassis 6x2, 215 Hp, with International Mcneiulis body, Metropack model of 25 Yd3
02	Collection truck	International year 2002, DT 4300, short chassis 4x2, 195 Hp, with compaction equipment, Mcneiulus, Metropack model of 20 Yd3
01	Dump truck	International year 2002, DT 4300, short chassis 4x2, 195 Hp, with dumping device of 7 m3.
01	Pick-up	Luv 2.3 year 2002, 115 Hp., double cab
01	Pick-up	Chevrolet Corsa, year 2002, 95 Hp., single cab
Vehicles gratuitously loaned by the City Hall		
Amount	Type	Description
02	Collection truck	Chevrolet, year 2002, Kodiak, 190 Hp, furnished with Cemnsa compaction devices, model Pak-Mor, 20 Yd3
01	Collection truck	International year 2002, DT 4300, 225 Hp, equipped with Mcneiulus compaction devices, model Metropack, 20 Yd3

With respect to the staff, the following figure shows the organization chart of the franchised company and the employee headcount for each activity or department. This flowchart includes the sweeping and final disposal personnel.



Flowchart of Servicios Ambientales Urbanos SA de CV. Source: Municipality of Solidaridad.

Figure C-44: Flowchart of the Franchised Company

In other locations the collection service is not rendered and, in general terms, the community burns the wastes.

d. Final Disposal

The collected wastes are disposed of at an open dumping site located 13 Km. north of downtown Playa del Carmen, on the side of the federal highway that joins this city with Cancún. The property has 10 has. and its operations began six years ago.

Prior to the beginning of operations of the current franchised company, such place had no control measures whatsoever; wastes were disposed of with no compacting and no coverage works were conducted, and thus allowed the proliferation of unsanitary vectors such as flies, mosquitoes, rodents and birds. Also, constant fires caused by the scavengers to allow their recovery of material existed as well; these fires generated important amounts of smoke that hindered the highway's visibility and even reached to Playa del Carmen.

Due to the above, the franchised company undertook the rehabilitation works of the site and the creation of proper conditions to continue with the disposal of the wastes and transform it in a control dumpsite.

The first stage of this rehabilitation plan was to put out the existing fire; later on, wastes were arranged and compacted throughout the entire area and the coverage of the same also took place. Drainage systems to vent biogas were also constructed. With the latter measures, the controlled operation of the site has been achieved, with a single waste unloading front and thus minimizing the severe impacts upon the environment.

Currently the final disposal site works Monday through Sunday 24 hours a day; however, the bulldozer that constructs and covers the waste cells works 48 hours per week from Monday through Saturday.

The site has a mobile booth for the staff that controls the entrance of the trucks; no additional works are conducted therein or no fencing exists either.

Despite of the fact that the coverage of wastes has been progressively taking place; the covering material is highly permeable, which facilitates the ingress of rainwater and the concentration of leachate. To date, no actions or monitoring have been conducted to determine the mobility of liquids into the subsoil or if the latter have contacted the groundwater.

The staff allocated for the operation of the dumpsite includes 10 people as follows: a supervisor; a bulldozer operator, three vehicle drivers, three laborers, one administrative person, a person to control the entrance of vehicles and one shift of guards.

The amount of vehicles and machinery operating in the landfill totals just one D8K bulldozer, which is a rental and is in good working conditions; however, its date of manufacturing is unknown. This equipment conducts the works of cell construction and coverage of the same.

Every month around 6,600 tons are unloaded at the site, out of which 83% correspond to household wastes collected by the franchised company and 17% belong to hotel wastes, all of the latter generated within the municipality of Solidaridad. The total of wastes is determined

by the number of trips and the capacity of the compaction body of the trucks, as no scale exists at the site.

The following table shows the details on the waste input to the dumpsite in the last twelve months.

Table C-56: Waste Input to the Sanitary Landfill

Unit: ton

Year	Month	Franchised company		Particulars	Total
		Playa del Carmen	Riviera Maya		
2002	June	3,949		2,174	6,123
	July	3,984		2,587	6,571
	August	3,472		3,120	6,592
	September	3,836		2,701	6,537
	October	3,966		2,625	6,591
	November	3,677		2,158	5,837
	December	3,837		2,210	6,047
2003	January	4,000	267	1,920	6,187
	February	3,540	1,736	837	6,113
	March	4,186	1,868	1,006	7,060
	April	4,230	1,987	1,020	7,237
	May	3,931	1,909	975	6,815
	Total	46,608	7,767	23,333	77,708

According to surveys conducted by the municipality and the franchised company, it is estimated that the site has a waste capacity of 823,000 tons; considering the population growth rate and with the same service coverage, the final disposal site is expected to last between 7 and 8 years.

e. Sweeping

The sweeping service is provided by the same franchised company and is conducted exclusively in the urban zone of Playa del Carmen.

The sweeping service is executed exclusively during the night shift six days a week as per the following scheme:

Table C-57: Sweeping Routes

Street or Avenue	From	To	Frequency
Av. Juárez	Federal highway	Av. 10 Norte	Daily
Av. 1 Sur	Federal highway	Av. 10 Norte	Monday, Wednesday and Friday
Av. 10 Norte	Av. Juárez	Av. 36 Norte	Daily
Av. 15 Norte	Av. Juaréz	Constituyentes	Tuesday, Thursday and Saturday
Av. 20 Norte	Av. Juárez	Constituyentes	Daily
Av. 30 Norte	Av. Juárez	Av. CTM	Daily
Av. 40 Norte	Av. Juárez	Av. CTM	Tuesday, Thursday and Saturday
Constituyentes	Federal highway	Playa	Monday, Wednesday and Friday
Av. CTM	Federal highway	Quinta Avenida	Tuesday, Thursday and Saturday

The sweeping service is conducted mechanically with the help of an Elgin mechanical, Pelican model P series, year 2002. The daily mechanical sweeping average adds up to 24 Km. and the collected wastes are disposed of in the dumping site.

f. Recycling

At the city of Akumal a waste separation program was carried out by the community, and the segregated items were cardboard, glass and aluminum. However, this program did not work out due to financing shortage.

At the city of Playa del Carmen, a pilot recycling program is being carried out by a private company, which has installed a total of 30 metallic containers that allow the segregation of the wastes. These containers are located in the tourism zone.

Wastes are carried to a gathering center to sell the items later. All the activities are executed by the private company, including cleaning and maintenance of the containers. In a way to meet its expenses, the municipality has authorized the company to stick ads onto the containers.

The following pictures show some aspects of the pilot plan.

Figure C-45: Pilot Recycling Plan at Playa del Carmen

C.3.4.4 Reviewing of State Plans

Within the 1999 – 2005 Base Plan structured by the government of Quintana Roo – whose purpose is to back up the society's needs with consideration to the ecological balance and protection of the environment –, the construction of a sanitary landfill for the location of Tulum to replace the current dumpsite is being regarded.

As per this initiative and the state strategy, the Secretaryship of Urban Development and Environment (SEDUMA) has planned the conduction of surveys and executive projects of a sanitary landfill in the municipalities of the state of Quintana Roo, including Tulúm.

Right to date, the project is under the Environmental Impact Manifest stage. The Executive Project and the Environmental Impact Manifest are being prepared by the company X2001 Grupo Empresarial S.A. de C.V.

As above stated, there is an open dumping site in Tulúm in poor sanitary conditions, which represents a severe environmental pollution risk. This dumpsite is located 9.2 Km north of Tulúm and 700 m west of the federal highway between Tulúm and Coba.

The site chosen to develop the project has an area of around 13 ha. and is located approximately 10.5 Km northwest of Tulúm, 400 m on the right side of the federal highway between Tulúm and Coba, between the coordinates 20°16' northern latitude and 87° 30' western longitude. The selected land is approximately 1.3 Km north of the dumping site.

At the zone, the aquifer is located at a depth of 10 m approximately and the soils are highly permeable; therefore, excavations no deeper than 4 m are regarded, and both the landfill and the leachate storage lagoons will be waterproofed with geomembranes.

The project is designed to receive 270,886 tons of wastes and the useful life is expected at 10 years. It also considers the construction of the following infrastructure: control booth; scale booth; administrative office; freight shed; perimeter fencing; potable water main; electricity, sewage network, inner roads, protection drainage, leachate gathering network, drying lagoon, signals, skip pits, and so on.

Water proofing of the landfill bottom is projected, with two layers of sascab, 20 cm thick and with a 90% compaction degree; two layers of high density polyethylene geomembrane, 0.0060 thick; two layers of geotextile material; drainage layer to extract leachate, 20 cm thick; and a granulated layer over the drainage layer.

The collection system of seepage will include drainages with gathering pipeline, located over the bottom waterproofing system. The liquids collected will be carried to two waterproofed drying lagoons, which will accumulate 11,335 m^3.

The construction of airshafts for biogas, which will be located within the waste cells and equidistant with a range of 50 m, is considered.

The projected landfill operates under the area method system, which contemplates the construction of daily cells with a height of 2 m. For the covering of the waste cells, the material resulting from the earthworks to prepare the land will be employed. As the volume to be dug up will be short of the needs, extraction of material from a loaned zone 30 Km. away from the project, on the Tulúm-Cancún highway is being considered.

For the biogas management, the construction of airshafts located at equal intervals of 50 m one of another will be carried out, and these airshafts will also be used for biogas monitoring. The percolated liquids will be gathered at the bottom of the landfill through a drainage system and will later be carried to drying lagoons. Two gathering and drying lagoons are considered that will handle a total volume of lechate of 11,275 m^3.

For the landfill operations an Angledozer, type D-3, tractor D-5, two tank trucks, a self-quenching gas pump and a dump truck will be considered. Regarding the personnel, an on-site civil engineer, a secretary, two field foremen, a guard, three tractor drivers, three general assistants, a weighmaster, a night watcher and two persons to arrange will be employed.

The project regards a monitoring program that includes:

- Biogas monitoring through portable equipment that will measure the concentration of CH_4, CO_2, N_2, O_2, H_2S, explosiveness; the monitoring encompasses the project area plus the surrounding areas to the dumpsite. The monitoring frequency is proposed every two weeks.
- Monitoring of percolated liquid: it regards the construction of nine wells to be distributed upstream and downstream of the landfill. Water samples will be extracted from the same and will be subject to physical, chemical and biological tests so as to detect infiltration of leachate.
- Monitoring of groundwater: a quality control will be carried out on the groundwater, for which purpose the above wells will be employed.
- Air quality monitoring: monitoring of the total suspended particles is being proposed and feasible particles. The monitoring frequency will be on a monthly basis.
- Noise monitoring: to be conducted as per the regulations currently in force.

Additionally, the project regards a closing and post-closing stage with the necessary actions to maintain sanitary and environmental conditions of the works once wastes are no longer disposed of in it.

Regarding the impacts generated by the project, the Environmental Impact Manifest concludes:

- Two significantly adverse impacts will take place during the operation stage on the soil and water due to the generation of leachate and the air due to the generation of biogas.
- Non-significant adverse impacts will appear throughout the construction and operation stages of the sanitary landfill and are caused by the preparation and construction of the works, which will affect the quality of air, water, soil, vegetation, wildlife and landscape. However, such effects will be enclosed only within the project site.
- Significant beneficial and non-significant impacts will take place during the construction and operation stages of the sanitary landfill and correspond to all of the measures aimed at the appropriate management of percolated liquids and biogas. As a social benefit, the creation of jobs and control of an important source of contamination that might affect the community's health, will be observed.

The sanitary landfill project outlined for the location of Tulúm represents a great progress towards the management of household solid wastes; however, costs will jump considerably, which poses an important risk to the continuity of the works.

This situation has to be borne in mind whenever a sanitary landfill project is involved; therefore, the suggestion is that the same serves several locations in order to maximize the economies of scale.

For the particular case of the municipality of Solidaridad, the waste collection and haulage service involves all the locations at the Mayan Riviera, the city of Playa del Carmen and other neighboring locations. This structure will allow the provision of the service at a lower cost and with the best utilization of the equipment. The same criterion should be regarded as for the final disposal, to consider a single sanitary landfill that serves all of the locations.

The above would not represent further issues or costs in the collection and haulage services, as wastes today are disposed of in the dumpsite of Playa del Carmen, regardless of the distance. If a sanitary landfill is intended between Playa del Carmen and Tulúm, its execution is feasible and such would allow the economies of scale, thus shrinking the investment and operational costs.

In addition to the above, the availability of a single landfill minimizes the pollution risks and eases monitoring and audit programs.

On the other hand, within the strategy to improve the final disposal of the wastes, no project is being devised to recover and close the Tulúm and Akumal dumpsites; and so unsanitary places would exist within the zone that pose an important environmental risk and that would carry diseases with an important impact on the tourism activity. Therefore, it is necessary that the closure of such dumpsites is planned along with new projects, ensuring that wastes are confined and the place monitored to spot any pollution issue right away and enforce the required corrective measures. The aforementioned is not difficult to achieve, especially when the recovery program of Playa del Carmen dumpsite has kicked off.

C.3.4.5 Organizational Structure

Within the organizational structure of the Municipality, the Bureau of Municipal Ecology is in charge of formulating the municipal policies on environmental aspects and its community implications; the Bureau of Municipal Public Services is in charge of providing the service of solid waste management.

In June 2002, the Municipality signed a contract with Servicios Ambientales Urbanos S.A de C.V. to provide the service of collection, sweeping, transportation, and final disposal in Playa del Carmen and in association with the Municipality, which hands over three collection units, the hotel zone of Riviera Maya, Chemuyil, Puerto Aventuras, Akumal and Tulúm. The localities of Coba, Manuel Antonio Hay, Francisco Uh May and Macario Gómez, receive collection service once a week.

The service contract is valid until April 9, 2004 and the present coverage at the municipal level is 85%. People in rural communities of less than 500 inhabitants burn their solid waste.

C.3.4.6 Financial System

Section 2.3.5.2 described the municipal taxes and fees. “Service fees” are charged by municipalities for diverse services, including solid waste services. In the case of Solidaridad Municipality, the new solid waste service fee was established in January 2003 as follows.

Table C-58: Solid Waste Service Charges in Solidaridad

User Class	User Sub-class	Pesos/Month	Pesos/Year
Hotel room	5 stars	34.76	417.12
	4 stars	25.74	308.88
	Small hotels	17.16	205.92
Restaurant	With alcohol	397.50	4,770.00
	Without alcohol	212.00	2,544.00
Mini-market, liquor	With alcohol	296.80	3,561.60
	Without alcohol	169.60	2,035.20
Commercial firms	General	132.50	1,590.00
	Banks	1,431.00	17,172.00
Vendors	With food	79.50	954.00
	Without food	31.80	381.60
Rental Department		23.80	285.60
Household		31.80	381.60
Volumetric	kg	0.53	

Source: Periodico Oficial, Chetumal, Q.Roo, 7 Enero 2003

Between January and May 2003, expenditures by Solidaridad Municipality on solid waste service amounted to 7.51 Million Pesos, while income from the service amounted to 3.83 Million Pesos, a deficit of 3.68 Million Pesos in 5 months. Income from solid waste service represented 2.9% of total income of 131.78 Million Pesos, while expenditures on solid waste service represented 9.1% of total expenditures of 82.71 Million Pesos during the first 5 months of 2003.

The solid waste concession service in Solidaridad Municipality is estimated to dispose 4,000 ton a month at a cost of 1.47 Million Pesos plus 10% tax. This is equivalent to around 405 Pesos per ton, or about USD40 per ton. CEPIS (Centro Panamericano de Ingenieria Sanitaria y Ciencias del Ambiente) indicated the acceptable range of solid waste collection cost per ton to be USD25-40, and USD4-10 per ton of disposal cost in 2001.

C.3.4.7 Accounting System

Section 2.5.5.1 on Public Finance presented the income and expenditures of Solidaridad Municipality, showing the different accounts used to describe the items in the municipal income and expenditures. The accounts are common to government offices. It is a government accounting. The overall income and expenditures table does not allow identification of the source of each income or expenditures, as they are grouped under broad headings like “Fee income” or “Personnel expenses”.

It is possible however to estimate the income and expenditures of solid waste service, as was already done by the Municipality at the request of the Study Team. This appears to be relatively easy in the case of Solidaridad Municipality as the details of municipal income specify Solid Waste Collection Fee in Playa del Carmen and Tulum within the broad category

of Fees. On the expenditure side, it appears that payment to the concessionaire of the solid waste service is handled as Other Services.

It can be seen that the accounting at present is geared to the management and control of the budget, which is understandable for a government office. If the Municipality could have a clear picture on the cost and income of a given service, as seems to be the case with solid waste service in Solidaridad, it would be possible to calculate some performance indicators of the service. The performance indicators are essential to implement a continuous monitoring system, a necessary step to improve the efficiency and effectiveness of the service.

C.3.4.8 Social Aspect

Social aspects and considerations are presented below.

Social Aspect	Consideration
Coverage of collection service	85% with private sector participation.
Solid waste disposal according to norms	100% of solid waste is disposed of without compliance with the official Mexican norms.
Conservation of health	Important incidence of diseases related with an inadequate management of solid waste: intestinal infection, dengue fever, typhoid fever, helminthiases
Drinking Water Quality	Preliminary calculation of leachate intrusion in the aquifer was estimated to correspond to a pollutant load of 719.8 ton of BOD per year

C.3.4.9 Environmental Education

The City Council of the Municipality of Solidaridad through the Environmental Office carries out a series of environmental education activities, training and events like:

a. Radial and television broadcastings

Radial broadcastings with information messages of environmental nature in different topics were carried out regarding the importance of protection and conservation of the swamp ecosystem, the importance of maintaining clean beaches, the protection of marine turtles, species in danger of extinction, the conservation of the coral reefs, the problem in Solidaridad regarding noise contamination and burning in urban areas, as well as the recovery project for beaches in the city of Playa del Carmen and the results of activities developed in environmental issues.

b. Cooperation to other relevant institutions

Support to Civil Protection Office with an educational program on harmful marine organisms developed by the Environmental Office for Intoxication and Poisoning Course for marine fauna to the personnel of Xel Ha Park. Collaboration in the development of the program of

environmental education of CALICA and coordination with SEDUMA for visits to XCACEL-XCACELITO in the nest season of marine turtles, etc.

c. Recycling program

On November of 2002, the Environmental Office of the Municipality of Solidaridad began a installation program of containers including didactic material for storing and recycling of solid waste in the schools of the municipality. This activity was carried out in coordination with the Education Office of the Municipality, a private company (Publimedia CORP. C.V.) and a primary school (Adolfo Cisneros Camera) in the community of "Ejidal". 30 containers were installed with the participation of schools of Playa del Carmen. The collection and maintenance of the containers will be carried out by the private company, as well as a program of environmental education in coordination with the cleansing supervisor of each school.

d. Cleaning of beaches

On October 5 of 2002, the Environmental Office in coordination with the Tourism Office of the Municipality of Solidaridad carried out a cleaning of beaches in commemoration of world day celebration of "The International Cleaning of Beaches" with the participation of high school students in beaches of the city of Playa del Carmen.

e. Infantile Scientific Encounter "For a always healthy planet"

On January 30 of the current year, an Infantile Scientific Encounter was carried out with the participation of children between 8 and 15 years old from public and private schools of the Municipality of Solidarity in topics like songs, poems, essay exposition, poster, drawing and story, with the cooperation of different offices of the Municipality and private sponsor entities.

f. Professional training

Development of courses for professional training:

- Ecological architecture
- Environmental Impact Assessment
- Tourism, sustainability and environment
- Basic and modern techniques for wastewater treatment.

g. International event "Riviera Maya Eco'03"

On June of 2003 an event was carried out with magisterial conferences, expositions, round table, environmental education workshop (recycling of paper), among other, for the environmental protection of Solidaridad.

h. Other Activities of Environmental Education in Solidaridad

Several non government organizations (NGO) and eco-tourist parks develop activities of environmental education: among these stand out Clean Planet, MOCE YAXCUXTAL A.C. and the Ecological Center of Akumal; Gea Urbilla in Tulum (in representation of Pronatura); Xel Ha Park and Xcaret Park.

i. State Plan of Environmental Education

SERMANAT through the Training Center for Sustainable Development (CECADESU) is promoting in each federative entity a State Plan for Environmental Education. In Quintana Roo this initiative is summed up by the University of the Caribbean in cooperation with the University of Quintana Roo. They are defined planning workshops with the educators of North and South sectors and the edition of respective results.

C.4 Other Issues of Environmental Sanitation

C.4.1 Industrial Waste Management

C.4.1.1 Introduction

The growth of the industrial sector has been regarded as crucial for the socioeconomic development of Mexico. The generation of permanent jobs, increased productivity and the growth of annual income depend largely on industrial activities. However, the lack of regulatory systems for the industrial sector generates negative impacts to the environment and human health; e.g. water scarcity and pollution, depletion of natural resources, energy problems, hazardous and non-hazardous solid waste, illness, etc., are some of the common problems related to industrial activity.

The federal government through the General Law of Waste Prevention and Integral Management has classified waste in different manners according to their characteristics: hazardous waste, waste of special management, and urban solid waste. It is important to mention that industrial waste may be considered as both hazardous and non-hazardous. According to the Centre of Environmental Quality, industrial waste is non-hazardous when it derives from construction and demolition activities. In Article 3, Section XXXII, Chapter 1, Title I, LGEEPA (General Law of Ecological Balance and Environmental Protection) defines as **hazardous waste** all waste that has *corrosive, reactive, explosive, toxic, flammable and biological-infectious characteristics that may cause dangers to the environment and ecological balance. Likewise it can be identified by its physical condition and chemical composition, e.g. pitch, solvents, lubricants, containers, sediments, dust, catalysts, noxious gas, etc.*[11]

Proper infrastructure for control of industrial waste in Mexico is very limited; in fact it was until 1970 that environmental regulations started to be enforced. According to statistical data from INE (National Institute of Ecology), only a quarter of the total annual generated amount of industrial waste is treated. This lack of infrastructure for control of hazardous and non-hazardous industrial waste, plus the absence of an inventory indicating the type and volume of industrial waste generated annually, causes great environmental impact. According to a 1999 report by INE, it was estimated that Mexico generates 8 million tones of hazardous industrial waste per year. From this, solvents and oils constitute more than 45% of the total; following with 10% are acids and resins; and finally paints and varnishes constitute 8%.

According to the highest concentration of industries per region, Mexico has been divided into five zones: Centre, North, Golf, Southeast and Border zone. Most industrial waste, 61% is

generated in the Central Zone, which includes Mexico City while only 3% is generated on the Southeast area, from which Quintana Roo forms part.

C.4.1.2 Legal framework

All industrial waste, hazardous and non-hazardous, is subject to control by the three government levels. The regulation of hazardous industrial waste is competence of the federal level; waste of special management and non-hazardous industrial waste are regulated by state governments and; urban solid waste is competence of the municipalities. Some laws and norms are the following:

- General Law of Ecologic Balance and Environmental Protection (LGEEPA)
- General Law of Waste Prevention and Integral Management
- Mexican Official Norms (NOMs)
- Law of Ecologic Balance and Environmental Protection of the State of Quintana Roo
- Municipal Organic Law of the Free and Sovereign State of Quintana Roo

a. Federal competence: Hazardous Industrial Waste

According to the Article 7, Title II, of the General Law of Waste Prevention and Integral Management, it is competence of the federal government:

I. To issue Mexican Official Norms (NOMs) and procedures for the management of hazardous waste.
II. To issue regulations to control the integral management of miner-metallurgist waste.
III. To regulate and control of hazardous waste coming from small generators, big generators and micro-generators.
IV. To regulate environmental aspects related to the haulage of hazardous waste.[12]

INE and SEMARNAT are the competent institutions responsible for the control and regulation of this type of waste. On the one hand, INE is in charge of the research, development and implementation of the Manifests of Environmental Impact. On the other hand, the federal government regulates the management of hazardous industrial waste through SEMARNAT. Specifically, the LGEEPA refers to all hazardous materials and waste (including industrial waste) in Chapter VI (articles 150-153) on the Title IV of Environmental Protection.

- Article 150 affirms that the management of hazardous waste should be done according to the law, regulations and NOMs issued by SEMARNAT.
- Article 151 determines that the management and final disposal of hazardous waste is responsibility of the generator.
- Article 152 establishes that SEMARNAT will promote programs aiming to reduce and prevent the generation of hazardous waste.

[11] The complete list of hazardous industrial waste can be found in the NOM 052-ECOL-1993.
[12] For a complete list of roles please consult the General Law of Waste Prevention and Integral Management.

- Article 153 mentions that the import and export of hazardous waste will be subjected to restrictions issued by the federal government.

SEMARNAT, on regard of hazardous waste, which includes industrial waste, has eight official norms (NOMs).

NOM-087- ECOL-1995: Requirements for separation, storage, collection, haulage and final disposal of biological-infectious waste generated on medical institutions.
NOM-052-ECOL-1993: Characteristics of hazardous waste, a list of this type of waste and the limits that turn waste in hazardous according to its toxicity to the environment.
NOM-053-ECOL-1993: Procedure for carrying out the extraction test in order to determine the components that turn waste in hazardous due to its toxicity to the environment.
NOM-054-ECOL-1993: Procedure to determine the incompatibility between two or more types of waste considered as hazardous by the NOM-CRP-01-93.
NOM-055-ECOL-1993: Requirements that should accomplish the sites assigned for confinement of hazardous waste, excepting radioactive waste.
NOM-056-ECOL-1993: Requirements for the design and construction of complementary works for the controlled confinement of hazardous waste.
NOM-057-ECOL-1993: Requirements that should be considered in the design, construction and operation of cells for the controlled confinement of hazardous waste.
NOM-058-ECOL-1993: Requirements for the operation of hazardous waste confinement

Furthermore, there are 3 additional norms concerned with the management of hazardous waste[13], 21 norms for its transport[14] and 7 manifests and reports concerning their generation and management by companies. Yet, the surveillance of law enforcement is responsibility of PROFEPA (Federal Attorney of Environmental Protection).

It is vital to mention that latest reforms in LGEEPA (Art. 11) allow the establishment of agreements among the federal, state and municipal level concerning the management of industrial waste considered of low danger.

b. State competence: waste of special management

According to modifications made by the federal government[15], it is now competence of the state (through SEDUMA) the regulation of waste of special management, which may be defined as waste that does not have the characteristics to be considered hazardous nor municipal solid waste[16]. According to the modifications of October 08, 2003, hazardous waste generated by micro-generators must be regulated by the state. Furthermore, non-hazardous industrial waste is regulated by the state as well.

On Article 9, Title II, of the General Law of Waste Prevention and Integral Management it is affirmed that is competence of the state the elaboration of programs concerning waste of

[13] NOM-001-ECOL-1996, NOM-007-ECOL-1993 and NOM-008-ECOL-1993.
[14] NOM-002-SCT2-1993, NOM-003-SCT2-1993, from NOM-004-SCT2-1994 to NOM-012-SCT2-1994, NOM-018-SCT2-1994, NOM-019-SCT2-1994, NOM-021-SCT2-1994, from NOM-023-SCT2-1994 to NOM-025-SCT2-1994, NOM-027-SCT2-1994, NOM-028-SCT2-1994, NOM-043-SCT2-1995, NOM-EM-008-SCT2-1995, NOM-EM-020-SCT2-1995
[15] Modifications made on SEMARNAT's Official Magazine on October 08, 2003.
[16] Article 5, Section XXX of the General Law of Waste Prevention and Integral Management.

special management and the authorization of its management. On Title III, Article 19 classifies such waste as:

1. Wastes of rocks that can be used for the production of construction materials.
2. Wastes of health services.
3. Wastes generated by fishing, agricultural, forest and cattle activities.
4. Wastes of transport services (consequence of the activities in ports, airports, train stations, etc).
5. Mud coming from residual waters.
6. Wastes of construction, maintenance and demolition.
7. Technological wastes coming from computer industries, electronic and car production.
8. Wastes generated by shopping malls
9. Other types of waste determined by SEMARNAT, states and municipalities.

c. Municipal competence: Urban solid waste

It is competence of the municipalities the control of urban solid waste, that is waste generated by residents. From Article 149 to 160 of the Law of Ecologic Balance and Environmental Protection it is mentioned that is competence of the municipality the promotion, regulation and installment of municipal systems of collection, storage, haulage and final disposal of waste. Specifically, Article 155 refers to the proper installment and operation of management systems of urban waste.

Finally, it is important to mention that Mexico has signed some international conventions, like the Basel Convention, which was adopted in 1990. Such agreement refers to the Control of Transboundary Movements of Hazardous Waste.

C.4.1.3 Inventory of business entities by municipalities[17]

On the three municipalities, as in the rest of the state, the industrial sector is incipient. It consist mostly of micro manufacture industries and concentrates in the food, tobacco, beverage, wood products and paper sub sectors. The current industrial infrastructure is concentrated in three parks: Puerto Morelos in Benito Juarez, Felipe Carrillo Puerto and Chetumal in OPB. However, in order to diversify the economy, the state government is developing a program which intends to promote the industrial sector. Among the projects it has been considered the establishment of the following plants: a citric processor plant, jalapeño chili dehydrator and processor plants, a marmalade production plant and a vegetable production plant. Yet, this is still a project.

Othón P Blanco

This municipality has been characterized for its administrative functions and lately for the development of tourism. Industrial activity is low, consisting mostly on micro industries and on an industrial park where once there were 41 industries settled (nowadays there are less than 10). Furthermore, in San Rafael Pucté there is a sugar industry, which diversifies the economy of rural communities in the south of the state.

Solidaridad

This municipality is characterized for the development of the touristic sector. Industrial activity is scarce, consisting mostly in tortilla shops and other micro industries. Yet, the construction industry is growing quickly due to the development of urban and touristic infrastructure.

Felipe Carrillo Puerto

In this municipality industrial activity consists mostly in the manufacture industry, with small workshops and sawmills, products made with wood and handicrafts. There is also an industrial park with 20 industries.

C.4.1.4 In-house management

According to INE (2000), there are 248 industries in Quintana Roo generating 48.68 tones of hazardous waste per year. In order to know the process of industrial waste management in the municipality, a survey was conducted among several industries. From the industries surveyed, some where located in the industrial park and others in Chetumal and Subteniente Lopez. On the case of the industrial park, due to the type of industries settled there, waste is not considered hazardous but waste of special management[18]. The only industry which generates hazardous waste is Turbo gas Xul Ha, a substation of the Federal Electric Commission.

Regarding management of hazardous liquid waste, all places that change oil and filters in Chetumal, have to be registered with PROFEPA (Federal Office for Environmental Protection) who is responsible for the control on the quantity and collection frequency of oil. Companies responsible for collecting used oil are from Merida. Furthermore, car batteries are collected every two weeks by the companies that produce them[19].

[17] An inventory of business entities by municipalities will be on the Annex.
[18] Because it does not have corrosive, reactive, toxic, flammable nor biological- infectious characteristics.
[19] Information taken on: Hiram Diaz. (2003) Recycling Report.

Consorcio Lechero S.A. de C.V.

This is a dairy industry which produces yogurt, cream and different types of cheese. Located on the Chetumal industrial park, this company has close to 20 employees. As a result of the industrial process, its waste is composed mainly of tetra pack cartons, plastics and serum. Everything but the serum is stored in plastic bags and disposed in an open-space incinerator located on the company's backyard. There are containers located within the installations where employees dispose their personal waste and these are also emptied on the incinerators. All solid waste is disposed together; there is no separation of materials at all. There are also small piles of scrap (steel waste), which were once part of the equipment. Regarding the management of liquid waste, there are not water treatment plants but only a tank where serum is temporary stored. Later on, this serum is sold to local farmers who use it to feed their pigs.

In sum, there is no appropriate infrastructure for waste management. Everything is disposed on the soil and burned in an open-space incinerator. The company does not use to recycle resources and staff does not receive any kind of training regarding waste management.

Cambium S.A. de C.V.

This industry produces wood floors which are exported to the United States. Located on the industrial park, it has almost 300 employees which work on the production of unfinished and prefinished wood floors made with different types of lumber. Its waste consists mostly of wood pieces (that do not have the quality conditions required by the market), sawdust, plastics, paints, solvents, sealers and other chemicals used in the industrial process. All wood waste is collected and transported with trucks rented to Buena Fe Constructions, and temporarily disposed in a courtyard owned by the company. The other materials (sawdust, plastics, paper, oils and chemicals) are disposed in metallic containers and later on transported to an illegal dumping site, where everything is thrown altogether without distinctions and afterwards burnt[20].

This company does not have an adequate plan for waste management. Everything is thrown away without control and non recycling activities are promoted. Due to the lack of appropriate systems of waste management, staff is not trained in this regard.

Turbo Gas Xul Ha

Due to regulations indicated in LGEEPA, the Federal Electric Commission (including its substations) has to submit a biannual report to SEMARNAT regarding recycling, treatment,

[20] Information given by some workers of the company. For pictures, consult the Annex.

incineration or confinement of their hazardous waste. In OPB, the Xul Ha turbo gas substation, responsible for the generation and distribution of electric energy, generates hazardous waste which consists mainly in stow impregnated of used lubricant oils (considered as toxic waste). According to the reports submitted to SEMARNAT, from 2000 to 2003, the substation did not send any hazardous waste to recycling, treatment, incineration or confinement. Yet, in 1999 the substation emitted 160 kilos of impregnated stow, which was stored in the substation and later delivered.

Regarding waste management, the substation has a warehouse for control of hazardous waste, where waste of lubricant oils is collected daily and stored in metallic containers of 200 liters. Waste is not treated within the substation and neither there is equipment for control of contaminants (like control to the emissions of dioxide sulfur, which is generated on the substation). Lubricant oil is sold every year for recycling and impregnated stow is incinerated. The report does not mention to which company the lubricated oil is sold and neither where the hazardous waste is finally disposed.

Calquin Industries S.A. de C.V.

Located near to Calderitas, this industry produces lime for commercial purposes. Its waste is composed mainly of rock pieces, dust, some metallic pieces and used oil (combustoleo), which is used on the boilers for the process of rock calcination. One of the problems with combustoleo is its high concentration of sulfur and vanadium, which may cause deterioration in the quality of air if it is used without control. Calquin is responsible for the emission of particles to the atmosphere as dust or ash, which causes problems to public health (irritation on the respiratory tract and reduction on the functions of the lungs) and the environment (reduction of the photosynthesis process when it falls as acid rain). Furthermore, there were small piles of lime rendered all over the ground; the problem with it is that when combined with rainfall, it filters to the aquifer and pollutes. However, when interviewed, the manager said that they do not emit any kind of waste and that only small quantities of waste (cartons, plastic, metallic pieces) are disposed on their land. He said that there was no need of a waste management system due that his industry does not generates waste, neglecting in this way that the industry's waste is a source of atmospheric pollution.

Artistic Ironworks "Ruben Perez Ventura"

Located in Chetumal, this business specializes in the production of metallic curtains, window protectors, metallic doors, etc. On general terms, this industry is regulated by SEMARNAT due to noise pollution (which can be defined as unwanted or offensive sounds that unreasonably intrudes into our daily activities). Yet, this industry also generates hazardous waste such as steel, lead and cadmium, i.e. there is a considerable amount of metals and

scraps that are abandoned without control on the fabric yard. According to the survey, all iron waste is disposed on the ground, not in containers and nothing is separated nor recycled. The municipality collects every four months all iron waste accumulated and send it to fuse companies in Merida.

In sum, this industry does not have any system of waste management and all residues of paint, solvents and other chemicals are just left on the yard. The main problem is that the continuous generation of metallic waste may cause serious problems to human health and the environment. In other words, waste does not receive any kind of treatment at all and staff is not trained on how to manage hazardous waste.

"Proplas" Plastic Company

Proplas is the only business in Othon P Blanco that produces plastic products for the market. They produce red, green and white plastics where household cleaners are stored. Waste is usually composed of papers and rest of plastics. The owner said that all rest of plastics are recycled, meaning that plastic of the same colors are grinded together in a mill and used again as raw material. However, the business does not use to recycle used plastic (or used bottles); they do not buy used plastic materials. The rest of the waste: papers, cartons and plastic bags, are usually stored in plastic bags which are placed within containers and finally collected by the municipality collection service. Regarding staff training, some people are trained on how to recycle plastic, that is, they are thought by the owner on how to cut, split and grind the resources.

Ligna International

Like Cambium S.A. de C.V., this industry (with about 50 or 60 employees) also produces wood floors to export to the US and other countries. Solid waste is usually composed in its majority of wood pieces and sawdust, although there is a considerable amount of plastics and papers. Liquid waste is usually composed of paint, oils and resins. There is no separation of solid waste, everything is placed together directly on the ground in the yard of the company. Each production area has collection staff that takes waste to the general storage site and according to the information given, collection service is given twice a week by a person who owns a truck; the company pays him for the service. This person should in theory take all waste to the municipal disposal site but instead he disposes it on a piece of land he owns because it is nearer to the company, than the public disposal place. The company does not give any kind of treatment to the waste they generate, they only pay for collection. However, they are accustomed to use some wood waste (like sawdust) on the cauldrons. Yet, they still throw away a huge amount of wood together with oil filters and other materials. It is important to mention that sometimes the company gives away pieces of wood waste to the

prisoners of the local jail, who use it to make wood handicrafts in order to sell them; however, the amount given to them is very low.

In sum, Ligna International does not have an established and organized industrial waste management system. Waste is thrown and disposed without control in the collector's backyard.

C.4.1.5 Management outside business entities[21]

This aspect refers to the management of industrial hazardous waste by specialized companies which have been approved by SEMARNAT. According to the federal law, the management of hazardous industrial waste is responsibility of whoever generates it (by disposing it themselves or by hiring specialized management companies), yet, in any activity concerning waste management, they have to observe the requirements by law stated. According to SEMARNAT, in Mexico there are 156 authorized companies for treatment and confinement of industrial hazardous waste, although only one in Quintana Roo. Despite the fact that the infrastructure for management has been growing, the capacity of management is very limited and only a small portion is treated, recycled or transported in satisfactory environmental or technical conditions. It is estimated that on a national level only 12% of hazardous industrial waste is properly controlled. Some of the activities developed for the control of industrial hazardous waste are the recycling of oils, solvents, energetic waste, waste with metals, exportation of polluted waste and confinements.

Finally, it is important to mention that since the launch of the 'Programme for the Integral Management of Hazardous Industrial Waste 1996-2000', SEMARNAT developed the CIMARIs (Integral Centers for Management and Exploitation of Industrial Hazardous Waste), which may be described as industrial facilities which use waste as input for new productive lines in processes of recycling and recuperation of resources and energy.

C.4.1.6 General comments

During the last two decades there has been an increase on the awareness of the potential damages caused by the uncontrolled generation and disposal of industrial waste, especially hazardous waste. Notwithstanding that Mexican industry is currently being subjected to more environmental policies and regulations, there is still a huge vacuum on environmental awareness by different society sectors: civil society, government levels and the industrial sector. This lack of interest and information may owe to the insufficiency of law's enforcement by the competent authorities, public opinion disinformation, lack of incentives for the proper reduction and treatment of industrial waste, lack of waste management

[21] For a complete list of the specialized companies please consult the Annex.

infrastructure, inexistent agreements between the three government levels and the industrial sector, non-developed markets and finally insufficient surveillance. For example, on the industrial park in Chetumal, there is neither control nor surveillance on the disposal of industrial waste.

Ideally, hazardous industrial waste should be reused or recycled. If not possible, it should be stored in safe containers and sent to incineration, reduction, neutralization and confinement in special sites. Yet, on the specific case of the municipalities where the Study Team is working, industries do not have an integrated and organized industrial waste management system, particularly in Othon P Blanco. The collection, storage, haulage and final disposal of industrial waste is not controlled despite the fact that already exist standing regulations. Law enforcement is almost inexistent.

It is necessary that all industries in Quintana Roo and in the country have an adequate system of waste management in order to halt the continuous generation of corrosive, reactive, toxic and flammable industrial waste, which jeopardizes public health and the environment.

C.4.1.7 Bibliography

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C.4.2 Medical Waste Management

C.4.2.1 Legal Framework of Solid Waste Management

a. Laws, Norms and Regulations

- Organic Law of the Public Federal Administration; competence of the federal ministries, Article 32 B, Sections IV, V and XII
- General Law for the Prevention and Integral Management of Waste (October 08th, 2003)
- Regulations of the General Law of Ecological Balance and Environmental Protection in Regards of Hazardous Waste (1998), Mexico.
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- NOM-087-ECOL-1994. Establishes the requirements for classification, separation, bottled, storage, collection, transport, treatment and final disposal of hazardous biological-infectious waste that are generated in places that offer medical care such as hospitals and consultation rooms as well as in clinic laboratories, laboratories of biological, teaching and research production for both human and veterinarian laboratories

b. Government departments that regulate and control the management of waste

Regarding hazardous waste and waste of special management, the current environmental legislation and the Organic Law of the Public Federal Administration that in its Article 32 *Bis*, Section IV, state that it is competence of the SEMARNAT the following: to establish, altogether with the participation of other departments and the municipal and state authorities,

Mexican official norms in respect of the preservation and restoration of the quality of the environment; on the natural ecosystems; on the sustainable exploitation of natural resources and wild flora and fauna, aquatic and terrestrial; on discharge of wastewater and mining resources; and on hazardous materials and hazardous solid waste; and the Ministry is responsible for regulation and control through its two decentralized institutions: the National Institute of Ecology (INE) and the Federal Office for Environmental Protection).

c. Responsible authorities and their functions

It is responsibility of INE to elaborate policies and legal ordinances for the control of waste of special management and hazardous waste, as well as to emit the respective authorizations, with the support of local offices of SEMARNAT. On the other hand, PROFEPA and its local offices oversee the execution of environmental legislation in respect of such waste.

Anyone who pretends to carry out works and/or public or private activities that may generate hazardous waste should have the authorization of INE and should be registered in the respective record.

The management of hazardous waste implies the set of operations that include storage, transportation, reuse, treatment, recycling, incineration and final disposal of this kind of waste. All these activities require the authorization of the National Institute of Ecology.

C.4.2.2 Inventory of hospital centers[22]

a. Othon P Blanco

At a municipal level there are 84 medical units from which 2 belong to the IMSS, 2 to ISSSTE, 1 to the Ministry of National Defense, 1 to the Marine Ministry, 72 to SESA and 6 to DIF. All these units belong to the government health sector. On the side of the private health sector there are 12 private hospitals. On the table below it can be appreciated:

Table C-59: Medical Units in Othon P Blanco

Medical units and material resources Othon P Blanco	
Public sector medical units	84
Private sector medical units	12
Beds subject to census in public sector medical units	159
Beds subject to census in private sector medical units	25

In regards of the management of hospital waste SESA has granted the collection service to a company located in Merida.

[22] Source: Departments and institutions which are in charge of the coordination of the health services in the state. State Ministry of Health.

b. Felipe Carrillo Puerto

The municipality holds thirty eight medical centers, which are composed on the following way: 1 which belongs to IMSS, 1 to ISSSTE, 33 to SESA, 22 to DIF and 1 to INI. The hospital centers may be seen in the following table:

Table C-60: Medical units in Felipe Carrillo Puerto

Medical units and material resources Felipe Carrillo Puerto	
Public sector medical units	38
Private sector medical units	3
Beds subject to census in public sector medical units	27
Beds subject to census in private sector medical units	0

c. Solidaridad

The health infrastructure in the municipality is composed of 13 medical units, from which 8 belongs to SESA, 1 to IMSS, 1 to ISSSTE and 3 to DIF. The following hospital centers are:

Table C-61: Medical units in Solidaridad

Medical units and material resources Solidaridad	
Public sector medical units	13
Private sector medical units	5
Beds subject to census in public sector medical units	10
Beds subject to census in private sector medical units	2

C.4.2.3 In-house management of hospital waste

a. Definition

Hazardous

According to the environmental legislation, are those wastes in any physical state that by its corrosive, toxic, poisonous, reactive, explosive, flammable and biologic-infectious characteristics represent a danger for public health and the environment.

b. Classification

- Non-infectious: waste coming from waiting areas of the area of external consulting rooms.
- Biological-infectious: coming from delivery and surgery rooms as well as those wastes coming from gynecological and obstetric rooms and those from the area of hospitalization.
- Hazardous: sharp objects such as syringes, glass, etc.

c. Separation

Within hospitals it is carried out a process of separation of waste, identifying the containers through the colors of the plastic bags placed inside. Three different colors are used: black, yellow and red. The black bag shows where non-infectious waste should be placed; the yellow bag is used for identifying the container where sharp or hazardous waste should be placed. In this case the company granted with the collection service gives white lids-red containers with yellow labels with capacity for 7 liters. The red bags are for containers with biological-infectious waste. In the hospitalization areas, where these containers are located, there are signs that explain the way in which these wastes must be separated.

d. Collection

Collection service is performed in most of the cases by staff of the company which was granted the service by the hospital administration. Cleaning activities take place three times per day. The waste collection route is indicated through the signs that are adhered to the walls.

e. Treatment

The only type of treatment given to waste by the hospital is refrigeration and this is only for organic material coming from the surgery room; the organs remain in the fridges until they are retired by the authorized company. Incineration or any other type of final disposal in hospitals is forbidden.

f. Training

Hospital staff receives training twice a year in regards of the management of biological-infectious waste. In case that the personal that collects the waste is staff from the cleaning company, the company offers training to any member that goes to work to any medical unit.

Table C-62: Type of waste disposal in the hospital centers

TYPE OF WASTE	PHYSICAL STATE	TYPE OF STORAGE	COLOUR
Blood Stored culture and stump of infectious agents Non-anatomic waste derived from the medical care to patients and laboratories	Solid	Plastic bag	Red
	Liquid	Hermetic recipients	Red
Pathologic	Solid	Plastic bag	Yellow
	Liquid	Hermetic recipients	Yellow
Used and non-used sharp objects	Solid	Rigid containers	Red

C.4.2.4 Waste management outside medical units

The collection of B.I.H.W. (Biological-infectious hazardous waste) in hospital centers belonging to the public health sector is carried out by a company called ECOLOGÍA DEL MAYAB, S.A. DE C.V.[23] which is located in Merida Yucatan. This company collects hospital waste twice a week.

Ecología del Mayab, gives red-lid plastic containers to hospitals. Such containers have capacity for 50 liters and they are used for gathering hospital biological-infectious waste. They are located in a special room outside the hospital.

The Ecología del Mayab S.A. de C.V company uses a model C-225 incinerator with containers, in order to give final treatment to biological-infectious waste.

Table C-63: Company that gives treatment to biological-infectious waste

AUTHORIZATION	COMPANY	ADDRESS	STATE	MUNICIPALITY	CAPACITY	UNIT
31-50-PS-VIII-10-99	ECOLOGÍA DEL MAYAB, S.A. DE C.V.	STREET 17-A No. 101-B, BETWEEN 12 Y 14, COL. ITZIMNÁ, C.P. 97100	MERIDA	YUCATAN	102	KG/HR

C.4.2.5 Final comments

Regarding the management of hazardous waste, hospitals look to observe the requirements established by the NOM-087-ECOL-1994. The PROFEPA is in charge of auditing, emitting recommendations and imposing sanctions in the cases deserve it. According to the General Law for Prevention and Management of Integral Waste, enforced in October 08, 2003, it is faculty of the states to authorize and to control waste generated or managed by microgenerators as well as to impose the sanctions that proceed.

[23] ANILLO PERIFÉRICO PONIENTE, C.P. 93300, TEL: 9270066, FAX:9270066, EMAIL: ecomab@sureste.com

Annex D

Assessment of the Present Situations and Confirmatoin of Key Problems

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D Assessment of the Present Situations and Confirmation of Key Problems

D.1 Introduction

In this chapter, present situations described by the previous chapters are assessed and key problems to be addressed in subsequent stages in the study are confirmed. When carrying out these issues, it is important to have a same viewpoint in common among the concerned organizations to the study. One of things that gives us such viewpoint is the study objective. The main objective of the study is:

"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."

In fact, it is expected that environmental sanitation management is to be carried out properly based on a Master Plan formulated in the study, and this contributes preservation of aquatic environment in the study area. However, there exists a question what the aquatic environment is.

Various counterpart agencies, C/P, are involved in the study. Respective agencies have respective objectives and targets. Meanwhile, resources and time allowed for the study team, S/T, are limited. Therefore, it is indispensable to have common objective to bring about fruitful results by integrating efforts and resources of all relevant agencies.

In order to have such common objective, what the most important aquatic environment has been discussed among C/P and S/T from viewpoints of the study objective, characteristics of the study area and sustainable development as described in D.2.

D.2 Assessment Criteria

D.2.1 Aquatic Environment to be Addressed

Among C/P and S/T, it has been discussed what the most important aquatic environment in view of environmental sanitation. In conclusion, we have reached a point that **groundwater is the most important aquatic environment to be addressed in the study.**

At the beginning, C/P was asked to raise important aquatic environment from respective viewpoints. Those are Mesoamerican Coral Reef, System of Cenotes and Caves,

Groundwater, Chetumal Bay and Rio Hondo. Next, problems regarding environmental sanitation that C/P has at present were presented and briefly analyzed as shown in Figure D-1.

It schematizes link between environmental sanitation and aquatic environment. Wastewater discharged is not necessarily collected by sewer pipe; it also goes septic tanks, latrines, etc. Then, the wastewater contaminates the groundwater. Even wastewater collected by sewer pipe has a possibility to contaminate the groundwater, because treated wastewater by a plant is injected to the ground. Many house wastewater drainages are connected to storm water pipe, and then it contaminates seawater directly. Solid waste discharged is carried to dumping site, and leachate generated at the site contaminates the groundwater. Waste that is not collected is often carried by storm sewer and contaminates the sea. As the figure shows clearly, the groundwater has many and significant links with environmental sanitation,

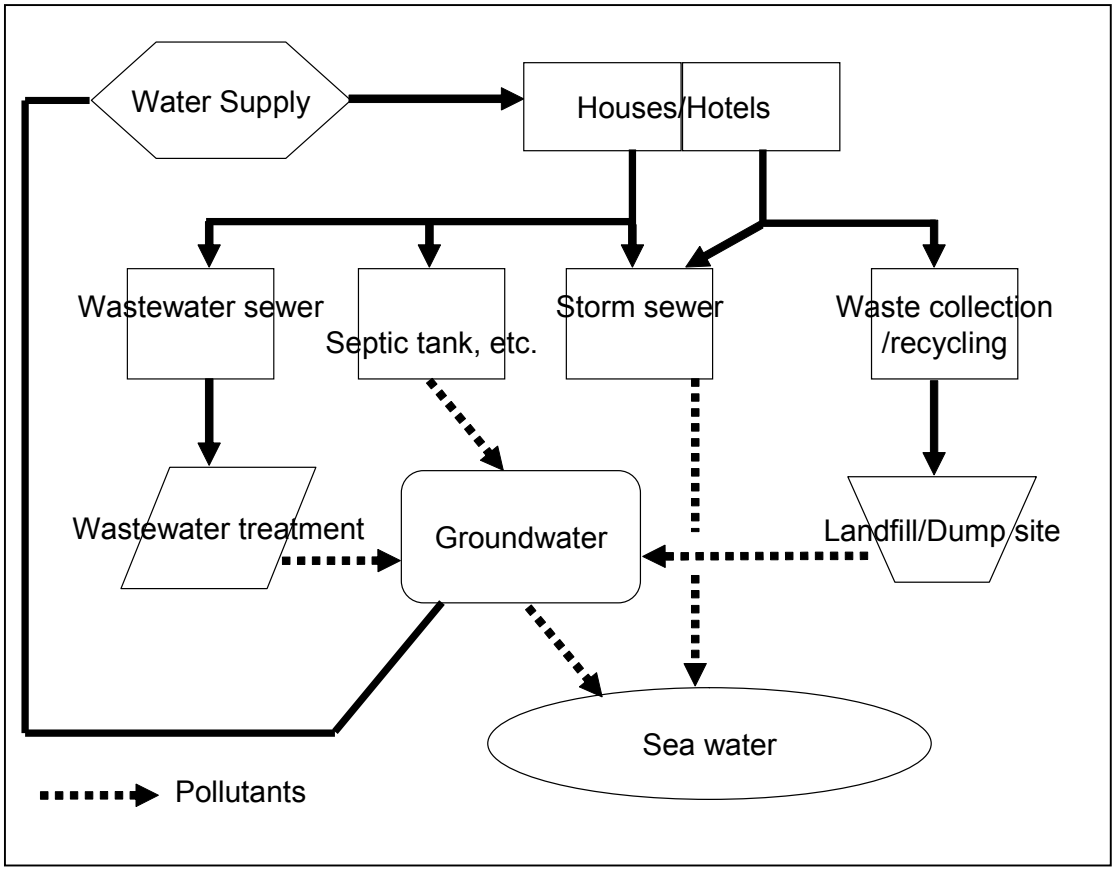

Figure D-1: Link Structure of Environmental Sanitation and Aquatic Environment

On the basis of the understanding on the present situations of environmental sanitation, it is confirmed that if this situation is left as it is and the tourism development proceeds, the groundwater, which is only source of water supply and has links between other aquatic

environments, is facing threats of pollution and depletion. Then, it would be a significant factor to hampers sustainable development of the study area in the future as shown in.

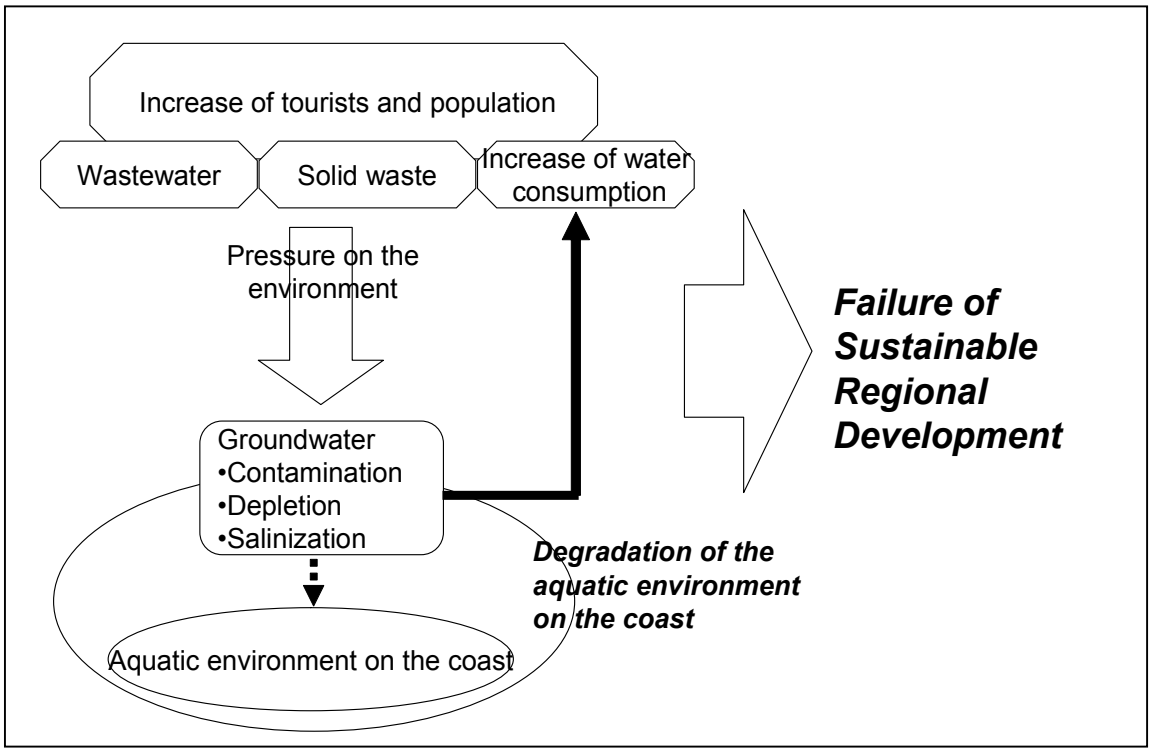

Figure D-2: Groundwater and Sustainable Development

D.2.2 General Purpose of Environmental Sanitation

Environment sanitation is generally synonymous with sanitation. To strengthen different points, sanitation tends to focus on improvement of living environment and habit in view of prevention of diseases. Meanwhile, environmental sanitation tends to talk about broader environment affected by wastewater discharge and solid waste disposal such as soil and water contamination. Therefore, hygiene should be taken into account for assessing the present situations.

D.2.3 Sustainable Development

This study is one of development studies having a purpose to contribute sustainable development of a targeted area and its country. Figure D-3 shows position of the study towards sustainable development of the study area. In fact, the study is a preparation stage to implement appropriate environmental sanitation management. The appropriate management contributes to groundwater preservation. It contributes to conservation of aquatic environment. Then, those lead to sustainable development of the study area, i.e., harmonization of tourism development and nature conservation.

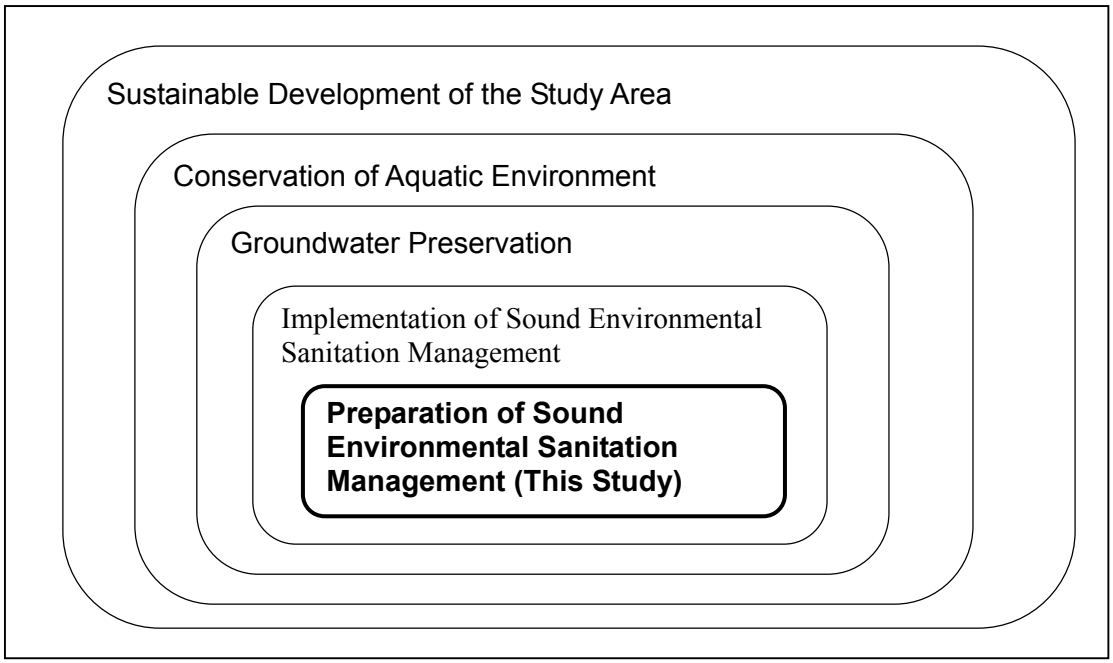

Figure D-3: The Study and Sustainable Development of the Study Area

D.2.4 Assessment Criteria

According to the discussion above, the present situations will be assessed in views of principally

- groundwater,
- hygiene and
- sustainable development.

D.3 Assessment and Key Problems

Assessment here means to judge the present situations from the viewpoints mentioned above. Meanwhile, key problems describe what the present situations should be in the future, which are induced from the assessment.

D.3.1 Wastewater Management

D.3.1.1 State Level

Key Problem 01

A system to integrate data and activities carried out by various institutions should be established.

Assessment 01

- Various observations on coastal water body and freshwater body 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 tourist industry has been developed rapidly and many injection wells of wastewater exist.

Key Problem 02

It should be considered necessity of specific regulation on water management with purpose to protect groundwater.

Assessment 02

- CNA has an intention to create a new regulation or modify existing regulation on water management in order to make them suit to specific geological condition, limestone terrain, of Yucatan Peninsula.
- Hotels are large water consumers and wastewater dischargers. Wastewater treatment facilities in hotels are not necessarily sufficient.

Key Problem 03

CAPA is like to be on the right track. It is recommendable to implement what they have planned.

Assessment 03

- 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 the 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 they are implemented and applied, it could result in an improvement of efficiency in general.
- CAPA has numerous data and this makes possible to implement 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.

D.3.1.2 Othon P. Blanco

Key Problem 11

Connection of house drainage to sewer pipe should be urgently promoted in Chetumal

Assessment 11

- BOD generation and discharge to the environment in Othon P. Blanco are highest in three municipalities.
- Only Chetumal has a population that makes up about 60% of total population of the municipality.
- CAPA has constructed about 8,800 connection pits that connect house drainage to sewer. However, it is estimated that houses actually have connection would be about 1,500.

Key Problem 12

Appropriate technology for rural and semi-urban areas should be established to reduce pollution road from the areas

Assessment 12

- Although there exists no operating sewerage system in the rural area at present, CAPA begins to introduce a system. However, it is concerned that the same problem about

connection to house drainage as in Chetumal would appear. A countermeasure to solve this problem is expected.

- Design parameters of the system are based on literatures, 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.

Key Problem 13

Financial status of water supply and sewer service in Othon P. Blanco conducted by CAPA should be improved. This could be achieved through improvement of 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.

Assessment 13

- The water supply and sewer services in Othon P. Blanco Municipality have resulted in financial deficits during the past three years.
- Low rate of micro-metering restricts the potential application of the 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 would be 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.

Key Problem 14

Various organizations (SEMARNAT, SEDUMA, CAPA, the Municipality, ONG, etc.) 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.

Assessment 14

- In the Municipality of Othon P. Blanco, environment education is given separately by a number of agencies and one NGO such as SEDUMA, CAPA, the Municipality of Othon P. Blanco and *"Amigos de Sian Ka'an"*.
- 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.

D.3.1.3 Felipe C Puerto

Key Problem 21

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.

Assessment 21

- An off-site system works in an area of Felipe C Puerto City, which targets only 567 residents. This leads to 3% of sewerage service coverage 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 litter/sec (432m^3/day). However, actual inflow is 1.34 litter/sec (116 m^3/day) or 27% of the rated capacity.

Key Problem 22

Appropriate technology for rural and semi-urban areas should be established to reduce pollution road from the areas.

Assessment 22

- 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 in the municipality, a certain adequate measures should be taken to meet the situation.

Key Problem 23

Financial status of water supply and sewer service conducted by CAPA should be improved. This could be achieved through improvement of 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.

Assessment 23

The water supply service in Felipe Carrillo Puerto Municipality has not paid for itself during the past three years.

- Low rate of micro-metering restricts the potential application of the 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 would be 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.

Key Problem 24

Appropriate use of latrines in rural area should be disseminated.

Assessment 24

- Latrine programs have been carried out in the past in some communities. However, due to adaptation problems and the 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.

D.3.1.4 Solidaridad

Key Problem 31

A new treatment plant should be constructed and operated to cope with increasing demand.

Assessment 31

- 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 to the rated capacity of the plant and expansion and/or construction of sewage treatment plant is urgent. In order to cope with this situation, CAPA has a plan to construct a plant having a capacity of 360 liter/sec (31,110 m^3/day).

Key Problem 32

Appropriate technology for rural and semi-urban areas should be established to reduce pollution road from the areas.

Assessment 32

- There exists no operating sewerage system in rural area at present. However, CAPA begins to introduce the sewerage system in the rural area and gets to work on a small scale collective sewage treatment facility and a sewer system at Puerto Aventuras and Akumal in Riviera Maya.
- Design parameters of the system are based on literatures, 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.

Key Problem 33

The good finance status should be sustained with 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.

Assessment 33

- 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 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 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.

D.3.2 Solid Waste Management

D.3.2.1 State Level

Key Problem 01

The framework where the state government and the municipalities collaborate on SWM should be encouraged in order to cope with the new requirements.

Assessment 01

- New and various requirements in SWM arise along with economic development such as collection service for growing population, sanitary landfilling and recycling, however the municipalities are not so capable as to meet with the requirement.
- 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.

Key Problem 02

Final disposal in the municipalities should be improved. Projects conducted by SEDUMA, which is for new landfills construction in Chetumal, Felipe C Puerto and Tulum, shall proceed. However, those may need to take into consideration respective conditions of municipalities, especially Felipe C Puerto and Solidaridad.

Current disposal operation manner should be improved. Closure and remediation of existing and abandoned dumping sites should be planned and implemented.

Assessment 02

- 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 would be preferable for the municipality. However, it may be difficult to realize other projects. Felipe C Puerto has pointed out high operation costs of the landfill, for which the municipality could not afford. Important aquifer may exist around the project site in Tulum.
- Any project does not consider improvement of current operation manner, closure and remediation of existing and abandoned dumping sites. Those 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.

D.3.2.2 Othon P Blanco

Key Problem 11

Management capability of the municipality should be strengthened by a careful record-keeping and introduction of indicators in order to provide stable, effective and efficient SWM services.

Assessment 11

- The waste collection works is well carried out, however, there are some threats to discontinue the good situation such as; unbalanced collection route design gives over workloads on collection vehicles and does not allow them to receive appropriate maintenance, and a long duration to obtain spare parts stays the collection vehicles away from works and it loses money.
- Final disposal amount in the site of Calderitas recorded by the municipality, about 9,000 tons of waste per month (300 ton/day), is far beyond the estimated disposal waste amount, 120 ton/day. To know correct disposal amount is fundamental not only for planning operation schedule but also for controlling operation costs. Waste amount should be recorded correctly.
- Income from 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. Then, a careful record-keeping of all service activities becomes essential to translate them into cost figures. The records will permit preparation of performance indicators of 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 solid waste management service.

Key Problem 12

The existing disposal site in Calderitas should be improved.

Assessment 12

- The disposal site in Calderitas presents a sever sanitary and environmental risk; proliferation of insects and animals, fire, leachate, etc.

Key Problem 13

A sound solid waste management including an appropriate final disposal system should be established in small towns.

Assessment 13

- There exist open dumpsites around small towns such as Bacalar. Although degree of adverse sanitary and environmental impacts is not yet significant compared with of the dumpsite in Calderitas, it may become considerable along with development in the future.

Key Problem 14

Introduction of composting should be considered chiefly from a viewpoint of financial feasibility.

Assessment 14

- The municipality shows their interest in composting. Recycling including composting is one of good manners to encourage resource conservation. However, those should be implemented based on financial feasibility to sustain their operation.

Key Problem 15

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.

Assessment 15

- In addition to the existing problems in solid waste management, new problems would arise in Costa Maya in the near future where large tourism development is expected.

Key Problem 16

The organizations (SEMARNAT, SEDUMA, CAPA, the Municipality, ONG, etc.) 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.

Assessment 16

- In the Municipality of Othon P Blanco, environment education is given separately by a number of agencies and one NGO such as SEDUMA, CAPA, the Municipality of

Othon P Blanco and *"Amigos del Sian Ka'an"*. 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.

D.3.2.3 Felipe C Puerto

Key Problem 21

The collection service coverage in the city of Chetumal should be improved.

Assessment 21

- Waste collection service is only provided to the city of Felipe C Puerto. 50% of the residents of the city is covered with the service. This is quite low service coverage for a city. The low service coverage reflects what clandestine waste dumping can be found at many places in the city.
- Poor status of collection vehicles makes it difficult to provide proper waste collection service.

Key Problem 22

Management capability of the municipality should be strengthened by a careful record-keeping and introduction of indicators in order to provide stable, effective and efficient SWM services.

Assessment 22

- Municipal records say that about 30 ton of waste is collected and disposed every day. However, estimated collection and disposal waste amount is around 10 ton/day. This misunderstanding may lead improper preparation of plan and operation. Correct waste amount should be recorded.
- The issue is the financial deficit of solid waste management service. Felipe Carrillo Puerto Municipality is provided 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. Then, a careful record-keeping of all service activities becomes essential to translate them into cost figures. The records will permit preparation of performance indicators of 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 solid waste management service.

Key Problem 23

The current dumping site should be improved immediately with taking into consideration lack of capability of the municipality.

Assessment 23

- The current disposal site is an open dumping site without control. It causes several problems such as fire, odor, proliferation of insects and animals, air pollution, groundwater contamination, etc.

Key Problem 24

Hospital waste should be carefully and separately disposed of.

Assessment 24

- Hospital waste is collected separately from ordinal waste collection service. However, it is disposed of with the ordinal waste. In order to minimize expansion of diseases, the hospital waste should be carefully and separately disposed of.

Key Problem 25

Public awareness on environmental issues should be encouraged.

Assessment 25

- 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 would be one of causes of the situation.

D.3.2.4 Solidaridad

Key Problem 31

The two abandoned dumping sites should be closed properly and immediately.

Assessment 31

- There are two abandoned dumping sites in the municipality, which have awful sanitary and environment conditions.

Key Problem 32

Financial feasibility should be taken into account for sustaining recycling activities.

Assessment 32

- 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.

Key Problem 33

Income should be improved by facilitating the application of service charges established in January 2003.

Assessment 33

- New solid waste service charges were established in January 2003, which appear to be comprehensive enough to cover the different types of service users, but maybe there 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.

Key Problem 33

Community participation in SWM should be encouraged in small towns.

Assessment 33

- 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.

D.3.3 Groundwater Management

Key Problem 01

Well design and geologic log data at construction time should be kept and maintained.

Assessment 01

- Well inventory of the Study Area is kept in the computer of CNA. However, the design of the registered well and geologic log at the construction time is not submitted and stored in the inventory. These data are important as a basis for construction of groundwater management tools, such as hydrogeological map, cross section and computer groundwater model. Particularly important are those of the injection wells.

Key Problem 02

Actual extracted and injected water amount should be recorded.

Assessment 02

- Although the inventory has the concession water amount of the well, actual amount of extraction and injection is not recorded. At least once a year, the users should report their actual amount as well as its water quality.

Key Problem 03

Inspection and monitoring system on water quality of wells should be established.

Assessment 03

- CNA should have a regular inspection on actual water amount of extraction and injection and their water quality in the selected wells at least once a year.
- Groundwater monitoring wells have been constructed recently in the area of Cancun-Tulum. Water levels and water quality is 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.

Key Problem 04

A standard on injection well should be established and enforced.

Assessment 04

- Many injection wells have already been operated in the Study Area. However, injection standard has not been established.

D.4 Detailed Assessment

D.4.1 Wastewater Management

D.4.1.1 Overview of the Study Area

a. Water Quality and Monitoring Conditions

Various observations on coastal water body and freshwater body in and around the study area have been carried out 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 tourist industry has been developed rapidly and many injection wells of wastewater exist.

In order to utilize data obtained by the various institutions for aquatic environmental management in the study area, a system to integrate their data and activities. Coordination of observation items, frequencies and timings are important for establishing the system.

b. Overview of BOD Pollution Load

Sewerage system covers limited areas in the study area. In areas without the system, wastewater is treated by septic tank or is directly discharged to sink hole. Even areas with the system, many residents are reluctant to connect their domestic drainage to public sewer, because all costs of the connection should be covered by the residents and they are not inconvenienced with the septic tank.

Final disposal is practiced in manners of open dumping or controlled dump in the study area. Neither sanitary landfill nor leachate control is found. Leachate generated percolates into underneath.

It is concerned that domestic wastewater and leachate may percolate into underneath and contaminate groundwater, as the study area is limestone region with high permeability.

In order to grasp this present situation quantitatively, BOD load caused by the domestic wastewater and solid waste is estimated as follows.

Table D-1: Assumption for Estimation of BOD Generation and Discharge Amount

Field	Item	Number of assumed
Wastewater	BOD generation amount	54 g/person/day a.
	Chetumal sewerage treatment plant	
	Inflow BOD concentration	139 mg/litter a.
	Effluent BOD concentration	1.9 mg/litter a.
	Treatment amount	645,942 m3/year a.
	Felipe Carrillo Puerto sewerage treatment plant	
	Inflow BOD concentration	101 mg/litter a.
	Effluent BOD concentration	2.2mg/litter a.
	Treatment amount	42,368 m3/year a.
	Solidaridad sewerage treatment plant	
	Inflow BOD concentration	323 mg/litter a.
	Effluent BOD concentration	11.2mg/litter a.
	Treatment amount	2,025,128 m3/year a.
Solid waste	Leachate BOD concentration	10,000 mg/litter b.
	Annual precipitation	1,290 mm/year e.
	Average high of dumping site	2 m c.
	Waste discharge rate	1.0 kg/person/day d.
	Bulk density of waste in dumping site	0.2 c.

Source: [a.] :CAPA, [b.] :Integrated solid waste management, McGraw-Hill, [c.] :Results of field reconnaissance, [d.] : SEDUMA , [e.]: Water plan 2001-2006 CNA

Table D-2: BOD Generation and Discharge Amount in the Study Area

			Othon P Blanco	Felipe Carrillo Puerto	Solidaridad	Total
Population (year 2001)		Resident	230,718	61,703	86,863	379,284
		Tourist	205,216	NA	1,504,052	1,709,268
BOD generation amount (ton/year)	Waste water	Resident	4,547.448	1,216.158	1,712.078	7,475.684
		Tourist	11.082	NA	81.219	92.301
		Wastewater total	4,558.530	1,216.158	1,793.297	7,567.985
	Solid waste	Resident	1,902.038	508.676	716.102	3,126.816
		Tourist	4.635	NA	33.971	38.606
		Solid waste total	1,906.673	508.676	750.073	3,165.422
Total BOD generation (ton/year)			6,465.203	1,724.834	2,543.370	10,733.407
Ratio			60.2%	16.1%	23.7%	100.0%
BOD generation from urban area (ton/year)			4,652.525	764.514	2,054.995	7,472.034
BOD generation from rural area (ton/year)			1,812.678	960.320	488.375	3,261.373
BOD remove amount by sewer system (ton/year)			88.559	4.186	631.435	724.180
BOD discharge from urban area (ton/year)			4,563.966	760.328	1,423.560	6,747.854
BOD discharge from rural area (ton/year)			1,812.678	960.320	488.375	3,261.373
Total BOD discharge amount (ton/year)			6,376.644	1,720.648	1,911.935	10,009.227
Ratio			63.7%	17.2%	19.1%	100.0%

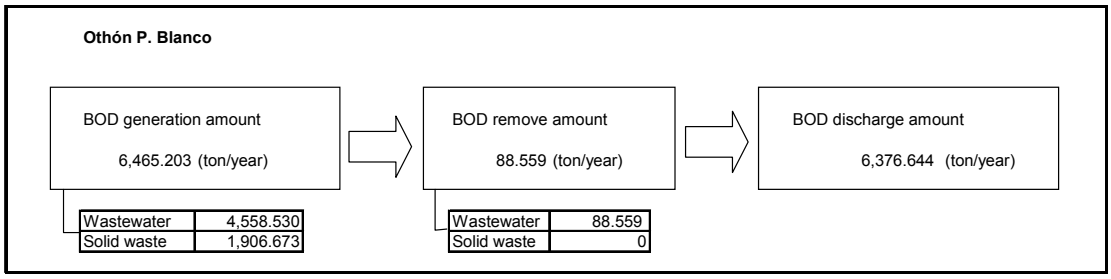

Figure D-4: BOD Balance of Othon P Blanco

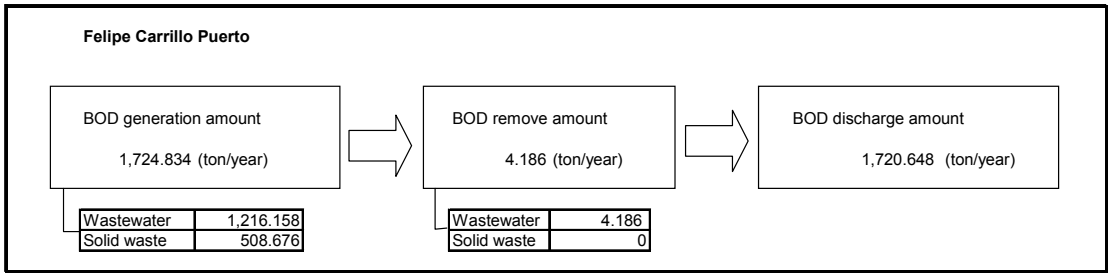

Figure D-5: BOD Balance of Felipe Carrillo Puerto

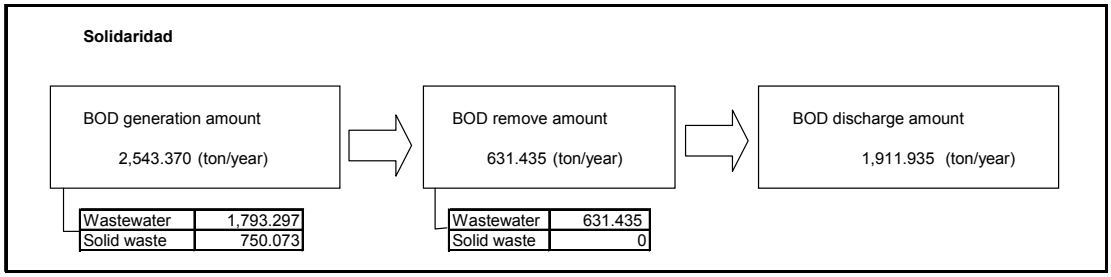

Figure D-6: BOD Balance of Solidaridad

According to the results above, BOD generation and discharge to the environment in Othon P Blanco are highest in three municipalities. BOD generation amount in Solidaridad is higher for the population as a large number of tourists visit the municipality. However, BOD reduction amount is also high in Solidaridad. Then, BOD discharge amount to the environment in the municipality is almost the same as one in Felipe C Puerto.

The estimation above says that only 7% of the BOD generation amount is removed by artificial treatment. However, it is surmised that BOD removal amount would be more than the 7% as there exist septic tanks in houses and wastewater treatment facilities owned by tourism developers.

In order to grasp BOD removal amount by septic tank, it is estimated as follows.

An investigation of wastewater treatment methods in an area without sewerage system in Playa del Carmen was carried out. As the following table shows, 24% of total population in the area was covered by septic tank, although the number of units is unknown.

Table D-3: Breakdown of Wastewater Disposal Method in Without Serer Service Area

Wastewater disposal method	Ratio
Septic tank	24%
Sink hole	72%
Latrine	2%
No system	2%

SOURCE : EVALUACIÓN SOCIAL DEL PLAN PARCIAL DE ALCANTARILLADO SANITARIO Y SANEAMIENTO DE LA CIUDAD DE PLAYA DEL CARMEN, CAPA SEPTENBER 2002

BOD removal amount is estimated as 34.6 g/person/day as shown in the following table.

Table D-4: Estimated BOD Removed Rate of Septic Tank

Intake BOD concentration (mg/litter)	250
Effluent BOD concentration (mg/litter)	90
BOD remove ratio (%)	64
BOD generation amount (g/person/day)	54
BOD removed amount (g/person/day)	34.6

Next, taking into consideration BOD removal function by septic tank, BOD removal and discharged amounts are estimated as shown in the following tables based on the following assumptions.

- Population who use septic tank is 24% of who are not covered with sewerage system
- BOD removal amount by septic tank is 34.6 g/person/day

Table D-5: Estimated Septic Tank BOD Removed Amount

Municipality	Sewer population	Without sewer population	Septic tank population	BOD removal amount (kg/day)	BOD removal amount (ton/year)
Felipe Carrillo Puerto	519	61,184	14,684	507	185.055
Othon P Blanco	6,420	224,298	53,831	1,860	678.900
Solidaridad	6,655	80,208	19,250	665	242.725
Total	13,594	365,690	87,765	3,032	1,106.680

Table D-6: BOD Discharge Amount Considering Septic Tank Effect

Item	Othon P Blanco	Felipe Carrillo Puerto	Solidaridad	Total
Total BOD discharge amount (ton/year)	6,376.644	1,720.648	1,911.935	10,009.227
Ratio	63.7%	17.2%	19.1%	100.0%
Septic tank removed amount (ton/year)	678.900	185.055	242.725	1,106.680
Total BOD discharge amount (ton/year)	5,697.744	1,535.593	1,669.210	8,902.547
Ratio	64.0%	17.2%	18.7%	100.0%

Consequently, if the septic tank system works as estimated above, 17% of BOD generation amount would be removed by the septic tank system and the sewerage system, (724.280 + 1,106.680) / 10,733.407 = 0.17).

Organic pollutants can be removed by oxidation. In the environment of surface water such as river, oxygen is supplied for decomposition of the organic pollutants, or the environment has a self-purifying function. However, the environment of groundwater has little chance to be supplied oxygen.

In the study area, wastewater and leachate percolate into underneath and they may reach the groundwater due to geological characteristic of the study area. Organic pollutants contained in the wastewater and the leachate would hardly have chance to be decomposed through oxygen supply, the groundwater that is the only source of water supply would be polluted.

Consequently, in order to preserve the groundwater, a system to treat pollutants caused by human activities should be established along with a monitoring system on contamination.

D.4.1.2 Othon P Blanco

a. Technical System

The table below shows number of communities and population with respect to population size of communities. Only Chetumal has a population more than 50,000. It makes up about 60% of total population of the municipality. Meanwhile, CAPA has a definition that communities having a population more than 2,500 are urban. According to the definition, population of urban area makes up about 70%. Pollution load such as BOD is in proportion to size of population. Therefore, it can be said that pollution load from the urban area makes up 70% of the total in the municipality.

Consequently, domestic wastewater management in the urban area has the first priority to be dealt with.

Table D-7: Population Distribution

		Population	Nos. of community
Number	More than 50,000	121,602	1
	49,999 to 15,000	0	0
	14,999 to 2,500	23,255	5
	2,499 to 100	59,920	95
	Less than 100	3,387	658
	Total	208,164	759
Component ratio	More than 50,000	58.4%	0.1%
	49,999 to 15,000	0.0%	0.0%
	14,999 to 2,500	11.2%	0.7%
	2,499 to 100	28.8%	12.5%
	Less than 100	1.6%	86.7%
	Total	100.0%	100.0%

Source : XII Censo INEGI 2000

a.1 Urban Area

An off-site system works only in Chetumal. A sewage treatment plant in Chetumal has a capacity of 137 liter/sec (11,837m^3/day). However, actual inflow is 20.48 litter/sec (1,770 m^3/day) or 15% of the rated capacity.

CAPA has constructed about 8,800 connection pits that connect house drainage to sewer. However, it is estimated that houses actually have connection would be about 1,500 based on an assumption that wastewater discharge amount would be 75% of water supply. This would be because dischargers, or residents, have to bear all costs of the connection and they do not feel inconvenience with the present septic tank system.

Consequently, the connection of house drainage to sewer pipe is a significant and urgent issue to be dealt with in Chetumal where the sewerage system is working at present.

a.2 Rural Area

There exists no operating sewerage system in the rural area at present. However, CAPA begins to introduce the sewerage system in the rural area and gets to work on a small scale collective sewage treatment facility and a sewer system in Subteninte López located southwest to Chetumal.

The system is planed to be completed around January 2004. However, it is concerned that the same problem about connection to house drainage as in Chetumal would appear. A countermeasure to solve this problem is expected.

The sewage treatment system planed in Subteniente López applies septic tank + upper flow filtration that does hardly require power. Design parameters are based on literatures, 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. It would be issues to be dealt with for considering wastewater management in the rural area; what is adequate size of community to apply the system, and what kind of alternatives could be available for communities being smaller than ones the sewage system is adaptable.

b. Management System

The water supply and sewer services in Othon P Blanco Municipality have resulted in financial deficits during the past three years. The deficit of actual income over budgeted expenditures amounted to some 30 Million Pesos in the year 2000, and 40 Million Pesos in 2001 and 2002.

CAPA is in a privileged position to have the autonomy to set the water rates, without depending on any regulatory authority. Better yet, water rates are constantly updated according to minimum wages and the national consumer price index. Water rates under five categories and detailed subcategories appear to be varied enough to fit the needs of all consumers. A combination of base rate and excess consumption rate gives users of water supply service further flexibility to choose.

However, the low rate of micro-metering restricts the potential application of the progressive water rates. It looks as if the potential to improve finances is contingent on the technical improvement of operation (micro-metering) of the water supply service. The all too common problem of rigid water rates does not exist in this case, and any efforts to fully apply the water rates are judged to be worthwhile.

Concerning charges for waste water service, defined as 20% surcharge over the water consumption, the data indicate that income from waste water service in Othon P Blanco systems accounted for less than 5% of water supply income, budgeted or actual, between 2000 and 2002, as coverage of sewer service (25% in Chetumal system, 0% in Othon P Blanco system) was quite lower than that of water supply (95% in Chetumal system, 88% in Othon P Blanco system).

There might be historical-cultural-political reasons, all quite valid, for the financial insufficiency of water supply and sewer services. If there is political will to make up with subsidies the accumulating financial deficits, and if resources are plentiful, then all is fine. Resources are, however, 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. Beneficiaries of services will have to be persuaded to assume more and more active roles in the provision and maintenance of service facilities. This implies payment of the cost of service.

To persuade service users to pay their share of service costs, it would be easier when service users are relatively satisfied with the service. This implies the need to improve all the technical and commercial aspects of operation: micro-metering, controlling water loss and illegal connections, invoicing without mistakes, clarifying the structure of service costs, reducing costs, facilitating payment, and promptly responding to customer complaints. Clearly understanding the cost structure is required in any effort to reduce costs, in addition to being necessary in the event of analyzing concession or privatization of the service. Progress in any of these aspects can be enhanced when the practice of constantly monitoring some performance indicators is introduced as a routine activity.

Fortunately, the CAPA head office has plans to complete installation of water meters (micro-metering) within the next two years, as their analyses showed that the cost of installation of micro-meters could be recovered in two years. CAPA already offers multiple possibilities of places to pay, including supermarkets, and this may be reflected in the high bill collection rate registered by CAPA. The logistics and management of increasing rate of billing will be important, as well as efforts to keep the bill collection rate high when CAPA increases de billing ratio. Overall bill collection rate of CAPA is estimated at 97%, only 3% delinquent accounts, and 70% of billing is estimated to be paid in the same month of billing. A list of performance indicators is already under consideration of CAPA top managers.

In summary, the issue is the improvement of finances. On one hand, water supply service needs to improve operations to enable 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. On the other hand, willingness to pay of users of the water supply service will need constant attention.

c. Environmental Education and Public Participation

In the Municipality of Othon P Blanco, environment education is given separately by a number of agencies and one NGO such as SEDUMA, CAPA, the Municipality of Othon P Blanco and *"Amigos de Sian Ka'an"*, among others. In formal education, environmental subjects are introduced to children starting from the pre-school age. In higher education, programs directly or indirectly related to the environment are offered in universities. In school programs, general environmental issues are included in the Natural Sciences. However, 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.

To achieve the above-mentioned objective and in view of the fact that the environment affects all, it is proposed that the various organizations (SEMARNAT, SEDUMA, CAPA, the Municipality, ONG, etc.) 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.

D.4.1.3 Felipe C Puerto

a. Technical System

The table below shows number of communities and population with respect to population size of communities. No city having population more than 50,000 exists in the municipality. The largest city is Felipe C Puerto. The population of the city makes up 30% of total municipal population. Meanwhile, CAPA has a definition that communities having a population more than 2,500 are urban. According to the definition, population of urban area makes up about 44%. Pollution load such as BOD is in proportion to size of population. Therefore, it can be said that pollution load from the rural area makes up 66% of the total in the municipality. Especially, pollution load from communities having population between 100 and 2,500 makes up large portion, 52%.

Consequently, not only domestic wastewater management in the urban area but also in communities having population between 100 and 2,500 are to be dealt with.

Table D-8: Population Distribution

Item		Population	Nos. of community
Number	More than 50,000	0	0
	49,999 to 15,000	18,545	1
	14,999 to 2,500	8,163	2
	2,499 to 100	31,548	60
	Less than 100	2,109	150
	Total	60,365	213
Component ratio	More than 50,000	0.0%	0.0%
	49,999 to 15,000	30.7%	0.5%
	14,999 to 2,500	13.5%	0.9%
	2,499 to 100	52.3%	28.2%
	Less than 100	3.5%	70.4%
	Total	100.0%	100.0%

Source : XII Censo INEGI 2000

a.1 Urban Area

An off-site system works in an area of Felipe C Puerto City, which targets only 567 residents. This leads to 3% of sewerage service coverage 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 liter/sec (432m^3/day). However, actual inflow is 1.34 litter/sec (116 m^3/day) or 27% of the rated capacity.

Consequently, the first priority in the urban area is to collect wastewater up to the rated capacity of the treatment plant. Then, the system is to be expanded.

a.2 Rural Area

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 in the municipality, a certain adequate measures should be taken to meet the situation.

CAPA begins to introduce a collective on-site sewerage system at three rural communities in the study area. The system is planed to be completed around January 2004. It is recommendable to clarify problems, to conduct improvements and to establish a manner to operate through operation of the system, then, to expand the system to other rural communities.

The sewage system mentioned above targets communities that have certain population density. It would be issues to be dealt with for considering wastewater management in the rural area; what is adequate size of community to apply the system, and what kind of alternatives could be available for communities being smaller than ones the sewage system is adaptable.

b. Management System

The water supply service in Felipe Carrillo Puerto Municipality has resulted in financial deficit during the past three years. The deficit of actual income over budgeted expenditures amounted to some 6.59 Million Pesos in the year 2000, 9.53 Million Pesos in 2001 and 8.07 Million Pesos in 2002. The service coverage was estimated at 87% for water supply and 1% for waste water service, but the income from the latter was zero.

CAPA is in a privileged position to have the autonomy to set the water rates. Better yet, water rates are constantly updated according to minimum wages and the national consumer price index. Water rates under five categories and detailed subcategories appear to be varied enough to fit the need of all consumers. A combination of base rate and excess consumption rate gives users of water supply service further flexibility to choose.

However, the low rate of micro-metering restricts the potential application of the progressive water rates. It looks as if the potential to improve finances through improved billing and collection is contingent on the technical improvement of operation (micro-metering) of the water supply service. The all too common problem of rigid water rates does not exist in this case, and any efforts to fully apply the water rates are judged to be worthwhile.

There might be historical-cultural-political reasons, all quite valid, for the financial insufficiency of water supply service. If there is political will to make up with subsidies the

accumulating financial deficits, and if resources are plentiful, then all is fine. Resources are, however, scarce by definition. Being realistic, it will likely be more and more difficult to depend on the higher levels of government to provide all necessary services. Beneficiaries of services will have to be persuaded to assume more and more active roles in the provision and maintenance of service facilities. This implies payment of the cost of service.

To persuade service users to pay their share of service costs, it would be easier when service users are relatively satisfied with the service. This implies the need to improve all the technical and commercial aspects of operation: micro-metering, controlling water loss and illegal connections, invoicing without mistakes, clarifying the structure of service costs, reducing costs, facilitating payment, and promptly responding to customer complaints. Clearly understanding the cost structure is required in any effort to reduce costs, in addition to being necessary in the event of analyzing concession or privatization of the service. Progress in any of these aspects can be enhanced when the practice of constantly monitoring some performance indicators is introduced as a routine activity.

Fortunately, the CAPA head office has plans to complete installation of water meters (micro-metering) within the next 2 years, as their analyses showed that the cost of installation of micro-meters could be recovered in two years. CAPA already offers multiple possibilities of places to pay, including supermarkets, and this may be reflected in the high bill collection rate registered by CAPA. The logistics and management of increasing rate of billing will be important, as well as efforts to keep the bill collection rate high when CAPA increases de billing ratio. Overall bill collection rate of CAPA is estimated at 97%, only 3% delinquent accounts, and 70% of billing is estimated to be paid in the same month of billing. A list of performance indicators is already under consideration of CAPA top managers.

In summary, the issue is the improvement of finances. On one hand, water supply service needs to improve operations to enable application of existing water rates through micro-metering, reduction in unaccounted for water, and improvements in water quality. These efforts should be monitored through selected performance indicators. On the other hand, willingness to pay of users of the water supply service will need constant attention.

c. Environmental Education and Public Participation

In 2002, CAPA carried out a program for sustainable potable water services and sanitation in rural communities. This program included awareness raising activities and training for water users on appropriate practices for the hygienic use of water, basic sanitation, and the operation and conservation of water resources and infrastructure in consideration of community participation. The awareness raising activities consisted of giving a simple

explanation to adults and schoolchildren on the importance and care of water and sanitation, supported by teaching aids such as videos.

According to information from the municipality of Felipe Carrillo Puerto, latrine programs have been carried out in the past in some communities. However, due to adaptation problems and the 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.

D.4.1.4 Solidaridad

a. Technical System

The table below shows number of communities and population with respect to population size of communities. Only Playa del Carmen has a population more than 15,000. It makes up about 68% of total population of the municipality. Meanwhile, CAPA has a definition that communities having a population more than 2,500 are urban. According to the definition, population of urban area makes up about 80%. Pollution load such as BOD is in proportion to size of population. Therefore, it can be said that pollution load from the urban area makes up 80% of the total in the municipality. Solidaridad has tourist centers such as Tulum and Akumal besides Playa del Carmen along Riviera Maya, which attracts about 1.5 million tourists every year. Most of the tourists stay in Playa del Carmen, then, the city is the largest pollution source in the municipality due to its residential population and tourists.

Consequently, domestic wastewater management in Playa del Carmen has the first priority to be dealt with.

Table D-9: Population Distribution

Item		Population	Nos. of community
Number	More than 50,000	0	0
	49,999 to 15,000	43,613	1
	14,999 to 2,500	6,733	1
	2,499 to 100	11,593	19
	Less than 100	1,813	263
	Total	63,752	284
Component ratio	More than 50,000	0.0%	0.0%
	49,999 to 15,000	68.4%	0.4%
	14,999 to 2,500	10.6%	0.4%
	2,499 to 100	18.2%	6.7%
	Less than 100	2.8%	92.6%
	Total	100.0%	100.1%

Source : XII Censo INEGI 2000

a.1 Urban Area

An off-site system works only in Playa del Carmen. A sewage treatment plant in Playa del Carmen has a capacity of 65 liter/sec (5,616 m^3/day). Actual inflow is 64.21 litter/sec (5,548 m^3/day), which almost reaches to the rated capacity. Besides the treatment plant, there exist activated sludge type of treatment plant and septic tanks installed to tourist facilities developed by the private sector.

CAPA has constructed about 1,800 connection pits that connect house drainage to sewer. It can be estimated based on the number of connection pits that about 6,700 residents are covered with the system and unit wastewater discharge amount is 834 liter/person/day. Meanwhile unit water supply amount is 322 litter/person/day, which is beyond the unit wastewater discharge amount. This may be caused by extraction well development at tourist facilities.

As contrasted to Chetumal where the residents are reluctant to connect their house drainage to sewer pipe and the actual inflow is fairly lower than the rated capacity of the treatment plant, in Playa del Carmen actual inflow almost reaches to the rated capacity of the plant and expansion and/or construction of sewage treatment plant is urgent. In order to cope with this situation, CAPA has a plan to construct a plant having a capacity of 360 liter/sec (31,110 m^3/day).

a.2 Rural Area

There exists no operating sewerage system in rural area at present. However, CAPA begins to introduce the sewerage system in the rural area and gets to work on a small scale collective sewage treatment facility and a sewer system at Puerto Aventuras and Akumal in Riviera Maya.

The sewage treatment system planed is the same one in Subteniente López in Othon P Blanco, which applies septic tank + upper flow filtration that does hardly require power. Design parameters are based on literatures, 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. It would be issues to be dealt with for considering wastewater management in the rural area; what is adequate size of community to apply the system, and what kind of alternatives could be available for communities being smaller than ones the sewage system is adaptable.

b. Management System

The water supply and sewer service in Solidaridad Municipality showed positive financial results during the past three years, 42.26 Million Pesos in the year 2000, 38.53 Million Pesos in 2001 and 74.56 Million Pesos in 2002. The positive balance was obtained despite the relatively low coverage in water supply service at 43%, even though coverage of waste water service was estimated at 15%. Still, the income from waste water service comprised only 2.3-5.6% of income from water supply service.

The financial sufficiency of water supply and sewer services in Solidaridad Municipality may be attributable a relatively high micro-metering rate of 56%, as well as to the 132 hotels identified in the area. An interesting exercise would be the determination of the share of hotels in consumption and income. Then, as hotels are expected to be large contributors, they should be given the importance and special care they deserve.

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 permanent basis. This includes efforts to improve all the technical and commercial aspects of operation: micro-metering, controlling water loss and illegal connections, invoicing without mistakes, clarifying the structure of service costs, reducing costs, facilitating payment, and promptly responding to customer complaints. Clearly understanding the cost structure is required in any effort to reduce costs, in addition to being necessary in the event of analyzing concession or privatization of the service. Progress in any of these aspects can be enhanced when the practice of constantly monitoring some performance indicators is introduced as a routine activity.

Solidaridad Municipality will further benefit from the CAPA head office plans to complete installation of water meters (micro-metering) within the next 2 years, as their analyses showed that the cost of installation of micro-meters could be recovered in two years. As water supply service coverage is still 43% in Solidaridad, service expansion may be done with the full installation of micro-meters. CAPA already offers multiple possibilities of places to pay, including supermarkets, and this may be reflected in the high bill collection rate registered by CAPA. The logistics and management of increasing rate of billing will be important, as well as efforts to keep the bill collection rate high when CAPA increases de billing ratio. Overall bill collection rate of CAPA is estimated at 97%, only 3% delinquent accounts, and 70% of billing is estimated to be paid in the same month of billing. A list of performance indicators is already under consideration of CAPA top managers.

In summary, the issue is to sustain the good finances. On one hand, to improve the application of existing water rates, micro-metering should be expanded beyond the estimated

56%, while keeping careful watch on unaccounted for water, and striving to constantly improve water quality. These efforts should be monitored through selected performance indicators. On the other hand, providing such information as cost and water quality to customers can enhance their willingness to pay for the water supply service.

c. Environmental Education and Public Participation

As in Felipe Carrillo Puerto, CAPA has carried out programs for sustainable potable water services and sanitation in rural communities, which included awareness-raising activities and training for water users' on appropriate practices for safe water, basic sanitation, and the operation and management of water resources and infrastructure in consideration of community participation. The awareness raising consists of giving a simple explanation to adults and schoolchildren on the importance and care of water and sanitation, supported by teaching aids such as illustrative materials and videos.

Regarding this, it is important to promote user/public participation in water management, and the control and treatment of wastewaters as well as to cultivate good habits for appropriate use in coordination with the municipality and other relevant institutions.

D.4.2 Solid Waste Management

D.4.2.1 Overview of the Study Area

a. Overview of Solid Waste Management in the Study Area

Table D-10 summarizes information on solid waste management in the study area. As the population size and waste amount show, scale of SWM in FCP is very smaller than of OPB and Solidaridad. OPB and Solidaridad have almost the same served population and waste amount, but characteristics of them are really different. Waste dealt with by the former is almost from residents. Meanwhile, the latter manages a large volume of waste from hotels and commercial activities besides from residents and has to keep up with the rapid tourism development.

Table D-10: Overview of Solid Waste Management in the Study Area

Item	Othon P Blanco	Felipe C Puerto	Solidaridad
1. Service (waste collection) population			
Urban population	175,000	28,500	134,000
Served population	110,000	9,000	113,000
2. Served (waste collection) area			
Served area	Chetumal City and several small towns	Felipe C Puerto City	Playa del Carmen and several small towns
3. Collection			
Collection amount (ton/day)	120	9	130
Collection frequency (times/week)	Residents: 3 Commercial: 7	Residents: 2 to 3 Commercial: 7	Various depending on area's character
Collection shift (times/day)	2	Residential: 1 Down town: 2	2
Collection method	Mainly door to door	Mainly door to door	Various
4. Road Sweeping			
Served area	Main avenue and down town in Chetumal city	Main avenue and down town in FCP city	Main avenue and down town in Playa del Carmen
Sweeping method	Manual and mechanical	manual	Mechanical
5. Final disposal			
Disposal amount (ton/day)	120	9	130
Landfill site	Calderitas	FCP	Playa del Carmen
Landfill method	Less controlled open dump	No control open dump	Controlled disposal site, but not sanitary landfill
Area	15 ha	N.A.	10 ha
Expect lifetime (year)	2 years	N.A.	7 to 8 years
6 Private participation			
Private participation	A private proprietor works in Mahahual	Two proprietors work in FCP	A private company has contract with the municipality and some small private proprietors also work

b. Institutional System

Provision of municipal solid waste management is clearly obligated to municipalities, as various laws at federal, state and municipal levels stipulates. This accountable legal framework should first be appreciated.

It is common cense that SWM is getting complicated due to various requirements resulted from environment preservation and resource conservation, such as sanitary landfilling and recycling. Then, SWM bodies should be enough capable to meet with the new requirements. However, the municipalities in the study area are not so capable and need to be strengthened.

There is a framework in which the state government supports the municipalities. SEDUMA is in charge of this task in technical aspect. It cannot be said that the framework functions well, however, existence of the framework itself should be appreciated. It could be a kind of social capital to encourage communication among them and to strengthen SWM capability of each municipality.

Likewise the framework mentioned above, there is communication between municipalities and small towns in their territories regarding SWM. Although the communication is like to be ineffective at present due to lack of resources, it should be also appreciated its existence. It would be a base to strengthen SWM within the municipalities.

As mentioned above, SWM is getting complicated and requires high management bodies' capability and large finance. Under the legal scheme of the country, municipality cannot access the federal governmental, bilateral and multilateral financial resources. It can be done only through the state government. Therefore, it is meaningful to strengthen communication and to establish a framework where the state government and the municipalities work together in order to meet with the financial requirement.

c. New Landfill Project

In general, capital cities of the municipalities are kept clean and small towns are not so deteriorated by clandestinely dumped waste. However, the municipalities have problems in final disposal. This is why SEDUMA carries out projects for constructing new sanitary landfills in Chetumal, Felipe C Puerto and Tulum. As of July 2003, plans and environmental impact statements of the projects have been submitted to SEDUMA.

According to information so far, a project in Chetumal would be preferable for the municipality. However, it may be difficult to realize other projects. Felipe C Puerto has pointed out high operation costs of the landfill, for which the municipality could not afford. Important aquifer may exist around the project site in Tulum.

Therefore, it might be necessary to reconsider the projects in Felipe C Puerto and Tulum carefully. Besides to the reconsideration, it should be mentioned that any project does not consider improvement of current operation manner, closure and remediation of existing and abandoned dumping sites. Those 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.

D.4.2.2 Othon P Blanco

a. Technical System

According to information obtained so far, Chetumal and some of towns are covered with the waste collection service. Specially, the service focuses on the city of Chetumal. This is well reasonable due to its large population size and high population density. It is said that the collection service covers 90% of the city's population. The coverage would not be far from actual one as what the city is kept relatively clean shows, although there are actually some areas where waste is accumulated. This should be appreciated and continued in the future.

The waste collection works is well carried out as mentioned above, however, there are some threats to discontinue the good situation such as; unbalanced collection route design gives over workloads on collection vehicles and does not allow them to receive appropriate maintenance, and a long duration to obtain spare parts stays the collection vehicles away from works and it loses money. This could be improved by introduction of a concept of service quality; the collection service shall be provided effectively and efficiently where appropriate service can be carried out with smaller resources. It is recommendable to begin with adoption of operation indicators into the management system.

Street sweeping is important to maintain a good image of the city. It is also well done in the city of Chetumal. This should be appreciated.

The existing disposal site is located in Calderitas that receives waste mainly from the city of Chetumal but also from neighboring small towns. Municipal records tell that the site receives about 9,000 tons of waste per month. This is equivalent to about 300 ton/day. However, estimated disposal waste amount is about 120 ton/day. The difference comes from the present manner of measuring the waste, i.e., volume capacity of vehicle multiplies number of trips. To know correct disposal amount is fundamental not only for planning operation schedule but also for controlling operation costs. Waste amount should be recorded correctly.

The disposal site in Calderitas presents a sever sanitary and environmental risk; proliferation of insects and animals, fire, leachate, etc. It is said that the site initially was operated as a kind of sanitary landfill. Then, the operation got worse like open dumping. The condition should

be remedied. It is, in that case, important to review why the sanitary landfill has fallen to the present situation.

There exist open dumpsites around small towns such as Bacalar. Although degree of adverse sanitary and environmental impacts is not yet significant compared with of the dumpsite in Calderitas, it may become considerable along with development in the future. Especially, a sound solid waste management including an appropriate final disposal system should be established in those small towns in the future.

Intermediate treatment or firm recycling systems are not found in the municipality. The municipality shows their interest in composting. Recycling including composting is one of good manners to encourage resource conservation. However, those should be implemented based on financial feasibility to sustain their operation.

In addition to the existing problems in solid waste management, new problems would arise in Costa Maya in the near future where large tourism development is expected. A solid waste management system should be established with participation of the tourism sector in order to cope with demands derived from the development.

b. Management System

The issue is the financial deficit of solid waste management service. It was already mentioned that income from solid waste service in Othon P Blanco Municipality covered only 8% of service costs in 2002.

Payment for solid waste services may be hampered by the options of self-disposal of solid waste available to anybody, be it by burying the waste in the backyard, or by illegally dumping the garbage. Then, there might be a pressing need to increase public awareness on the environmental damage caused by the improper management of solid waste, but such improved awareness may simultaneously result in a better willingness to pay for solid waste services.

Since the solid waste management is handled as one of the many municipal activities/services that are jointly managed from the viewpoint of income and expenditures, the importance of clarifying the income and cost specifically applicable to solid waste service cannot be emphasized enough. The proper operation and management of solid waste services requires large amounts of financial resources, and striving for financial self-sufficiency of the service might be a worthwhile goal.

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. Then, a careful

record-keeping of all service activities becomes essential to translate them into cost figures. The records will permit preparation of performance indicators of 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 solid waste management service.

c. Environmental Education and Public Participation

In the Municipality of Othon P Blanco, environment education is given separately by a number of agencies and one NGO such as SEDUMA, CAPA, the Municipality of Othon P Blanco and *"Amigos de Sian Ka'an"*, among others. In formal education, environmental subjects are introduced to children starting from the pre-school age. In higher education, programs directly or indirectly related to the environment are offered in universities. In school programs, general environmental issues are included in the Natural Sciences. However, there are few programs directed specifically at solid waste management with the objective of preserving the environment. In some schools, children took part in recycling activities and tree planting. However, these kinds of actions are still performed on a small scale and there are only a few examples. Society as a whole can barely grasp the magnitude of environmental sanitation problems; as a result, limited participation from the population in SWM and modest public awareness on environmental issues has been observed.

To achieve the above-mentioned objective and in view of the fact that the environment affects all, it is proposed that the various organizations (SEMARNAT, SEDUMA, CAPA, the Municipality, ONG, etc.) 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.

D.4.2.3 Felipe C Puerto

a. Technical System

According to information obtained so far, the waste collection service is only provided to the city of Felipe Carrillo Puerto. 50% of the residents of the city is covered with the service. This is quite low service coverage for a city. The low service coverage reflects what clandestine waste dumping can be found at many places in the city. The service coverage should be improved.

Municipal records say that about 30 ton of waste is collected and disposed every day. However, estimated collection and disposal waste amount is around 10 ton/day. This misunderstanding may lead improper preparation of plan and operation. Correct waste amount should be recorded.

Poor status of collection vehicles makes it difficult to provide proper waste collection service. Collection vehicles should be maintained and renewed in order to provide secure service.

The current disposal site is an open dumping site without control. It causes several problems such as fire, odor, proliferation of insects and animals, air pollution, groundwater contamination, etc. The site should be improved immediately with taking into consideration lack of capability of the municipality.

Hospital waste is collected separately from ordinal waste collection service. However, it is disposed of with the ordinal waste. In order to minimize expansion of diseases, the hospital waste should be carefully and separately disposed of.

b. Management System

The issue is the financial deficit of solid waste management service. It was already mentioned that solid waste service in Felipe Carrillo Puerto Municipality is provided free of charge. No solid waste service charges have been established up to the present, but the need for such charges is beginning to get the attention of the municipal authorities.

Payment for solid waste services may be hampered by the options of self-disposal of solid waste available to anybody, be it by burying the waste in the backyard, or by illegally dumping the garbage. Then, there might be a pressing need to increase public awareness on the environmental damage caused by the improper management of solid waste, but such improved awareness may simultaneously result in a better willingness to pay for solid waste services.

Since the solid waste management is handled as one of the many municipal activities/services that are jointly managed from the viewpoint of income and expenditures, the importance of clarifying the income and cost specifically applicable to solid waste service cannot be emphasized enough. The proper operation and management of solid waste services requires large amounts of financial resources, and striving for financial self-sufficiency of the service might be a worthwhile goal.

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. Then, a careful record-keeping of all service activities becomes essential to translate them into cost figures. The records will permit preparation of performance indicators of 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 solid waste management service.

c. Environmental Education and Public Participation

There are few environmental education activities on solid waste management developed in Felipe Carrillo Puerto. In the whole municipality, basic sanitation activities such as cleaning up litter, have mainly been carried out through the effort of the Municipality alone without effective resident participation. Therefore, in many areas in the periphery of Felipe Carrillo Puerto, materials such as plastic bags and plastic bottles are seen scattered in the streets and open areas. This situation is the result of the population's limited participation in SWM and modest public awareness on environmental issues.

D.4.2.4 Solidaridad

a. Technical System

According to information obtained so far, about 110,000 residents are covered with the collection service. In addition to the residents, the tourism industry must generate significant amount of waste in the municipality. In total, about 130 ton/day of waste is collected and disposed of. Collection coverage obtained is about 85% which should be appreciated in a municipality experiencing the rapid population growth along with the tourism development.

The waste collection service is carried by the private sector. One company has a contract with the municipality regarding waste collection and disposal services. Some small private proprietors also carry waste of hotels. In general, no accumulation of wastes on curbs is observed. The works can be appreciated.

The private company manages operation of a controlled dumping site. Sanitary and environmental conditions of the site are much better than other open dumping sites in the study area. It should be strengthened that the site was previously uncontrolled and gave huge adverse impacts on the environment, but has been improved. This should be appreciated and a good example for other dumping sites to improve.

However, there are two abandoned dumping sites in the municipality, which have awful sanitary and environment conditions. They should be closed properly and immediately.

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. It is recommendable to encourage recycling for resource conservation, but financial feasibility should be taken into account for sustaining the activity.

b. Management System

It was already mentioned that a new solid waste service charges were established in January 2003. However, income and expenditures data during the first five months of 2003 indicate

that income has been falling short of expenditures. Due to the concession of the solid waste management service, the Municipality has the obligation to pay about 1.5 Million Pesos every month. On the other hand, the average monthly income between January and May was 0.77 Million Pesos. The data considered referred to January-May 2003, whereby the expectation is that a balance or surplus will be achieved at the end of the year.

The service charges established in January 2003 appear to be comprehensive enough to cover the different types of service users, but maybe there 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. An information campaign may be in order.

Payment for solid waste services may be hampered by the options of self-disposal of solid waste available to anybody, be it by burying the waste in the backyard, or by illegally dumping the garbage. Also, tourists may not be familiar with the specific way to dispose solid waste or may not be as careful as desired, which may increase littering and the ensuing management cost increase. Then, there might be a pressing need to increase public awareness on the environmental damage caused by the improper management of solid waste, but such improved awareness may simultaneously result in a better willingness to pay for solid waste services.

As expenditures of solid waste service are fixed by the contract with the concessionaire, the issue is to improve income by facilitating the application of service charges established in January 2003.

c. Environmental Education and Public Participation

As mentioned in Chapter 4, the Municipality of Solidaridad has carried out a series of activities including environmental education, training and events related to solid waste management, such as recycling programs with the participation of schools and a private company, the cleaning of beaches with the participation of students, the participation of children in the elaboration of topics related to a healthy environment, etc.

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 for the preservation of the aquatic environment, which is the goal of the present study.

D.4.3 Groundwater Management

a. General Issues

According to the first field survey conducted during June 2003, the following general groundwater management issues can be pointed out from the technical points of view. These issues do not include legal and institutional points.

(1) Well design and log data

Well inventory of the Study Area is kept in the computer of CNA. However, the design of the registered well and geologic log at the construction time is not submitted and stored in the inventory. These data are important as a basis for construction of groundwater management tools, such as hydrogeological map, cross section and computer groundwater model. Particularly important are those of the injection wells.

(2) Reporting of extraction periodically

Although the inventory has the concession water amount of the well, actual amount of extraction and injection is not recorded. At least once a year, the users should report their actual amount as well as its water quality.

(3) Regular inspection

Regarding the previous point, CNA should have a regular inspection on actual water amount of extraction and injection and their water quality in the selected wells at least once a year.

(4) Monitoring wells

Groundwater monitoring wells have been constructed recently in the area of Cancun-Tulum. Water levels and water quality is 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.

b. Injection Issues

As many injection wells have already been operated in the Study Area, establishment of the injection standard is a problem of vital importance. In order to establish the standard, the following technical issues must be studied.

(1) Injection depth in the saltwater layer

Injected water migrates and/or diffuses in the saltwater layer. The behavior of injected water must be analyzed by computer simulation, so that a safety depth or zone of the injection could be estimated.

(2) Hydraulic parameters of carbonate aquifer

It is important to know the depth of the freshwater / saltwater interface in the injection area. A standard method of conductivity logging should be established. Regarding aquifer parameters such as permeability coefficient or velocity of groundwater, storativity or effective porosity, fluid density, temperature etc must be investigated. Methodology and procedure to estimate these parameters should be specifically considered, because the area is composed of the carbonate aquifers. There are many fractures and cavities in the carbonate aquifers, thereby Darcy's Law might not be applicable to estimate behavior of groundwater flow in a local area or a narrow area.

(3) Well design and pump etc.

It is dispensable to determine the injection well design, structure, casing and screen material, method of construction, particularly sealing of the annular space between bore wall and the casing, and specification of the injection pump etc. In addition, proper operation and maintenance methodology must be established for the safety of the groundwater environments.

Annex E

Planning Frameworks

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E Planning Frameworks

This chapter sets up key figures for preparing a Master Plan, such as numbers of population and tourists, economic indicators, wastewater amount and solid waste amount in the future.

E.1 Social Framework

E.1.1 Future Developments

"*Programa Estatal de Desarrollo Urbano del Estado de Quintana Roo* (PEDU)" has been officially published in "*Periódico Oficial del Gobierno del Estado de Quintana Roo*" on 22 April 2002. This program develops 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 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 a superior plan.

E.1.2 Future Population

a. Residential population

Population forecast is based on the estimate of PEDU except Playa del Carmen where the actual population exceeds the estimate.

Table E-1: 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

Number of tourists is estimated in Costa Maya, Playa del Carmen, Aventuras - Akumal and Tulum where number of tourists at present and in the future exceeds much more than the permanent population. Table E-2 presents a summary of the estimation of tourist numbers.

Table E-2: 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

b.1 Forecast of the Number of Tourists in Costa Maya

Forecast of tourist number to Othon P Blanco is 49,000 in 2002, 217,000 in 2005, 221,000 in 2010 and 225,000 in 2015 according to FONATUR (See Table E-3). It is estimated that 95% of the forecast tourist numbers is to arrive at the pier in Mahahual by cruisers. Therefore, it is supposed that all tourists to Othon P Blanco are to visit Costa Maya. Table E-4 is tourist numbers in the future used in preparing the Master Plan.

Table E-3: Number of Tourists in Othon P Blanco (Forecast)

Year	No. of tourists
2002	49,000
2005	217,000
2010	221,000
2015	225,000
2020	235,000
2025	376,000

Source: FONATUR

Table E-4: Number of Tourists in Costa Maya for Planning

Year	2003	2005	2010	2015
Costa Maya	80,468	217,000	221,000	225,000

b.2 Forecast of the Number of Tourists in Playa del Carmen, Aventuras – Akumal and Tulum

Number of tourists in the future in Playa del Carmen, Aventuras - Akumal and Tulum is forecast based on estimated number of rooms in the future. Number of about 80 tourists per room per year in Riviera Maya is estimated as shown in Table E-5 and Table E-6. With this number and forecast number of rooms shown in Table E-7, number of tourists presented in Table E-8 is prospected. However, Table E-8 does not give number in each year by 2015. Then, approximated curves are obtained from the table and numbers of tourists in each year are estimated as shown in Table E-9 which is to be used in the Master Plan.

Table E-5: Number of Tourists (Present)

Destination	No. of rooms	Occupation (%)	No. of tourists	No. of stay (days)
Cozumel	3,602	64.5	289,000	4.9
Riviera Maya	15,830	72.7	1,249,000	7.1
Caribe Norte	45,019	74.1	4,407,000	4.9

Source: Programa Estatal de Desarrollo Urbano

Table E-6: Number of Tourists per Room

Destination	No. of rooms	No. of tourists	No. of tourists per room
Cozumel	3,602	289,000	80
Riviera Maya	15,830	1,249,000	79
Caribe Norte	45,019	4,407,000	98

Table E-7: Number of Hotel Rooms (Forecast)

Year	2000	2005	2010	2025
Puerto Morelos	2,491	5,950	6,932	9,974
Playa del Carmen	8,140	14,312	16,674	26,149
Aventuras-Akumal	4,051	9,093	10,594	13,686
Tulum	1,036	2,134	2,486	6,497
Total	15,718	31,489	36,686	56,306

Source: Programa Estatal de Desarrollo Urbano

Table E-8: Number of Tourists (Forecast)

Year	2000	2005	2010	2025
Puerto Morelos	199,280	476,000	554,560	797,920
Playa del Carmen	651,200	1,144,960	1,333,920	2,091,920
Aventuras-Akumal	324,080	727,440	847,520	1,094,880
Tulum	82,880	170,720	198,880	519,760
Total	1,257,440	2,519,120	2,934,880	4,504,480

Table E-9: Number of Tourists in Playa del Carmen, Aventuras – Akumal and Tulum for Planning

Year	2003	2005	2010	2015
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	1,677,025	1,939,471	2,478,138	2,930,645

b.3 Cumulative Number of Tourists

The estimation above does not consider how many days each tourist stays in the regions. According to a statistical material[1], average length of stay per person in Riviera Maya is 6.59 days. With this number, cumulative number of tourists per year and day are estimated as shown in Table E-10 and Table E-11.

[1] ANUARIO ESTADISTICO Quintana Roo edición 2002 / INEGI

Table E-10: Cumulative Number of Tourists per Year

Year	Costa Maya	Playa del Carmen	Aventuras – Akumal	Tulum	Total
2003	530,283	6,039,050	4,203,046	809,502	11,581,881
2004	870,830	6,522,670	4,545,257	883,989	12,822,746
2005	1,430,030	6,993,598	4,824,864	962,654	14,211,146
2006	1,435,302	7,451,834	5,061,268	1,045,497	14,993,901
2007	1,440,574	7,897,377	5,266,051	1,132,518	15,736,520
2008	1,445,846	8,330,228	5,446,682	1,223,717	16,446,473
2009	1,451,118	8,750,387	5,608,262	1,319,094	17,128,861
2010	1,456,390	9,157,853	5,754,429	1,418,649	17,787,321
2011	1,461,662	9,552,627	5,887,869	1,522,382	18,424,540
2012	1,466,934	9,934,708	6,010,622	1,630,294	19,042,558
2013	1,472,206	10,304,098	6,124,273	1,742,383	19,642,960
2014	1,477,478	10,660,795	6,230,080	1,858,650	20,227,003
2015	1,482,750	11,004,799	6,329,056	1,979,096	20,795,701

Table E-11: Cumulative Number of Tourists per Day

Year	Costa Maya	Playa del Carmen	Aventuras – Akumal	Tulum	Total
2003	1,453	16,545	11,515	2,218	31,731
2004	2,386	17,870	12,453	2,422	35,131
2005	3,918	19,161	13,219	2,637	38,935
2006	3,932	20,416	13,866	2,864	41,078
2007	3,947	21,637	14,428	3,103	43,115
2008	3,961	22,823	14,922	3,353	45,059
2009	3,976	23,974	15,365	3,614	46,929
2010	3,990	25,090	15,766	3,887	48,733
2011	4,005	26,172	16,131	4,171	50,479
2012	4,019	27,218	16,467	4,467	52,171
2013	4,033	28,230	16,779	4,774	53,816
2014	4,048	29,208	17,069	5,092	55,417
2015	4,062	30,150	17,340	5,422	56,974

c. Number of Economic Activity Population

Supposing that number of Economic Activity Population (EAP) is to grow with economic growth rate, EAP is estimated as shown in Table E-12 based on EAP in the census in 2000.

Table E-12: Forecast of Economic Activity Population

	OTHON P BLANCO	FELIPE CARRILLO PUERTO	SOLIDARIDAD	Total
2000	63,808	16,626	27,162	107,596
2001	66,360	16,959	32,594	115,913
2002	69,014	17,298	38,461	124,773
2003	71,775	17,644	43,076	132,495
2004	74,646	18,085	49,537	142,268
2005	78,005	18,537	56,968	153,510
2006	81,515	19,000	62,665	163,180
2007	85,591	19,475	68,932	173,998
2008	90,299	19,865	75,825	185,989
2009	95,265	20,262	83,408	198,935
2010	100,505	20,667	91,749	212,921
2011	104,525	20,977	97,254	222,756
2012	108,706	21,292	103,089	233,087
2013	113,054	21,611	109,274	243,939
2014	117,576	21,935	115,830	255,341
2015	122,279	22,264	122,780	267,323

E.2 Economic Framework

This section sets up economic framework regarding economic growth and industrial structure.

E.2.1 Economic Growth

Economic growth data must be derived from macroeconomic sources, which usually refer to the country level, but also to the State level in the case of Mexico. The relevant data are not available at the Municipal level in most countries. Even when past macroeconomic data are readily available, the forecast of future economic growth is difficult, as projecting past trends into the future requires careful judgment. The difficulty is compounded when past data are not available, as in the case of forecasting economic growth at the Municipal level.

Past macroeconomic data indicated that growth rates of the country and the State accelerated after 1996. The State of Quintana Roo appeared to perform slightly better than Mexico during economic downturns, but when the economy grew at an acceptable pace of 3.5-4.0% per year, growth rates of the country and the State were similar. Accordingly, in 2003 and 2004, Quintana Roo State was assumed to grow slightly more than Mexico. For Mexico in 2004, the assumed growth rate was similar to the National Development Plan for the case without structural reforms. On the other hand, in 2005 and 2006, some structural reforms were assumed to be implemented, so that growth rates were estimated to be slightly higher than those indicated by the National Development Plan.

Fortunately, for the forecast of economic growth by Municipality, population projection was made in this Study for each of the three Municipalities comprising the Study Area. The following table shows the population growth rates used in the population projection.

Table E-13: Forecasted Population Growth Rates

Municipality	2001-2005	2006-2010	2011-2015
Othon P Blanco	4.11	3.14	2.39
Felipe Carrillo Puerto	2.22	1.33	0.92
Solidaridad	23.23	9.42	5.87

Source: Progress Report 1

The population forecast resulted from careful analyses of diverse development plans, general and specific, such as the development plan of the State, public utilities development plans, urban development plans, and tourism development plans. Then, the basic premise was that the economic growth rate had to exceed the population growth rate, if residents of a Municipality, or State or country, were to be better off.

Other considerations in the analysis were recent economic events that were perceived as negative, like the uncertain recovery of the US economy to which the Mexican economy is closely linked, the slowdown in tourism and maquila activities, and the weakening competitiveness of Mexican products in the US market. On the other hand, positive considerations included the macroeconomic stability, the confidence of international investors, the increasing inflow of hard currency as remittance from the US, and the expected implementation of some structural reforms during the second half of the current administration term. In addition, reactions of private economic agents and the public sector were assumed as likely to take place regarding the influx of Chinese products fiercely competing and displacing Mexican products in the US market. If such reactions were to take place, productivity would increase and competitiveness would improve. Therefore, higher growth rates were estimated around the middle of the Master Plan period.

The presidential election scheduled for 2006 was estimated to pump in resources to invigorate the economy. Also, the new administration after the 2006 election would likely pump in more resources into the economy, to fulfill election promises. Therefore, higher growth rates were further foreseen toward the middle of the Master Plan period.

Table E-14 summarizes forecast of economic growth in three municipalities.

Table E-14: Forecast of Economic Growing Rate

Economic growing rate	OTHON P BLANCO	FELIPE CARRILLO PUERTO	SOLIDARIDAD	Quintana Roo total
2000				5.5%
2001	4.0%	2.0%	20.0%	5.0%
2002	4.0%	2.0%	18.0%	4.0%
2003	4.0%	2.0%	12.0%	3.0%
2004	4.0%	2.5%	15.0%	4.0%
2005	4.5%	2.5%	15.0%	4.0%
2006	4.5%	2.5%	10.0%	4.5%
2007	5.0%	2.5%	10.0%	5.0%
2008	5.5%	2.0%	10.0%	5.5%
2009	5.5%	2.0%	10.0%	5.5%
2010	5.5%	2.0%	10.0%	5.5%
2011	4.0%	1.5%	6.0%	5.0%
2012	4.0%	1.5%	6.0%	5.0%
2013	4.0%	1.5%	6.0%	5.0%
2014	4.0%	1.5%	6.0%	5.0%
2015	4.0%	1.5%	6.0%	5.0%

a. Othon P Blanco

Othon P Blanco was assumed to grow more or less at the same rate as Quintana Roo State and the country, as an economy based on government employment was estimated to be less sensitive to fluctuating economic conditions. However, uncertainty lingered concerning more

government offices relocating in Cancun, thereby less growth in Othon P Blanco than in Quintana Roo State was estimated farther into the future.

b. Felipe C Puerto

Felipe Carrillo Puerto, already heavily dependent on transfer of federal funds, was estimated to move along the line of federal government spending, that is, increasing before the 2006 presidential election and later during the initial stage of the incoming new administration. In other words, the economy was estimated to grow only slightly ahead of the population growth, helped by the resources of the public sector, which were estimated as likely to increase before and after the presidential election.

c. Solidaridad

Solidaridad was estimated to grow rather independently of the growth in other Municipalities or the State, as EAP in 2000 was already heavily concentrated in the service sector. Continued growth in tourism was estimated to be reflected in the forecasted high population growth rates, assuming that recommendations in the State Development Plan 2000-2025 were followed in order to diversify the prevailing sun & beach tourism into cultural, convention, golf, adventure types of tourism.

E.2.2 Industrial Structure

Rather than the existing partial data on the value of production by economic sector, the outlook on the industrial structure by Municipality was drawn from the data on population and the economically active population (EAP) of the Population Census 2000, in addition to the assumed labor participation rate (EAP/population) and the assumed economic growth rates. Table E-15 summarizes forecast of EAP distribution.

Table E-15: Assumed Industrial Structure as per EAP Distribution

Municipality	Sector	2001-2005	2006-2010	2011-2015
Othon P Blanco	Agriculture	20	15	10
	Industry	16	20	20
	Service	64	65	70
Felipe C Puerto	Agriculture	50	45	40
	Industry	12	15	15
	Service	38	40	45
Solidaridad	Agriculture	5	5	5
	Industry	20	20	20
	Service	75	75	75

a. Othon P Blanco

Labor participation rate in Othon P Blanco was assumed to be 35%, as indicated by the Population Census 2000. For the 2001-2005 period, EAP distribution in agriculture, industry and service was assumed to be the same as indicated by the Population Census 2000: 20%, 16% and 64%, respectively. For the 2006-2010 period, a shift away from agriculture was assumed, and EAP distribution in agriculture, industry and service was assumed to be 15%, 20% and 65%, respectively. Tourism development in Costa Maya was considered to entail the shift of EAP in agriculture to the manufacturing sector needed to support tourism activities, rather than directly to the service sector. And for the 2011-2015 period, EAP distribution in agriculture, industry and service was assumed to be similar to the EAP distribution in Quintana Roo State in 2000: 10%, 20% and 70%, respectively.

b. Felipe C Puerto

Labor participation rate in Felipe Carrillo Puerto was assumed to be 30%, as indicated by the Population Census 2000. For the 2001-2005 period, EAP distribution in agriculture, industry and service was assumed to be the same as indicated by the Population Census 2000: 50%, 12% and 38%, respectively. For the 2006-2010 period, a shift away from agriculture was assumed, and EAP distribution in agriculture, industry and service was assumed to be 45%, 15% and 40%, respectively. This would be a normal and gradual shift of EAP in agriculture to the other sectors, a process in which dramatic growth was not foreseen in any sector. And for the 2011-2015 period, a further gradual shift from agriculture to service was assumed, and EAP distribution in agriculture, industry and service was assumed to be 40%, 15% and 45%, respectively.

c. Solidaridad

Labor participation rate in Solidaridad was assumed to be 45%, as indicated by the Population Census 2000. The EAP distribution in 2000 was highly skewed, indicating a heavy concentration of EAP in the service sector. However, this skewed EAP distribution was estimated to remain stable, as a necessity to keep pace with the rapidly expanding tourism development in the Municipality. Therefore, for the whole 2001-2015 period, EAP distribution was assumed to remain the same as in 2000: 5% in agriculture, 20% in industry and 75% in service.

E.3 Future Wastewater Amount and Quality

This section estimates wastewater amount in the future considering both residential population and number of tourists.

E.3.1 Wastewater Generation Rate

Wastewater generation rate is defined based on a manual of CNA[2]. The manual recommends for employing 75% of design water supply rate as wastewater generation rate for planning of sewerage facilities. Also, it recommends water supply rate depending on climate as shown in Table E-16.

Table E-16: Waste Supply Rate

	High (liter /person/day)	Middle (liter /person/day)	Low (liter /person/day)
Hot climate	400	230	185
Semi-hot climate	300	205	130
Temperate climate	250	195	100

Source: Manual de Agua Potable, Alcantarillado y Saneamiento, Ver 3.0, 2001 CNA

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

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

E.3.2 Wastewater Amount

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

Table E-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

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

E.3.3 Future Wastewater Quality

The manual of CNA also defines pollutant load rates as shown in Table E-18, which are considered as appropriate with taking into account ones in Japan. With the pollutant load rates and the wastewater generation rate, wastewater quality is assumed as one shown in Table E-19.

Table E-18: Pollutant Load Rate

Item	Pollutant Load Rate(g/person/day)
BOD	54
COD	110
SS	52
T-N	8
T-P	4.60

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

Table E-19: Wastewater Quality

Item	Water Quality (mg/liter)
BOD	312
COD	636
SS	300
T-N	46
T-P	27

E.4 Future Waste Amount and Composition

E.4.1 Assumptions

Detailed investigations on waste amount and composition were recently carried out in Chetumal, Felipe C Puerto City and Tulum in "Executive Projects of Sanitary Landfills" financed by IDB. In this planning of the Master Plan, data resulted from the investigations are basically to be employed.

E.4.2 Waste Generation Rate

E.4.2.1 Households Waste

Table E-20 shows waste generation rates of households obtained by the IDB projects, meanwhile Table E-21 presents ones in Latin-American countries obtained from JICA studies. In comparison with each other, it is found that the waste generation rates obtained by the Executive Projects tend to be higher than ones of the JICA studies, especially the figures in Tulum.

In order to obtain waste generation rate that is close to reality, results of waste amount surveys are often modified with taking into account statistical data obtained from weighbridge, as raw data of waste amount surveys tend to be higher than reality. However, there no exist such statistical data in the Study Area.

With taking into account the above mentioned, waste generation rates that are employed in the planning of the M/P are set as shown in Table E-22, and it is supposed that the rates in the future would not change as the rates already show high values.

Table E-20: Waste Generation Rate (Households) obtained from Executive Projects of Sanitary Landfills

Unit: g/person/day

Source	Chetumal	FCP City	Tulum	Average
High	1,030	840	1,163	1,011
Middle	946	733	1,055	911
Low	933	833	1,287	1,018
Average	970	802	1,168	980
Difference (%)	-1.0	-18.2	19.2	-

Table E-21: Comparison of Waste Generation Rate in Latin American Countries

Sources		unit	PANAMA City1	San Salvador/ El Salvador2	México3 DF/1998	Nicaragua principal cities4 1996	Nicaragua Managua5/ 1995	Paraguay Asuncion6/ 1994
Household	High income	g/person/ day	898.3	600	616	675	664	682
	Middle income		655.8	540				
	Low income		440.2	420				
Commercial	Restaurant	g/employee/day	6,373	NA	NA	NA	NA	NA
	Others		1,918	482	NA	1,676	NA	NA
Institutional			201	NA	NA	NA	NA	NA
Market			4,178	1,674	1,025	2,827	NA	NA
Street sweeping		g/m/day	16	198	NA	NA	50	NA

Source: 1 JICA study 2002, 2 JICA study 2001, 3 JICA study 1999, 4 JICA study 1997, 5 JICA study 1995, 6 JICA study 1996

Table E-22: Household Waste Generation Rate

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

E.4.2.2 Non-household Waste

Non-household waste amount has close relation with economic activity. Therefore, non-household waste generation rate per economic activity population is estimated in this section.

Table E-23 shows non-household waste generation amount resulted from the Executive Projects. The figures were obtained from records and/or experiential estimation of municipal personnel. Then, it is considered that some of figures do not reflect the reality.

From Table E-23 and number of Economic Activity Population (EAP) shown in Table E-24, non-household waste generation rate per EAP is calculated as shown in Table E-25. Considerable differences are found among the generation rates, 601.0 g/day/EAP in Chetumal, 1,772.2 g/day/EAP in FCP and 7,764.7 g/day/EAP in Tulum. If these rates are adopted for respective whole municipalities, portions of non-household waste amount and household waste amount become: non-household 16% and household 84% in Othon P Blanco, 38% and 62% in Felipe C Puerto, and 78% and 22% in Solidaridad. Considering economic activities in Felipe C Puerto and Solidaridad, those portions are assumed not to reflect the reality.

Consequently, 601.0 g/day/EAP is employed in the planning as non-household waste generation rate.

Table E-23: Waste Generation (Non households) obtained from Executive Projects of Sanitary Landfills

Unit: ton/day

Source	Chetumal	FCP City	Tulum
Commercials	7.41	2.50	5.80
Public offices	2.31	-	-
Markets	9.38	2.50	1.90
Schools	3.55	3.00	1.90
Public areas	2.42	-	-
Hotels	3.64	3.00	5.50
Coastal area	-	-	3.60
Archaeological area	-	-	1.10
total	28.71	11.00	19.80

Table E-24: Number of Economic Activity Population

Chetumal,	Felipe Carrillo Puerto	Tulum
47,769	6,207	2,550

Source: Conformación de la base de datos por localidad ITER23/ ENEGI

Table E-25: Non-household Waste Generation Rate

Item	Chetumal	FCP	Tulum
Economic activity population (EAP)	47,769	6,207	2,550
Non-household waste (ton/day)	28.71	11.00	19.8
Non-household waste generation rate (g/day/EAP)	601.0	1,772.2	7,764.7

E.4.2.3 Waste Generation Rate per Tourist

Tourists should be considered as waste generator in tourism areas. The same waste generation rate as one of household is employed for tourists, as length of stay is fairly long, 6.59 days/tourist.

E.4.3 Waste Composition

The results of the Executive Projects are shown in Table E-26 and Table E-27. And, Table E-28 shows waste composition in ten categories converted from previous tables. The values are considered appropriate with taking into account observations of the present situation, such as disposal sites, collection works, etc. Consequently, the values are employed in the planning.

Table E-26: Waste Composition (Households) in Chetumal obtained from Executive Projects of Sanitary Landfills

Unit: %

Composition	Portion
Iron	0.33
Born	0.50
Rubber	4.81
Textile	4.48
Hardening plastic	2.89
Can	2.80
Sanitary goods	11.09
Colored glass	1.23
Plastic film	0.14
Clear glass	3.54
Carton	3.77
Garden waste	23.48
Paper	9.68
Dust	8.95
Kitchen waste	13.24
Others	9.07
Total	100.00

Table E-27: Waste Composition (Households) in Felipe C Puerto and Tulum obtained from Executive Projects of Sanitary Landfills

Unit: %

Composition	FCP City	Tulum
Cotton	0.02	0.02
Aluminum	0.21	0.42
Metals	1.46	0.71
Carton	6.51	5.14
Wax coating carton	2.21	1.89
Ceramic, tile	0.42	0.14
Leather	0.08	0.25
Born	0.63	0.36
Rubber	6.88	6.73
Can	1.70	3.33
Tire	0.00	0.00
Wood	1.10	0.79
Iron	0.58	1.02
Construction waste	1.20	1.09
Sanitary goods	9.81	9.90
Paper	8.27	4.76
PET	5.21	5.21
Plastic film	0.09	0.01
Hardening plastic	2.66	1.57
Garden waste	14.89	11.31
Dust	6.89	2.48
Kitchen waste	14.74	26.76
Textile	2.63	2.61
Unicel	0.20	0.68
Colored glass	3.97	2.08
Clear glass	7.01	8.18
Shoes	0.63	2.56
Others	0.00	0.00
Total	100.00	100.00

Table E-28: Waste Composition in Ten Categories

Unit: %

Composition	Chetumal	FCP City	Tulum	Average
Paper	13.45	16.99	11.79	14.08
Kitchen waste	13.74	15.37	27.12	18.74
Textile	15.57	12.46	12.53	13.52
Grass & wood (garden waste)	23.48	15.99	12.10	17.19
Plastic	3.03	7.96	6.79	5.93
Rubber & leather	4.81	7.59	9.54	7.31
Metal	3.13	3.95	5.48	4.19
Glasses	4.77	10.98	10.26	8.67
Soil, stone, ceramic	8.95	8.51	3.71	7.06
Others	9.07	0.20	0.68	3.32
Total	100.00	100.00	100.00	100.00

E.4.4 Bulk Density

Table E-29 shows bulk density of waste at generation point obtained from the Executive Projects. The average, 0.169, is employed in this planning.

Table E-29: Bulk Density (Households) obtained from Executive Projects of Sanitary Landfills

Item	Chetumal	FCP City	Tulum	Average
High	0.154	0.171	0.190	0.172
Middle	0.159	0.157	0.175	0.164
Low	0.162	0.179	0.176	0.172
Average	0.158	0.169	0.180	0.169
Difference (%)	-6.50	0.00	6.50	-

E.4.5 Waste Amount

E.4.5.1 Present Waste Amount

Waste amount in 2003 is estimated based on the population forecast and the waste generation rates that are set previously. Non-household waste is assumed to be generated in communities which are estimated to have a population of 2,500 and over in 2015. And waste generated by tourists is considered in tourism areas. Table E-30 shows the waste generation amount in 2003.

Table E-30: Waste Generation Amount in 2003

Municipalities	Household (ton/day)	Non-household (ton/day)	Tourist (ton/day)	Total (ton/day)
Othon P Blanco	221.8	42.2	1.5	265.5
Felipe Carrillo Puerto	51.0	10.6	-	61.6
Solidaridad	138.4	25.9	29.4	193.7
Total	411.2	78.7	30.9	520.8

E.4.5.2 Present Waste Stream

Figure E-1, Figure E-2 and Figure E-3 show waste steams in 2003 that are obtained based on the waste amount and collection coverage rate shown in Table E-31.

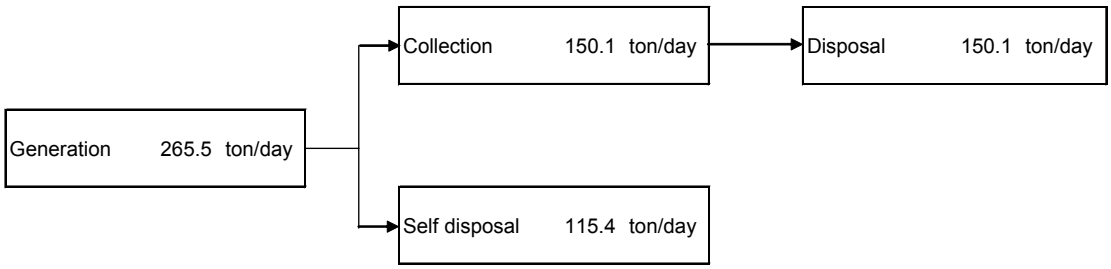

Figure E-1: Present Waste Stream (Othon P Blanco)

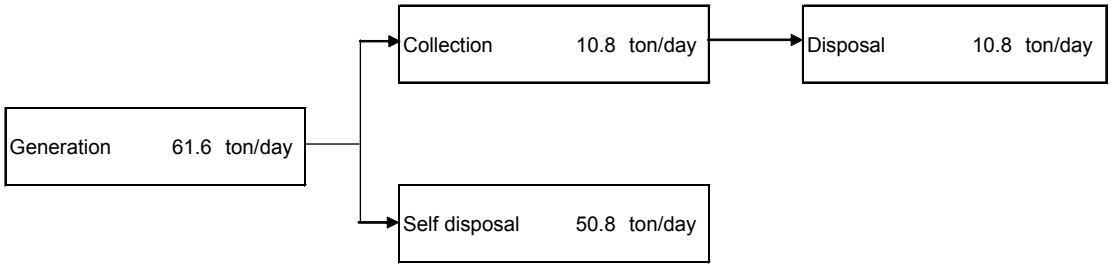

Figure E-2: Present Waste Stream (Felipe Carrillo Puerto)

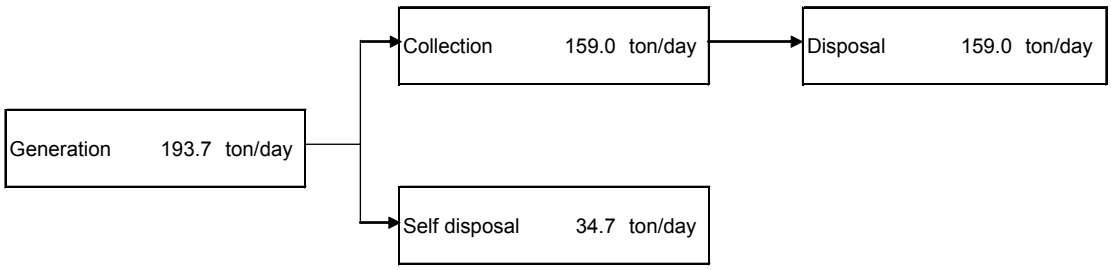

Figure E-3: Present Waste Stream (Solidaridad)

Table E-31: Present Waste Collection Area and Coverage

Municipality	Cities	Collection service coverage
Othon P Blanco	Chetumal	90%
	Subteniente López	100%
	Xul-Ha	100%
	Huay-Pix	100%
	Raudales	100%
	Laguna Guerrero	100%
	Luis Echeverría	100%
Felipe Carrillo Puerto	Felipe Carrillo Puerto	50%
Solidaridad	Playa del Carmen	90%
	Tulúm	100%
	Chemuyil	100%
	Puerto Aventuras	100%
	Akumal	100%
	Coba	100%
	Manuel Antonio Uh May	100%
	Francisco Uh May	100%
	Macario Gómez	100%

E.4.6 Future Waste Amount

Table E-32 shows estimation of waste generation amount in the future.

Table E-32: 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

Annex F

Threats in the Future

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F Threats in the Future

In the Progress Report (1), present problems are picked up and analyzed. This section discusses what sorts of threats would arise in the future, if no measures are taken in regard to the problems.

On the basis of the understanding on the present situations of environmental sanitation described in the P/R(1), it is confirmed that if the situation is left as it is and the tourism development proceeds, the groundwater, which is only source of water supply and has links between other aquatic environments, is facing threats of pollution and depletion. Then, it would be a significant factor to hamper sustainable development of the study area in the future as shown in Figure F-1.

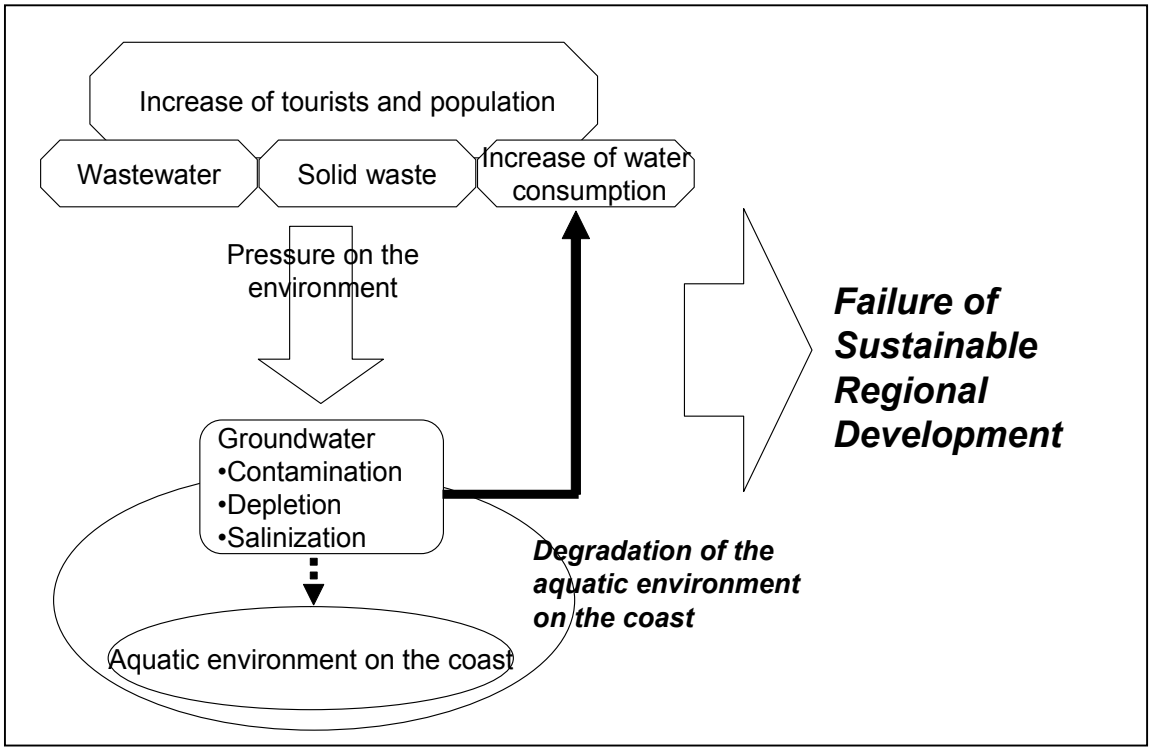

Figure F-1: Groundwater and Sustainable Development

F.1 Threats to the Groundwater

It has been qualitatively understood in the Study that Wastewater Management (WWM) and Solid Waste Management (SWM) are closely related to contamination of groundwater. This section tries to understand the relation quantitatively. Although there are various indicators to grasp pollution load originated from wastewater and solid waste, it is recommendable to focus on BOD in the planning of the Master Plan, as wastewater and solid waste in the Study Area are originated from domestic activities and BOD is the most common indicator to evaluate pollution load cased by domestic activities. This section discusses how the wastewater and the solid waste have an effect on the groundwater with focusing on BOD.

If no new measures are taken in the WWM and the SWM in the future, BOD discharge amount to the environment would increase from about 13 thousand ton in 2003 to about 26 thousand ton in 2015 as shown in Table F-1. From the BOD amount and the water balance (See Table F-2), BOD concentration is obtained as shown in Table F-3. As the table shows, BOD concentration in the groundwater is estimated to increase up to 4.9 mg/liter in 2015. Only wastewater and solid waste are considered in the estimation. Therefore, it is presumed that BOD concentration in the groundwater would be higher than 4.9 mg/liter as there are other pollution sources such as agriculture.

Question is what sort of degree the BOD concentration of 4.9 mg/liter. As there is no environment standard of public water body in Mexico, the standard in Japan is taken up as a reference. The BOD concentration of 4.9 mg/liter is categorized in Class B, being very close to Class C (See Table F-4 and Table F-5). Class C is defined as waste body that is required sophisticated purification for water supply.

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

Table F-1: 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 F-2: Water Balance in Quintana Roo State

Unit: million m^3／year

Item	Othón P. Blanco	Felipe C. Puerto	Solidaridad	Others	Total
Recharge and Flow in					
Recharge	1,801.3	1,611.0	346.0	1,265.9	5,024.1
Flow in	366.6	211.3	124.1	731.3	1,433.2
Total	2,167.8	1,822.3	470.1	1,997.1	6,457.3
Groundwater amount					
To sea	-927.8	-2,428.6	-862.6	-815.6	-5,035
Extraction	-124.0	-21.2	-30.0	-94.7	-270
Flow out to another area	-811.8	-31.0	0.0	-310.0	-1,153
Total	-1,863.6	-2,480.8	-892.6	-1,220.3	-6,457.3

Table F-3: 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 F-4: Environmental Standard of Public Water Body (River) 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 F-5: 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

F.2 Threats in Wastewater Management

A case where no new measures are taken is set as: portion between BOD generation amount and discharge amount in the future would be the same as at present.

Wastewater treatment facilities in the Study Area are basically categorized into the public sector and the private sector. Wastewater treatment facilities in the public sector belong to CAPA, and CAPA has record of treatment capacity of the facilities, actual treatment amount, intake quality and effluent quality. Table F-6 presents actual BOD removal amount obtained from the data of CAPA.

Meanwhile, as for the facilities in the private sector, only rated capacities are declared to CNA and recorded. Table F-7 shows wastewater treatment amount based on the record. Supposing BOD concentration of 312 mg/liter for intake and 75 mg/liter for effluent, BOD removal amount is estimated as shown in Table F-8.

Comparing BOD generation amount and removal amount, it is found that removal rates are only 3.06% in Othón P Blanco and 0.33% in Felipe C Puerto, and 57.56% in Solidaridad that is considerably higher than the other municipalities (See Table F-9).

Table F-10 shows BOD generation, removal and discharge amounts in the future, in case where portion of present BOD generation and removal amounts does not change. As the table shows, BOD discharge amount would double in 2015 compared with one in 2003. Other pollutants such as coliform, nitrogen and phosphorus would increase as the same as BOD, because BOD amount has close relation to those pollutants. Then, risk of disease outbreak caused by those pollutants would also increase.

Table F-6: BOD Removal Amount by the Public Facilities

Municipality	Item	Number
Othón P. Blanco	Chetumal sewerage treatment plant	
	Inflow BOD concentration	139 mg/liter a
	Effluent BOD concentration	1.9 mg/liter a
	Treatment amount	645,942 m3/year a
	BOD removal amount	88.6 ton/year
Felipe Carrillo Puerto	Felipe Carrillo Puerto sewerage treatment plant	
	Inflow BOD concentration	101 mg/liter a
	Effluent BOD concentration	2.2mg/liter a
	Treatment amount	42,368 m3/year a
	BOD removal amount	4.2 ton/year
Solidaridad	Solidaridad sewerage treatment plant	
	Inflow BOD concentration	323 mg/liter a
	Effluent BOD concentration	11.2mg/liter a
	Treatment amount	2,025,128 m3/year a
	BOD removal amount	631.4 ton/year
TOTAL BOD removal amount		724.2 ton/year

Source: [a.] :CAPA,

Table F-7: Wastewater Treatment Amount by the Private Facilities

Unit: m^3/year

Municipality	Location	Wastewater treatment facility effluent
OTHON P. BLANCO	BACALAR	189,012
	CHETUMAL	9,886
	FRANCISCO VILLA	12,264
	Total	211,162
SOLIDARIDAD	AKUMAL	1,483,532
	CAPITAN LAFITTE	32,000
	PARAISO	1,767
	PLAYA DEL CARMEN	4,032,868
	TULUM	25,623
	X-CARET	39,420
	Total	5,615,210
TOTAL		5,826,372

Source: CNA injection well inventory

Table F-8: BOD Removal Amount of other than Public Sewer System

Unit: ton/year

Municipality	Location	Wastewater treatment facility effluent
OTHON P. BLANCO	BACALAR	44.8
	CHETUMAL	2.3
	FRANCISCO VILLA	2.9
	Total	50.0
SOLIDARIDAD	AKUMAL	351.6
	CAPITAN LAFITTE	7.6
	PARAISO	0.4
	PLAYA DEL CARMEN	955.8
	TULUM	6.1
	X-CARET	9.3
	Total	1,330.8
TOTAL		1,380.9

Assumption: Intake BOD concentration : 312 mg/liter
BOD concentration of treated water : 75 mg/liter

Table F-9: Present BOD Generation and Removal Amount

Item	OTHON P. BLANCO	FELIPE CARRILLO PUERTO	SOLIDARIDAD
Generation amount 2003 (ton/year)	4,535.9	1,254.5	3,408.7
Removal amount (ton/year)			
Sewer system	88.6	4.2	631.4
Other than sewer system	50.0	-	1,330.8
Total	138.6	4.2	1,962.2
Discharge amount (ton/year)	4,397.3	1,250.3	1,446.5
Removal ratio	3.06%	0.33%	57.56%

Table F-10: Future BOD Generation, Removal and Discharge Amount

Item	Wastewater	2003	2005	2010	2015
Generation	OTHON P. BLANCO	4,535.9	5,392.5	7,140.7	8,263.4
	FELIPE CARRILLO PUERTO	1,254.5	1,303.6	1,393.0	1,456.6
	SOLIDARIDAD	3,408.7	4,711.8	7,019.9	8,999.4
	Total	9,199.1	11,407.9	15,553.6	18,719.4
Removal	OTHON P. BLANCO	138.8	165.0	218.5	252.9
	FELIPE CARRILLO PUERTO	4.1	4.3	4.6	4.8
	SOLIDARIDAD	1,962.0	2,712.1	4,040.7	5,180.1
	Total	2,104.9	2,881.4	4,263.8	5,437.8
Discharge	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

a. Othón P. Blanco

In Othón P Blanco, pollution load originated from wastewater in 2015 would be 1.8 times that in 2003, if no new measures are taken. This would lead to contamination of the groundwater and Chetumal Bay. Furthermore, risks of disease outbreak originated from wastewater would increase as the same as increase of the pollution load.

b. Felipe Carrillo Puerto

In Felipe C Puerto, increase of the pollution load would be slight; it in 2015 is estimated to be 16% higher than in 2003. It is anticipated that the municipality would not face serious problem compared with other two municipalities from a viewpoint of pollution load to the environment.

c. Solidaridad

In Solidaridad, pollution load in 2015 would be 2.6 times that in 2003. This would lead to contamination of the groundwater and the coastal aquatic environment such as cenotes, caves and coral reefs. Furthermore, risk of disease outbreak would increase as the same as increase of the pollution load.

F.3 Threats in Solid Waste Management

This section discusses what sorts of threats the study area would face in the future if no measures are taken in the field of solid waste management.

a. Threats in General

As Table F-11 explains, future threats estimated in the SWM system would hamper sustainable development of the study area.

Table F-11: Threats without a Master Plan

Technical Framework	Threats without a Master Plan
At generation sources of waste	• Waste generation ratio per capita would increase due to change of life style by urbanization • Waste discharge amount will increase without any efforts to reduce waste, e.g. avoid to purchase voluminous merchandise, recycling, composting
Collection and transport	• If collection capacity is not strengthened, uncollected waste would be increased and the citizens' living environment would be deteriorated (malodour, degradation of aesthetics, proliferation of vectors, epidemics of diseases）。
Treatment and recycling	• If recycling is not encouraged, waste disposal amount would not be reduced.
Final disposal	• The existing dump site would be full immediately with increased waste amount. • Inappropriate manner of disposal will be increased due to closure of the exiting dumping sites.
⇩	
The above threats would incur the following damages • Depletion of resources: consumption of natural resources by the present generation will hamper sound development of the next generation. • Degradation of living environment: sanitation of the living environment will get worse and citizens' health will be deteriorated • Contamination of aquatic environment: clandestine dumping and open dumping will increase leachate amount, and it contaminates the groundwater which has close relation with cenotes, caves, lagoons, coastal waters	
⇩	
Contamination of aquatic environment would bring: • Depletion of potable water resources, • Destruction of the coastal aquatic environment and biodiversity • Loss of appeal to tourists • Failure of sustainable development of the study area	

b. Threats in Respective Municipalities

In case where no new measures are taken, or waste collection capacity is not improved and waste disposal capacity is not expanded, uncollected waste would accumulated around houses and communities and those jeopardize health of citizens, and even collected waste would be

disposed in forests and wetlands due to lack of appropriate disposal site and those deteriorate the environment.

Degree of adverse impacts on living and natural environments depends on amount of wastes uncollected and inappropriately disposed; those are called “unknown waste” temporarily here. The amount of unknown waste in Othón P Blanco would increase drastically from 115 ton/day in 2003 to 480 ton/day in 2015 (see Table F-2). In Felipe C Puerto, it grows slightly from 50 ton/day in 2003 to 73 ton/day in 2015 as the population of the municipality is small at present and would not increase so much (see Table F-3). In Solidaridad, although the present collection coverage (82%) is the highest among the municipalities, the amount of unknown waste would increase up to 517 ton/day in 2015 due to expected large development of the municipality (see Table F-4). The total amount of unknown waste in the three municipalities in 2015 would be 390,000 ton/year which is 5 times as much as 73,000 ton/year in 2003 (see Table F-5).

Figure F-2 shows accumulated amount of unknown waste in the environment. Although, strictly speaking, waste amount left in the environment will decrease due to biological decomposition and other means, such phenomena are ignored from a viewpoint of checking the maximum environmental load of the unknown waste. In Othón P Blanco, accumulated unknown waste would become 1,652,000 ton by 2015 if no any measure are taken, as the present collection coverage is low (57% = 150.1/265.5), the present disposal site would be closed in a few years, the present population is the largest in the three municipalities and it is expected to increase largely in the future too, and large scale tourism development in Costa Maya is anticipated.

In Felipe C Puerto, accumulated waste amount by 2015 would become 310,000 ton which is one fifth of Othón P Blanco, as the population at present is small and it in the future would be in the same way..

In Solidaridad, increasing rate of accumulated amount of unknown waste would be less than one in Othón P Blanco, as the present population size is smaller than Othón P Blanco, the present waste collection coverage is high and the present disposal site is expected to use by 2010. However, the accumulated amount would increase rapidly after 2010 due to closure of the disposal site and tourism development. It is estimated that the amount would become 1,269,000 ton by 2015.

In summary, waste left in the environment by 2015 in Othón P Blanco would be the largest among the three municipalities. Furthermore, it would increase rapidly in the near future, or after 2005. In Solidaridad, the accumulated amount of unknown waste would be slightly less than Othón P Blanco. However, it would be still serious and the increase rate would be

hastened after 2010 rapidly. Meanwhile, the amount in Felipe C Puerto would be very small compared with the two municipalities. Consequently, a comprehensive program has to be prepared and implemented immediately in order to avoid the accumulation of unknown waste. In Solidaridad, such action is not required so urgently compared to Othón P Blanco. However, it should be taken as early as possible. Felipe C Puerto has a time. It is recommendable to take required actions gradually in response to increase of waste amount in the future.

Table F-12: Future Waste Amount in Othón P Blanco without Master Plan

Unit: ton/day

Year	2003	2005	2010	2015
Generation	265.5	311.4	411.0	479.1
Collection	150.1	150.1	150.1	150.1
Disposal	150.1	150.1	0.0	0.0
Unknown	115.4	161.3	411.0	479.1

Remarks: Supposing that the existing disposal site in Othón P Blanco would be closed by 2005.

Table F-13: Future Waste Amount in Felipe C Puerto without Master Plan

Unit: ton/day

Year	2003	2005	2010	2015
Generation	61.6	64.2	69.1	72.7
Collection	10.8	10.8	10.8	10.8
Disposal	10.8	10.8	0.0	0.0
Unknown	50.8	53.4	69.1	72.7

Remarks: Supposing that the existing disposal site in Felipe C Puerto would be closed by 2005.

Table F-14: Future Waste Amount in Solidaridad without Master Plan

Unit: ton/day

Year	2003	2005	2010	2015
Generation	193.7	266.0	400.6	516.8
Collection	159.0	159.0	159.0	159.0
Disposal	159.0	159.0	159.0	0.0
Unknown	34.7	107.0	241.6	516.8

Remarks: Supposing that the existing disposal site in Solidaridad would be closed by 2005.

Table F-15: Unknown Waste Amount in the Future without Master Plan

Unit: ton/year

Year	2003	2005	2010	2015
OPB	42,121	58,875	150,016	174,872
FCP	18,542	19,491	25,222	26,536
SOL	12,666	39,055	88,184	188,632
Total	73,329	117,421	263,422	390,040

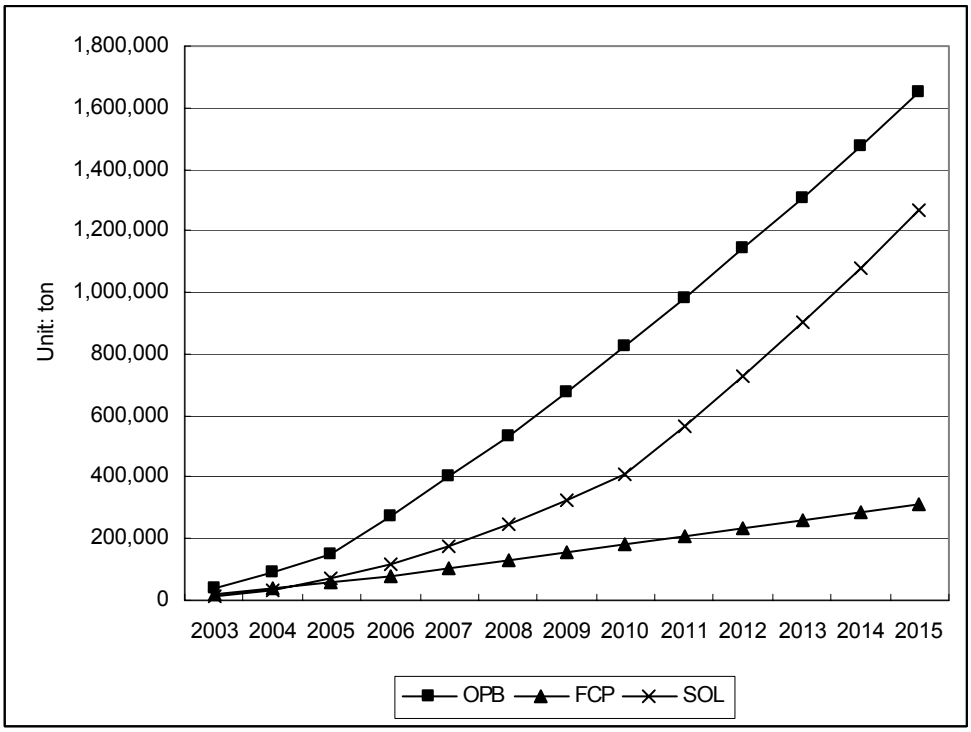

Figure F-2: Accumulation of Unknown Waste without Master Plan

c. Threats to the Groundwater

This section presents what degree the unknown waste would give adverse impact on the groundwater.

As shown in Table F-16 and Figure F-3, BOD generation amount originated from solid waste in the study area is estimated as 2,364 ton/year in 2003. It would increase to 12,579 ton/year in 2015 which is about 6 times as much as in 2003. The largest contributor to the BOD generation in 2003 is estimated to be Othón P Blanco whose generation amount occupies 57% of the total. However, Solidaridad (48%) would exceed Othón P Blanco (45%) in 2015.

In summary, the groundwater would face a risk of contamination by the large amount of BOD originated from solid waste, if no measure is taken in the future. The degree of the risk in 2015 would be six times as much as in 2003. Most of BOD would generated from Othón P Blanco and Solidaridad.

Table F-16: BOD Generation Amount from Unknown Waste

Unit: ton/year

Year	2003		2005		2010		2015	
OPB	1,358	57%	1,899	50%	4,838	57%	5,640	45%
FCP	598	25%	629	17%	813	10%	856	7%
SOL	408	17%	1,260	33%	2,844	33%	6,083	48%
Total	2,364	100%	3,788	100%	8,495	100%	12,579	100%

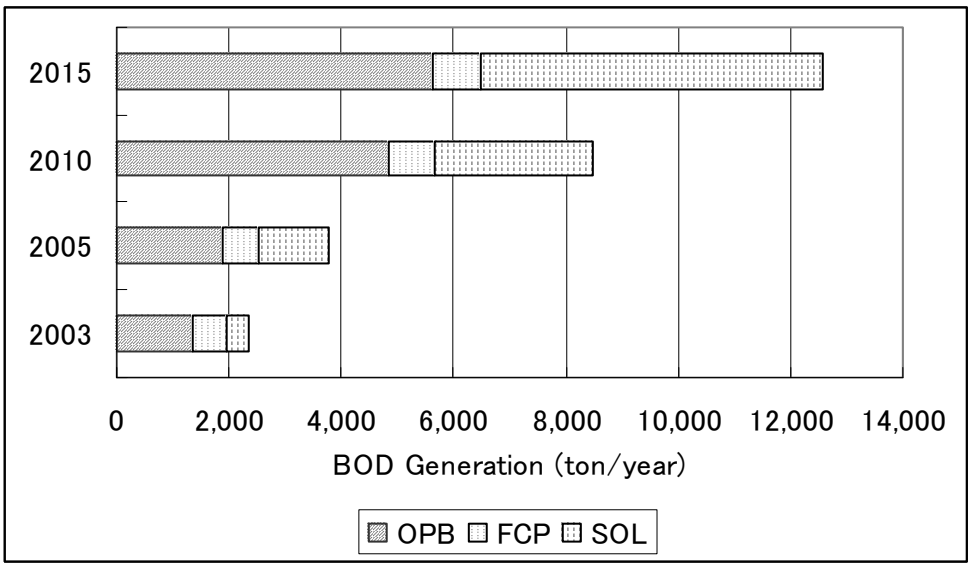

Figure F-3: BOD Generation Amount from Unknown Waste