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

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

Final Report
Volume III
ANNEX I

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

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

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Abbreviations

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

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

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

Annex A

Profile of the Study Area

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A Profile of the Study Area

A.1 Profile of the Country

A.1.1 Profile of the Study Area

A.1.1.1 Macro-economy

a. Gross Domestic Product (GDP)

The World Bank list of economies, dated April 2003, indicated Mexico as "upper middle income" and "less indebted" country. The upper middle income group was defined by the World Bank Atlas method as gross national income (GNI) per capita between USD 2,976 and USD9,205. Clarification was made that income did not necessarily reflect development status. Less indebted economies were defined as those in which the present value of debt service comprised 60% or less of GNI.

The Human Development Index (HDI) of the United Nations classifies countries taking as criteria life expectancy, per capita income and education level. The Mexican HDI in 2003 is 0.800, position 55 in the world, in the group of countries with high human development but with certain deficiency in sanitation.

On the other hand, INEGI data indicated that the gross domestic product (GDP) of Mexico in the year 2000 was 4,974,464 Million Pesos at current prices. As the 2000 Census indicated a total population of 97,361,711, the per capita GDP in the year 2000 would be estimated as about 51,000 Pesos. At the exchange rate of 9.57 Pesos per US dollar at the end of December 2000, the 2000 GDP would be approximately USD520,000 Million, and the equivalent per capita GDP would be around USD5,300.

According to INEGI data, the Mexican GDP valued at 1993 prices was 1,155,132 Million Pesos in 1993 and 1,474,726 Million Pesos in 2000, implying a yearly growth rate of 3.55% between 1993 and 2000. Sector performance differed, as the yearly growth rate was lower for the agriculture sector (1.58%), while higher for the industrial sector (4.56%) and the service sector (3.31%). According to the data, Mexico is a predominantly service economy, with the service sector accounting for around two-thirds of GDP, followed by the industry sector with a little over one-fourth of GDP, while the agriculture sector comprised less than 10% of GDP.

Table A-1: Gross Domestic Product (GDP) of Mexico

Sector	GDP 1993 (Million Pesos)	GDP 2000 (Million Pesos)	1993 Sector Share (%)	2000 Sector Share (%)	1993-2000 Growth Rates (%)
Total GDP	1,155,132	1,474,726	100.0	100.0	3.55
Agriculture	72,703	81,129	6.3	5.5	1.58
Industry	308,897	423,466	26.8	28.7	4.56
Service	772,532	970,131	66.9	65.8	3.31

Source: Anuario Estadistico 2002, Quintana Roo, INEGI
Sistema de Cuentas Nacionales de Mexico 1993-2000, INEGI

The 2000 GDP broken down into activities indicated "commerce, restaurant, hotel" with 21.9%, followed by "manufacturing" with 21.5%, "communal, social, personal services" comprising around 20% of GDP, "financial service, insurance, real estate" with 15.5%, "transport, storage, communications" with 11.3%, "agriculture" with 5.5%, "construction" with 4.3%, and 3% combined for "mining" and "electricity, gas, water".

The hoped for 3% growth in 2003 hinges upon a dynamic recovery of the Mexican economy during the second half of the year. Coordination between fiscal and monetary policies has been regarded as a basis of solid macroeconomic fundamentals, but attention has been called on the rigid tax structure and the close ties with the US economy.

b. Exchange Rate

The exchange rate of Mexican Pesos per US dollar showed the following monthly variations between 1997 and 2001.

Table A-2: Exchange Rate – Monthly Average Pesos per US Dollar

	1997	1998	1999	2000	2001
January	7.8299	8.1798	10.1104	9.4793	9.7701
February	7.7926	8.4932	10.0150	9.4456	9.7027
March	7.9628	8.5689	9.7694	9.2959	9.6186
April	7.9037	8.4996	9.4461	9.3748	9.3513
May	7.9057	8.5612	9.3623	9.5081	9.1467
June	7.9465	8.8948	9.5418	9.7978	9.0957
July	7.8857	8.9040	9.3671	9.4688	9.1560
August	7.7843	9.2596	9.3981	9.2846	9.1272
September	7.7792	10.2154	9.3403	9.3319	9.3841
October	7.8114	10.1523	9.5403	9.5182	8.3685
November	8.2837	9.9874	9.4205	9.5179	9.2223
December	8.1360	9.9117	9.4151	9.4439	9.1672
Yearly Average	7.9185	9.1357	9.5605	9.4556	9.2592
End of December	8.0833	9.8650	9.5143	9.5722	9.1423

Source: Anuario Estadistico de los Estados Unidos Mexicanos, Edicion 2002, INEGI

The exchange rate is reported in two ways: at the end of the month and also as a monthly average. The above table shows the exchange rate as the yearly average based on the monthly average exchange rates, and also at the end of December of each of the past 5 years. It can be

seen that both values of exchange rates were more similar between 1999 and 2001: about 9.5 Pesos per USD in 1999 and 2000, and around 9.2 Pesos per USD in 2001.

c. Interest Rate

The following table shows some examples of interest rates between 1997 and 2001.

Table A-3: Interest Rate (%)

	1997	1998	1999	2000	2001
Savings Deposit	7.65	6.85	5.69	3.84	2.46
Inter-bank rate (a)	20.41	36.60	18.67	18.39	7.96
Fixed-term Deposit					
30 days	12.82	16.10	7.60	6.79	2.85
90 days	12.47	16.34	7.88	7.17	3.20
180 days	12.43	16.13	8.04	7.37	3.52
(a) TIIP, determined by the Bank of Mexico					

Source: Anuario Estadistico de los Estados Unidos Mexicanos, Edición 2002, INEGI

The inter-bank rate is determined by the Bank of Mexico on the basis of proposals from credit institutions participating in a bid to receive or set up deposits in the Bank of Mexico.

The above table shows that all types of interest rates went down between 2000 and 2001. During the first week of July 2003, the interest rate on Treasury Certificate was 4.38% for 28 days, 5.04% for 91 days, and 5.77% for 182 days.

d. Inflation

The inflation rate in Mexico at the end of December 2002 stood at 4.7%. And, during the first week of July 2003, the inflation accumulated for the past 12 months was estimated at the same rate, that is, 4.7%. In Chetumal, the general inflation rate between January and December 2001 was estimated at 5.04%, varying from a decline of 2.86% for the component of "furniture & domestic appliances", to an increase of 12.98% for the component "education, recreation".

Despite the declining trend in the inflation rate, it was not as low in Mexico as in the United States, where during the first week of July 2003, the inflation rate accumulated over the past 12 months was estimated at 2.1%.

e. Public Debt

The latest data on public debt up to May 2003 indicated the total foreign debt of the public sector of Mexico to be USD77,400 Million. There was a decline of USD3,200 Million during May 2003, but an increase of USD1,500 Million over the public debt figure on December 31, 2002. The public debt figure compares well with the GDP numbers.

A.1.1.2 Public Finance

An abbreviated version of the financial situation of the Federal Government between 1997 and 2001 is shown in the following table.

Table A-4: Financial Situation of the Federal Government (Million Pesos)

Item	1997	1998	1999	2000	2001
INCOME	503,555	545,175	674,349	868,267	939,114
Tax Income	312,116	404,224	521,683	581,703	654,870
Income tax	135,101	169,476	216,123	258,754	285,523
Value added tax	97,742	119,871	151,184	189,606	208,408
Tax on production & service	45,351	76,598	106,704	81,544	110,689
Import tax	18,103	21,488	27,303	32,861	28,902
Others	15,819	16,791	20,369	18,938	21,348
Non-tax Income	191,439	140,951	152,666	286,564	284,244
EXPENDITURES	546,726	612,476	754,389	952,083	996,950
Programmable	327,481	392,695	469,240	589,402	631,529
Current expenditures	267,092	329,580	399,256	507,610	539,373
Personnel	45,123	56,084	67,536	86,480	93,132
Other expenses	23,828	18,798	19,925	44,331	29,960
Aid, subsidy, transfers	198,141	254,698	311,795	376,799	416,281
Capital expenditures	60,389	63,115	69,984	81,792	92,156
Non-Programmable	219,245	219,781	285,149	362,681	365,421
Financial cost	114,224	95,711	144,834	176,461	166,826
Participations	94,573	113,665	140,671	178,136	196,931
Others	10,448	10,405	-356	8,084	1,664
BALANCE	-43,171	-67,301	-80,040	-83,816	-57,836

Source: Anuario Estadístico de los Estados Unidos Mexicanos, Edición 2002, INEGI

It can be seen that the balance has been negative between 1997 and 2001, but the budget deficit has been reduced from around 12% of total income in 1998 and 1999 to less than 10% in 2000, and around 6% in 2001. On the income side, tax income accounted for around 70%, of which Income Tax comprised around 30% and Value Added Tax around 20%, followed by Tax on Production and Service with around 10-15%, Import Tax with some 4%, and other taxes 2-3%.

On the expenditure side, the largest component was Aid, Subsidy, Transfers comprising around 45%, followed by Financial Cost with about 20%, Participations with around 20%, Capital Expenditures with 10-12%, Personnel with around 10%, and Other Expenses with 3-5%.

A.1.1.3 Population

The first census in Mexico was taken in 1895. Since 1900 the census has been taken every 10 years except in 1921. In 1995, an extra statistical survey was made for population survey. The last census, 12^{th} census, was taken in year 2000.

Total population of Mexico was 97,361,711 according to the year 2000 census (Source; INEGI census book "Estados Unidos Mexicanos" XII Censo General de Poblacion y Vivienda 2000, Resultados Preliminares). XII Censos showed that the population of Quintana Roo state is 873,804. However, the population figure varies according to information sources. It is 874,963 according to "ANUARIO ESTADISTICO, QUINTANA ROO, edicion 2002" issued jointly from INEGI and Quintana Roo state. It is 889,988 and the population within the Study Area is 344,649 according to CAPA's report "PLAN ESTRATEGICO DE LOS SERVICIOS DE AGUA POTABLE, ALCANTARILLADO Y SANEAMIENTO 2001-2025" which base source is INEGI. Although, it is the figure of the same year, it may vary according to a period of a year, e.g. beginning, middle or end of year. Or it may be a preliminary figure.

The characteristics of the population in the study area are its explosive growth and a considerable magnitude of tourists. The magnet of Cancun has made tourists overflow into the Study Area in further south. The number of tourists in Cancun in 2001 was approximately 3 million. While the one of Riviera Maya was approximately 1.5 million in 2001 according to the State Secretary of Tourism. A large number of people have flown into the Study area attracted by expanding tourism developments, Particularly the Solidaridad municipality, adjacent to Cancun, has registered 17.7% of an annual population growth. And a further increase rate of 49% in urban area is forecasted up to 2005 according to "PLAN ESTRATEGICO DE LOS SERVICIOS DE AGUA POTABLE, ALCANTARILLADO Y SANEAMIENTO". This rate is the highest in Latin America and probably in the world. This fact appears in census figures in a peculiar manner, showing there are 17% more male population than female in Solidaridad. This explosive population growth by tourism makes social infrastructure in the area especially for treatment of wastewater and solid waste not to be able to keep pace with the growth in the number of tourists and residents. Consequently, improper disposal of raw effluents and solid waste in open dumping has posed a tremendous threat to the coastal environment, which is the important resource for the tourism.

A.1.2 Environment Policy

A.1.2.1 General Review

a. Hierarchy of the Laws

The right to propose and set up laws at a federal level belongs to the President of the Republic, Deputies and Senators of the Congress of the Union, as wells as to the legislative chambers of the respective states.

The laws issued by the Congress of the Union have supremacy over the state-level legislation.

b. Institutional hierarchy in Environmental issues

The implementation of legal instruments for the environmental sector at a federal level is as follows: the Political Constitution of the United Mexican States; the General Law of Ecological Balance and Environment Protection (LGEEPA); the Law on Domestic Waters; the Federal Law on Water Rights and the Mexican Official Standards.

The governing body of the sector is the Secretariat of Environment and Natural Resources (SEMARNAT), with several decentralized entities: the National Water Commission (CNA); the Federal Environmental Protection Agency (PROFEPA); the National Ecology Institute (INE); the Mexican Institute of Water Technology (IMTA) and the National Commission of Natural Protected Areas (CNANP). The SEMARNAT has an agency in the state of Quintana Roo, and so has the CNA.

c. Brief Summary of Environmental Laws

c.1 Political Constitution of the United Mexican States

The Political Constitution regards the following articles with respect to environmental issues: 4th, 5th, 25th, 27th and 115th.

On individual rights

Article No. 4

The article hereby guarantees two of the fundamental human rights: Every person is entitled to a suitable environment for his/her development and well-being, and, Every person is entitled to the protection of his/her health.

Likewise, this article specifically protects children rights, stating that: Children are entitled to the satisfaction of their nourishment, health, educational and healthy recreation needs for their integral development.

Article No. 5

With respect to the provision of public services, the Constitution refers to specific secondary laws to be legislated: As to public services, they will be mandatory only under the terms set out by the corresponding laws.

Article No. 25

With the purpose of strengthening the Nation's sovereignty and its democratic system, the Government is responsible for directing the national development, under social justice and productiveness criteria, enterprises of the economy's social and private sectors will be

supported and impelled, being these entities subject to the modalities issued by the public interest and to the utilization of the productive resources for general benefit, **while caring for their conservation and the environment** so as to guarantee the latter to be integral and sustainable.

The Constitution issues the chief rules on the use of productive resources and establishes that:

Article 27

This article states the Nation's ownership and rights over the land and waters within the national territory, and outlines the conditions on private property in this matter.

The Nation, at all times, will have the right to impose the methods issued by the public interest onto the private property, as well as to regulate the exploitation of those natural resources susceptible to appropriation, for the social benefit, in order to conduct a fair distribution of public wealth, to watch over their conservation, to achieve the country's balanced development and to improve the living conditions of rural and urban populations.

With the purpose of safeguarding the environment, urban development will be regulated; thus, as a consequence to the above paragraph, this article determines the following:

The necessary steps to arrange human settlements will be dictated and the suitable provisions, land, water and forest use, reserves and purpose will be established, so as to execute public works and design and regulate the foundation, conservation, upgrading and development of population centers, while preserving and restoring the ecological balance…

The Nation has the domain and ownership of waters throughout the national territory:

The territorial waters…the lagoons and estuaries in direct or intermittent communication with the sea; interior lakes of natural formation; lakes, lagoons and ponds; springs gushing at the beaches, maritime zones, river beds, riversides and lagoon basins, lakes and tidelands are of the Nation's property.

Regarding the management of underground waters, the Constitution points out that:

Subsoil waters can be freely illuminated with artificial works and appropriated by the land owner; however, whenever required by the public interest or when other resources are damaged, the Executive branch will be able to set rules on their extraction and exploitation, and even establish interdiction zones, including the waters belonging to the nation.

Natural resources, but specially the waters, are watched over by and remain within the Nation's boundaries and property:

The Nation's property is inalienable and inextinguishable; the exploitation, utilization or use of the related resources both by particulars or companies established under the Mexican laws will not be permitted but by means of authorizations granted by the Executive branch, as per the rules and conditions set forth by the laws.

Federal and State laws in their corresponding venues set out the instances when appropriation of private property takes place for the sake of public interest, and the price set as expropriation damages for the property expropriated jurisdictions will be based on the amount estimated as per the fiscal assessment recorded in cadaster (census data) offices.

On the Federation's States and the Federal District (Mexico City)

Article 115

The Constitution outlines the public services under the responsibility of municipalities and city halls' powers to issue police and good government edicts:

II. Municipal councils will have the power to pass, in accordance with municipal laws to be issued by the State Congresses, the police and government edicts; administrative regulations, provisions and notices of general observance within their corresponding venues; to set up the municipality's public administration; to regulate the matters, procedures, functions and public services under their jurisdiction and to ensure citizen and vicinal participation.

III. The municipalities will have the following functions and public services under their responsibility:

a) Potable water, sewer systems, drainage, treatment and disposal of wastewaters

c) Cleansing, collection, haulage, treatment and final disposal of wastes

Without prejudice to their constitutional jurisdiction, to the execution of their functions or rendering of the services under their responsibility, the municipalities will observe what is provided by federal and state laws.

V. As per the federal and state laws in force, the municipalities are empowered to:

a) Set out, approve and manage municipal plans of urban development and zoning.

d) Authorize, control and oversee soil exploitation

g) Take part in the creation and administration of ecologic sanctuaries and in the preparation and enforcement of bodies of law in this matter.

c.2 General Law of Ecological Balance and Environmental Protection (LGEEPA)

Background: The earliest records on environmental policy in Mexico date back to the 1940's with the promulgation of the Law on Soil and Water Conservation. In the early 70's, the Law to Prevent and Control Environmental Pollution is proclaimed and the Undersecretary Office for Environmental Enhancement Improvement, under the Secretariat of Health and Assistance, is created. Environmental issues are approached from a sanitary perspective.

In the beginning of the eighties, Mexico adopts an development strategy based on the substitution of imports (ECLAC), under which the industrial sector is granted privileges over the primary sector, whose outcome is the intensive exploitation of natural resources and a significant environmental impact in terms of an unruly urban growth and degradation of air, soil and water quality.

In 1982 the Secretariat of Urban Development and Ecology (SEDUE) is created with the purpose of ensuring the compliance of the laws in force at that time and of enforcing the policies after the constitutional reform and the creation of new institutions. The General Law on Environment Protection is promulgated.

In 1988, the Congress of the Union issues the General Law of Ecological Balance and Environment Protection (LGEEPA) with the participation of the three governmental hierarchies: Federal, State and Municipal levels. The latter set the foundations for Mexico's current environmental policy.

The LGEEPA regulates the constitutional provisions in respect of the preservation and restoring of ecological balance and environmental protection; its clauses belong to public order and social interest matters and have the purpose of propitiating a sustainable development.

As of 1989 new entities are formed: the National Water Commission as the ruling federal entity on water management, protection of hydrologic basins and surveillance for compliance with the rules on water discharge and treatment; the National Ecology Institute (INE); the Federal Environmental Protection Agency (PROFEPA); and the Mexican Institute of Water Technology (IMTA).

In November 2000, the Law of Federal Public Administration is amended and creates the Secretariat of Environment and Natural Resources (SEMARNAT).

The environmental policy has a governmental rank and has cross-relations with the work agendas of the three government orders: Social and Human Development, Order and respect and Qualitative Growth.

Purpose of the Law:

This set of laws regulates, based on the Political Constitution, the provisions related to the preservation and restoring of ecological balance and protection of the environment; its provisions belong to the public order and social interest and aim at the sustainable development and the establishment of the groundwork, among others, for:

Sustainable utilization, preservation and, where applicable, restoring of the soil, water and other natural resources, in a way that economic benefits and the society activities match along with the preservation of ecosystems;

Competency of Governmental Levels

Article 4th stipulates that the Federal Government, the states, the Federal District (Mexico City) and the municipalities will exercise their powers in the preservation and restoring of ecological balance and protection of the environment, according to the apportionment of competencies foreseen in this law and in other law codes.

The principal competencies of each governmental level are:

Federal hierarchy:

- Issuance of Mexican Official Standards and overseeing their compliance.
- Regulation and control of those activities regarded as hazardous; of the generation, handling and final disposal of materials and residues that pose a risk to the environment and preservation of natural resources.
- Formulation, enforcement and assessment of general ecology law bodies of the territory and of ecological maritime laws.
- Environmental impact assessment of the works or activities referred to in article 28th of this law and, where applicable, issuance of the corresponding permits;
- Regulation of sustainable exploitation, protection and preservation of forestry resources, soil, domestic waters, biodiversity, flora, fauna and other natural resources within its jurisdiction.

State hierarchy:

- Regulation of activities not deemed as extremely hazardous to the environment, as set forth in article 149 of the present law;
- Regulation of collection, haulage, storage, handling, treatment and final disposal systems of solid and industrial wastes not regarded as hazardous, as per the provisions of article 137 of the current law;
- Enforcement of juridical provisions regarding the prevention and control of environmental impacts as a consequence of the collection, haulage, storage, handling, treatment and final disposal activities of solid and industrial wastes not regarded as hazardous, as per the provisions of article 137 of the current law;
- Preservation and restoring of ecological balance and protection of the environment in population centers, in relation with the consequences arising from local sewerage, cleansing, marts, central markets, graveyards, slaughterhouses, traffic and transportation activities; as long as they are not powers granted to the Federal level or the states in the current law;
- Regulation of sustainable utilization and prevention and control of water pollution within the state jurisdiction; as well as of domestic waters under their venue;
- Vigilance of the compliance with Mexican Official Standards issued by the Federal level with respect to the matters and instances referred to in fractions III, VI and VII of this article;
- Conduction of state information and broadcasting of environmental matters;
- Promotion of social participation in environmental matters, pursuant with the provisions of this law;
- Environmental impact assessment of the works or activities not expressly endowed to the Federation by means of the current law and, where applicable, issuance of the corresponding permits, pursuant to the provisions of article 35 BIS 2 of the present law;
- Controlling of actions for the protection, preservation and restoring of the ecological balance and protection of the environment within the federal maritime and terrestrial zones, as well as of national water bodies within the federal zone.

Municipal hierarchy:

- Enforcement of juridical provisions for preventing and controlling pollution of waters discharged at drainage and sewerage systems within population centers, as well as of domestic waters under its jurisdiction, with the participation of the corresponding state governments pursuant to the local laws in this matter.

c.3 Law on Domestic Waters

This law establishes the rules as per Article 27th of the Political Constitution in the field of domestic waters.

Purpose of the Law

To regulate the exploitation, utilization or right of use of such waters, their distribution and control; as well as to preserve their sufficiency and quality so as to achieve their integral and sustainable development.

Competency of Governmental Bodies

Within the organizational structure of the Secretariat of Environment and Natural Resources, a decentralized administrative body is created: the National Water Commission (CNA)

c.4 Federal Law on Water Fees

It sets out the fees to be disbursed for the use or exploitation of the Nation's public property goods, as well for the services being rendered by the Government.

Competency of Governmental Bodies

Execution of this law is in charge of the National Water Commission.

c.5 Other Entailing Laws

FEDERAL LEVEL

- Organic Law of the Federal Public Administration
- Federal Statute of the Seas
- Federal Law on Metrology and Standardization
- Planning Law
- General Law on National Property
- Federal Law on Administrative Procedures
- Law on Statistical and Geographic Information
- Expropriation Law
- General Law on Human Settlements
- Federal Law on Tourism

- Code on the Use and Exploitation of Territorial Waters, Water, Beaches, Federal Maritime and Terrestrial Zones and Reclaimed Lands

c.6 Regulations Currently in Force

MEXICAN OFFICIAL STANDARDS (NOM) RELATED TO THE STUDY
Potable and Waste Waters

Standard	Objective	Issuance in the Official Gazette of the Federation (DOF)
NOM-001-ECOL-96	Permissible boundaries of contaminants when discharging waste waters in domestic waters and national property	06-01-97 Currently under review CNA directly participating, overseeing it
NOM-002-ECOL-96	Permissible boundaries of contaminants when discharging waste waters in urban or municipal drainage/sewerage systems	03-06-98
NOM-003-ECOL-97	Maximum permissible boundaries of contaminants in treated waste waters to be reutilized in public services	21-09-98 CNA participating in tandem with the Secretariat of Health (SSA)
Amendment NOM-127-SSA1-1994	Environmental health – Water for human use and consumption – Permissible quality boundaries and treatment that water must undergo to become potable	22-11-00 CNA participating in tandem with the Secretariat of Health Mr. Martín Castillo Castro martin.castillo@cna.gob.mx
NOM-179-SSA1-98	Vigilance and assessment of quality and control of water for human use and consumption and distributed by public supply systems	24-09-01 CNA participating in tandem with the Secretariat of Health
NOM-003-CNA-1996	Requirements during the construction of water extraction wells to prevent the pollution of aquifers	03-02-97
NOM-004-CNA-1996	Requirements for the protection of aquifers during maintenance and rehabilitation of water extraction wells and for the closure of wells in general	08-08-97
ANTEPROY-NOM-000-CNA-0000 PRELIMINARY DRAFT	Requirements for the disposal of surface and groundwater	Preliminary draft by the Work Group currently under review Mr. Rubén Chavez Guillen ruben.chavez@cna.gob.mx
ANTEPROY-NOM-000-CNA-0000 PRELIMINARY DRAFT	Requirements for the artificial recharge of aquifers	The corresponding work group concluded the final version of the preliminary draft to be signed soon
PROY-NOM-004-ECOL-2001 IN THE WORKS	Environmental protection – sludge and bio-solids – specs and maximum permissible boundaries of contaminants for their utilization and final disposal	18-02-02 Issued in the DOF for public inquiry. On September 24th, 2002, the response to 138 comments arising from the public inquiry was approved, as well as the standard draft, to be issued in the Official Gazette of the Federation.

Standard	Objective	Issuance in the Official Gazette of the Federation (DOF)
		Mr. Martín David Castillo Castro. Tel. No. 9159-1100 ext. 4353 martin.castillo@cna.gob.mx
MEXICAN STANDARDS – SLUDGE ANALYSIS		
SLUDGE ANALYSIS	Determine the presence of helminthes eggs – test procedure	
SLUDGE ANALYSIS	Determine the presence of coliform in feces – test procedure	
SLUDGE ANALYSIS	Determine the presence of heavy metals – test procedure	

MEXICAN OFFICIAL STANDARDS (NOM)

Municipal and Biological Infectious Solid Wastes

Standard	Objective	Issuance in the DOF
NOM-052-ECOL-93	Outlines the features of hazardous wastes, a list of them and the boundaries that turn a waste into a hazardous one due to its toxicity to the environment	22-10-93
NOM-053-ECOL-93	Establishes the procedure to carry out the extraction test to determine the constituents that turn a waste into a hazardous one due to its toxicity to the environment	22-10-93
NOM-054-ECOL-1993	Establishes the procedure to determine incompatibility between two or more wastes regarded as hazardous by the Mexican Official Standard NOM-052-ECOL-1993	22-10-93
NOM-055-ECOL-1993	Outlines the requirements to be met by the locations devoted to the controlled containment of hazardous wastes, except radioactive residues	22-10-93
NOM-056-ECOL-1993	Establishes the requirements for the plotting and construction of complementary of a controlled containment for hazardous wastes	22-10-93
NOM-057-ECOL-1993	Establishes the requirements to be observed in the plotting, construction and operation of cells of a controlled containment for hazardous wastes	22-10-93
NOM-058-ECOL-1993	Outlines the requirements for the operation of a controlled containment for hazardous wastes	22-10-93
NOM-083-ECOL-1996	Establishes the conditions to be met by the sites devoted to the final disposal of municipal solid wastes (Clarification dated March 7th, 1997)	25-11-96
Mexican Official Standard Draft NOM-084-ECOL-1997	Outlines the requirements for the plotting, construction, operation and monitoring of a sanitary landfill, and provides the basic guidelines for the specific design of the sanitary landfill, its	

Standard	Objective	Issuance in the DOF
	pollutant control works and complementary works, as well as construction and operative specs to suitably run the landfill and the establishment of an on-site environmental monitoring program	
NOM-087-ECOL-1995	Establishes the requirements for the segregation, , packing, storage, collection, haulage, treatment and final disposal of hazardous, biologically infectious generated at the medical attention facilities (Clarification June 12th, 1996)	07-11-95
NOM-133-ECOL-2000	Environmental protection – polychlorinated biphenyls (PCBs) – handling specs	10-12-01
Mexican Standard NMX-AA-15-1985	Protection of the environment – soil pollution – Municipal solid wastes – volume reduction method. It establishes the volume reduction method for municipal solid wastes and obtaining of specimens for laboratory analyses	
Mexican Standard NMX-AA-19-1985	Protection of the environment – soil pollution – municipal solid wastes – bulk density. It outlines a method to determine bulk density of municipal solid wastes at the location where the volume reduction operation took place	
Mexican Standard NMX-AA-22-1985	Protection of the environment – soil pollution – municipal solid wastes – selection and quantification of by-products. It establishes the selection criteria and methods for the quantification of by-products in municipal solid wastes	
Mexican Standard NMX-AA-061-1985	Protection of the environment – soil pollution – municipal solid wastes – Generation. It outlines the techniques to develop the calculation of the generation of wastes by the population to be served	
Mexican Standard NMX-AA-91-1985	Protection of the environment – soil pollution – municipal solid wastes – Terminology. Support for the understanding of the concepts employed within the standards referred above.	

A.1.2.2 Organization Concerned

a. Secretariat of Environment and Natural Resources (SEMARNAT)

Its fundamental purpose is to build a governmental policy on environment protection that revert the ecological deterioration trends and sets the ground for a sustainable development of the country.

Its vision is a country in which every person harbors a sincere and profound concern about the protection and care of the nature's gift to Mexico by making up the human genius with

the fragile balance of the rest of the living beings and their environment, in order to achieve the sustainable development.

Its mission is to incorporate criteria and devices through all of the society and public duty ambits that ensure the optimal protection, conservation and utilization of the country's natural resources, thus shaping an integral and all-inclusive environmental policy within the framework of sustainable development.

Its core activities comprise the formulation, conduction and evaluation of national policies on environment and natural resources; also, to promote and encourage the sustainable development of natural resources, to oversee the compliance with environmental codes, halt and revert deterioration of the environment.

b. National Water Commission (CNA)

Created by Presidential decree in January 1989 as a decentralized administrative body of the former Secretariat of Agriculture and Hydraulic Resources as the instance in charge of the integral management of water. Currently the CNA is found within SEMARNAT structure.

The CNA expects Mexico to be a nation with a safe supply of water required for its development, to efficiently use this resource, to acknowledge the strategic and economic value of water, to protect water bodies and to preserve the environment for future generations.

In order to fulfill this national purpose, the CNA has the vision of being a regulative body with technical excellence and promoter of society participation and users duly organized for water administration; it also has the mission to manage and preserve domestic waters with the participation of the society, so as to achieve a sustainable use of water.

c. Mexican Institute of Water Technology (IMTA)

Created by presidential Decree on August 7th, 1986, as a decentralized body of the Secretariat of Agriculture and Hydraulic Resources, with the purpose of developing technology and raising the required and qualified human resources to ensure a rational and integral utilization and management of water.

Currently this institute lies within SEMARNAT's administrative structure.

Its vision is the required transformation of the water sector to attain a sustainable management of this resource, whereas its mission is to research, develop, adapt and transfer technology, render technological services and prepare competent human resources for the management, conservation and rehabilitation of water and its setting, to contribute to the sustainable development.

d. National Ecology Institute (INE)

Its vision is to become a leading public body in applied environmental research, developing and promoting scientific cooperation projects that effectively solve Mexico's acute environmental issues and support the conservation and restoring of the environment throughout the country.

Its mission is the output of scientific and technical data on environmental issues and training of human resources to inform the society, support the decision-making process, drive the environmental protection, and promote the sustainable use of the natural resources that support the conservation and restoring of the environment throughout the country.

e. Federal Environmental Protection Agency (PROFEPA)

Its vision is to become a solid and reliable institution in which the Environmental Law responds to the ideal of justice demanded by the population, within a society in which each one of its members is a guardian of the friendly cohabitation between the human being and the nature.

Its mission is to strive for environmental justice through the strict compliance with the law, driving away impunity, corruption, apathy and authority voids, involving all sectors of the society in this fight and the three governmental levels, under the purest principles of fairness and justice.

f. Other bodies involved

- Secretariat of Health and Assistance (SSA)
- Secretariat of Social Development (SEDESOL)
- Ministry of Tourism (SECTUR)
- National Bank of Works and Public Services (BANOBRAS)
- National Commission of Natural Protected Areas (CNANP)

A.1.2.3 Environmental Impact Evaluation Process in the Country

The federal procedures are outlined in the LGEEPA, articles 28th through 35th bis 3 and in the codes of the Law on Ecological Balance and Environmental Protection in Environmental Impact Assessment Matters.

At a state level, the code in force is the Law of Ecological Balance and Environment Protection of the state of Quintana Roo, articles 24th through 39th.

Within the boundaries of the study herein, the following are the works that demand authorization as environmental impact is concerned, according to the LGEEPA regulations:

- Federal level (SEMARNAT): waste water treatment facilities that discharge liquids or sludge in bodies that belong to national property;
- State level (SEDUMA): Non hazardous, solid waste management and disposal systems.

A.1.2.4 Other Environmental Policy

Environmental Policy

The General Law of Ecological Balance and Environment Protection set the foundations for public policies on environmental issues and on the utilization of natural resources.

Thus, for the purposes of the formulation and conduction of the environmental policy (codes, guidelines, standards and other instruments), the Federal Executive branch will observe the following core principles:

- Every person has the right to enjoy a proper environment for his/her development, health and well-being. Under the terms herein and other laws, the authorities will take the necessary steps to warrant such right. (Article 4th of the Political Constitution).
- The ecosystems are the society's common property; thus, life and the country's productive possibilities rely on its equilibrium. Ecosystems must be exploited through an optimal and sustainable productivity, compatible with such equilibrium and wholeness.
- Anyone executing works or activities that actually damage or might affect the environment will be obligated to prevent, minimize or repair the damages caused, as well as to assume the costs arising from such damage. On the other hand, anyone protecting the environment and utilizing the natural resources in sustainable manner must be somehow rewarded (universal principle of "the pollutant pays" principle).
- Prevention of the causes behind the ecological imbalances is the most efficient method to avoid them.
- Coordination between public administration entities and bodies and among the different governmental levels and the agreement with the society are indispensable for the efficacy of ecological actions;
- Women fulfill an important function in the protection, preservation and sustainable

utilization of natural resources and in development. Their entire participation is of the essence to achieve the sustainable development;

- Control and prevention of environmental contamination, the suitable exploitation of natural resources and upgrading of natural settings at human settlements are primal to increase the population's quality of life.

The principles below, contained within the New Environmental Policy in Mexico, were the basis for the elaboration of the 2001-2006 National Plan of the Environment and Natural Resources:

- Development in harmony with the nature
- Growth with a human character and environmental quality
- Attachment to legality and rendering of accounts
- Alliance with social players

A.1.3 Natural Conditions (Climate, Topography, Geology)

A.1.3.1 Climate

Many types of climates can be found in the Mexican Federation. INEGI has identified 6 main types of climate: dry, very dry, mild sub-humid, mild humid, hot humid, hot sub-humid.

Table A-5: Types of Climate in Mexico

Classification		Temperature (Co)	Rainfall (mm)	Other Characteristics
Dry	Dry	18 - 26	300 - 600	Found in Central and Northern part of the country. It covers about 28.3% of the country.
	Very Dry	18 - 26	100 - 300	Found in Central and Northern part of the country. It covers about 20.8% of the country.
Mild	Mild Sub-humid	10 - 22	600 - 1000	It covers about 20.5% of the country.
	Mild Humid	18 - 22	2,000 - 4,000	It covers about 2.7% of the country.
Hot	Hot Sub-humid	22 - 26	1,000 - 2,000	It covers about 23% of the country.
	Hot Humid	22 - 26	2,000 - 4,000	It covers about 4.7% of the country.

Source: INEGI

A.1.3.2 Topography

The country has a large variety of topographical features. The Federation can be divided into 15 physiographical provinces. The most outstanding features can be considered the Western Sierra Madre which extends from the border with Arizona to river Santiago in Nayarit; the Eastern Sierra Madre which runs from northwest to southeast and extends through Coahuila, Nuevo Leon, San Luis Potosí, Hidalgo, Puebla and Veracruz; the Southern Sierra Madre which runs through the states of Nayarit, Jalisco, Colima, Michoacán, Mexico, Gerrero, Oaxaca, Puebla, and Veracruz. Additonally, the Transversal Volcanic Sierra extends through

the states of Nayarit, Jalisco, Colima, Michoacán, Guanajuato, Querétaro, México, Morelos, Distrito Federal, Hidalgo, Tlaxcala, Puebla, and Veracruz; the Transversal Volcanic Sierra is formed by the highest elevations that can be found in the Federation, such as, Pico de Orizaba, Malinche, Popocatépetl, Iztlazíhuatl, Nevado de Toluca, and Volcan de Colima. Another important topographical feature is the Peninsula of Yucatan which covers the States of Campeche, Yucatán, and Quintana Roo.[1]

Table A-6: Physiographic Provinces

Physiographic Province	Name
I	Baja California Peninsula
II	Sonora Desert
III	Western Sierra Madre
IV	Northern Sierra and Plains
V	Eastern Sierra Madre
VI	North American Plains
VII	Pacific Coastal Plain
VIII	Northern Gulf Coastal Plain
IX	Central Plateau
X	Neo-volcanic Axis
XI	Yucatan Peninsula
XII	Southern Sierra Madre
XIII	Southern Gulf Coastal Plain
XIV	Sierras of Chiapas and Guatemala
XV	Central American Mountain Range

Source: INEGI

A.1.3.3 Geology

The geology of Mexico shows a large variety of rocks, structure and formations of high economic interest which were produced by volcanic, tectonic, and other phenomena, both internally and externally, which have taken place during the geological time.

The Republic lies almost completely on the North American plate; however, this plate is also interacting with three other plates, such as the Caribbean plate to the southeast of the country, and the Cocos plate and the Pacific Plate to the west and northwest of the country.

The predominant formations in the western part of the Mexican Republic are mostly extrusive cenozoic igneous rocks; few of them are metamorphic, intrusive and extrusive igneous from the Mesozoic and Paleozoic; and even fewer rocks are sedimentary Paleozoic. In the eastern part of the Republic, there are abundant marine sedimentary rocks from the Mesozoic and the Cenozoic; most of them are calcareous rocks and few of them are clastic. Additionally, continental deposits from the Superior Cenozoic are scattered extensively.[2]

[1] México Hoy, 2000, INEGI
[2] INEGI

A.2 Profile of Quintana Roo State

A.2.1 Natural Conditions

A.2.1.1 Location

The State is located in the Southeastern part of the Federation between the following coordinates: 21°37' and 17°53' latitude north, and 86°42' and 89°20' longitude west. Quintana Roo borders to the north with Yucatan State and the Gulf of Mexico; to the east with the Caribbean Sea; to the south with the Chetumal Bay and Belize; to the west with Campeche and Yucatan State. [3]

A.2.1.2 Topography

The State is composed of flat regions which follow the Yucatan Peninsula coastline; these areas extend further inland. However, some elevated areas are found in the middle of the Yucatan Peninsula; consequently, the highest points in the State are found along the border with the Campeche State and the northwestern part of the State in the border with Yucatan State. The highest points are Cerro El Charro (230 meters above sea level/masl), Cerro Nuevo Bécar (180 masl), and Cerro El Pavo (120 masl).

From the physiographical perspective, Quintana Roo can be classified in three sub-regions: Yucatecan Carso (limestone plateau) which covers 50% of the State surface, Campeche Carso (limestone plateau) and Lomeríos (hilly area) which covers 32% of the State surface, and Low Coastline of Quintana Roo which covers 18% of the State.[4]

A.2.1.3 Climate

According to the classification shown in Table A-5, the climate in the Study Area is classified as hot sub-humid and/or hot humid. The main climatic parameters are the following:

Rainfall

The records of the USMN (Unidad del Servicio Meteorológico Nacional/Unit of the Meteorological National Service) shows that during a 60 year period (1941-2001) Quintana Roo State ranks as No. 6 out of a total of 32 States in annual rainfall as the Table A-7 shows.

[3] Geostatistical Framework, INEGI, 2000
[4] INEGI, Physiographical Map 1:1 000 000

Table A-7: Rainfall Values in the Ten States with Highest Rainfall (1941-2001)

Unit: mm

Ranking	Federative Entity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
1	Tabasco	179	120	80	76	123	244	213	253	384	352	210	192	2 426
2	Chiapas	78	58	46	57	134	268	271	269	342	232	111	102	1 968
3	Oaxaca	30	26	22	31	88	254	268	258	292	152	63	38	1 522
4	Veracruz	42	34	34	45	78	206	239	205	292	163	88	58	1 484
5	Puebla	30	26	27	46	83	187	199	195	234	139	63	36	1 265
6	Quintana Roo	66	38	31	34	100	175	121	140	209	165	95	82	1 256
7	Campeche	28	21	18	17	62	163	190	203	212	132	60	37	1 143
8	Guerrero	10	3	3	9	49	198	222	220	256	107	24	6	1 107
9	Yucatán	35	33	30	32	79	162	167	165	184	114	52	45	1 098
10	Nayarit	19	9	5	4	8	139	280	275	216	74	15	17	1 061
	National	26	18	15	19	40	103	138	137	141	74	32	29	772

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

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

Temperature

The average temperature is 25.5 C^{o} based on data from stations Ideal, Kantunilkin, Solferino, Victoria, Cancún, Leona Vicario, Chetumal, Alvaro Obregón, Lázaro Cárdenas, Señor, Felipe Carrillo Puerto, Tihosuco, Tulum, Coba, and La Presumida.

Table A-8: Average Temperature in the Study Area

Units: ^{o}C

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

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

Hurricanes

The State was affected by at least 12 climatic phenomena which include Hurricanes and Tropical Depressions during the period between 1980 and 2001.

Table A-9: Hurricanes, Tropical Storm, and Tropical Depression

Year	Name	Category	States affected	Period	Winds km/h
1980	Allen	H3	Tamps, NL, Coah, Q.Roo	31 Jul-11 Aug	185
1980	Hermine	TS	Q.Roo, Camp, Ver, Oax	20-26 Sep	110
1982	Alberto	TD	Q.Roo	2-6 Jun	37
1988	Gilbert	H5	Q.Roo, Yuc, Tam, NL, Coah	8-13 Sep	270
1988	Keith	TS	Q.Roo	17-24 Nov	110
1995	Opal	TD	Camp, Yuc, Q.Roo, Tab	27 Sep-2 Oct	55
1995	Roxanne	H3	Q.Roo, Yuc, Camp, Tab, Ver	Aug-20	185
1996	Dolly	H1	Q.Roo, Yuc, Camp, Ver, Tam, SLP,NL	19-24 Aug	130
1999	Katrina	TD	Q.Roo, Camp, Yuc, Tab, Chis	28 Oct-1 Nov	55
2000	Gordon	TD	Q.Roo, Yuc, Camp	14-18 Sep	55
2000	Keith	H1	Q.Roo, Camp, Tab, Tamps, NL, SLP, Ver	3-5 Oct	140
2001	Chantal	TS	Q.Roo, Yuc, Camp, Tab	15-22 Aug	115

Note: According to Saffir/Simpson, H1 (119 to 153 km/h); H2 (153 to 177 km/h); H3 (177 to 209 km/h); H4 (209 to 250); H5 (more than 250 km/h); TS (Tropical Storm for winds between 61 and 119 km/h); TD (Tropical Depression for winds less than 61 km/h).

A.2.1.4 Geological Conditions

The geologic history of the Yucatan Platform is difficult to establish due to the paucity of deep well data, exposed anatomic strata, and relative inaccessibility of the inland terrain. In a quest for potential oil reserves in the early 1970's, PEMEX (Petroleos Mexicanos) drilled 10 exploratory wells into this platform. Most of these wells were drilled in the state of Yucatan, often in excess of –2000 m. Data from the test wells summarize the stratigraphy of the Mexico Isthmian portion of the Yucatan Peninsula as that of a great limestone platform (Ward and Weidie, 1978; Weidie, 1985). Paleozoic metasediments form the basement strata at varying depths exceeding -2400 m. Early Mesozoic redbed sediments (the Todos Santos Formation) overlie these Paleozoic strata unconformity, maintaining an average thickness of over 100 m.

The Cretaceous period launched the onset of numerous marine transgressions that would submerge much of this isthmus under warm shallow seas until the Pleistocene. During the Cretaceous over 1300 m of limestone strata were formed, while during the Tertiary period another 1000 m of essentially pure carbonate sediments was deposited. This includes the uppermost (Miocene-Pliocene) Carrillo Puerto Formation, a 15 m thick deposit that surrounds the shallow portions of many cave systems.

Uplift in the south-central area of the isthmus began in the Oligocene, encouraging the Carrillo Puerto Formation to be deposited in stages over the ever-expanding margins of the peninsula. This slow uplift continued until the Pleistocene. Most Quaternary deposits on the

isthmus are restricted to the present margins of the peninsula. These deposits are typically thin, extending 1-3 km inland from the Caribbean.[5]

Tectonic setting has not been very well defined in the study area. The only visible reference is the change in the current direction in the folding of Sierra Madre in Chiapas which is NW-SE and the folding system and faults in northern Guatemala and Belize which is NE-SW; the previous condition might indicate a rotation of the peninsula from the east of its current position.[6]

A.2.1.5 Hydrogeology

a. Regional Hydrogeology

The Peninsula of Yucatan is a geologic unit composed mainly of limestone intercalating evaporites, such as dolomite, gypsum and halite. These carbonate rocks are highly permeable and soluble. Dissolution of these rocks has created a karst topography with sinkholes (*Cenote*) that are generally found along fractures accompanied by regional north-northeast trending faults.

High precipitation in the rainy season directly infiltrates to the underground through fractures and sinkholes. Infiltrated water is stored in the soil, fracture and sinkholes, and mostly extracted to the air through evapo-transpiration. The rest of water reaches to the water table of limestone aquifer, then flows through the porous and fractured media and finally discharged to the sea.

According to the structural geologic analysis, at least two aquifer regions are identified in the Quintana Roo State. The first one is an aquifer composed of carbonate rocks of Paleocene and Eocene ages, which is distributed in the southern part of the state. The second aquifer is composed of the carbonate rocks of Miocene and Pliocene ages and distributed mainly in eastern part along the coast and the northern part of the state.

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

Figure A-1 shows a schematic hydrogeology cross section in northern Yucatan Peninsula from Cancun to Mérida. As shown in the figure, the saturated thickness of fresh water grows

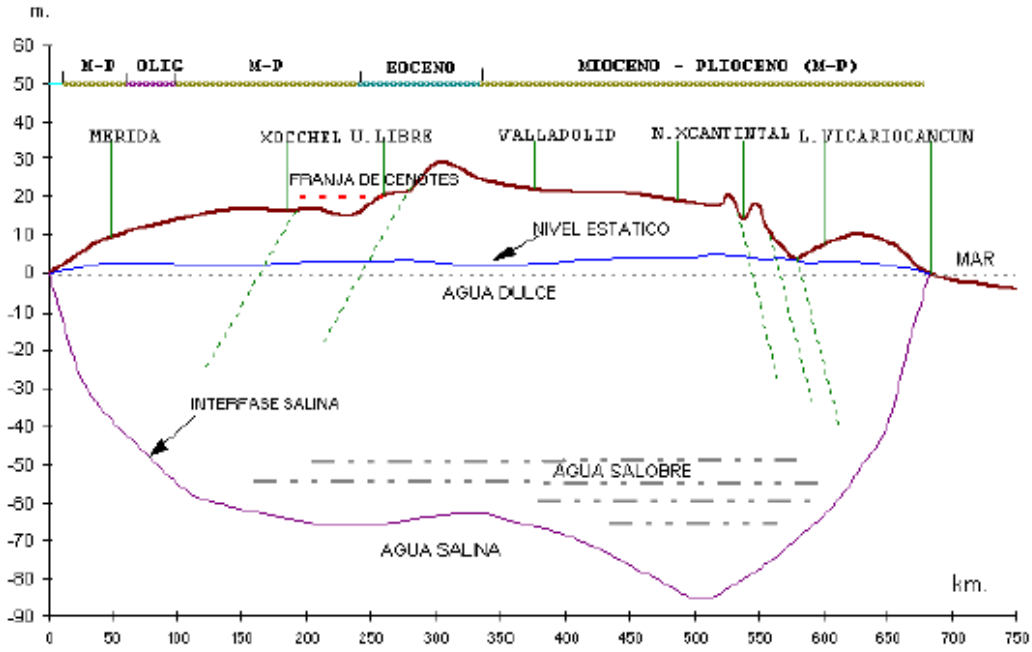
[5] Quintana Roo Speleological Survey
[6] Hydrological Study of Quintana Roo State, INEGI, 2002

toward inland. Thickness of fresh water lens is smaller than 30 m in width of 20 Km from the coast and 30 to 50 m in the rest of the plains. In thickest area, it reaches nearly 100 m.

b. Hydrologeologic Conditions

b.1 Depth of the static water level

Information of groundwater levels in the study area is very scarce. Although it is an old data, INEGI conducted a field measurement and made a contour map of the depth of the static water level in 1984. Figure A-2 shows this map. According to the map, the smallest depths are located in the coastal area in the peninsula. It generally ranges from 5 m to 10 m. The depth increases toward inland. It ranges from 10 to 20m. In the central part of the peninsula, the depth exceeds 30 m to 50 m. particularly, in the southern center of the peninsula; groundwater exists in deeper zone between 70 and 150 m depth. However, the perched water body can be found locally in these areas at a depth from 5 to 10 m.



Fuente: CNA

Figure A-1: Schematic Hydrogeological Cross Section in Northern Yucatan Peninsula

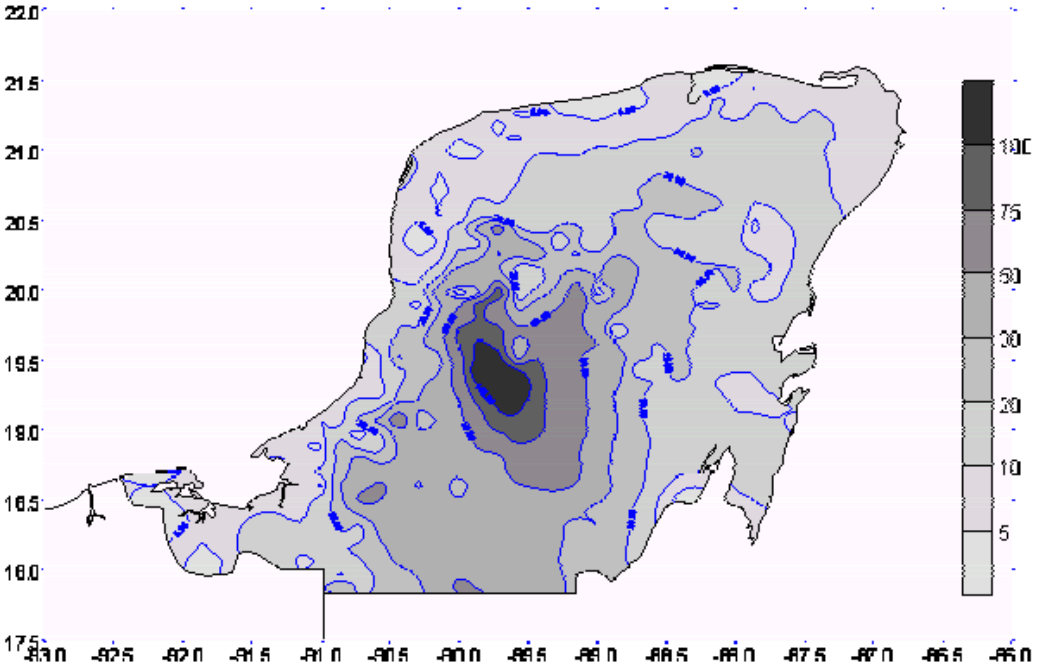


Figure A-2: Depth of the Static Water Level

b.2 Elevations of the static level

As groundwater leveling has not been carried out since 1980's, elevation of static water levels is not well known at present. However, INEGI presented an elevation contour map of the Quintana Roo State in year 2002.[7] According to the map, contour lines of 1 m to 10 m are distributed almost in parallel with the coast and in width of approximately 45 to 50 km. This means that the hydraulic gradient of the water table is very small. It is merely about 1/5,000.

On the other hand, groundwater level in southwestern part of the state shows 15 m to 30 m. The hydraulic gradient is slightly become high; however, it is about 3/5,000

Groundwater flow perpendicular to equi-poential line (elevation contour line). Therefore, in most of the state, groundwater flows toward the coast. In the southwestern part of the state, it flows in the direction of northeast to the Yucatan State and east to the sea. In Cancun and Kantnilikin areas, groundwater flows toward east and north. There are several municipalities' CAPA well fields in the area. Depression of water levels might have occurred, however, no such indication is found in the present contour map.

[7] ESTUDIO HIDROLOGICO DEL ESTADO DE QUINTANA ROO, INEGI 2002

b.3 Water level change

Continuous water leveling data, which is recorded such as automatic water level gauge, does not exist in the state. Recently CNA installed 30 monitoring wells in the northern part of the state, Cancun-Tulum. Figure A-3 shows the location of the monitoring wells and Table 2-1 also shows the static water levels in November 2002 and April 2003. The station are periodically visited for leveling, however, the data is only available at 6 months interval at present.

Comparing with November 2002 and April 2003, groundwater levels slightly declined in April. This may be caused by 6 months dry period between end of rainy season (November) and beginning of dry season (April).

Although the change is small, it may result in decrease of freshwater lens thickness according to Ghyben-Herzberg Law. For instance, 10 cm of decline becomes approximately 4.0 m of decrease of freshwater lens. Therefore, it is very important to observe the water level changes continuously, particularly, in the coastal area.

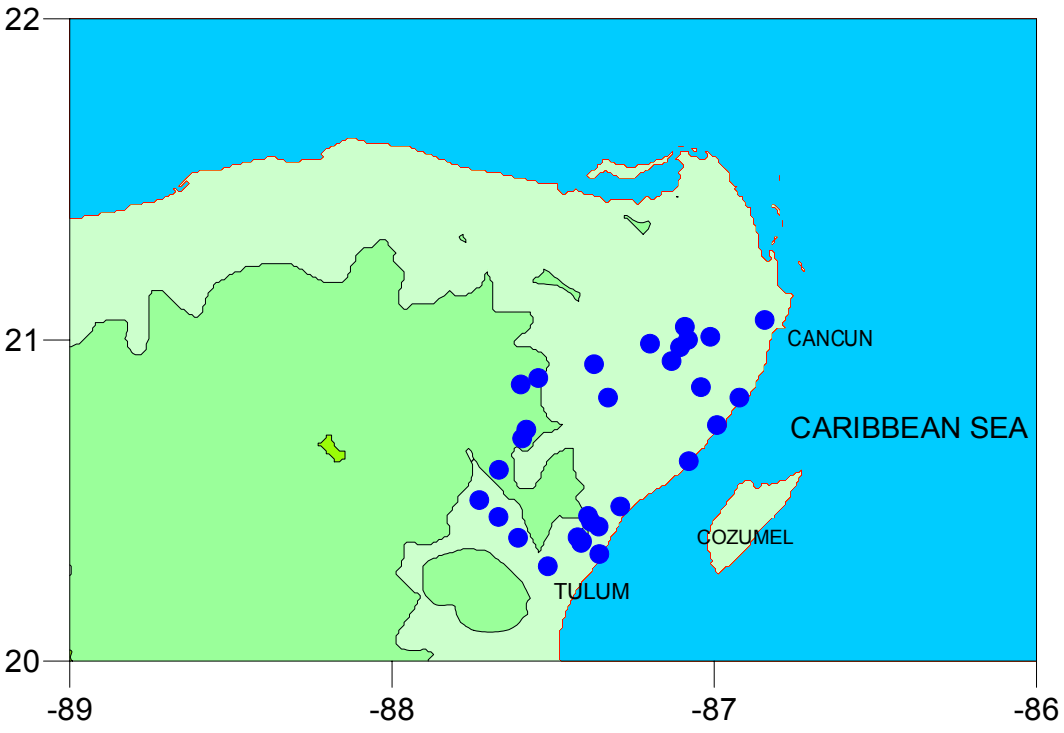


Figure A-3: Location of Monitoring Wells in Cancun-Tulum

b.4 Groundwater extraction

The aquifers of the Peninsula of Yucatan are exploited by means of thousands of wells. As shown in Table A-10, 1,685 production wells are registered in CNA. Most of the well water is used for agricultural purpose and urban water supply purpose stands the second. Actual amount of extraction is being recorded at CNA's data file. It will be processed in the next phase of the Study.

Table A-10: Number of Production and Injection Wells Registered in CNA

Item	Production Well				Injection Well			
Purpose of Use	OPB	FCP	SOL	Total	OPB	FCP	SOL	Total
Agriculture	658	336	35	1,029	0	0	0	0
Domestic	65	1	11	77	0	0	0	0
Industry	19	1	11	31	6	1	10	17
Multiple	0	0	1	1	0	0	3	3
Livestock	95	33	8	136	0	16	0	16
Public Urban	147	74	26	247	3	1	2	6
Recreation	0	0	1	1	0	0	0	0
Service	29	4	129	162	82	3	169	254
Total	1,014	449	222	1,685	91	21	184	296

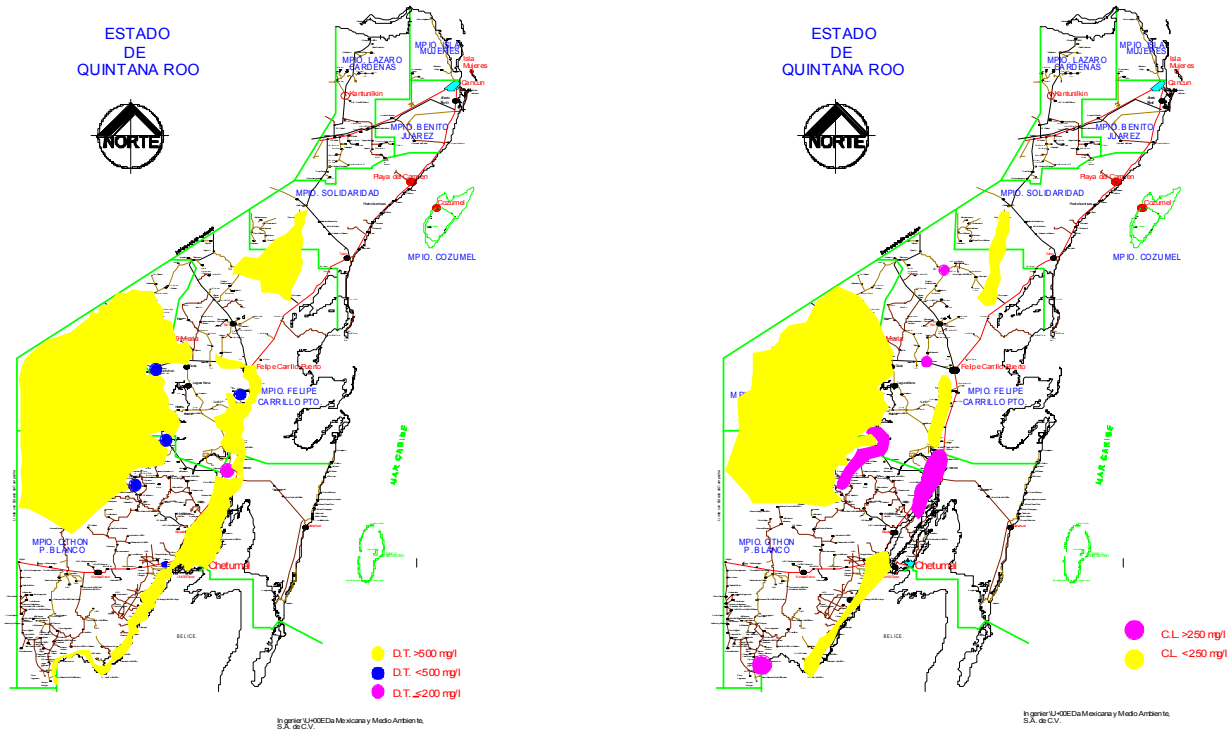
FCP: Felipe Carrillo Puerto, OPB: Othón P. Blanco SOL: Solidaridad

Table A-11: List of Monitoring Wells in Cancun-Tulum

No	WELL	Coordinates (o ' ")		depth	DIAM PERFOR	Type of well	Curb	depth of the static level including the curb					
		LAT N	LONG W				height(msnm)	DATE	(m)	DATE	(m)	DATE	(m)
1	Villa de Mora	21 03 45	86 50 37	7.95	s/d	well	3.13	Nov-01	2.34				
2	Zona Agricola	21 02 31	87 05 29	38.45	16"	well	7.862	Nov-01	6.05	21-Nov-02	6.34	23-Apr-03	6.54
3	Leona Vicario	20 59 19	87 11 58	6.95	85 cm	treadmill	8.109	Nov-01	5.905				
4	Juarez	20 49 15	87 19 47	6.55	s/d	treadmill	7.746	Nov-01	5.619				
5	Santo Domingo	20 55 29	87 22 23	41.1	10"	well	10.636	Nov-01	8.299	20-Nov-02	8.48	23-Apr-03	8.89
6	El Ideal	20 52 54	87 32 46	17.35	s/d	treadmill	18.981	Nov-01	16.368				
7	Nuevo Xcan	20 51 42	87 36 02	48.35	10"	Deep well	20.49	Nov-01	17.86	19-Nov-02	17.35	22-Apr-03	17.76
8	Nuevo Durango	20 43 16	87 35 00	23.65	s/d	Sink hole	22.896	Nov-01	20.093				
9	Tres Reyes	20 41 37	87 35 46	s/d	s/d	well	23.021	Nov-01	20.127	19-Nov-02	20.54	22-Apr-03	20.87
10	Campamento Hidalgo y Cortez	20 35 45	87 40 06	21.45	s/d	treadmill	24.025	Nov-01	20.964				
11	Coba	20 30 06	87 43 45	34.25	s/d	Deep well	7.862	Nov-01	4.87			22-Apr-03	4.53
12	Artesanias Lool Che	20 26 57	87 40 11	17.65	s/d	treadmill	19.938	Nov-01	16.93				
13	Rancho San Isidro	20 23 03	87 36 32	19.35	s/d	treadmill	20.713	Nov-01	17.79				
14	Rancho Viejo	20 17 44	87 31 00	23.35	s/d	well	13.566	Nov-01	10.943	19-Nov-02	10.89	22-Apr-03	10.95
15	Restaurante La Esperanza	20 20 01	87 21 24	3.15	s/d	treadmill	3.895	Nov-01	2.562				
16	Chemuyil Caseta	20 22 22	87 24 37	18.25	s/d	Deep well	12.669	Nov-01	10.871	19-Nov-02	10.9	22-Apr-03	10.92
17	Chemuyil-2	20 22 06	87 24 47	12.15	s/d	Deep well	11.517	Nov-01	9.696			22-Apr-03	9.76
18	Chemuyil 3 Reyes	20 23 09	87 25 27	s/d	s/d	Deep well	7.011	Nov-01	5.112	20-Nov-02	5.12	22-Apr-03	5.13
19	Uxuxubi-1	20 25 09	87 21 32	20.55	s/d	well	13.895	Nov-01	12.023	19-Nov-02	12.07	22-Apr-03	12.06
20	Akumal 1	20 27 08	87 23 30	44.55	s/d	Deep well	6.887	Nov-01	5.107			24-Apr-03	5.14
21	Akumal 2	20 26 02	87 22 57	52.95	s/d	Deep well	12.776	Nov-01	11.017			24-Apr-03	11.06
22	Rancho Paty	20 28 54	87 17 30	10.95	s/d	treadmill	12.022	Nov-01	10.463				
23	Noria en Playa del Carmen	20 37 22	87 04 45	8.85	s/d	treadmill	8.76	Nov-01	8.016				
24	Rancho Zazil-Ha	20 44 07	86 59 30	4.65	s/d	treadmill	2.448	Nov-01	1.762				
25	Rancho Loma Bonita	20 49 15	86 55 19	13.15	s/d	well	6.277	Nov-01	5.565			23-Apr-03	5.78
26	Central Vallarta	20 51 12	87 02 29	28.75	s/d	Deep well	5.575	Nov-01	4.253	21-Nov-02	4.31	23-Apr-03	4.46
27	Km. 10	20 56 04	87 07 57	35.25	16"	Deep well	6.915	Nov-01	5.362	21-Nov-02	5.4	23-Apr-03	5.77
28	Aeropuerto 17	21 00 02	87 04 54	22.5	3"	Deep well	8.425	Nov-01	6.686			23-Apr-03	7.13
29	Aeropuerto 23	20 58 40	87 06 22	55.95	3.5"	Deep well	8.916	Nov-01	7.187			23-Apr-03	7.64
30	Aeropuerto 92	21 00 36	87 00 44	22.95	8"	Deep well	9.277	Nov-01	7.602			23-Apr-03	8

b.5 Groundwater Quality

Groundwater quality of the state is investigated by CNA. Figure A-4 shows the distribution of hardness and chloride in groundwater. In the southwestern part of the state the concentration of both chloride and hardness is high, which is showing more than 500 mg/l. High concentration belt is also extending in northeast direction, which is concordant with the regional faults direction.



ISODUREZAS
ISO-HARDNESS

ISOCLORUROS
ISO-CHLORIDE

Figure A-4: Distribution of Hardness and Chloride (After CNA)

Groundwater quality is being monitored in CAPA production wells and CNA's monitoring wells. Monitoring parameters are, generally, color, chloride, hardness, calcium, magnesium, pH, electric conductivity, turbidity, coliformes total, fecal coliformes etc. Geochemical parameters, such as sodium, bicarbonate, nitrate, nitrite and sulfate are not analyzed.

b.6 Groundwater Balance of the Study Area

According to CNA (1989)[8], a groundwater balance calculation is presented as shown in Table A-12. On the other hand, based on the surface water balance presented in the same report, the Quintana Roo State receives 60,000 Mm^3/year of precipitation and about 80% of this amount

[8] SINOPSIS GEOHIDROLOGICA DEL ESTADO DE QUINTANA ROO, SECRETARIA DE AGRICULTURA Y RECURSOS HIDRAULICOS, COMISION MACIONAL DEL AGUA (1989)

returns to the air through evapotranspiration. An estimated amount of recharge is 13,350 Mm^3/year. Most of this groundwater amount flows out to Caribbean Sea and only 2.6% of the recharge was extracted by pumping in 1989.

Table A-12: Groundwater Balance in the Quintana Roo State

(Quantity in Million m^3/Year)

REVENUE	Quintana Roo State	Cozumel Island
Recharge	13,350	144
Total	13,350	144
EXPENDITURE		
Evapotranspiration	6,300	710
Discharge to sea	4,500	
Discharge to other area	1,350	
Discharge to Rio Hondo	850	
Pumping extraction	350	
Total	13,350	

A.2.2 Socioeconomic Conditions

A.2.2.1 Regional Economy

INEGI data indicated that the gross regional product (GRP) of Quintana Roo State in the year 2000 was 69,474 Million Pesos at current prices. As the 2000 Census indicated a population of 873,804, the per capita GRP in the year 2000 would be estimated as about 79,500 Pesos. At the exchange rate of 9.57 Pesos per US dollar at the end of December 2000, the 2000 GRP would be approximately USD7,260 Million, and the equivalent per capita GRP would be around USD8,300. This indicates that the per capita GRP of Quintana Roo State in 2000 was higher than the country as a whole. Tourism development in Quintana Roo State during the past 30 years has had the effect of greatly improving the GRP of the State, as one-third of tourism income of Mexico is estimated to be generated in Quintana Roo. Tourism induced development, however, has not taken place in a balanced manner among regions of the State, as tourism benefits have been concentrated mostly in the northern region of the State on the Caribbean Sea. This situation seems to be changing, as new tourism development is planned and taking place in other coastal regions of the State.

According to INEGI data, the GRP of Quintana Roo State valued at 1993 prices was 14,847 Million Pesos in 1993 and 19,555 Million Pesos in 2000, implying a yearly growth rate of 4.0% between 1993 and 2000. This growth rate was slightly higher than the country as a whole during the same period. Sector performance differed, as the yearly growth rate was negative for the agriculture sector (-6.0%), while positive for the industrial sector (1.8%) and the service sector (4.3%). The same data also indicated the increasing share of the service

sector and the declining shares of the agriculture and the industrial sectors in the Quintana Roo State GRP between 1993 and 2000, as indicated in the following table.

Table A-13: Gross Regional Product (GRP) of Quintana Roo State

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

Source: Anuario Estadistico 2002, Quintana Roo, INEGI

The 2000 GRP broken down into activities indicated the service sector comprising more than 90%, the most important activities being “commerce, restaurant, hotel” comprising around 54% of GRP, followed by “communal, social, personal services” with some 16%, “financial service, insurance, real estate” with 14%, “transport, storage, communications” with 9%, “manufacturing” with 3%, “construction” with 2%, and around 2% combined for “agriculture”, “mining” and “electricity, gas, water”.

In terms of the number of the economically active population employed in diverse activities in Quintana Roo in February 2000, “hotel and restaurant” accounted for around 18%, “commerce” 17%, “agriculture” 10%, “construction” 8%, “manufacturing” 7%, and “transportation and storage” 6%. Available data on yearly income by activity in Quintana Roo refers to 1998, indicating the following.

Table A-14: Estimated Yearly Income in Quintana Roo State

Activity	Yearly Income in 1998 (Pesos)
Agriculture	4,000
Manufacturing	19,000
Retail commerce	18,000
Transportation & storage	43,000
Financial & insurance service	38,000
Professional service	76,000
Hotel & restaurant	34,000

Source: Anuario Estadistico 2002, Quintana Roo, INEGI

A.2.2.2 Financial Condition

a. Income and Expenditures of Quintana Roo State & Municipalities

The income and expenditures of Quintana Roo State in the year 2000 amounted to 5,105 Million Pesos. On the other hand, the income and expenditures of all Municipalities in the State in the year 2000 amounted to 1,350 Million Pesos.

On the income side, around 95% consisted of income accrued during the year, and around 5% were funds available from the previous year. “Transfers” comprised around 49% of the State income, and 17% of income of Municipalities. Another big income component was “federal participation” or “federal share” at around 35% in the budget of both State and all Municipalities. “Taxes” comprised around 5% of State income and 17% of income of all Municipalities. “Fees” comprised 2% of State income and 12% of income of all Municipalities. “Public debt” comprised around 2% of income of all Municipalities.

“Transfers” and “Federal Participation” comprised around 85% of Quintana Roo State income, and 50% of Municipal income. “Taxes” and “Fees” are relatively more important in the Municipal income.

On the expenditures side, “Transfer payment” was the largest component for the State at 69% (composed of 55% subsidy, 13% participation and 1% aid). Other expense items were “Administrative expenses” at 15%, and “Public works & promotion” at 11% (6% public works and 5% promotion & acquisition). “Public debt” comprised 1% of expenditures of the State.

The largest expenditure of all Municipalities was “Administrative expenses” with 62%, followed by “Public works & promotion” with 22% (18% public works and 4% promotion & acquisition). “Transfer payments” comprised 11% of expenditures of all Municipalities, composed of 8% participation and 3% aid. “Public debt” comprised 4% of expenditures of all Municipalities.

The following table shows details of income and expenditures of Quintana Roo State and of all Municipalities of the State in the year 2000.

Table A-15: Income and Expenditures of Quintana Roo State & Municipalities in 2000

Income and Expenditures	Monetary Value (Million Pesos)		Percentage		
	Q. Roo State	Municipalities	Q. Roo State	Munic.	Mun/State
INCOME	5,105.10	1,350.38	1.0000	1.0000	0.2645
Income during 2000	4,865.59	1,307.70	0.9531	0.9684	0.2688
Taxes	250.79	229.84	0.0491	0.1702	0.9165
Federal share	1,810.73	470.97	0.3547	0.3488	0.2601
Improvements	0.00	0.55	0.0000	0.0004	
Fees	124.43	155.56	0.0244	0.1152	1.2502
Products	83.99	20.02	0.0165	0.0148	0.2384
Exploitation	46.04	93.00	0.0090	0.0689	2.0200
Public debt	0.00	31.69	0.0000	0.0235	
Third party	62.38	0.00	0.0122	0.0000	0.0000
Transfer	2,487.23	232.80	0.4872	0.1724	0.0936
Other Income	0.00	73.27	0.0000	0.0543	
Funds from Previous Year	239.51	42.68	0.0469	0.0316	0.1782
EXPENDITURES	5,105.10	1,350.38	1.0000	1.0000	0.2645
Administrative Expenses	774.65	833.76	0.1517	0.6174	1.0763
Administrative office	409.59	502.83	0.0802	0.3724	1.2276
Public security	13.82	0.00	0.0027	0.0000	0.0000
Public education	1.60	0.00	0.0003	0.0000	0.0000
Miscellaneous	349.64	330.93	0.0685	0.2451	0.9465
Public Works & Promotion	550.55	290.96	0.1078	0.2155	0.5285
Public works	295.19	246.18	0.0578	0.1823	0.8340
Promotion & acquisition	255.36	44.78	0.0500	0.0332	0.1754
Transfer Payments	3,505.54	141.84	0.6867	0.1050	0.0405
Subsidy	2,771.90	3.08	0.5430	0.0023	0.0011
Aid	56.10	37.28	0.0110	0.0276	0.6645
Participation & pay back	677.54	101.48	0.1327	0.0751	0.1498
Public Debt	55.79	54.58	0.0109	0.0404	0.9783
Available Funds (Disponibilidades)	26.67	26.88	0.0052	0.0199	1.0079
Third Party	186.93	1.49	0.0366	0.0011	0.0080
Other Expenses	4.97	0.87	0.0010	0.0006	0.1751

Source: Anuario Estadistico 2002, Quintana Roo, INEGI

Income and Expenditures at the State and Municipal levels suggest that a large component of income consists of funds transferred from the immediately higher level government, and these funds are spent as transfer payments on the immediately lower level government. In other words, the State government receives funds from the Federal Government and transfers them to Municipal governments. These transfers reportedly take place at a 80:20 ratio, that is, the Federal Government keeps 80% of income and transfers 20% to States. A State, in turn, keeps 80% of the transfer received from the Federal Government and transfers 20% to Municipalities. This allocation ratio appears to be the subject of some debate, as local governments, especially those with large tourist inflows, apparently would like a revision toward a higher share in the federal income.

b. Public Investment in Quintana Roo State

Public investment in Quintana Roo State in 2001 amounted to 885.09 Million Pesos, with varied financing sources as indicated below.

Table A-16: Public Investment by Sector in Quintana Roo in 2001

Sector	Monetary Value (Million Pesos)				
	Total	Federal	State	Municipal	Credit
Total	885.09	230.71	354.49	295.37	4.52
Education	299.05	84.90	162.04	52.11	0.00
Urban Development	218.31	66.78	39.30	110.09	2.14
Communication & Transport	69.50	35.15	25.11	7.71	1.53
Administration & Finance	60.32	2.29	20.43	36.96	0.64
Agriculture & Forestry	57.50	13.33	42.44	1.73	0.00
Drinking Water	46.05	16.46	27.18	2.20	0.21
Social Welfare	27.68	0.00	7.27	20.41	0.00
Electricity	23.47	0.95	2.98	19.54	0.00
Ecology	18.33	0.29	17.44	0.60	0.00
Security	17.02	0.00	0.00	17.02	0.00
Sport	16.68	0.98	0.34	15.36	0.00
Culture	10.56	0.00	7.08	3.48	0.00
Tourism	9.57	9.47	0.10	0.00	0.00
Health	4.09	0.00	0.00	4.09	0.00
Housing	3.95	0.11	0.11	3.73	0.00
Trade & Supply	2.74	0.00	2.43	0.31	0.00
Fishing	0.27	0.00	0.24	0.03	0.00

Source: Anuario Estadistico 2002, Quintana Roo, INEGI

The above table shows that public investment during 2001 in specific sectors amounted to 46.1 Million Pesos in the Drinking Water, 18.3 Million Pesos in Ecology, 9.6 Million Pesos in Tourism, and 4.1 Million Pesos in Health.

Federal funds financed mostly Education, Urban/Social Development, and Communications & Transportation Sectors. State funds were concentrated in financing Education, Agriculture & Forestry, and Urban/Social Development Sectors. Municipal funds financed Urban/Social Development, Education and Administration & Finance Sectors. Credit financed Urban/Social Development, Communication & Transportation, and Administration & Finance Sectors. These sectors amounted to 70% or more of each financing source.

A.2.2.3 Population

a. Population

The population of Quintana Roo state and of each municipality in 2000 are as following table.

Table A-17: Population of Quintana Roo State 2000

		Total	Male	Female	M/F %
Quintana Roo State		874,963	448,308	426,655	105.1
Municipality	Benito Juarez	419,815	215,352	204,463	105.3
	Cozumel	60,091	31,060	29,031	107.0
	Felipe Carrillo Puerto	60,365	30,682	29,683	103.4
	Isla Mujeres	11,313	5,930	5,383	110.2
	Jose Maria Morelos	31,052	16,023	15,029	106.6
	Lazaro Cardenas	20,411	10,537	9,874	106.7
	Othón P. Blanco	208,164	104,314	103,850	100.4
	Solidaridad	63,752	34,410	29,342	117.3

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

In terms of administration area Quintana Roo state is divided into 8 municipalities. And 8 municipalities are divided into 2,167 communities, which are called 'localidades'. Localidad is a minimum legal administrative unit. There is no administrative unit in between municipality and localidad. In most cases the area boundary of localidad is not clear. This may be observed as a historical heritage that people have been living in dispersed small communities, el Ejido, in a vast area without much worrying about their exact boundary with neighboring communities.

An important characteristic of Quintana Roo population is of its distribution pattern. Populations are dispersed in many small rural communities. It is vital to understand this population distribution structure for planning appropriate sanitation systems for respective communities. The following tables shows number of communities according to the population size in the Study area.

Table A-18: Communities and Population - 1

	Othón P. Blanco		Felipe Carrillo Puerto		Solidaridad	
Range of Population	Number of commun.	Total Pop.	Number of commun.	Total Pop.	Number of commun.	Total Pop.
Rural communities(1 – 2,499)						
1 - 49	652	2,936	137	1255	259	1,487
50 – 99	6	451	13	854	4	326
100 – 499	48	11,957	39	10,799	12	3,720
500 – 999	30	22,005	13	8,675	3	2,121
1000 – 1999	16	23,682	6	7,567	4	5,752
2000 - 2499	1	2,276	2	4,507	0	
Sub total and % of total	753	63,307 30%	210	33,657 56%	282	13,406 21%
Semi urban communities(2,500 – 14,999)						
2500 – 4999	4	14,016	2	8,163	0	
5000 – 9999	(Bacalar) 1	9,239	0		(Tulum) 1	6,733
10000 - 14999	0		0		0	
Sub total and % of total	5	23,255 11%	2	8,163 13%	1	6,733 11%
Urban Communities(15,000 -)						
15000 - 19999	0		(Felipe C.P) 1	18,545	0	
20000 - 49999	0		0		(Playa del C)1	43,613
50000 - 99999	0		0		0	
100000-499999	(Chetumal)1	121,602	0		0	
Sub total and % of total	1	121,602 59%	1	18,545 31%	1	43,613 68%
Total	1	208,164	1	60,365	1	63,752

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

Table A-19: Communities and population – 2

Municipality	Population based on community size			Total
	Rural (1 – 2,499)	Semi urban (2,500 – 14,999)	Urban (15,000 -)	
Othón P. Blanco	63,307	23,225	121,602	208,134
Felipe Carrillo P.	33,657	8,163	18,545	60,365
Solidaridad	13,406	6,733	43,613	63,732
Number of Communities	1,245	8	3	1,256
Total Population Percentage	110,370 33%	38,121 12%	183,760 55%	332,251 100%

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

The communities are classified in three categories according to the population size. This division of urban, semi urban and rural is in accordance with SEDUMA's information which is based on INEGI's data. Population line of 2,500 is also used by CAPA for the classification of urban and rural areas in their report of "PLAN ESTRATEGICO LOS SERVICIOS DE AGUA POTABLE, ALCANTARILLADO Y SANEAMIENTO 2001 – 2025".

These two tables show that communities in the Study area span a wide variety in scale and characteristics, ranging from cities to villages. Total number of communities is 1,256. Among those 1,245 are rural communities with a population less than 2,499. Within these 1,245

communities, 33% of the total population of the Study area lives. Urban community is only one for each state. In Felipe Carrillo Puerto 56% of the municipal population are living in rural areas. While in Othón P. Blanco, this figure reaches 30% and in Solidaridad is 21%. Population tends to concentrate in urban areas where a rapid population growth takes place like in Playa del Carmen, where people can find jobs related with urban developments and tourism developments.

Population growth of the study area in the past 20 years is as follows;

Table A-20: Population Growth (1970 – 1990)

Item	1970	1980	1990
Quintana Roo	88,150	225,985	493,277
Felipe C Puerto	32,134	32,506	47,234
Othón P Blanco	36,347	97,999	172,563
Solidaridad/Cozumel*	12,622	32,270	44,903

Source; INEGI, * Solidaridad was together with Cozumel until 1994. Population of 1970, 1980, and 1990 includes Cozumel and Solidaridad. After 1994 Solidaridad was an independent municipality.

For the purpose of the analysis of current population the population, figures of INEGI were used. INEGI is the responsible government agency for the national census. However, INEGI does not make a population projection. On the other hand CONAPO (Consejo Nacional de Poblacion) and COESPO (Consejo Estatal de Poblacion) are the agencies which make population projections.

CONAPO makes national level projection, while COESPO makes state level projection. CONAPO's figure is general in a sense. COESPO's projection is only up to 2005. Because COESPO considers that the mobility of local communities is too great to project beyond more than 5 years ahead. The Study Team found a population projection up to 2025 in the report "PLAN ESTRATEGICO DE DESARROLLO INTEGRAL DEL ESTADO DE QUINTANA ROO 2001-2025". The projected population is in between the one of CONAPO and COESPO. Accordingly the Study team proposed to use this figure for future population, which was agreed at the 2nd Counterpart meeting on 20th Jun 2003.

The projected population is shown in the following table;

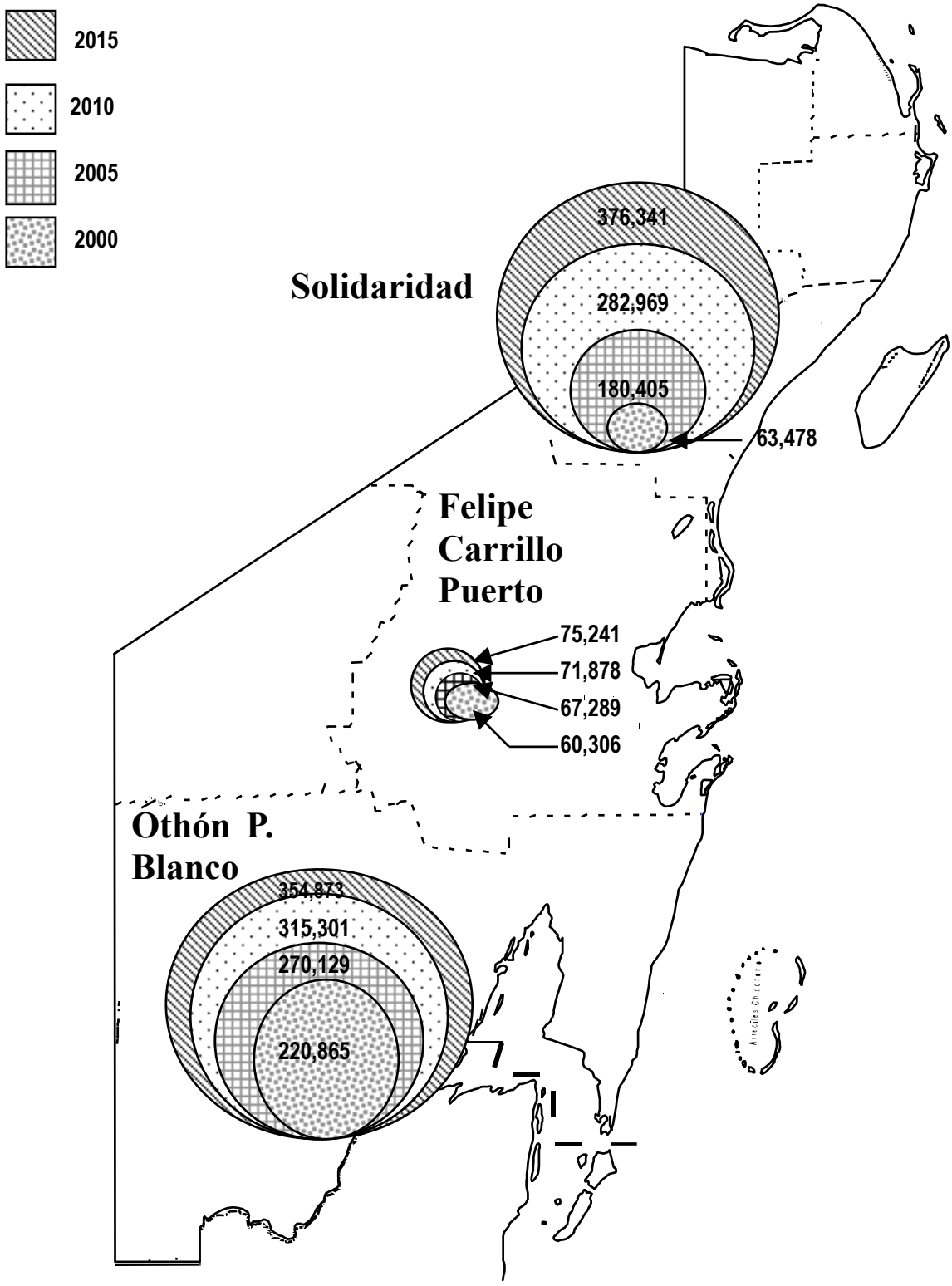
Table A-21: Population Projection

Item	2000	2005	2010	*2015
Quintana Roo	889,988	1,178,571	1,441,914	1,717,098
Felipe C Puerto	60,306	67,289	71,878	75,241
Othón P Blanco	220,865	270,129	315,301	354,873
Solidaridad	63,478	180,405	282,969	376,341
Total of 3 Municipalities	344,649	517,823	670,148	806,455

Source; PLAN ESTRATEGICO DE DESARROLLO INTEGRAL DEL ESTADO DE QUINTANA ROO, 2000-2015.
*Tabulated by the Team from the report´s figures

For the purpose of population projection, CAPA referred to the following documents (Bibliography for the population projection):

- COESPO Quintana Roo. Proyecciones Demográficas 1999, 1999
- CONAPO. Encuesta Nacional de Migración en Áreas Urbanas, 1986-1987
- CONAPO. Proyecciones de la población de México 1995-2020 Quintana Roo,1999
- INEGI. Encuesta Nacional de la Dinámica Demográfica, 1992
- INEGI. Perfil Socieconómico de Quintana Roo, 1997
- INEGI. Cuaderno Estadístico Municipal Benito Juárez, Quintana Roo, 1998
- INEGI. Cuaderno Estadístico Municipal Cozumel, Quintana Roo, 1998
- INEGI. Cuaderno Estadístico Municipal Felipe Carrillo Puerto, Quintana Roo,1998
- INEGI. Cuaderno Estadístico Municipal Isla Mujeres, Quintana Roo, 1998
- INEGI. Cuaderno Estadístico Municipal José María Morelos, Quintana Roo, 1998
- INEGI. Cuaderno Estadístico Municipal Lázaro Cárdenas, Quintana Roo, 1998
- INEGI. Cuaderno Estadístico Municipal Othón P. Blanco, Quintana Roo, 1998
- INEGI. Cuaderno Estadístico Municipal Solidaridad, Quintana Roo, 1998
- INEGI. Anuario Estadístico del estado de Quintana Roo, 1999



Source; drawn up by the Study Team based on Table 2-5

Figure A-5: Population projection in Study area 2000-2015

b. Tourists

Quintana Roo state has abundant tropical forests, lagoons, bays, as well as culture and history, however, in spite of the multi efforts of the state, tourism has been promoted for activities of sun and beach so far. Unfortunately or fortunately historical and archeological heritages of tourism resources are secondary. According to the state ministry of tourism number of incoming tourists is as follows;

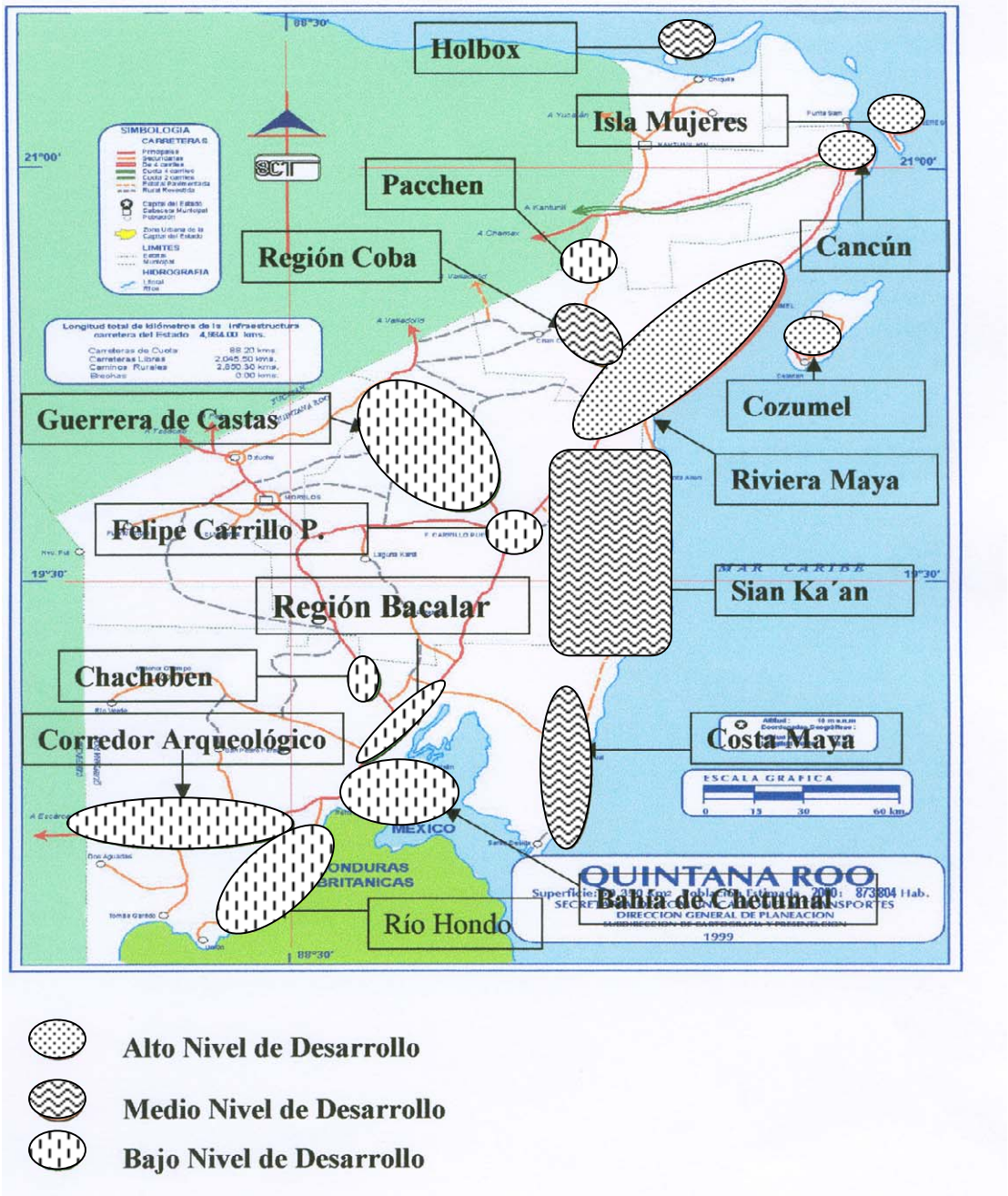
Table A-22: Number of incoming tourist in Quintana Roo

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

Source; State Ministry of Tourism, Quintana Roo

In the above table the Study area includes Riviera Maya and Chetumal. However, in future Costa Maya will be developed for a sun and beach tourism. Table A-21 related to Population projection has taken into account the population increment due tourism.

The area of tourism destinations are shown in the following figures according to current level of tourism, Beach and sun tourism, Rural tourism, Eco-tourism, and Adventure tourism.



Source: State ministry of tourism

Figure A-6: Current level of tourism

A.2.3 Development Plan

a. Development Plans

There have been many development plans prepared not only by the state level, but also by federal level and municipal level. There are general plans and sector plans. They are not always integrated. The relationship and hierarchy are not always clear. There are some duplications and some vacuums. Related plans and programs are as follows;

a.1 Plan Nacional de Desarrollo 2001-2005 (PND)

This sets the basic policy of the development of the country. Some of sector programs are yet in course of preparation.

a.2 Programa Nacional de Desarrollo Urbano (PNDU)

This is one of the sector programs of the above "Plan Nacional de Desarrolo 2001-2005.

This program sets the guide lines for the federal policy on urban development; it is also the reference to state and municipal levels of urban development and human settlements.

In fact PNDU 2001-2006 had not been completed when the state program for the urban development was prepared. Therefore, PNDU 1995-2000 was referred to draft the state program.

a.3 Programa Estatal de Desarrollo Urbano de Quintana Roo 2000-2025 (PEDU)

This is a state level development program following to (PNDU). This sets the urban development policy for the whole state in general. SEDUMA is the main body to prepare this Program. In this development plan SEDUMA forecasts the influx of population and the resulting urban expansion will continue in the tourist areas, but in the rest of area the population increase will be within the natural increase. The magnitude of population increase is remarkable in the tourist oriented coastal area.

a.4 Programa de Ordenamiento Ecologico Territorial (POET)

These ordinances of programs focus on rapidly developing areas where the conservation of ecology is necessary in the state. This will be described in more detail in clause 2.2.2.5 Land Use.

a.5 Programa Estatal de Ordenamiento Territorial (PEOT)

This covers the entire state of Quintana Roo, specially those areas which are not covered by any (POET). This is the tool for protecting natural resources in the state. This focuses on two perspectives;

- To control natural protected areas until more precise management program (POET) will be prepared.
- To control any activity based on the framework of the ecological ordinance

a.6 Plan Estrategico de Desarrollo Integral de Quintana Roo 2000-2025 (PEDI)

In addition to 6 year State Development Plan, Quintana Roo prepared this long term plan by the initiative of the governor. In order to develop Quintana Roo state the following four points are mentioned;

- - To achieve the state development on the bases of the tourism development
- - To achieve the development balance among the communities
- - To achieve a sustainable development
- - To link Quintana Roo state to the global world

a.7 Plan Estrategico de los Sevicios de Agua Potable, Alcantarillado y Saneamiento 2001-2025

This is one of the sector plans of above PEDI

a.8 Plan Basico de Gobierno (2000-2006)

This is made every 6 years for a new governor's term. This is prepared by the coordination of SEPLADER (Secretario de Planeacion y Desarrollo Regional). This plan forms the base of the state policy.

a.9 Programas Municipales de Desarrollo Urbano (PMDU)

This is municipal level urban development plan subordinating to PND, PEDU and other federal and state level plans. This plan is of 3 year plan.

In general programs are law, while plans are plan.

b. Sian Ka'an (Biosphere reservation of Sian Ka'an)

In 1986 Sian Ka'an area (528,147ha) was designated for the first time in the country as a special preservation area of the country. 90% of designated area is owned by the federal government and 10% is by private. The 10% owned by private is mostly along the coast. A development pressure was on the area in 1980s. In order to cope with the development

pressure a legal document for protection and management of Sian Ka'an was made in1986 for the first time of this kind.

In the mid coast of Sian Ka'an there is a small village This was the first village to have been developed as a high class resort area. This is not for ordinary tourists. Punta Pajaros was also developed almost at the same time. Later another development has taken place in Isla Pajaro. It is a bungalow style hotel for VIP with a runway for a small airplane. It is operated 6 months a year only.

In the southern part of Sian Ka'an there are many sand dunes. These areas are mainly owned by private individuals. In the middle part of Sian Ka'an there is no developer who shows interest in developing the area. In northern part of Sian Ka'an there is a group who is interested in developing the area. So there is a pressure for a development at present. The construct of an access road to seashore of Sian Ka'an is also desired.

May 2002 Quintana Roo state established a zoning plan by enacting an ecological ordinance, ORDENAMIENTO ECOLOGICO DE LA ZONA COSTERA DE LA RESERVA DE LA BIOSFERA DE SIAN KA'AN. Any development and construction has to follow this ordinance. For instance, 1 room per ha is prescribed for a tourism accommodation development. However, this may be altered after 5 years when the ordinance is reviewed.

In the south of Sian Ka'an there is Uaimyl area, which is also rich in a natural biosphere. This area has been studied by Amigos de Sian Ka'an financed by Quintana Roo state. Eventually this area (89,118ha) was included to the Sian Ka'an biosphere reservation in May 1992, which made a total area of Sian Ka'an special reservation 617,265ha.

Amigo de Sian Ka'an was established in 1986 in the same year that Sian ka'an special reservation area was designated by the country, aiming the preservation of the area. They have published "Guidelines for low-Impact Tourism along the coast of Quintana Roo". This is concise, practical, and well written. This includes guidelines for building on beaches and dunes, and guidelines to consider when designing developments near lagoons, wetlands and other water bodies. This is translated into English by the University of Rhode Island's Coastal Resource Center.

There is a government organization for Sian Ka'an Biosphere Reserve and regional coordination of natural protected areas. This has offices in Cancun and Felipe Carrillo Puerto. This office is under CONANP (Comision Nacional de Areas Naturales Protegidas). All developments in Sian Ka'an must get permissions from this office besides the municipal and state office.

Access to Sian Ka'an by land is via 4 roads only. The roads from Tulum and Mahuhal are paved. The road from La Esperanza to Vigia Chico is not paved. The road from Felipe Carrillo Puerto to Vigia Chico is not good. The access to the area is controlled but open to general public.

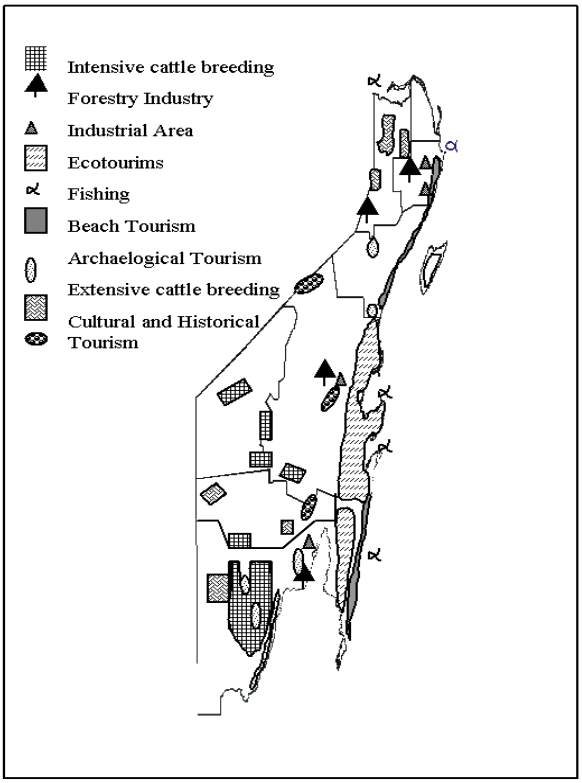
Development of Mahahual is written in the Regional Development Plan of Othón P Blanco.

A.2.4 Land Use

a. Present land use

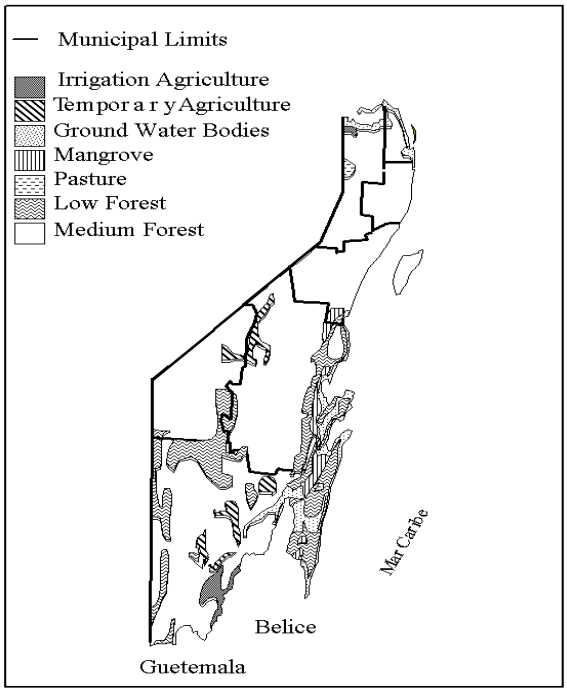
The development plan of the state (PEDU) analyzes the current land use of the state from several different points of view, for instance, area of potential use, main area of economic activity, area by type of vegetation, and area with land use problems, etc. However, a land use map showing current land use itself was not found, yet. Probably because it may be difficult to define and to calculate the area according to the actual use of land. Or such sort of land use map may not be practical, since vast area of the territory is covered with forest and jungle, and vast area is not highly utilized. Only tiny portion of the state is intensively utilized.

According to the official figure of the Quintana Roo government the state area is 50,843Km2. Within this the urban area, the area inhabited by more than 2,500 populations, is only 9,832ha (0.2%). Strategic forest reservation area is 633,973ha (12.4%). Figure A-7 shows areas of main economic activities, like intensive cattle breading, tourism, industrial area, and etc. Figure A-8 shows the current situation of vegetation types in Quintana Roo. Figure A-9 shows potential area for agricultural use in Quintana Roo and Figure A-10 shows potential area for livestock use in Quintana Roo. The potential area means the areas which are not used or only partially used, but are suitable for particular uses. The following figures will lend a hand to understand outline of land use in Quintana Roo state.



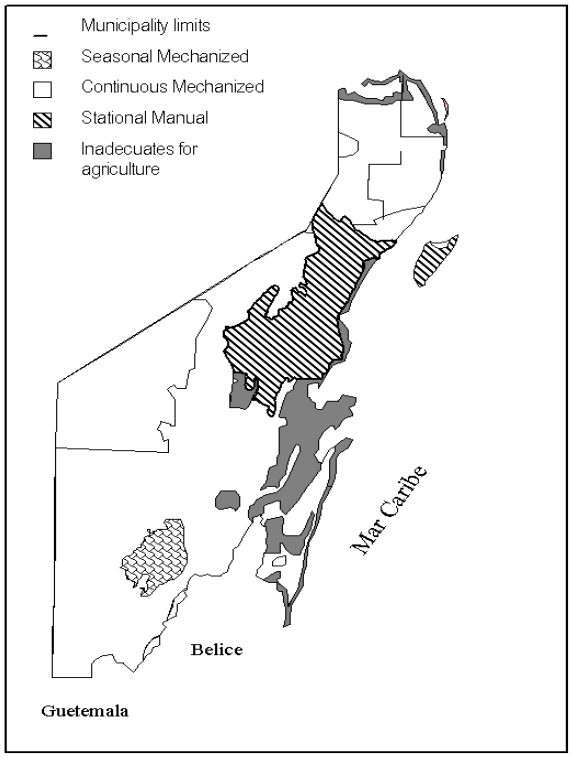
Source:PEDU by SEDUMA

Figure A-7: Area of Main Economic Activities in Quintana Roo



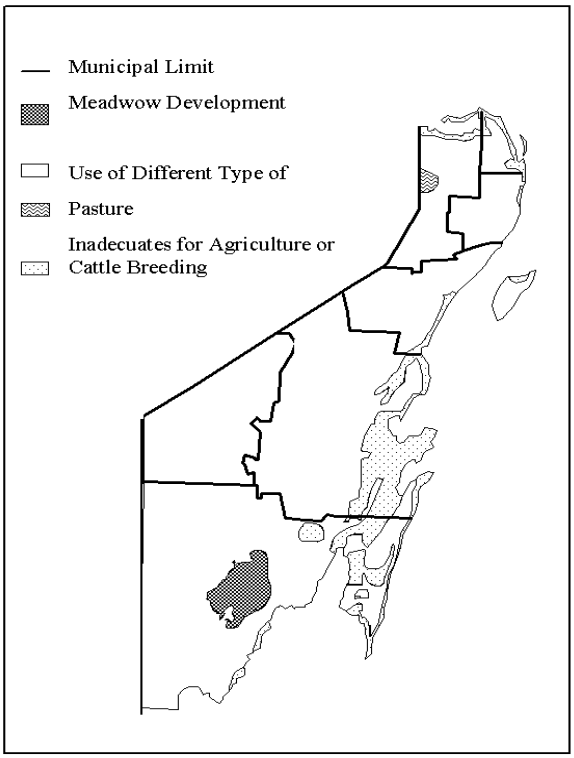
Source:PEDU by SEDUMA, original source is INEGI

Figure A-8: Type of Vegetation in Quintana Roo



Source:PEDU by SEDUMA

Figure A-9: Potential Use for Agricultural Use in Quintana Roo



Source: PEDU by SEDUMA

Figure A-10: Potential Area for Livestock Use in Quintana Roo

b. Land use control

The land use was used to be controlled mainly by Federal (SEMARNAT), State (SEDUMA), and partially by Municipality. However, this system of land use control was altered in 2000, giving much power to Municipal government. Therefore, developers who intend to make a development should approach to the corresponding municipality (Department of Urban Development and Ecology). Then the municipal government will guide the developer to consult with the federal or/and state government according to the location, scale, and kind of development.

b.1 POET

Roughly speaking most of coastal areas are controlled according to POET (Programa de Ordenamiento Ecológico), and rest of the areas are controlled according to PEOT. (Refer to Figure 2-1)

Quintana Roo State government designated areas of urban development control or nature conservation areas by issuing the ordinance of land use zoning with maps and tables (POET). The detailed land use and restrictions are illustrated in POET, which includes;

- Designated areas
- Policy on the areas, e.g. conservation area, protection area, economic activity area, etc.)
- Land use

  Dominant land use, e.g. low density tourism area
  Suitable land use, e.g. flora and fauna management
  Restricted use, e.g. tourism
  Prohibited use, e.g. agriculture, timber industry

- Detail criteria, e.g. allowable building area, number of rooms per ha

However, this land use control will be adjusted every 5 years. For instance, even though the allowable number of rooms are 1 room per hectare at present, later it may be changed to 2 rooms per hectare.

The following figure shows the location of areas covered by each POET and the covered area by PEOT & ANP(National Protected Area).

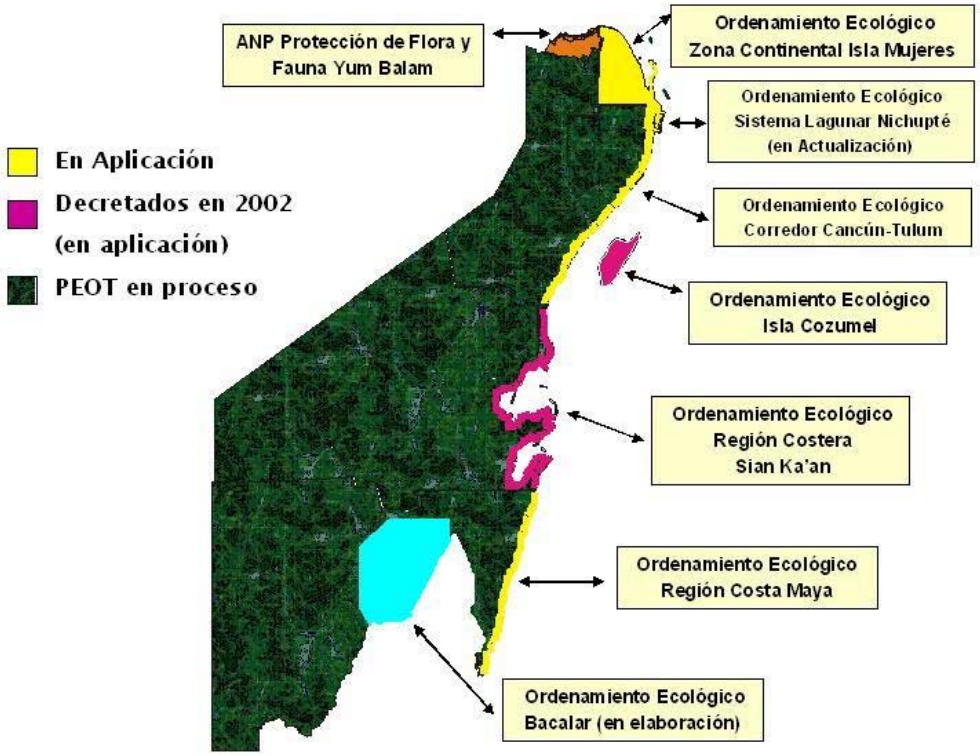


Figure A-11: Location of POET area and PEOT coverage

POET Bacalar is currently in process. Other 6 POETs are already enacted. However, POET Sistema Lagunar Nichupte is in process of revising. In the Study area there are following three POETs.

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

b.2 Nature protection area

Besides above there are 10 areas of nature protection and conservation controlled by the federal government. These 10 areas cover 981,172ha. Among 10 there are following 5 areas within the Study area.

Table A-23: Natural Protection Area under Federal Control in Study Area

	Category	Location	Date of Decree	Area (ha)
1	Archeological monument in Tulum (National Tulum Park)	Solidaridad	23 April 1981	664
2	Biosphere reservation of Sian Ka'an	Felipe Carrillo Puerto, Solidaridad	20 Jan. 1986	528,147
3	Coral reef reservation of Sian Ka'an	Felipe Carrillo Puerto, Solidaridad	2 Feb. 1998	34,927
4	Flora and fauna protection area in Uaymil	Felipe Carrillo Puerto, Othón P Blanco	17 Nov. 1994	95,415
5	Biosphere reservation of Chinchorro coral reef	Othón P Blanco	19 Jul. 1996	144,360
Total				803,513

Source: Gobierno del Estado de Quintana Roo

Quintana Roo state by itself decided 6 areas of natural protection, covering 284,548ha in total. Among those the following 2 areas are in the Study area.

Table A-24: Natural Protection Area under State Control

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

Source: Gobierno del Estado de Quintana Roo

A.2.5 Environment Policy

A.2.5.1 General Review

a. Hierarchy of the laws

At a state level, the right to propose laws and decrees is vested in the Governor of the State, Deputies of the local legislative term and the Municipal Councils.

b. Institutional Hierarchy in Environmental Issues

At a state level, the main legal devices are as follows: the Political Constitution of the Free and Sovereign State of Quintana Roo; Law of Ecological Balance and Environment Protection of the state of Quintana Roo; Law on Potable Water and Sewerage of the state of Quintana Roo. Municipalities legislate based on police and good government edicts.

Within the state's organizational structure, the Secretariat of Urban Development and Environment (SEDUMA) and the Committee of Potable Water and Sewerage (CAPA).

There exists an administrative unit in environmental matters within the administrative structure of the three municipalities embraced in the Study.

c. Brief Summary on Environmental Legislation

c.1 Political Constitution of the Free and Sovereign State of Quintana Roo

On individual rights

Regarding health matters, the Political Constitution of the State of Quintana Roo makes reference to the constitutional right of entitlement to health. No reference is made to environmental matters.

Article 13th

The State Government guarantees legal equality for all of its dwellers: every person is entitled to the protection of their health.

On the Municipalities

The Constitution of the State is extensive in reference to the legislation involving the municipalities. The municipal liability regarding the rendering of the solid waste management service is set forth.

Potable water and sewerage services will be provided by the municipalities under an agreement with the Committee of Potable Water and Sewerage (CAPA).

Articles 128th and 161th

The municipalities are empowered to formulate, approve and manage municipal urban development zoning and plans.

Likewise, they will be in charge of public functions and services: cleaning, collection, haulage, treatment and final disposal of wastes; potable water, drainage, sewerage, treatment and final disposal of its wastewaters.

c.2 Law of Ecological Balance and Environment Protection of the State of Quintana Roo

Objective of the Law

The law herein has the purpose of encouraging the sustainable development and regulating the actions related to the preservation and restoring of the ecological balance, as well as to the protection of the environment in the state of Quintana Roo.

Jurisdiction of Governmental Levels

The State Government, by means of the Secretariat of Urban Development and Environment, has the following obligations, among others:

- Formulation, execution and evaluation of the state's environmental policy
- The enforcement of policy instruments
- Regulation of the collection, haulage, storage, handling, treatment and final disposal systems of non hazardous wastes.
- Regulation of sustainable utilization and prevention and control of pollution in the state's jurisdictional waters, as well as of the domestic waters assigned to it
- Overseeing the compliance with Mexican Official Standards
- Assessment of environmental impacts arising from the works or activities not expressly reserved to the Federal Government.

c.3 Law on Potable Water and Sewerage of the State of Quintana Roo

The law herein sets the foundations for the rendering of potable water and sewerage systems throughout the state; thus, its provisions have a public order and social interest feature and are of general observance.

The attributions will be coordinately executed between the State and the municipalities through the Committee of Potable Water and Sewerage (CAPA) and the operative entities.

The way of executing such public services will be ruled by the demographic features of the place, the need for such services and the urban issues.

In article 36^{th} it is established that the owners or proprietors of improved and mercantile/industrial property and of any other facility that, given its nature, use potable water are also obligated to connecting to the sewerage network system at those places where such service exists, within the stipulated terms.

Where the obligation of connecting to the sewerage network is not carried out, the Secretariat of Health will be informed so as to demand the compliance with the related norms.

c.4 Other Entailing Laws

STATE LEVEL

- Law on Human Settlements of the State of Quintana Roo
- Organic Planning Law of the State of Quintana Roo
- Cadastre Law of the State of Quintana Roo
- Law on Lot Division of the State of Quintana Roo
- Law of the Housing Institute of the State of Quintana Roo

PLANS AND PROGRAMS

- 2000 – 2025 Strategic and Integral Development Plan of the State of Quintana Roo
- Ecological Arrangement of the Territory
- 2001 – 2005 Strategic Plan of potable Water and Sewerage Services
- Sanitary landfill Projects

A.2.5.2 Organization Concerned

a. Secretariat of Urban Development and Environment (SEDUMA)

SEDUMA's vision is to achieve a harmonic and balanced development with due respect to ecology, arrangement of human settlements and consolidation of urban and traffic infrastructure, promoting betterment of life quality of all the dwellers in Quintana Roo.

The Secretariat's mission is the harmonic and balanced development of the state through an organic structure that fosters a planned and focused development of the human settlements; the regulation of urban development and housing; the sustainable management and utilization of the natural resources and preservation of the environment; regulation of transportation and communications of local competence and the execution of public works; so as to provide the state's population with a sustainable and integral development under the pillars of legality, honesty, efficiency and efficacy for the sake of Quintana Roo people.

b. Committee of Potable Water and Sewerage (CAPA)

In its article 18th, the Law on Potable Water and Sewerage creates the Committee of Potable Water and Sewerage (CAPA) as a decentralized public entity of a mixed (state and municipal) nature, which will be in charge of the public services of water and sewerage at a whole state level.

Its mission is to plan, construct, reinstate, expand, operate, conserve and upgrade potable and desalted water systems, sewerage, treatment and reuse of waste waters, pursuant to the terms of the respective state and federal laws.

A.2.5.3 Other Environmental Policy

Environmental Policy

The environmental policy at a state hierarchy stems basically from the LGEEPA, the State System of natural Protected Areas (SEANAP), the State Development Plan, the state's Law of Ecological Balance and Environment Protection and Mexican Official Standards.

For the purposes of formulating and executing the state's environmental policy, the following principles will be taken into consideration, additionally to those regarded at a federal level:

- Restoring of debased areas, as well as reforesting and re-population with native species (e.g., remediation of dump sites)
- Promotion of ecological arrangement must be ensured throughout the state territory so as to locate and regulate the productive activities and services and thus guarantee the duration of natural resources (e.g., Urban and Regional Arrangement).

A.2.6 Overview of Wastewater Management

Sewer System Service Coverage and Investment Plan

Table A-25 shows sewer system service coverage over urban areas, which are communities having 2,500 and over population, in Quintana Roo State as of year 2000. Those values indicate development of facilities. Lower value between one of sewer line and of sewage treatment capacity indicates sewer service coverage. However, number of houses that have connection to sewer should be in reality taken in to account for consideration of sewer service coverage.

Rural areas which have population less than 2,500 are hardly covered by the service. As an exception, Mahahual is covered by the service along with adjoining large scale development. Type of the system provided is a vacuum sewer. A private developer bears 100% of investment cost for wastewater treatment plant, and CNA and CAPA respectively bear 50% of investment cost for the vacuum sewer system. As of June 2003, 20 houses are covered by the system.

Seeing the whole picture of the Quintana Roo State, although urban area of Benito Juarez Municipality that has one of the greatest tourism area in the world or Cancun indicates higher coverage of the sewer service, while of the rest of municipalities shows lower coverage. Rural areas are hardly covered by the service.

Table A-25: Sewer System Service Coverage in the Quintana Roo State in 2000

Municipality	City	Population	Service coverage		
			Water supply	Sewer line	Sewage treatment capacity
BENITO JUAREZ	CANCUN	400,307	100%	70%	100%
	ALFREDO V. BONFIL	7,292	100%	0%	0%
	LEONA VICARIO	4,714	100%	0%	0%
	PUERTO MORELOS	2,972	100%	0%	0%
	Total	415,285	100%	68%	96%
ISLA MUJERES	ISLA MUJERES	10,580	100%	90%	100%
COZUMEL	COZUMEL	59,350	92%	80%	100%
SOLIDARIDAD	PLAYA DEL CARMEN	39,005	50%	30%	15%
	TULUM	7,975	79%	0%	0%
	Total	46,980	55%	25%	13%
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%
LAZARO CARDENAS	KANTUNILKIN	5,624	90%	0%	0%
JOSE MARIA MORELOS	JOSE MAR IA MORELOS	8,967	89%	0%	0%
	DZIUCHE	2,762	94%	0%	0%
	Total	11,729	90%	0%	0%
OTHON P. BLANCO	CHETUMAL	118,553	96%	50%	40%
	BACALAR	9,047	88%	0%	0%
	CALDERITAS	4,617	92%	0%	0%
	INGENIO ALVARO OBREGON	3,331	97%	0%	0%
	NICOLAS BRAVO	3,524	92%	0%	0%
	ALVARO OBREGON	3,019	91%	0%	0%
	SERGIO BUTRON CASAS	2,712	98%	0%	0%
	Total	144,803	95%	41%	33%
State total		720,567	95%	57%	73%

Source: CAPA Plan Estratégico APAS 2001-2025

CAPA made a strategic plan[9] of wastewater management for the whole Quintana Roo State in 2001. The plan defines urban area that has a population 2,500 and over, and rural area that has less than 2,500. Then, it sets goals as shown in Table A-26. In the strategic plan, rural areas do not have goals in municipality. Only goals at state level are set. Implementation period is divided into three stages, and each stage has goals respectively.

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

Table A-26: Goals of the Strategic Plan

Item		2001 to 2005	2006 to 2025
Urban area (population : more than 2,500)	Water supply	Service coverage : 98%	Service coverage : 100%
	Sewer system (collection system)	Service coverage : 80%	Service coverage : 100%
	Sewage treatment	100% of collected sewage	100% of collected sewage
Rural area (population : less than 2,499)	Water supply	Service coverage : 92%	Service coverage : 100%
	Sanitation system	Service coverage: 80% (latrine and septic tank)	Service coverage : 100% (latrine and septic tank)

Source : CAPA Plan Estratégico APAS 2001-2025

Table A-27: Outline of Phased Implementation Plan in the Quintana Roo State

Item	Short term 2001 to 2005	Medium term 2006 to 2010	Long term 2011 to 2025
Water supply amount	1,850 litter /sec (159,840 m3/day)	1,375 litter /sec (118,800 m3/day)	4,172 litter /sec (360,460 m3/day)
	1,850 litter /sec (159,840 m3/day)	3,225 litter /sec (278,640 m3/day)	7,397 litter /sec (639,100 m3/day)
Installation of sewer line	3,826 ha	2,206 ha	6,750 ha
	3,826 ha	6,032 ha	12,782 ha
Sewage treatment amount	1,647 litter /sec (142,300 m3/day)	837 litter /sec (72,317 m3/day)	2,669 litter /sec (230,602 m3/day)
	1,647 litter /sec (142,300 m3/day)	2,484 litter /sec (214,618 m3/day)	5,153 litter /sec (445,219 m3/day)
Nos. of installation Latrine and septic tank	8,885	1,144	3,253
	8,885	10,029	13,282
Investment amount for whole system (million pesos)	1,872.4	1,111.0	3,408.1
	1,872.4	2,998.4	6,391.5
Investment amount for urban system (million pesos)	1,834.9	1,062.9	3,271.2
	1,834.9	2,897.8	6,169.0
Investment amount for rural system (million pesos)	37.5	48.1	136.9
	37.5	85.6	222.5

Source : CAPA Plan Estratégico APAS 2001-2025

A.3 Othón P. Blanco

A.3.1 Natural Environment

A.3.1.1 Topography

Othón P. Blanco is the only municipality in the Study area where the three most important physiographical features of the State are found, i.e, Yucatecan Carso (limestone plateau) which is found in the central northern part of the municipality; the Campeche Carso (limestone plateau) and Lomerios which is found in the western part of the municipality along the border with the Campeche State precisely; and the Low Coastline of Quintana Roo which is found in the south and east of the municipality.

A.3.1.2 Climate

Temperature and rainfall figures were obtained from Chetumal (1953-2001), Alvaro Obregon (1966-1995), and Lazaro Cardenas (1975-2001) stations. Those years which did not have information for every month were discarded.

Table A-28: Temperature and Rainfall Data

	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEPT	OCT	NOV	DEC	AVERAGE
TEMPERATURE (0C)													
ALVARO OBREGON	22.2	22.9	24.6	26.2	27.7	27.7	27.1	27.4	27.1	26.3	24.4	22.8	25.5
CHETUMAL	23.1	24.0	25.9	27.6	28.4	28.3	28.1	28.2	28.0	26.8	25.0	23.8	26.5
LAZARO CARDENAS	22.9	23.3	24.6	26.3	27.2	27.2	26.9	27.2	27.0	26.1	24.6	23.5	25.6
AVERAGE	22.7	23.4	25.1	26.7	27.8	27.7	27.4	27.6	27.4	26.4	24.7	23.3	25.8
RAINFALL (mm)													
ALVARO OBREGON	64.1	34.6	33.2	38.9	101.5	250.5	204.1	163.0	200.7	150.9	76.1	74.6	1392.2
CHETUMAL	60.4	36.2	25.0	42.9	133.3	187.9	151.1	145.4	196.6	158.2	93.1	71.2	1301.2
LAZARO CARDENAS	84.5	39.2	38.4	43.2	119.1	189.8	150.2	159.8	244.2	197.0	113.1	95.9	1474.5
AVERAGE	69.7	36.7	32.2	41.7	118.0	209.4	168.5	156.1	213.8	168.7	94.1	80.6	1389.3

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

A.3.1.3 Geological Condition

Limestone and gypsum are the rocks most commonly found in the study area; these rocks´ age range from the Paleocene to the Quaternary. Their age increases from north to south and from east to west. Consequently, in the south-western part of Othón P. Blanco are located the oldest formations in the municipality. In OPB can be found Paleocene, Miocene, and Tertiary Superior limestone.[10]

[10] Hydrological Study of Quintana Roo State, INEGI, 2002

A.3.2 Land Use and Urban Planning

A.3.2.1 Urban Planning

Urban plan is integrated in the municipal plan of Othón P Blanco. The population of urban areas in the state will grow about 43,000 by 2005. In Othón P Blanco there are 8 urban communities, which are listed in Population Density. By year 2015 the urban communities are forecasted to be 16. Especially the urban growth of Mahahual is great. The detail of Mahahual development is described in Regional Development Plan.

A.3.2.2 Land use

The municipal area of Othón P Blanco is 18,760 km2. There are 759 localities in the municipality. Among these urban localities are 7 according to PEDU by SEDUMA, which are Chetumal, Bacalar, Carderitas, Nicolas Bravo, Ingenio Alvaro Obregón, Alvaro Obregón, and Sergio Butron Casas. While rural localities are 752. The area of urban localities is 2,773ha, which is about 0.15% of the total municipal area. There is no figure for the rural localities area.

As for the area of Coast Maya a land use zoning map and related documents are prepared by the state of Quintana Roo in order to control the development in Costa Maya. This is Program of Ecological Land Development for Cost Maya Region (POET, 6 Oct. 2000). This ordinance consists of tables and zoning maps, and describes the detail rules of land use. The map covers approx. 120km long area of Costa Maya. The contents of POET are described in 2.2.4 Land use.

A.3.2.3 Population Density

The population density of whole municipality in 2000 was 0.12 inhabit/ha, while Chetumal is 73 inhabit/ha. Ingenio Alvaro Obregón, a sugar cane factory town, has the highest density in Othón P Blanco. The Population density of urban areas of Othón P Blanco in 2000 is shown in the following table.

Table A-29: The population density of Othón P Blanco in 2000

	Current urban area	Population density
Othón P Blanco	1,876,000 ha	0.12 inhabit/ha
Chetumal	1,621 ha	73 inhabit/ha
Bacalar	281 ha	32 inhabit/ha
Carderitas	177 ha	26 inhabit/ha
Nicolas Bravo	140 ha	25 inhabit/ha
Ingenio Alvaro Obregón	35 ha	96 inhabit/ha
Alvaro Obregón	366 ha	8 inhabit/ha
Sergio Butron Casas	153 ha	18 inhabit/ha

Source; Urban area density from PEDU by SEDUMA (page 29), Municipality density was tabulated by the Team

A.3.2.4 Regional Development Plan

The municipality of Othón P Blanco has three year development plan, "Programa de Desarrollo Urbano del Municipio de Othón P Blanco" This guides strategies to distribute population with better balance in the area of municipality based on a territorial potential, and strategies to generate urban structures. The ambitious but desirable scenario, based on this state development plan, states the following forecasts;

- Mahahual would grow to 60,000 inhabitants in 2010 and 100,000 in 2025
- Bacalar would accommodate 17,428 inhabitants in 2010 and 30,000 in 2025
- Limones would have 13,127 inhabitants in 2010 and 30,000 in 2025
- Chetumal would have 149,665 inhabitants in 2010 and 190,498 in 2025
- Xahuachol would accommodate 12,000 inhabitants in 2010 and 30,000 in 2025

The development of Mahahual has taken place as follows;

The development of Mahahual started 2 years ago, when Mexican private investor constructed a pier about 3km north of the present Mahahual village. First the area was developed for the temporary housing of laborers working for the pier construction. The government helped to construct an access road, water supply, and electric power supply. It was only about 8 or 12 months ago . Until then there was no electricity nor proper water supply in the present Mahahual village. 1,700 ha of area is to be developed along the seashore of 3.5km for 60,000 population. The development of 2,000 hotel rooms is planed, which is speculated to generate 23,000 jobs in the area. The construction laborers are mainly recruited from Chetumal and may stay in Mahahual even after the construction works have been finished.

Number of arriving cruisers and passengers to Mahahual Pier is 2-3 cruisers every week. From the beginning of the year until middle of May 76 cruisers with approximately 150,000 passengers have arrived according to the data of State Ministry of Tourism.

A.3.3 Socioeconomic Conditions

A.3.3.1 Regional Economy

Of 348,750 economically active population (EAP) of Quintana Roo State in the year 2000, Othón P. Blanco Municipality accounted for 74,223 or 21% of the State. Judging from the sector distribution of EAP, the structure of the economy in Othón P. Blanco Municipality had a more active agriculture sector and less active service sector than Quintana Roo State as a whole. In fact, EAP in the agriculture sector comprised 20% in Othón P. Blanco, while only 10% in the State. EAP in the industrial sector was even at 16% both in Othón P. Blanco Municipality and the State. Conversely, EAP in the service sector was higher at 73% in Quintana Roo State, and 64% in Othón P. Blanco Municipality.

A.3.3.2 Administration

Othón P. Blanco is the largest municipality of the State. Its capital city Chetumal is the government headquarters and where other government branches are located: the State Congress and the Judiciary. Also located in this city are the Federal Delegations, Quintana Roo University and Chetumal Institute of Technology.

According to the 2000 Census, the Municipality has 753 rural communities with 30.4% of the population and 5 cities where population ranges between 2,500 and 10,000 and account for 10.6% of the population. The remaining 59% of the population lives in the city of Chetumal (121,602)

The city government is composed of the Mayor, one Vice Mayor, 9 representatives elected by relative majority and 6 representatives elected by proportional representation; substitutes are also elected for the Vice Mayor and the representatives.

The residents can get organized in town governments, delegations and subdelegations to manage their interests in accordance to the number of inhabitants in each locality

Town governments in Othón P. Blanco are the following: Bacalar, Luis E. Silveira Gómez, Nicolás Bravo, Ribay Salazar Pérez, Dos Aguadas, Camilo Hernandez L., Cerro de las Flores, César Ardoney Pérez, Calderitas, Joel Pérez Flores, Javier Rojo Gómez, and, Marco A. Delgado. There are also 34 delegations and 92 subdelegations.

The Municipality through its Bureau of Urban Development and Ecology is in charge of the administration of urban development and the Bureau of Municipal Public Services has the responsibility for solid waste management (cleansing/sweeping and collection).

The cleansing and collection service can be contracted out to the private sector, or can be done in association between the Municipality and the State, and/or the Federation; municipal public services are subjects to tariffs approved by the Municipal Government and the respective Commission.

A.3.3.3 Population

The population of Othón P Blanco was rapidly increased from 1970 to 1990. It is forecasted to increase steadily. Chetumal, as the capital city of the state and also as a base town for adjacent tourism resources, will keep on attracting population from out side. The population increase in Othón P Blanco from 1970-1990 is as the following table.

Table A-30: The population change in Othón P Blanco 1970-1990

	1970	1980	1990
Othón P Blanco	36,347	97,999	172,563

Source; INEGI

The population increase in urban area is great, while it is much small in rural area. The forecast of the population increase in Othón P Blanco is as follows;

Table A-31: The population forecast of Othón P Blanco 2000-2015

	2000	2005	2010	2015
Othón P Blanco total	220,865	270,129	315,301	354,873
Urban area	157,382	200,624	241,441	279,848
Rural area	64,483	69,505	73,860	75,024

Note; Urban area means the area which has more than 2,500 populations.
Rural area means the area which has less than 2,499 populations.
Source; CAPA, "PLAN ESTRATEGICO DE LOS SERVICIOS DE AGUA POTABLE, ALCANTARILLADO Y SANEAMIENTO 2001-2025". 2015 figures were tabulated by the Team from CAPA figure.

A.3.3.4 Industry

Located in Othón P. Blanco Municipality is Chetumal, the main city of the Municipality and the capital city of Quintana Roo State. Government offices are located in Chetumal, implying the need for government workers to live in the city, thereby increasing the EAP in the service sector.

Despite inadequate soil, agriculture has been traditionally important within Othón P. Blanco Municipality, with extensive sugarcane plantations (19,800 ha harvested in 2001) and a sugar processing plant in the area. Another important perennial crop was orange with around 790 ha harvested in 2001. On the other hand, corn was the most important annual crop with 19,400 ha harvested, beans with 3,400 ha harvested, and jalapeño pepper with 1,900 ha harvested in 2001. Livestock in Othón P. Blanco in 2001 consisted of around 60,000 heads of cattle (60% of the State), about 45,000 pigs, 32,000 sheep, 2,000 goats, 121,000 chickens, and 11,000 beehives.

Industrial development is yet to take place, as indicated by the 16% of EAP employed in this sector. Except for the sugar processing plant, manufacturing consists of small scale processing of agricultural products. The service sector is more important with 64% of EAP, the top tertiary activity being commerce with 14% of EAP, followed closely by government service with 12% of EAP. Commercial activities are promoted by the existence of a free trade zone right across the border in Belize. One tourism development plan that is being implemented targets cruise ships, with considerable investments already made in the Costa Maya area, specifically Mahahual. Recent investments of more than USD20 Million in the Mahahual dock for cruise ships and supporting facilities (duty free shops, open air theatre) have brought in already more than 140 cruise ships and more than 305,000 passengers, thereby quickly becoming one of the main cruise ship destination in Mexico. Hence, future expectations for tourism development are high on the basis of servicing cruise ship

passengers, ecotourism and such attraction as the largest coral reef in the northern hemisphere, Banco Chinchorro, off the coast of Mahahual.

A.3.3.5 Education

The Municipality of Othón P. Blanco is the one that more wide educational covering offers in the whole state. The municipality has 6 schools of initial education, 8 of special education, 168 of elementary education, 223 of primary education, 97 of secondary education, 2 of middle professional education, 32 of middle-high education, 1 of normal education and 7 of college education.

The index of the population's literacy of 15 years old was of approximately 89.0% in 1995, percentage, which stays as the same level up to the 2,000.

According to the Development Plan of the Municipality of Othón P. Blanco, the city of Chetumal presents a surplus in the diverse types of schools that it possesses; Bacalar and Calderitas have deficit of kindergartens and primary schools; Nicolás Bravo has deficit in kindergartens, while Javier Rojo Gómez as Alvaro Obregón, according to the population's amount would require of tele-secondary schools, elements that don't possess, but they count with high schools where both communities have a surplus.

A.3.3.6 Community Structure

The municipality of Othón P. Blanco is the second settlement of Quintana Roo with regard to population's concentration. Here is the seat of the capital of the state, consequently, acquires great importance in the social and political sphere. A great mixture of cultures exists, because the municipality inhabits many populations coming from the central part of Mexico and other vicinity states.

Regarding the population figures, the municipality with 220,865 inhabitants in year 2000, represents 23.8% of the state population, however its territorial density of 11.7 inhabitants per km2 is low comparing the great territorial magnitude (18,760 km2) of the municipality.

The social development of the municipality of Othón P. Blanco has been subjected to the influence of several factors like the population's origin, the centralization of administrative activities of the different government levels, the level of the population's well-being, etc. The municipality has high percentage of population from other states that inhabits the territory, coming from all parts of the country. This situation generates an amalgam of customs and diverse traditions in the main communities like Chetumal, and Bacalar, showing insufficient root or local identification by its inhabitants toward the territory.

The populations of the municipality are distributed in three regions (Costa Maya, Los Ríos and Rio Hondo) and a sub-region, the Mayan, shared with the Municipality of Felipe Carrillo Puerto.

With regard to the ethnic groups who speak an indigenous language in the municipality of Othón P. Blanco, only the data on those who are of 10 years and older were referred to.

In year 2,000, 208,164 inhabitants were of 10 years and older and the predominant indigenous language in the municipality was Mayan followed by Mame and Kanjobal, which represented 14.4%.

A.3.3.7 Poverty Conditions

The population of the municipality is young, since more than 48% is conformed by people less than 20 years old according to figures of INEGI (General Census of Population and Housing, 2,000). According to the National Commission of the Minimum wages (data of January 2003), the minimum wage of Quintana Roo is considered in 40.30 pesos daily. This amount can also be applied for the municipality of Othón P. Blanco.

The economy of the municipality has had in the last years an unbalanced growth, while in some sub-sectors a growth has been shown, others presented decrease that indicates the lack of economic integration. It can predict that the economy of Othón P. Blanco is tertiary, being the services and trade the activities that more have contributed to the production. In the secondary sector the most important activities are those related with the foods and drinks, while in the primary sector, the production of sugar cane is the most important activity. Of the total active population in year 2,000, a great percentage was employed revealing low unemployment and poverty indexes. As is shown in the following table, 11.6% of the municipality population was under poverty situation whose percentage is the lowest among the municipalities considered in the study and the state.

Table A-32: Poverty Index in Quintana Roo (Othón P. Blanco)

Municipality	Poverty index	Population under poverty	Percentage of population
Quintana Roo	1.00	88,330	12.6
Othón P. Blanco	0.92	23,363	11.6
Felipe Carrillo Puerto	1.66	11.,719	20.9
Solidaridad	1.72	6,221	21.6

Source: Information provided by SEDUMA based on INEGI statistic data

A.3.3.8 Public Health

This municipality has the two levels of health service provided by the State Health Services (SESA), Mexican Institute of Health Insurance (IMSS), Health Insurance Institute for State

Workers (ISSTE) and the service provided by military navy. There are also clinics and hospitals of general medical care as much as specialties provided by the private sector.

At community level or population level, Chetumal has two health centers, Bacalar has a health center, Calderitas, Alvaro Obregon, Nicolas Bravo and Sergio Butron Casas has a rural health center each, and Javier Rojo Gómez has an IMSS medical unit for families.

There are 63 rural medical units at municipality level, 7 urbans, 1 general hospital and 1 hospital for specialties shown in the Table below:

Table A-33: SESA's Medical Units of Othón P. Blanco

Medical Units	Othón P. Blanco
Rural	63
Urban	7
General hospital	1
Specialty hospital	1
Total	72

According to the Development Plan of the Municipality of Othón P. Blanco, in Bacalar and Nicolas Bravo there are sufficient medical units, while the towns of Calderitas, Javier Rojo Gomez and Alvaro Obregón has an adequate equipment in the health sector. With regard to the city of Chetumal, there is a deficit of clinics and beds in the public services of the State provided through SESA.

Regarding the Epidemic Surveillance there are hundred of units distributed in the whole municipal territory having a flow of information from the operative level, toward the state level, and finally to the national level, maintaining a feedback of the information toward the three sanitary jurisdictions and other health sector institutions (IMSS, ISSSTE, SEDENA, SEDEMAR and INI).

The three sanitary jurisdictions are responsible and involve the following municipalities:

Sanitary Jurisdiction no.1:	Chetumal – Municipality of Othón Pompeyo Blanco
Sanitary Jurisdiction no.2:	Cancún – Municipalities of Solidaridad, Benito Juárez, Cozumel, Isla Mujeres and Lázaro Cárdenas
Sanitary Jurisdiction no.3:	Felipe Carrillo Puerto – Municipalities of Felipe Carrillo Puerto and José María Morelos

The municipality of Othón P. Blanco is the second of the state in term of population concentration after Benito Juarez. This municipality is the seat of capital of the state, acquiring great importance in the social and political environment.

The Sanitary Jurisdiction No. 1 is the responsible of the municipality of OPB regarding epidemic surveillance and supervision, and it is divided in three big areas that are:

Table A-34: Medical Units and most common diseases in the Municipality of OPB

Zone	Medical units in:	Common diseases	%
Zone I or "Fronteriza"	Alvaro Obregón, Allende, Cacao, Cocoyol, La Unión, Palmar, Pucté, Ramonal, Rovirosa, Sabidos, Subteniente Lopez, Ucum, Juan Sarabia and Ingenio Alvaro Obregón (UMF No. 5 IMSS).	Acute respiratory infection Intestinal infection Urinal tract infection Intestinal parasites by ascariasis, other helminthiasis and intestinal amebiasis. Transmission by vectors (malaria, dengue and leismaniasis)	66.0 8.9 8.4 9.0 0.6
Zone II or "Limitrofe"	Caobas, Dos Aguadas, El Tesoro, Felipe Angeles, La Libertad, Cresencio Rejón, Morocoy, Nachicocom, Nicolás Bravo, Nuevo Becar, Nuevo Veracruz, San Pedro Peralta, Sergio Butron Casas, Tomas Garrido and Tres Garantias	Acute respiratory infection Intestinal infection Urinal tract infection Intestinal amebiasis	65.0 7.8 5.3 5.3
Zone III or "Reforma"	Altos de Sevilla, Andrés Quintana Roo, Buena Esperanza, Blanca Flor, David Gustavo, Francisco Villa, Francisco J. Mújica, Huatusco, Melchor Ocampo, Miguel Alemán, Otilio Montaño, Reforma, Río Verde, San Román and Zamora.	Acute respiratory infection Intestinal infection Urinal tract infection	76.8 5.4 4.0
Zone IV or "Bacalar"	Avila Camacho, Bacalar, Buena Vista, Caanlumil, Chacchoben, Divorciados, Kuchumatán, Lázaro Cárdenas, Limones, La Laguna, Maya Balam, Margarita Maza, Mahahual, Valle Hermoso, Xul-Ha and Modulo ISSSTE Bacalar.	Acute respiratory infection Intestinal infection Urinal tract infection Intestinal amebiasis	70.9 9.2 6.4 2.9
Zone V or "Chetumal"	Chetumal (HGZ No. 1 IMSS, Clínic Hospital ISSSTE, Navy Hospital, Enfermería Militar, General Hospital of Chetumal, Children Maternal Hospital Morelos, Calderitas, Raudales and Luis Echeverría	Acute respiratory infection Intestinal infection Urinal tract infection Intestinal amebiasis	64.6 11.0 8.7 3.8

Source: Subbureau of Epidemiology of Chetumal, State Health Services (SESA)

It is important to point out that Zone I is considered as Malaria or Dengue proliferation areas. One of the main factors of risk is the agricultural production (the cane of sugar) since in crop times it is common that workers from other states and the neighboring country of Belize are hired, where there are local transmissions of Malaria or Dengue, and during the crop periods, an increment is observed in this disease incidence.

The towns of Zone II are located mostly in the bordering area of the State of Campeche, considered socially and economically as marginal areas, situation that represent a high risk factor for this area..

The biggest population proportion of Area III belongs to the Mayan people that is very influenced and/or attached to their traditions and customs and to some religious sects that in some situation represent important risk factors for health, because some of them prohibit the acceptance of immunizations and active participation in family planning programs, among others.

In Zone IV are located the towns which comprise the called Mayan Coast (main tourist area in the south of the State). Also, in this area there are three towns that until some years ago were Guatemalan refugees' camps and that now they are nationalized Mexicans with rights similar to the national people, but with traditions and culture of their origin country and same as Zone III can represent factors of risk in health aspects.

Zone V or Chetumal is the seat of the capital of the State, which concentrates the biggest number of population of the municipality, being a reception and concentration town of patients with pathologies that cannot be solved in the rural areas or cases that require a first level of medical care. Due to this situation, the biggest number of cases is registered in this city. Also, the second level of attention of all institutions in the south of the state is represented or concentrated on this city.

A.3.4 Financial Conditions

A.3.4.1 Public Finance

The income and expenditures of Othón P. Blanco Municipality in the year 2000 amounted to 200.1 Million Pesos, equivalent to 14.8% of the budget of all Municipalities in Quintana Roo State. The most important income source was “Federal participation” or “Federal share” with 79.3 Million Pesos (39.6%), followed by Transfers with 68.8 Million Pesos (34.4%), Taxes with 11.7 Million Pesos (5.9%), Public Debt at 11.33 Million Pesos (5.7%), and Fees with 10.6 Million Pesos (5.3%). Income as Taxes and Fees in Othón P. Blanco Municipality was lower than the average of all Municipalities in the State, while Federal Participation and Transfers were quite a bit higher.

On the expenditure side, Administrative Expenses amounted to 112.1 Million Pesos (56%), followed by Public Works & Promotion with 66.6 Million Pesos (33.3%), and Transfer Payments with 16.4 Million Pesos (8.2%). Expenditures on Public Works & Promotion in Othón P. Blanco Municipality were considerably higher than the average of all Municipalities in the State.

Table A-35: Income & Expenditures of Othón P. Blanco in 2000

Income & Expenditures	All Municipalities (Million Pesos)	Othón P. Blanco (Million Pesos)
INCOME	1,350.38	200.13
Income during 2000	1,307.70	200.13
Taxes	229.84	11.74
Federal share	470.97	79.26
Improvements	0.55	0.00
Fees	155.56	10.60
Products	20.02	3.37
Exploitation	93.00	6.11
Public debt	31.69	11.33
Third party	0.00	0.00
Transfer	232.80	68.84
Other Income	73.27	8.88
Funds from Previous Year	42.68	0.00
EXPENDITURES	1,350.38	200.13
Administrative Expenses	833.76	112.10
Public Works & Promotion	290.96	66.60
Transfer Payments	141.84	16.39
Public Debt	54.58	5.01
Available Funds (Disponibilidades)	26.88	0.00
Third Party	1.49	0.00
Other Expenses	0.87	0.03

Source: Anuario Estadistico 2002, Quintana Roo, INEGI

Taxes (Impuestos) and Fees (Derechos) will be described in the next section. Therefore, this section will describe the other sources of municipal income.

a. Products (Productos)

a.1 Sale of Municipal Goods

a.2 Exploitation of Municipal Goods

- Rentals
- Interests

a.3 Business Set Up

- Printing
- Markets
- Slaughterhouses
- Cemeteries
- Cultural and recreation centers

a.4 Others

b. Exploitations (Aprovechamientos)

b.1 Recovery (Recuperaciones)

- Surcharges
- refunds

b.2 Fine and Penalty

b.3 Contribution (Aportaciones)

- Federal
- State
- Municipal
- Others

b.4 Donations

b.5 Others

c. Contributions on Improvements (Contribuciones de Mejoras)

- Public works
- Public service

d. Federal and State Participation (Participaciones Federales y Estatales)

d.1 Federal Participation

- General participation fund
- Municipal development fund
- Vehicle ownership/use tax
- Tax on new vehicles
- Special tax on production and services
- Federal administrative fine
- Tax administration incentive

d.2 State Participation

e. Federal and State Contributions (Aportaciones Federales y Estatales)

e.1 Contributions of "Ramo General 33"

- Basic education fund
- Health service fund
- Municipal social infrastructure fund
- Municipal strengthening fund
- Technical and adult education fund
- Public security fund

e.2 Federal Resources Reassigned by Agreement

e.3 State Resources

f. Other Municipal Income

g. Third Party

- Federal Government
- State Government
- Municipal Government
- Social Security Institutions
- Worker Union
- Insurance companies
- Diverse withholdings

h. Finance

h.1 Loan or Credit

- From the Federal Government
- From the State Government
- From the Municipal Government
- From banks: development or commercial banks
- From international finance institutions
- From other sources

h.2 Deficit Financing

i. Funds Initially Available

A.3.4.2 Taxation System and Public Utilities

Taxes are applied at the Federal, State and Municipal levels.

The term "Fiscal Federalism" (*Federalismo Fiscal*) is used to describe an arrangement that turns over to the Federal Government some tax functions of Federal Entities. Under this arrangement, the Federal Government coordinates and receives from taxpayers most of the taxes, and then allocates the collected taxes in pursuance of distributive justice and administrative efficiency.

The "National System of Fiscal Coordination" (*Sistema Nacional de Coordinacion Fiscal*) encompasses the legal bases on the distribution mechanism of participations, on the possibility of making agreements on fiscal matters and administrative cooperation. The objectives of this system are to clarify the tax roles and eliminate double taxing among the three levels of government, in order to make the best use of each income source.

Known as "Ramo 28" is the federal participation, or money that the Federal Government returns to States and Municipalities to compensate for the income forgone upon implementation of the National System of Fiscal Coordination. The sources of federal income for this participation are income tax, value added tax, special tax on production and services, fees on petroleum and mining, amounting to around 880,000 Million Pesos in 2002.

a. Federal Taxes

Federal taxes include the following.

- Income tax
- value added tax
- Corporate asset tax
- Tax on production & services
- Foreign trade tax

Two taxes, income tax and value added tax, account for the bulk of collected federal taxes.

b. State Taxes

State taxes include the following.

- Payroll tax
- lodging tax
- Tax on sale of vehicles
- Tax on professions

State fees include the following.

- License fees
- Registration fees
- Fees on transportation services and vehicle control
- Fees on property registration and commerce

c. Municipal Taxes and Fees

Taxes that are sources of municipal income are classified as “direct taxes”, “indirect taxes”, “additional taxes” and “other taxes”.

c.1 Direct Municipal Taxes

c.1.1 Ownership taxes

- Land tax
- Vehicle ownership/use tax
- Tax on sale of goods
- Tax on transfer of real estate
- Tax on acquisition of real estate
- Tax on publicity

c.1.2 Taxes on remunerations

- Payroll tax
- Tax on personal service
- Tax on professional service fees
- Tax on contracts

c.1.3 Other Direct Taxes

c.2 Indirect Municipal Taxes

c.2.1 Tax on commerce

- Tax on commercial activities

- Tax on commerce of books and magazines

c.2.2 Tax on production

- Tax on industrial activities
- Tax on mining

c.2.3 Tax on service

- Tax on lodging
- Tax on public transportation
- Tax on public entertainment
- Tax on lottery, raffles
- Tax on diverse services

c.2.4 Other Indirect Taxes

c.3 Additional Taxes

- Tax for education
- Tax for urban infrastructure works
- Tax for tourism promotion
- Tax for public security
- Diverse additional taxes

c.4 Other Taxes

Likewise, fees that are sources of municipal income are classified as follows.

c.5 Registration Fees

- Fee on civil status registration
- Fee on registration of property
- Fee on notary service
- Fee on diverse registration activities

c.6 Certification Fees

- Fee on issuance of education certificate
- Fee on issuance of certificate on health status
- Fee on issuance of certificate on ecology and environmental impact
- Fee on diverse certifications

c.7 Licenses and Permits Fees

- Fee on license on itinerant street vendors
- Fee on license for harmful commerce
- Fee on license of transportation companies
- Fee on license for construction
- Fee on diverse license

c.8 Inspection Fees

- Fee on inspection of industrial equipment

- Fee on inspection of sanitation
- Fee on diverse inspection

c.9 Fees on Transportation Service

- Fee on internal combustion vehicle
- Fee on mechanical vehicles
- Fee on animal drag vehicles

c.10 Fee on Drinking Water Supply

c.11 Fee on Urban Development Service and Public Works

- Fee on urbanization

c.12 Service Fees

- Fee on cemeteries
- Fee on slaughterhouses
- Fee on markets
- Fee on parking
- Fee on public security
- Fee on public lighting
- Road toll
- Fee on diverse services

c.13 Other Fees

Federal funds comprised around 75% of income in Othón P. Blanco Municipality, while taxes and fees accounted for around 5% each.

Public utilities are not under the direct jurisdiction of a municipal government. CAPA is in charge of drinking water supply and sewer services, but the municipal government may contribute part of the required investment.

The Federal Electricity Commission is responsible for electricity supply, but municipal governments are in charge of street lighting as part of public security, which is a municipal responsibility. Electricity users are categorized into Industry, Residence, Commerce, Agriculture, and Services, as shown in the following comparative table between Quintana Roo State and Othón P. Blanco Municipality.

Table A-36: Electricity Consumption in Othón P. Blanco Municipality, 2001

Type of Service	Number of Users		Consumption (Mwatt-hr)		Cons. Value (Mill Pesos)	
	Q.Roo	O.P.B.	Q.Roo	O.P.B.	Q.Roo	O.P.B.
Total	244,912	12,733	2,029,422	100,922	1,521.31	69.75
Industry	2,193	365	1,237,868	75,691	791.26	54.14
Residence	213,500	10,810	497,464	12,657	367.16	6.16
Commerce	27,456	1,369	214,415	3,795	280.46	5.19
Agriculture	254	60	4,673	439	0.88	0.08
Services	1,509	129	75,002	8,340	81.55	4.18

Source: Anuario Estadistico, Edicion 2002, INEGI

The above table shows that Othón P. Blanco Municipality relative to the State in 2001 accounted for around 5% of the number of electricity users, 5% of electricity consumed and 5% of value of electricity consumption. Within Othón P. Blanco Municipality, residential users accounted for 85% of the number of users, but only 12% of electricity consumed and 9% of the value of electricity consumption. On the other hand, industrial users accounted for only 3% of the number of users, but 75% of electricity consumed and 78% of the value of electricity consumption.

A.3.5 Environment Policy

A.3.5.1 General Review

Othón P. Blanco Municipality is subject to laws, regulations and federal and state norms on environmental protection, wastewater and solid waste management.

The Municipality has not officially sanctioned a document on environmental policy for its management.

None of the final disposal sites comply with the norms on solid waste management. The dump site serving the city of Chetumal is a real risk to the health and the quality of aquifer due to the possibility of percolation of leachate.

SEDUMA is in the last stage of procedures to approve a project on sanitary landfill for the city of Chetumal, which will be operated under the responsibility of the Municipality.

CAPA is in charge of drinking water and wastewater. Infiltration ditch/cesspool (fosa séptica) is the most widely used system in the Municipality; out of 48531 inhabited houses, 30435 use this system (63%). Discharge from these infiltration ditches contaminate the aquifer and is one of the main causes of the high incidence of water borne diseases; CAPA is making efforts to get Chetumal residents to discharge their wastewater into the collector system of the city.

Presumably, there are clandestine connections of wastewater into the rainwater drainage system operated by the Municipality; these waters are discharged into the Chetumal Bay, thereby causing its contamination.

The management of solid waste and wastewater is similar in other localities within the Municipality: Bacalar, Calderitas, Javier Rojo Gómez, Nicolás Bravo, Carlos A. Madrazo, Sergio Buitrón C., Xcalak, Subteniente López and Alvaro Obregón

Public interest is not perceived on these aspects on environmental health.

A.3.5.2 Organization Concerned

All federal agencies have territorial jurisdiction over Othón P. Blanco, including the federal delegation of the Secretariat of the Environment and Natural Resources (SEMARNAT) related to the general control of the environment and the approval of environmental permits, and the federal delegation of National Water Commission (CNA) in the management of national waters.

One of the state entities with jurisdiction on environmental matters is the Secretariat of Urban Development and the Environment (SEDUMA) related to environmental protection aspects and urban development, and the advisory and control functions in the management of solid waste. All projects of public or private works should have the environmental permit of this Secretariat before proceeding to construction and/or installation.

Additionally, Potable Water and Sewer Commission (CAPA) is in charge of water supply and sewer, including the treatment and disposal of wastewater. This is a State/Municipal entity.

At the organizational municipal level, there are the Bureau of Urban Development and Ecology and the Bureau of Municipal Public Services, which are responsible for urbanizations and urban location and the provision of solid waste management service.

The directory of the non-governmental sector in SEMARNAT has registered the following NGOs: Educación Cultural y Ecología A.C., Amigos del Manatí A.C, and Colegio de Biólogos del Sistema Tecnológico A.C.

No private companies provide services in water supply and sewer or in the solid waste management.

A.3.5.3 Other Environmental Policy

At the municipal level, solid waste management is regulated by the Organic Municipal Law of Quintana Roo State, the Police and Good Governance Decree of December 12 of 1981, and the Regulation on Public Service for Cleaning, Collection and Treatment of Solid Waste

in the Municipality of Othón P. Blanco which was published in the Official Gazette of June 15, 1994.

A.3.6 Other Infrastructure

A.3.6.1 Water Supply

The estimated population in Othón P. Blanco in 2002 was approximately 240,000 and it was estimated that 234,000 were serviced with water supply for a total coverage of 97%. The major urban areas are serviced by 17 production wells with a capacity of 877 Lps. The rural areas are serviced by local systems with their own well, elevated tank, and distribution lines.[11]

A.3.6.2 Road and Traffic

Othón P. Blanco has 2,227 kilometers of roads which are distributed as follows:

- 238 kilometers are federal highways which are paved.
- 551 kilometers are state roads which are either paved or coated.
- 1,438 kilometers are rural roads which are either paved or coated.

Table A-37: Vehicles Registered According to the Type of Service

Vehicles				Buses for passengers			
Total	Official	Public	Particular	Total	Official	Public	Particular
20,247	1,993	2,333	15,921	280	65	80	135
Trucks				Motorcycles			
Total	Official	Public	Particular	Total	Official	Public	Particular
10,055	2,016	1,109	6,930	2,510	370	0	2,140

Source: Anuario Estadístico de Quintana Roo, INEGI, 2002

Othón P. Blanco municipality has maritime ports in Chetumal, Mahahual, Xcalak. Additionally, there are one airport of 2,209 meters long runway in Chetumal and other minor airfields in Xcalak, Mahahual, Kohunlich, and Pulticub (length of runway between 1,000 and 1,200 meters).[12]

A.3.6.3 Power Supply

The power supply service in Othón P. Blanco municipality is described in the following table.

[11] Information provided by CAPA to the S/T
[12] Anuario Estadístico de Quintana Roo, INEGI, 2002

Table A-38: Power Supply Figures in OPB

I. By Type of Service[a]	Total	Industrial	Residential	Commercial	Agricultural	Services[b]
No. of Customers by type of Service by 31/12/2001	58,444	365	51,263	6,320	111	385
Sales volume by type of Service in 2001 (Megawatts-hour)	212,375	75,691	89,982	32,101	1,731	12,870
II. By unit of transmission and distribution	Transmission Sub-station	Capacity of the Transmission Sub-station (Megavolts-amperes)	Distribution Sub-station	Capacity of the Distribution Sub-station (Megavolts-amperes)	Distribution Transformers	Capacity of the distribution transformers (Megavolts-amperes)
Units of Transmission and Distribution by 31/12/2001	0	0	6	88	3,057[c]	96

[a] It refers to the number of contracts signed for power supply
[b] Includes public lighting, pumping of water supply and wastewater, and temporary.
[c] It refers to the Chetumal area which includes: municipalities of Othón P. Blanco, Felipe Carrillo Puerto, and José María Morelos.
Source: Anuario Estadístico de Quintana Roo, INEGI, 2002

A.3.6.4 Telecommunications

Quintana Roo ranked as 14th out of the 32 federal entities in telephone lines density with 14 lines per 100 persons in 2002. Regarding cellular telephones, Othón P. Blanco had a total of 24, 651 subscribers in 2001. The municipality had 8 radio broadcasting companies in 2001 (4 AM and 4 FM). Additionally, Othón P. Blanco had 5 television stations and 4 of them were repeaters in 2001.[13]

A.3.6.5 Priority Ranking of Infrastructure Investment

Public investment during 2001 in Othón P. Blanco amounted to 351.1 Million Pesos, the top places being 91.3 Million Pesos in Urban/Social Development, and 68.5 Million Pesos in Education. A more detailed investment by sector is shown below.

[13] Comisión Federal de Telecomunicaciones

Table A-39: Public Investment in Othón P. Blanco in 2001

Public Investment	Q.Roo (Million Pesos)	Othón P. Blanco (Million Pesos)
Total	885.08	351.07
Education	299.05	68.45
Urban/Social Development	218.31	91.34
Communication & Transport	69.50	59.01
Administration & Finance	60.32	39.18
Agriculture & Forestry	57.50	12.00
Drinking Water	46.05	35.03
Social Welfare	27.68	9.91
Electricity	23.47	13.79
Ecology	18.33	3.88
Security	17.02	4.77
Sport	16.68	1.14
Culture	10.56	7.16
Tourism	9.57	1.01
Health	4.09	0.08
Housing	3.95	2.34
Trade & Supply	2.74	1.95
Fishing	0.27	0.03

Source: Anuario Estadistico 2002, Quintana Roo, INEGI

The above table shows that public investment in specific sectors in Othón P. Blanco Municipality during 2001 amounted to 35.0 Million Pesos in the Drinking Water, 3.9 Million Pesos in Ecology, and 1.0 Million Pesos in Tourism.

A.4 Felipe C. Puerto

A.4.1 Natural Environment

A.4.1.1 Topography

In Felipe Carrillo Puerto only two distinct topographical features are found: the Yucatecan Carso and Lomeríos to the east of the municipality and the Low Coastline of Quintana Roo which runs along the shores of the Caribbean Sea.

A.4.1.2 Climate

Temperature and rainfall figures were obtained from Felipe Carrillo Puerto (1952-1999), Tihosuco (1952 – 2000), and Señor (1971-2000) stations. Those years which did not have information for every month were discarded.

Table A-40: Temperature and Rainfall Data

	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEPT	OCT	NOV	DEC	ANNUAL
TEMPERATURE (OC)													
SEÑOR	23.9	24.6	25.0	26.6	26.9	28.0	27.6	27.5	27.5	26.1	24.5	24.3	26.0
FCP	23.0	23.6	25.4	26.9	27.9	27.9	27.9	27.8	27.7	26.7	25.1	23.5	26.1
TIHOSUCO	23.4	23.9	25.4	26.9	27.8	27.5	27.5	27.3	27.1	26.2	24.9	23.7	26.0
AVERAGE	23.4	24.1	25.3	26.8	27.6	27.8	27.6	27.5	27.4	26.3	24.8	23.8	26.0
RAINFALL (mm)													
SEÑOR	75.2	57.3	39.0	61.6	136.2	237.2	165.4	200.3	229.2	188.5	108.0	68.9	1566.9
FCP	57.4	41.5	40.1	39.1	109.8	176.7	149.0	157.1	213.7	153.3	88.6	58.9	1285.0
TIHOSUCO	42.7	26.5	40.6	63.5	105.5	163.3	146.9	198.0	191.2	155.1	60.7	59.7	1253.7
AVERAGE	58.5	41.8	39.9	54.7	117.1	192.4	153.8	185.1	211.4	165.6	85.8	62.5	1368.5

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

A.4.1.3 Geological Condition

In Felipe Carrillo Puerto the rocks´ age increases from East to West. In the western part of the municipality, limestone from the Eocene can be found, in the central part of the municipality limestone from Superior Tertiary can be found; finally, in the eastern part of the municipality, Quaternary soil can be found in the area of Punta Tupac.[14]

A.4.2 Land Use and Urban Planning

A.4.2.1 Urban Planning

The urban plan is integrated in the municipal development plan of Felipe Carrillo Puerto. The total urban area is only 0.067% of the municipal area.

[14] Geological Map 1:1 000 000, CGSNEGI

The municipal development plan in general establishes the bases and defines strategies for the internal and sustainable development of the municipality, which is broken down to sectors like economic development, social development, quality of life, and etc. The general objective of the urban development is "to encourage strategic population centers by providing urban infrastructure, facilities and urban services".

The municipal development plan says that the urban planning policy includes the following strategies;

- In down town area to avoid an inappropriate development which is not suitable to residential area
- To maintain the current urban appearance
- To develop corridors connecting the urban center with neighboring towns
- To improve the urban image by means of regulations and design elements of construction

A.4.2.2 Land use

The municipal area of Felipe Carrillo Puerto is 13,806km2. There are 213 localities in the municipality. Among these urban localities are three, which are Felipe Carrillo Puerto, Chunhuhub, and Tihosuco. While rural localities are 210. The total area of urban localities is 930ha, which is only 0.067% of the total municipal area. There is no figure for the area of rural localities. There is no land use map showing current land use in general, so far.

However, the federal government designated Sian ka'an as a special reservation area of the country in 1986. In order to control developments in Sian Ka'an area Quintana Roo state made an ordinance, Program of Ecological land Development for Sian Ka'an Biosphere Reservation (POET, 14 May 2002). This development control ordinance consists of tables and zoning maps, describing the detail control of land use. The contents of POET are described in 2.2.4 Land Use. In fact Sian Ka'an area is strictly protected by law. Practically it is quite difficult to begin a development in this area.

A.4.2.3 Population Density

The population density of whole municipality in 2000 is 0.044 inhab./ha, while Felipe Carrillo Puerto, Chunhuhub, and Tihosuco are 25hab/ha, 38hab/ha, and 34 inhab./ha respectively. In the municipality of Felipe Carrillo Puerto the population of rural area is greater than the one of Urban area. In general, populations are scattered around the municipal area. It is forecasted that this situation will continue to be so more or less until 2015.

Table A-41: The population density of Felipe Carrillo Puerto in 2000

	Current urban area	Population density
Felipe Carrillo Puerto Municipality	1,380,600 ha	0.044 inhab./ha
Felipe Carrillo Puerto	695 ha	25 inhab./ha
Chunhuhub	113 ha	38 inhab./ha
Tihosuco	122 ha	34 inhab./ha

Source; Urban area density from PEDU by SEDUMA (page 29)
Municipality density was tabulated by the Team.

A.4.2.4 Regional Development Plan

Felipe Carrillo Puerto prepared "Programa de Desarrollo Urbano del Centro de Poblacion de Felipe Carrillo Puerto, Quintana Roo" in order to define and establish the strategies, approaches and actions for the economic, tourism, ecological, and urban integral development. This three year plan has been prepared in coordination with the state government basic plan 1999-2005. It also aims to improve administrative instruments for the development of municipality by securing the investments with better coordination between the governments and private sectors. In this plan the current local situations are analyzed, focusing on socioeconomic, urban, ecological and tourism aspect.

The following policies are stated in the Plan as strategies for the development of the region;

- Urban development

In the down town area a development which does not fit to residential should be avoided

  - To maintain the current urban appearance
  - To develop corridors connecting the urban center with neighboring towns
  - To improve the urban image by means of regulations and construction elements

- Ecology

  - To protect the ecological value of wild nature and forest
  - To restrict the urban growth toward Sian Ka'an reservation
  - To complete the drainage system and urban sewage treatment

- Tourism development

  - To increase the facility for tourism
  - To develop the controlled access to Sian Ka'an reservation from Felipe Carrillo Puerto
  - To promote the attractiveness of the Maya culture

- Housing

  - To promote housing with basic quality services and appropriate conditions for low income families

- Land classification

  - To conserve forest areas and tree-lined areas with high ecological value
  - To improve degraded areas which have potential to improve the urban environment
  - To protect areas of highly ecological value
  - Land use for urban development, industrial development, tourism development, and agricultural development
  - To develop areas which are suitable to commercial use

Besides above the Plan mentions;

- Solid waste final disposal sites to be located far from the city, i.e., to the west of the city and near an industrial area
- Regarding waste water treated water to be reuse

In accordance with Quintana Roo regional strategic plan, it puts Felipe Carrillo Puerto on a strategic position of Yucatan ring corridor, which is shown in the following figure;

Source; Felipe Carrillo Puerto Development Plan

Figure A-12: Strategic Position of Felipe Carrillo Puerto

A.4.3 Socioeconomic Conditions

A.4.3.1 Regional Economy

Of 348,750 economically active population (EAP) of Quintana Roo State, Felipe Carrillo Puerto Municipality accounted for 17,595 in 2000, and the EAP in the city of Felipe Carrillo Puerto was estimated at around 2,500. Judging from the sector distribution of EAP, the structure of the economy in Felipe Carrillo Puerto Municipality was quite different from that of Quintana Roo State as a whole. In fact, EAP in the agriculture sector comprised 50% in Felipe Carrillo Puerto Municipality, while only 10% in the State. EAP in the industrial sector was 12% in Felipe Carrillo Puerto Municipality and 16% for the State. EAP in the service sector was lopsided in Quintana Roo State at 73%, but only 38% in Felipe Carrillo Puerto Municipality.

A.4.3.2 Administration

The Municipality of Felipe Carrillo Puerto was created in 1975. It has an area of 13,806 Km2, equivalent to 27.2% of the State.

It has 210 rural communities with 55.8% of the population (33,657); 2 localities with 13.2% of the total (8163); and the capital city Felipe Carrillo Puerto accounts for the remaining 31% (18,545).

The Municipal government is composed of the Mayor, one Vice Mayor, six representatives elected by relative majority and three representatives elected by proportional representation; substitutes are also elected for the Vice Mayor and the representatives.

Organisms representing the municipal authority were created to support the Mayor, including town governments, which are decentralized collegiate organisms in charge of cleansing and solid waste collection, among other services. The town mayors are elected in direct elections in neighborhood assemblies in the corresponding communities. Delegations and Subdelegations are organs that depend from the Mayor; their members are elected in neighborhood assembly and their duties include promotion of public services and surveillance of public order.

There are two townships: Chunhuhub and Tihosuco, 4 delegations and 81 subdelegations.

The cleansing service is provided by the Bureau of Municipal Public Services, which coordinate their activities directly with the Mayor.

Drinking water supply and sewer services are responsibility of CAPA.

A.4.3.3 Population

The population of Felipe Carrillo Puerto is rather stable compared with other 2 municipalities in the Study area. Mainly because a fashionable tourism development along white a sand beach hardly takes place in this municipality. Though, Felipe Carrillo Puerto has beautiful Sian Ka'an, which is reserved under the federal control. The population increase from 1970 to 1990 is as the following table.

Table A-42: The Population change in Felipe Carrillo Puerto 1970-1990

Item	1970	1980	1990
Felipe Carrillo Puerto	32,314	32,506	47,234

Source; INEGI

The forecast of the population increase in Felipe Carrillo Puerto is as follows;

Table A-43: The population forecast of Felipe Carrillo Puerto2000-2015

Item	2000	2005	2010	2015
Felipe Carrillo Puerto total	60,306	67,289	71,878	75,241
Urban area	26,216	31,881	36,568	38,279
Rural area	34,090	35,408	35,310	36,963

Note; Urban area means the area which has more than 2,500 populations.
Rural area means the area which has less than 2,499 populations.
Source; CAPA, "PLAN ESTRATEGICO DE LOS SERVICIOS DE AGUA POTABLE, ALCANTARILLADO Y SANEAMIENTO 2001-2025", 2015 figures are tabulated by the Team from CAPA figure.

A.4.3.4 Industry

Within Felipe Carrillo Puerto Municipality, agriculture was the main economic activity, but in the city of Felipe Carrillo Puerto, commerce and service were the most important economic activities. Agricultural development is hindered by inadequate soil and low technology. The main annual crop was corn with about 24,000 ha harvested, while the main perennial crop was orange with around 1,000 ha harvested in 2001. Livestock in Felipe Carrillo Puerto in 2001 consisted of around 7,300 heads of cattle, 19,700 pigs, 16,200 sheep, 332,200 chickens, and 62,800 beehives producing honey of high quality. Felipe Carrillo Puerto Municipality is rich in highly valued wood species, and has been the top producer of forestry products within Quintana Roo State.

The industrial sector is rather weak, as indicated by the 12% of EAP employed in this sector. Manufacturing consists of small scale processing of agricultural or forestry products. The service sector employed 38% of EAP, the most important activity being commerce, followed by non-financial service. Tourism is not developed yet, but as the Sian Ka'an biosphere reserve was declared a World Heritage site by UNESCO in 1987, potential development in the future may be based on ecology related attractions.

A.4.3.5 Education

The municipality of Felipe Carrillo Puerto counts with all the educational levels, from the elementary education up to the higher education. The municipality has an educational substructure that depends of the State Secretariat of Education and Culture and it consists of:

- An Educational and Cultural Services Sub-bureau of the city Center Zone
- Two sector headquarters (formal primary, pre-school and indigenous primary school)
- Six supervisions of school zones of formal education and seven supervisions of indigenous education.
- Each one of the schools has a director, with teachers' group or without group as it is the case.

The municipality has 17 schools of formal pre-school education and 41 schools of indigenous pre-school education. There are 44 formal primary schools and 32 indigenous primary schools. At secondary level there are 5 high schools and 33 tele-secondary schools. At higher education level it has 6 colleges, the Regional Center of Pre-school Formal Education and the High Technological Institute.

A.4.3.6 Community Structure

This municipality is located in the central part of the state and has been called the Mayan Zone of the State, since concentrates most of the Mayan population. One of the important aspects of this area is the current migratory population inside of and outside of the municipality mainly looking for work opportunities.

Populations of the municipality of Felipe Carrillo Puerto are divided in urban and rural. According to information provided by the Municipality, the urban populations with a number up to 1,000 inhabitants have the basic services (electricity, potable water and paved roads) as the municipal head of Felipe Carrillo Puerto, Tihosuco and Noh'bec.

The majority of rural populations have electricity, potable water but not all of them have paved roads and others denominated “rancherias” don't have the basic services.

The majority of the people of the municipality of Felipe Carrillo Puerto consist of Mayan indigenous population. The predominant religion is the Catholic, the one that is practiced in the most important ceremonial centers of Tulum, Tixcacal Guardia, Chancah Veracruz de Repente and the Cruz Parlante of Felipe Carrillo Puerto. In urban population's centers as in some communities is practiced other religions like the witness of Jehova, the evangelical, the Baptist and the Mormons.

The inhabitants of the 82 communities of Felipe Carrillo Puerto participate in a high percentage in all beneficial works for the community as well as in social, cultural or political activities of the municipality.

A.4.3.7 Poverty Conditions

Felipe Carrillo Puerto is one of Quintana Roo State municipalities with more poverty index, because there are no sufficient employment sources that guarantee to the families an economic stability. As is shown in the table below, 20.9% of the municipality population was under poverty line whose percentage is high compared with the municipality of Othón Blanco and the State.

Table A-44: Poverty Index in Quintana Roo (Felipe Carrillo Puerto)

Municipality	Poverty index	Population under poverty	Percentage of population
Quintana Roo	1.00	88,330	12.6
Othón P. Blanco	0.92	23,363	11.6
Felipe Carrillo Puerto	1.66	11.,719	20.9
Solidaridad	1.72	6,221	21.6

Source: Information provided by SEDUMA based on INEGI statistic data

Most of the population lives of traditional agriculture (tree cut-down, clearance and burning) and the production is only for the family maintenance. A production that allows the commercialization to improve the family economy and the type of agricultural practices it is of temporary type. Therefore, the crops depend on the rains and to bear the family expenses, parents and children should emigrate toward tourist centers looking for jobs.

The four municipalities located in the north (Benito Juarez, Cozumel, Isla Mujeres y Solidaridad) are the only ones that present a bigger index than the state level. Particularly it stands out the fact that Benito Juarez possesses a higher GDP per capita six times more than Felipe Carrillo Puerto. However, it is important to mention that this fact expresses another reality: Benito Juarez produces 29 times more wealth than Felipe Carrillo Puerto. Somehow the compensation mechanisms are working but they don't reach to close such a drastic breach determined by the market.

A.4.3.8 Public Health

According to parameters of the State Health Services (SESA) provided by the Municipality of Felipe Carrillo Puerto, the municipality has a 100% health coverage. The State Health Service has a Mobile Health Unit to provide health care in small rural communities and to make examination trips to cover the required medical attention.

The 10 main consultation causes or illnesses notified during 2002, were acute respiratory infections that represented 65.6% and others, as shown in the following table.

Table A-45: The most common diseases in the Municipality of FCP

No.	Disease	Percentage
1	Acute respiratory infection	65.6
2	Urinal tract infection	6.4
3	Intestinal amebiasis	6.1
4	Intestinal infections from other organisms	5.8
5	Ascariasis	4.5
6	Acute otitis media	2.0
7	Ulcerative gastritis and duodenitis	1.4
8	Urogenital candidiasis	1.0
9	Other helminthiasis	0.9
10	Urogenital tricomoniasis	0.7

Source: Subbureau of Epidemiology of Chetumal, State Health Services (SESA)

As shown in the Table above, acute respiratory infections, urinal tract and intestinal infections and parasites occupies the first places in the population's health damages, being probably the main risks of school drops, socioeconomic and cultural conditions among others.

A.4.4 Financial Conditions

A.4.4.1 Public Finance

The budget of Felipe Carrillo Puerto Municipality in the year 2000 amounted to 73.2 Million Pesos, equivalent to 5.4% of the budget of all Municipalities in Quintana Roo State. The most important income source was “Federal participation” or “Federal share” with 38.6 Million Pesos (52.7%), followed by Transfer Payments with 26.4 Million Pesos (36.1%), Public Debt at 3.8 Million Pesos (5.2%), while Taxes with 0.56 Million Pesos comprised only 0.77% of income, and Fees with 0.49 Million Pesos comprised only 0.67% of income. It appears that some 90% to 95% of municipal income in Felipe Carrillo Puerto came from federal sources as “Participaciones” (Federal participation or share) and “Fondo de Aportaciones Federales” (Federal contribution or transfer). On the other hand, Taxes (“Impuestos”) and Fees (“Derechos”) comprised less than 1% of municipal income.

On the expenditure side, Administrative Expenses amounted to 41.7 Million Pesos (56.9%), followed by Transfer Payments with 20.6 Million Pesos (28.1%), and Public Works & Promotion with 10.8 Million Pesos (14.7%). Administrative Expenses, which include Personnel, Materials & Supplies, and General Services, comprised around 55% of total expenses. Public Works & Promotion as an expenditure item, jumped from around 15% of total expenditure in 2000 to around 40% in 2002. On the other hand, Transfer Payments decreased from around 28% in 2000 to 4% in 2002. A new expenditure item in 2002 was Municipal Strengthening with about 1% of total expenditures.

The budget of Felipe Carrillo Puerto Municipality in the year 2000 was balanced, but the 2002 results, just published in newspapers on June 24th 2003, indicated an income shortfall of 1.59 Million Pesos. The deficit was reportedly caused by an unexpected decline in federal funds foreseen as income in the budget.

A comparison of budgets of all Municipalities in Quintana Roo State and that of Felipe Carrillo Puerto Municipality is shown in the following table.

Table A-46: Municipal Budget of Felipe Carrillo Puerto in 2000

Budget	All Municipalities (Million Pesos)	F. Carrillo Puerto (Million Pesos)
INCOME	1,350.38	73.20
Income during 2000	1,307.70	71.92
Taxes	229.84	0.56
Federal share	470.97	38.56
Improvements	0.55	0.00
Fees	155.56	0.49
Products	20.02	0.96
Exploitation	93.00	1.02
Public debt	31.69	3.80
Third party	0.00	0.00
Transfer	232.80	26.39
Other Income	73.27	0.14
Funds from Previous Year	42.68	1.28
EXPENDITURES	1,350.38	73.20
Administrative Expenses	833.76	41.69
Public Works & Promotion	290.96	10.77
Transfer Payments	141.84	20.60
Public Debt	54.58	0.00
Available Funds (Disponibilidades)	26.88	0.00
Third Party	1.49	0.00
Other Expenses	0.87	0.14

Source: Anuario Estadistico 2002, Quintana Roo, INEGI

A.4.4.2 Taxation System and Public Utilities

In general, the taxation system is similar to that described under Othón P. Blanco Municipality.

Land tax is the most important tax in Felipe Carrillo Puerto Municipality. Still the share of taxes in the municipal income is quite low, as federal funds comprised 90% or more of total income.

The Federal Electricity Commission is responsible for electricity supply, but Felipe Carrillo Puerto Municipality provides materials required for street lighting, which is a municipal responsibility concerning public security. Interested communities apply for these materials, which are distributed according to a priority order. Once street lighting is operational, the city government pays for the electricity consumption.

Electricity users are categorized into Industry, Residence, Commerce, Agriculture, and Services, as shown in the following comparative table between Quintana Roo State and Felipe Carrillo Puerto Municipality.

Table A-47: Electricity Consumption in Felipe Carrillo Puerto Municipality, 2001

Type of Service	Number of Users		Consumption (Mwatt-hr)		Cons. Value (Mill Pesos)	
	Q. Roo	F.C.P.	Q. Roo	F.C.P.	Q. Roo	F.C.P.
Total	244,912	12,410	2,029,422	29,389	1,521.31	19.06
Industry	2,193	42	1,237,868	4,158	791.26	3.45
Residence	213,500	10,810	497,464	12,657	367.16	6.16
Commerce	27,456	1,369	214,415	3,795	280.46	5.19
Agriculture	254	60	4,673	439	0.88	0.08
Services	1,509	129	75,002	8,340	81.55	4.18

Source: Anuario Estadistico, Edición 2002, INEGI

The above table shows that Felipe Carrillo Puerto Municipality relative to the State in 2001 accounted for around 5% of the number of electricity users, 1.5% of electricity consumed and 1.3% of value of electricity consumption. Within Felipe Carrillo Puerto Municipality, residential users accounted for 87% of the number of users, 43% of electricity consumed and 32% of the value of electricity consumption. Industrial users accounted for only 0.3% of the number of users, but 14% of electricity consumed and 18% of the value of electricity consumption. Commercial users accounted for 11% of the number of users, 13% of electricity consumed and 27% of value of electricity consumption.

Solid waste service is provided only in the urban area of the city of Felipe Carrillo Puerto, without cost to users. A plan was made to impose user charges to residential and commercial customers, but it was not put into practice. The cost of solid waste service in Felipe Carrillo Puerto in 2002 was estimated at 1.16 Million Pesos, out of total municipal expenditures of 86.6 Million Pesos.

A.4.5 Environmental Policy

A.4.5.1 General Review

Just like in the case of Othón P. Blanco Municipality, wastewater management activities are regulated by the National Water Law and the Federal Law on Water Rights; and solid waste disposal is regulated by State provisions under assistance and control of SEDUMA.

The Municipality of Felipe Carrillo Puerto has not formulated a policy on environmental management in its territory.

Solid waste in the city of Felipe Carrillo Puerto is disposed of in an open air dump. Solid waste is not covered at all. It does not comply with the Mexican norms on the matter and it is possible that leachate resulting from the contact between rain water and solid waste is affecting the quality of the aquifer.

SEDUMA is in the last stage of procedures leading to the environmental approval of an executive project for a sanitary landfill for the city of Felipe Carrillo Puerto. The Municipality has expressed its fears that the costs of construction and operation of the project might be higher than the capacity to pay by its residents.

The costs of preparation of the Executive Project, environmental studies and the construction of facilities are temporarily assumed by SEDUMA but the Municipality will have to pay back.

Drinking water supply and sewer services are provided directly by CAPA according to the Water and Wastewater Law of Quintana Roo State.

CAPA service the main cities in the Municipality: Felipe Carrillo Puerto, Chunhuhub and Tihosuco, in addition to provide water supply services to 64 rural communities.

A.4.5.2 Organization Concerned

Relevant Federal agencies are SEMARNAT and CNA, while at the State level they are SEDUMA and CAPA.

The administrative structure of the Municipality does not have a unit in charge of environmental management. Solid waste management is the responsibility of the Department of Waste Collection in the Bureau of Municipal Public Services.

The NGO´s registry in SEMARNAT contains U´yo´olche C.A.

A.4.5.3 Other Environmental Policy

Solid waste management is regulated by the Organic Municipal Law of Quintana Roo State, Police Faults and Good Governance Regulation of the Municipality and the Cleansing Regulation for Felipe Carrillo Puerto Municipality.

A.4.6 Other Infrastructure

A.4.6.1 Water Supply

The estimated population in Felipe Carrillo Puerto in 2002 was 65,861 and it was estimated that 58,000 were serviced with water supply for a total coverage of 88%. The major urban

areas are serviced by 4 production wells with a capacity of 197 Lps. The rural areas are serviced by local systems with their own well, elevated tank, and distribution lines.[15]

A.4.6.2 Road and Traffic System

Felipe Carrillo Puerto has 1,108 kilometers of roads which are distributed as follows:

- 338 kilometers are federal highways which are paved.
- 45 kilometers are state roads which are paved.
- 725 kilometers are rural roads which are either paved or coated.

Table A-48: Vehicles Registered According to the Type of Service

Vehicles				Buses for passengers			
Total	Official	Public	Particular	Total	Official	Public	Particular
1,364	14	514	836	14	0	9	5
Trucks				Motorcycles			
Total	Official	Public	Particular	Total	Official	Public	Particular
896	15	370	511	131	1	0	130

Source: Anuario Estadístico de Quintana Room, INEGI, 2002

Most of the coast of Felipe Carrillo is part of the natural reserve of Sian Ka´an; consequently, there are not important marine ports in Felipe Carrillo. On the other hand, two airfields are found in this municipality; one of them is the Felipe Carrillo airfield (1,000 meters long runway) and Punta Pajaros (600 meters long runway).[16]

A.4.6.3 Power Supply

The power supply service in Felipe Carrillo Puerto municipality is described in the following table.

[15] Information provided by CAPA to the S/T
[16] Anuario Estadístico de Quintana Roo, INEGI, 2002

Table A-49: Power Supply Figures in FCP

I. By Type of Service[a]	Total	Industrial	Residential	Commercial	Agricultural	Services[b]
No. of Customers by type of Service by 31/12/2001	12,410	42	10,810	1,369	60	129
Sales volume by type of Service in 2001 (Megawatts-hour)	29,389	4,158	12,657	3,795	439	8,340
II. By unit of transmission and distribution	Transmission Sub-station	Capacity of Transmission Sub-station (Megavolts-amperes)	Distribution Sub-station	Capacity of Distribution Sub-station (Megavolts-amperes)	Distribution Transformers	Capacity of distribution transformers (Megavolts-amperes)
Units of Transmission and Distribution by 31/12/2001	1	19	3	19	0	0

[a] It refers to the number of contracts signed for power supply
[b] Includes public lighting, pumping of water supply and wastewater, and temporary.
Source: Anuario Estadístico de Quintana Room, INEGI, 2002

A.4.6.4 Telecommunications

Quintana Roo ranked as 14th out of the 32 federal entities in telephone lines density with 14 lines per 100 persons in 2002. Specifically in Felipe Carrillo Puerto, there were 5 radio broadcasting companies in 2001 (3 AM and 2 FM). Additionally, Felipe Carrillo Puerto had 2 television stations and 1 of them was a repeater in 2001.

A.4.6.5 Priority Ranking of Infrastructure Investment

Public investment during 2001 in Felipe Carrillo Puerto Municipality amounted to 73.2 Million Pesos, the top places being 22.2 Million Pesos in Education, and 21.0 Million Pesos in Agriculture & Forestry. A more detailed comparison of investments by sector in Quintana Roo State and Felipe Carrillo Puerto Municipality is shown below.

Table A-50: Public Investment in F. Carrillo Puerto in 2001

Public Investment	Q.Roo (Million Pesos)	F. Carrillo Puerto (Million Pesos)
Total	885.08	73.19
Education	299.05	22.21
Urban/Social Development	218.31	9.17
Communication & Transport	69.50	1.18
Administration & Finance	60.32	4.06
Agriculture & Forestry	57.50	21.03
Drinking Water	46.05	0.75
Social Welfare	27.68	7.42
Electricity	23.47	1.11
Ecology	18.33	0.70
Security	17.02	2.47
Sport	16.68	1.62
Culture	10.56	0.00
Tourism	9.57	0.10
Health	4.09	0.00
Housing	3.95	0.82
Trade & Supply	2.74	0.55
Fishing	0.27	0.00

Source: Anuario Estadistico 2002, Quintana Roo, INEGI

The above table shows that public investment in Felipe Carrillo Puerto Municipality during 2001 in specific sectors amounted to 0.75 Million Pesos in the Drinking Water, 0.7 Million Pesos in Ecology, and 0.1 Million Pesos in Tourism.

A.5 Solidaridad

A.5.1 Natural Environment

A.5.1.1 Topography

The predominant topographical feature is the Yucatecan Carso and Lomerios which is found in most of the municipality and it is only interrupted by a narrow land strip along the coastline which has the features of Low Coastline of Quintana Roo.

A.5.1.2 Climate

Temperature and rainfall figures were obtained from Coba (1973-2000) and Tulum (1965-2000) stations. Those years which did not have information for every month were discarded.

Table A-51: Temperature and Rainfall Data

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVERAGE
TEMPERATURE (0C)													
TULUM	23.4	23.6	25.3	25.8	26.6	27.0	27.0	26.8	26.6	25.6	25.0	24.0	25.6
COBA	21.2	21.4	22.9	25.0	26.5	27.0	26.5	26.5	26.4	24.9	22.7	21.1	24.3
AVERAGE	22.3	22.5	24.1	25.4	26.5	27.0	26.7	26.6	26.5	25.2	23.9	22.5	24.9
RAINFALL (mm)													
TULUM	70.9	35.6	26.4	37.0	96.5	117.4	66.8	112.3	195.4	171.7	86.4	84.2	1100.6
COBA	63.6	27.7	31.7	47.9	110.9	149.6	102.0	181.2	218.0	162.4	63.8	39.7	1198.3
AVERAGE	67.3	31.7	29.0	42.4	103.7	133.5	84.4	146.8	206.7	167.1	75.1	61.9	1149.5

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

A.5.1.3 Geological Condition

Similar to the situation in Felipe Carrillo Puerto, the rocks´ age increases from East to West in Solidaridad municipality. Quaternary limestone can be found in the coastal sector which includes Playa del Carmen; meanwhile, to the west of the municipality, Superior Tertiary limestone is found.

A.5.2 Land Use and Urban Planning

A.5.2.1 Urban Planning

The urban planning of Playa del Carmen is integrated in the municipal planning of Solidaridad. One of main concerning matters is the way how to cope with the housing of the exploding population. Since the urban population of approx.47,000 as of 2000 is forecasted to expand to 163,000 in 2005. The urban plan guides the expansion of housing area to northeast

and west of the existing urban area. The strategies for development and particular objectives are described in Regional Development Plan.

Evolution of Playa del Carmen

Originally Playa del Carmen was a small village of fishermen, functioning as a shipping point to Cozumel Island. In 1950s the regional economy began to move towards the tourism by building the first hotels in Cozumel and Isla Mujeres. However, Playa del Carmen continued being a shipping point to Cozumel Island. In 1970 the construction of tourism infrastructure began in Cancun. 1974 the president of the Mexico declared the state of Quintana Roo as similar to a free state and sovereign. Then Playa del Carmen becomes a part of Cozumel.

In 1989 a tourist group Playacar triggered the growth of Playa del Carmen. Since then Playa del Carmen is constantly growing as a tourist town and integrated into the Cancun Tulum tourism corridor. In 1994 Solidaridad was separated and independent from Cozumel.

Playa del Carmen has been expanded in extraordinary speed both in terms of the population and the administration area. In 1990 the population was only about 3,000. It became 6 times larger in 5 years. Then it expanded almost 3 times larger again in next 5 years. Table A-52 shows the population growth of Playa del Carmen.

Table A-52: Population Growth in Playa del Carmen

Item	1990	1995	2000
Playa del Carmen	3,098	17,621	47,483

Source; The Development Plan of Playa del Carmen

A.5.2.2 Land Use

The municipal area of the Solidaridad is 4,419 Km2. There are 284 localities in the municipality. Among these urban localities are only 2, which are Playa del Carmen and Tulum, while rural localities are 282. Urban localities have an area of 257ha, which is 0.057% of the total municipal area. There is no figure for the area of rural localities.

Regarding the land use control of Riviera Maya a land use zoning map and related documents are prepared by the state of Quintana Roo, which is Program of Ecological Land Development for Cancun Tulum Corridor (POET, 16Nov.2001). This ordinance consists of tables and zoning maps, describing the detail control of land use. The map covers approx.120km long and 10-20km wide coastal area between Cancun and Tulum. The contents of POET are described in 2.2.4 Land Use. Playa del Carmen, Tulum, and Akumal are dominant residential areas, followed by Chemuyil and Puerto Aventuras, while approx. half length of the beach area is designated as a tourism area.

A.5.2.3 Population Density

The population density of whole municipality in 2000 is 0.14 inhab./ha, while Playa del Carmen and Tulum were 193 inhab./ha and 142 inhab./ha respectively. Most of the population in Solidaridad is concentrated in the coastal area. This situation will become more extreme as the development of Cancun-Tulum corridor progresses, since the much population growth is forecasted in Ciudad Chemuyil and Nuevo Akumal besides Playa del Carmen and Tulum. On the other hand the population density in most of rural area remote from the seashore will stay quite sparse.

Table A-53: The population density of Solidaridad in 2000

Item	Current urban area	Population density
Solidaridad municipality*	441,900 Km2	0.14 inhab./ha
Playa del Carmen	202 ha	193 inhab./ha
Tulum	55 ha	142 inhab./ha

Source; Urban density from PEDU by SEDUMA (page 29), * Municipality density was tabulated by the Study Team.

A.5.2.4 Regional Development Plan

The municipality of Solidaridad has its own three year development plan, "PLAN DE DESARROLLO MUNICIPAL DE SOLIDARIDAD, 2002-2005". It states the fundamental objectives of the administration and it will govern the state government action during the next three years. It shows the current socioeconomic reality and the strategies to reach the objectives. It was made considering people's demand, and the development commitments that come off from the National and State respective Plans. The plan also emphasizes on strategies to mitigate gaps between the area of economic growth and the one left behind. The civic participation is well emphasized by always opening the door to the civic participation.

Through the analysis of current situation of the municipality from the points of economy, population, housing, natural conditions, and etc., the Plan sets strategies for the development like follows;

- To regulate the urban development by establishing the bases for improvement and conservation.
- To define the land use and to regulate the expanding area in order to achieve the sustainable development
- To improve the level of people's life

The current Plan has following particular objectives;

- To provide housing to people who are generated by the tourism development.
- To provide an attractive appearance of the city
- To supplement and contribute to the attractiveness for tourism as a region

- To encourage the establishment and the development of local companies which contribute the state economy through tourism

In 2000 the municipal office became the first contact place to get a development permit. Then the municipal office guide developers where to go and what to do for development and building permits. This power transfer from the state and federal to municipality put the municipality in a much better position to control the development within the territory.

A.5.3 Socioeconomic Conditions

A.5.3.1 Regional Economy

Of 348,750 economically active populations (EAP) of Quintana Roo State, Solidaridad Municipality accounted for 28,604, or around 8% of the State in 2000. Judging from the sector distribution of EAP, the structure of the economy in Solidaridad Municipality was more similar to that of Quintana Roo State as a whole, although with a smaller share of the agriculture sector, and slightly higher shares of industry and service sectors than the State as a whole. In fact, EAP in the agriculture sector comprised 5% in Solidaridad Municipality and 10% in the State, while EAP in the industrial sector was 19% in Solidaridad Municipality and 16% in the State, and EAP in the service sector was 76% in Solidaridad Municipality and 73% in Quintana Roo State.

A.5.3.2 Administration

The Municipality was created in 1993. Its area covers 4,245 Km2, equivalent to 8.35% of the State.

It has 282 rural communities which represent 21% of the total population of the Municipality (13406); a locality of 6733 inhabitants (Tulum) representing 11% of the total; and the remaining 68% (43613) corresponds to the capital city Playa del Carmen.

The Municipal government is composed of a Mayor, in addition to one Vice Mayor, six representatives elected by relative majority and three representatives elected by proportional representation, all with their substitutes.

The executive structure is composed of the Mayor, General Secretary, Treasurer and the administrator.

As support to administration, there are the Bureaus of Planning and Development, Public Works, Urban Development and Ecology, and Municipal Public Services. The last one has the responsibility for the cleansing service.

The administration has 6 delegations and 10 subdelegations.

A.5.3.3 Population

The population of Solidaridad is expanding quickly mainly because of the population explosion in Playa del Carmen, Tulum, and Nuevo Akumal. The Municipality of Solidaridad was separated from Cozumel in 1994. Until then Solidaridad and Cozumel was one municipality. The population increase from 1970 to 1990 is as the following table.

Table A-54: The population change in Solidaridad/Cozumel 1970-1990

Item	1970	1980	1990
Solidaridad/Cozumel	12,622	23,270	44,903

Source; INEGI

In Solidaridad the rural population is forecasted to decrease from 2005 to 2010, while in urban area it will increase enormously. The forecast of the population increase in Solidaridad is as follows.

Table A-55: The population forecast of Solidaridad 2000-2015

Item	2000	2005	2010	2015
Solidaridad total	63,478	180,405	282,969	376,341
Urban area	46,980	163,000	266,580	358,913
Rural area	16,498	17,405	16,389	17,428

Note; Urban area means the area which has more than 2,500 population.
Rural area means the area which has less than 2,499 population.
Source; CAPA, “PLAN ESTRATEGICO DE LOS SERVICIOS DE AGUA POTABLE, ALCANTARILLADO Y SANEAMIENTO 2001-2025”, 2015 figures are tabulated by the Team from CAPA figure.

A.5.3.4 Industry

Within Solidaridad Municipality, tourism is the main economic activity, blessed with such tourist attractions as Playa del Carmen and Tulum, which are visited by approximately one million tourists a year. Agriculture is almost non-existent, but still some 3,200 ha of corn were harvested in 2001, probably for consumption of farmer families in rural areas of Solidaridad Municipality.

The industrial sector is not well developed as indicated by the 19% of EAP employed in this sector. Manufacturing consists of small scale processing of agricultural or food products and forestry products for the tourist market. The service sector was unquestionably the most important with 76% of EAP in 2000. Hotels & restaurants concentrated around 34% of EAP, followed by commerce with around 14%, non-government service with about 7%, transportation service with around 4%, and entertainment with another 4%. Known as Riviera Maya, 132 hotels are estimated to operate in the area, and the huge inflow of tourists has required people of different skills to service the visitors, thereby giving rise to the highest population growth rate registered in Latin America.

A.5.3.5 Education

This municipality has an educational system from the elementary up to middle-higher education. There are 2 schools of special education, 29 of elementary education, 39 of primary education, 11 of secondary and only 2 of middle-high education.

The lack of opportunities in higher education levels has forced the youths to go other vicinity municipalities, especially Cozumel and Benito Juarez. In the case of higher education level, the students change their residence place toward Chetumal or Yucatan.

The index of illiteracy in Mexico is of 9.5%. Quintana Roo occupies the 13th place regarding the fight against illiteracy (7.2%). The Municipality of Solidaridad occupies the fourth position regarding the State (8.2% of its population is illiterate).

The attendance of the school population to the educational centers is shown in the following Table:

Table A-56: Attendance of the School Population in Solidaridad

School level	Students	Attendance population (%)	Non- attendance (%)	Establishments
Special	213	N.A.	N.A.	2
Elementary	3,142	74.6	25.4	36
Primary	10,881	96.1	3.9	51
Secondary	3,310	80.7	19.3	22
Middle	1,820	36.6	63.4	10
Professional	122	N.A.	N.A.	1
Total	19,488			122

A.5.3.6 Community Structure

Great number of inhabitants of Solidaridad comes from other municipalities of Quintana Roo State, as well as of the states of Yucatan Peninsula, in smaller number from the central part of the country and about 3% from foreign countries.

Most of the municipality population consists is young from 15 to 35 years old with 43.3%, followed by youths of 0 to 14 years old with 34.7%, 20.8% of the population consist of 36 to 64 years old and 1.2% inhabitants are older than 65 years old.

The municipality counts with more 9800 inhabitants who speak Mayan, of them 81.8 percent speaks Spanish and the Mayan, and 18.2 percent doesn't speak Spanish.

The migratory index of 25% registered in the last years and the creation of employments by the development of the tourist infrastructure, they have derived in serious infrastructure lacks to give answer to the growing and permanent demand of the new residents. Consequently, the existing services, due to the lack of own and external resources, they have become obsolete

A.5.3.7 Poverty Conditions

In Solidaridad, the migratory index mentioned previously, and the creation of jobs for the development of the tourist infrastructure, concentrates the economy of the municipality on the coastal area of the municipality presenting unequal development and disproportionate distribution of the economic activity. Poverty is a social problem that originates from a culture and society, which includes a low sustained level of revenues of community members. It includes the access deprivation to services like education, markets, health care or possibility to make decisions, and also the lack of community services as water, sewerage, highways, transport and communications.

According to the poverty indicators provided by the municipality of Solidaridad, approximately 23,300 people are in poverty condition with a 21.6 percent of its population.

Table A-57: Poverty Index in Quintana Roo (Solidaridad)

Municipality	Poverty index	Population under poverty	Percentage of population
Quintana Roo	1.00	88,330	12.6
Othón P. Blanco	0.92	23,363	11.6
Felipe Carrillo Puerto	1.66	11.,719	20.9
Solidaridad	1.72	6,221	21.6

Source: Information provided by the Municipality of Solidaridad based on INEGI statistic data

A.5.3.8 Public Health

In the municipality of Solidaridad medical care is provided by SESA and IMSS. There is also a Mobile Health Unit for health care in rural areas that are also part of the Mayan area.

There are 9 health centers and a health center with hospital equipment facilities called intermediate care. The patients that requires medical care of second level are transferred to the city of Cancun.

The health infrastructure in the municipal territory is composed by 9 health centers of first level and 6 hospitals, 3 of them privates and of second level. Also there are several clinics, laboratories for clinical analysis and radiology, among others.

Playa del Carmen, capital of the municipality has a General Hospital of SSA (109 beds), a General Hospital of IMSS (225 beds), a clinic hospital (186 beds) and several clinics for family medical care and urban health centers.

The main causes of medical care registered in Solidaridad, during the period 2002 are represented by the following ten diseases: acute respiratory infections with 60.3%, in second place is the intestinal infections from other organisms with 14.2%, followed by urinal tract infections with a percentage of 7.8%, in fourth place helminthiasis appears with 4.4% and

ulcerate gastritis y duodenitis with 2.1%, in sixth place the intestinal amebiasis appears with 1.4%. An disease also important is urogenital candidiasis with 1.2% which appears in the seventh place, and occupying the last three places with percentages of 1%, 0.8% and 0.6% are chicken pox, acute otitis media and asthma are shown respectively.

Table A-58: The most common diseases in the municipality of Solidaridad

No.	Diseases	Percentage
1	Acute respiratory infection	60.3
2	Intestinal infections from other organisms	14.2
3	Urinal tract infection	7.8
4	Helminthiasis	4.4
5	Ulcerate gastritis y duodenitis	2.1
6	Intestinal amebiasis	1.4
7	Urogenital candidiasis	1.2
8	Chicken pox	1.0
9	Acute otitis media	0.8
10	Asthma	0.6

Source: Subbureau of Epidemiology of Chetumal, State Health Services (SESA)

A.5.4 Financial Conditions

A.5.4.1 Public Finance

The budget of Solidaridad Municipality in the year 2000 amounted to 190.4 Million Pesos, equivalent to 14.1% of the budget of all Municipalities in Quintana Roo State. The most important income source was Taxes with 64.7 Million Pesos (34%), followed by "Federal participation" or "Federal share" with 47.1 Million Pesos (24.7%), Exploitation with 24.0 Million Pesos (12.6%), Fees with 20.2 Million Pesos (10.6%), Public Debt with 16.5 Million Pesos (8.6%), and Transfers with 14.1 Million Pesos (7.4%). The effect of tourism development can be seen in the income structure of Solidaridad Municipality, as taxes comprised a significant share of the total income, around twice of the average of all Municipalities. On the other hand, income as Transfers was considerably lower, less than half of the average of all Municipalities of the State, thereby suggesting that tourism development in Solidaridad have created income sources that make public finance of this Municipality less dependent on transfers from the higher levels of government.

On the expenditure side, Administrative Expenses amounted to 119.7 Million Pesos (62.9%), followed by Public Works & Promotion with 39.7 Million Pesos (20.9%), Transfer Payments with 18.7 Million Pesos (9.8%), and Public Debt with 12.2 Million Pesos (6.4%). This expenditure structure is in line with the average of all Municipalities in the State.

Table A-59: Municipal Budget of Solidaridad in 2000

Budget	All Municipalities (Million Pesos)	Solidaridad (Million Pesos)
INCOME	1,350.38	190.40
Income during 2000	1,307.70	190.40
Taxes	229.84	64.67
Federal share	470.97	47.05
Improvements	0.55	0.00
Fees	155.56	20.19
Products	20.02	1.82
Exploitation	93.00	24.04
Public debt	31.69	16.45
Third party	0.00	0.00
Transfer	232.80	14.07
Other Income	73.27	2.11
Funds from Previous Year	42.68	0.00
EXPENDITURES	1,350.38	190.40
Administrative Expenses	833.76	119.73
Public Works & Promotion	290.96	39.71
Transfer Payments	141.84	18.67
Public Debt	54.58	12.19
Available Funds (Disponibilidades)	26.88	0.00
Third Party	1.49	0.00
Other Expenses	0.87	0.10

Source: Anuario Estadistico 2002, Quintana Roo, INEGI

A.5.4.2 Taxation System and Public Utilities

In general, the taxation system is similar to that described under Othón P. Blanco Municipality.

Compared with other municipalities in the study area, a clear difference in the case of Solidaridad Municipality was the large share of taxes, around 34% of total income in the year 2000. Likewise, fees accounted for almost 11% of total income, and "aprovechamientos" for around 13%. These data indicate that, in Solidaridad Municipality, own sources of income accounted for a larger share of total income than federal funds, as participations comprised around 25%, and contributions about 7%. In other words, Solidaridad Municipality is financially more self-supporting, making it clear the benefits of tourism on tax collection under the same tax system.

The Federal Electricity Commission is responsible for electricity supply. Electricity users are categorized into Industry, Residence, Commerce, Agriculture, and Services, as shown in the following comparative table between Quintana Roo State and Solidaridad Municipality.

Table A-60: Electricity Consumption in Solidaridad Municipality, 2001

Type of Service	Number of Users		Consumption (Mwatt-hr)		Cons. Value (Mill Pesos)	
	Q.Roo	Solidaridad	Q.Roo	Solidaridad	Q.Roo	Solidaridad
Total	244,912	12,411	2,029,422	340,575	1,521.31	241.33
Industry	2,193	381	1,237,868	269,640	791.26	163.35
Residence	213,500	9,354	497,464	35,315	367.16	33.47
Commerce	27,456	2,590	214,415	27,986	280.46	36.48
Agriculture	254	7	4,673	494	0.88	0.01
Services	1,509	79	75,002	7,140	81.55	8.02

Source: Anuario Estadistico, Edicion 2002, INEGI

The above table shows that Solidaridad Municipality relative to the State in 2001 accounted for around 5% of the number of electricity users, 17% of electricity consumed and 16% of value of electricity consumption. Within Solidaridad Municipality, residential users accounted for 75% of the number of users, but only 10% of electricity consumed and 14% of the value of electricity consumption. On the other hand, industrial users accounted for only 3% of the number of users, but 79% of electricity consumed and 68% of the value of electricity consumption. Commercial users comprised 21% of the number of users, 8% of electricity consumed and 15% of the value of electricity consumption.

Solid waste service in Solidaridad Municipality is provided in Playa del Carmen and Tulum. User charges for this service were published on January 7, 2003, for hotels, restaurants, liquor shops, commercial firms, street vendors, rental apartments, houses, as monthly fixed charges, while unit charges per kilogram would be applied to large generators of solid waste. Income from solid waste service during the first five months of 2003 amounted to around 3.8 Million Pesos, while payments for the service amounted to around 7.5 Million Pesos.

A.5.5 Environment Policy

A.5.5.1 General Review

Activities related to the environment in Solidaridad Municipality are regulated by laws, regulations and official Mexican norms at the federal and state levels.

The Municipality has the responsibility to provide the solid waste management service. For this purpose, the service in some areas is provided with own personnel and equipment, while in other areas the service is contracted out to the private sector.

Except the controlled dump in Playa del Carmen, all the other final disposal sites do not comply with the Mexican norms, as they have the characteristics of open air dumps.

SEDUMA contracted the preparation of a project on sanitary landfill for Tulum. The project is in the stage of environmental impact assessment and its construction will be done through

public bidding and will be turned over to the Municipality for its operation. The Municipality will have to pay back to SEDUMA the expenses incurred in this project.

All drinking water supply and sewer systems are directly operated by CAPA.

A.5.5.2 Organization Concerned

CNA and CAPA participate in the water supply and sewer sector. CNA participates in the application of the National Water Law and in the collection of charges for its environmental services, while CAPA participates as the operator of drinking water and sewer services.

Within the administrative structure of the Municipality, the Urban Administration Bureau has the following rights and duties on matters related to the Environment, Ecology and Environmental Management:

- To formulate and conduct the policy for the municipal environmental management in accordance with the principles and criteria of the federal and state ecological policy
- To undertake the ecological planning of the municipal territory
- To establish and apply the necessary measures and sanctions for infractions of the Municipal environmental management regulation, of the state law on environmental protection and other legislation

The Social Development Bureau is in charge of the following matters concerning municipal public services:

- To manage, operate and supervise the public services provided by the Municipality
- To apply sanctions to transgressors of regulations and administrative provisions of public services
- To verify and supervise the compliance of concessionaires of public services, on matters related to quality, efficiency, time and form of their contractual obligations

The NGO registry in SEMARNAT contains the following NGOs: Ombligo Verde A.C., Amigos de Sian ka´an, Centro Mexicano de Derecho Ambiental CEMDA A.C., Planeta Limpio A.C., Protortuga A.C., Grupo Gema, Silvatica A.C.

A.5.5.3 Other Environmental Policy

At the municipal level, solid waste management service is regulated by the Regulation on Municipal Public Administration of Solidaridad, the Regulation for the Public Service on Collection, Transport, Treatment and Final Disposal of Solid Waste in the Solidaridad

Municipality, and the contract signed with the company providing the solid waste management service.

A.5.6 Other Infrastructure

A.5.6.1 Water Supply

The estimated population in Solidaridad in 2002 was 111,533 and it was estimated that 105,600 were serviced with water supply for a total coverage of 94.7%. The major urban areas are serviced by 12 wells which are in operation out of a total of 15 production wells; the production capacity is 393 Lps. The rural areas are serviced by local systems with their own well, elevated tank, and distribution lines.[17]

A.5.6.2 Road and Traffic System

Solidaridad has 360 kilometers of roads which are distributed as follows:

- 101 kilometers are federal highways which are paved.
- 175 kilometers are state roads which are either paved or coated.
- 84 kilometers are rural roads which are either paved or coated.

Table A-61: Vehicles Registered According to the Type of Service

Vehicles				Buses for passengers			
Total	Official	Public	Particular	Total	Official	Public	Particular
6,369	1	1,959	4,409	43	0	2	41
Trucks				Motorcycles			
Total	Official	Public	Particular	Total	Official	Public	Particular
1,885	2	406	1,477	1,426	7	31	1,388

Source: Anuario Estadístico de Quintana Roo, INEGI, 2002

The most important marine ports in this municipality are Playa del Carmen, Punta Venado, Aventuras, and a small fishermen port called Punta Allen. Additionally, there are two airfields in Solidaridad; one of them is Playa del Carmen (667 meters long runway) and Tulum (1,850 meters long runway).[18]

A.5.6.3 Power Supply

The power supply service in Solidaridad municipality is described in the following table.

[17] Information provided by CAPA to the S/T
[18] Anuario Estadístico de Quintana Roo, INEGI, 2002

Table A-62: Power Supply Figures in Solidaridad

I. By Type of Service[a]	Total	Industrial	Residential	Commercial	Agricultural	Services[b]
No. of Customers by type of Service by 31/12/2001	12,411	381	9,354	2,590	7	79
Sales volume by type of Service in 2001 (Megawatts-hour)	340,575	269,640	35,315	27,986	494	7,140
II. By unit of transmission and distribution	Transmission Sub-station	Capacity of Transmission Sub-station (Megavolts-amperes)	Distribution Sub-station	Capacity of Distribution Sub-station (Megavolts-amperes)	Distribution Transformers	Capacity of distribution transformers (Megavolts-amperes)
Units of Transmission and Distribution by 31/12/2001	0	0	3	25	1,278[c]	47

[a] It refers to the number of contracts signed for power supply
[b] Includes public lighting, pumping of water supply and wastewater, and temporary.
[c] It refers to the Mayan Riviera which includes the municipality of Solidaridad, Cozumel, and southern part of Benito Juárez.
Source: Anuario Estadístico de Quintana Roo, INEGI, 2002

A.5.6.4 Telecommunications

Quintana Roo ranked as 14th out of the 32 federal entities in telephone lines density with 14 lines per 100 persons in 2002. Regarding cellular telephones, Solidaridad had a total of 4,328 subscribers in 2001. The municipality had 4 radio broadcasting companies in 2001 (1 AM and 3 FM). Additionally, Solidaridad had 1 television station which was a repeater in 2001.[19]

A.5.6.5 Priority Ranking of Infrastructure Investment

Public investment during 2001 in Solidaridad amounted to 81.6 Million Pesos, the top places being 37.5 Million Pesos in Education, and 25.9 Million Pesos in Urban/Social Development. A more detailed investment by sector is shown below.

[19] Comisión Federal de Telecomunicaciones

Table A-63: Public Investment in Solidaridad in 2001

Public Investment	Q.Roo (Million Pesos)	Solidaridad (Million Pesos)
Total	885.08	81.55
Education	299.05	37.54
Urban/Social Development	218.31	25.86
Communication & Transport	69.50	2.43
Administration & Finance	60.32	0.92
Agriculture & Forestry	57.50	1.00
Drinking Water	46.05	4.36
Social Welfare	27.68	2.08
Electricity	23.47	3.33
Ecology	18.33	0.72
Security	17.02	0.00
Sport	16.68	3.29
Culture	10.56	0.00
Tourism	9.57	0.00
Health	4.09	0.02
Housing	3.95	0.00
Trade & Supply	2.74	0.00
Fishing	0.27	0.00

Source: Anuario Estadistico 2002, Quintana Roo, INEGI

The above table shows that public investment in specific sectors in Solidaridad Municipality during 2001 amounted to 4.4 Million Pesos in the Drinking Water, and 0.7 Million Pesos in Ecology.

Annex B

Field Investigations

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B Field Investigations

B.1 Wastewater Treatment Capacity Survey

B.1.1 Objectives

The survey encompasses the following objectives: to assess the treatment capacity of a plant and to examine the countermeasures for solving the problems existing in a sewage treatment plant.

B.1.2 Methodology

In general, the causes of declining efficiency in the treatment of wastewater using activated sludge can be divided in two large groups: the first one, where problems arise in the aeration tank; and the second one, where problems arise in the sedimentation of the activated sludge, causing the outflow of mixed activated sludge and effluents.

In order to assess the capacity of treatment and to examine the countermeasures appropriate for the problem, the following analyses were conducted:

- Water quality analysis,
- Sludge analysis to grasp the situation of activated sludge in the process of sewage treatment and
- Flow analysis (measurement of flow volume) to examine variation in wastewater inflow amount and its retention time in the wastewater treatment process.

The analyses were carried out in Playa del Carmen's sewage treatment plant, where is known that there are operation problems. Sampling point and analysis types are shown below.

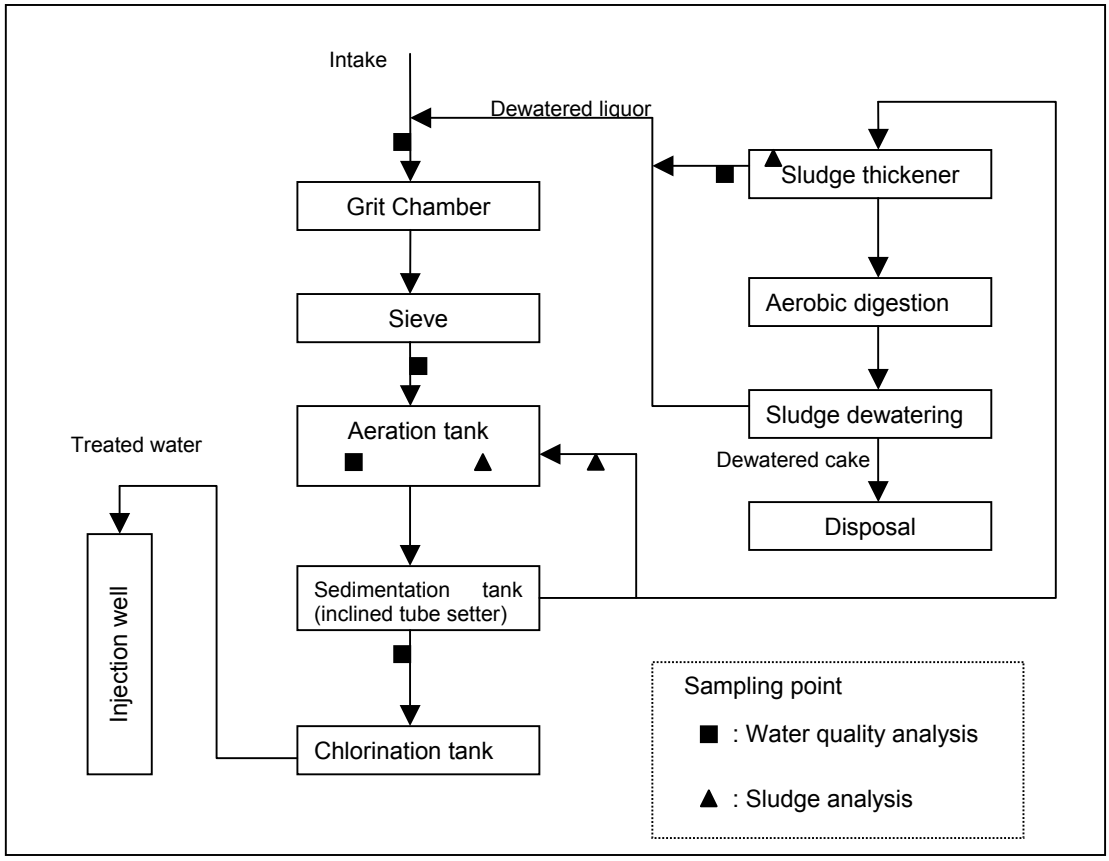

Figure B-1: Flow Sheet and Sampling point of Playa del Carmen Sewerage Treatment Plant

Number of samples and analysis items are shown in the table below.

Table B-1: Sampling Point and Number of Samples

Places of Sampling	Number of Samples		Flow Volume Measurement
	Water Quality Analysis	Sludge Analysis	
Grit Chamber	1	-	-
Aeration Tank intake (After sieve)	1 (inflow water)	-	24 hours (intake sewer and return sludge)
Aeration Tank	1 (taken from the outlet of the aeration tank)	2 (taken from the inlet and return sludge)	-
Final Sedimentation Tank	1 (treated water)	1 (Sludge blanket area)	24 hours
Water from Sludge Thickening	1	-	-
Sludge Storage Tank	-	1	-
Sub Total	5 samples	4 samples	3 places
Number of Sampling/ Measurement Times	3 times		
Total	15 samples	12 samples	9 places

Table B-2: Analysis Items

Water Quality Analysis	Sludge Analysis	Flow Volume Measurement
BOD, COD, T-N(total nitrogen), NH3-N(ammoniac nitrogen), NO2/NO3-N(nitrite/ nitrate nitrogen), Cl-(Chlorine ion concentration), SS, water temperature, pH	MLSS, MLVSS, SV (measured only for the samples from the aeration tank; settled sludge volume after 1, 5, 10, 20, 30, 40, 50, 60, 120, and 180 minutes settling)	Manual measuring: water level and flow velocity Automatic measuring: reading current mater displayed number

B.1.3 Survey Records

The survey was conducted three times (from the 3rd to the 4th of July, from July 14th to 15th and from July 20th to 21st). The results of the survey are shown in the Annex.

B.1.3.1 Water Quality Survey

Results of water quality survey are shown in the tables below.

Table B-3: Results of Water Quality Survey (average value)

Item	Intake	After sieve	Aeration tank	Sedimentation tank over flow	Sludge thickener over flow
Water temp (°C)	28.4	28.2	30.3	29.9	25.9
pH	7.0	6.8	6.8	6.4	6.8
BOD (mg/liter)	354.3	350.0	286.3	21.0	24.3
COD (mg/liter)	692.0	717.7	441.0	39.3	45.7
SS (mg/liter)	280.7	592.7	4,683.3	21.0	10.0
VSS (mg/liter)	244.0	507.3	3,575.0	12.7	6.0
T-N (mg/liter)	36.4	34.2	12.6	11.9	10.7
T-KN (mg/liter)	34.7	32.6	9.6	7.4	6.9
NH4-N (mg/liter)	19.5	21.4	5.2	4.1	3.6
NO2-N (mg/liter)	1.6	1.5	2.8	4.4	3.7
NO3-N (mg/liter)	0.064	0.158	0.206	0.138	0.099
Cl- (mg/liter)	491.3	443.1	273.6	326.9	266.1
DO (mg/liter)	1.2	5.0	2.1	1.0	1.6

Table B-4: Results of Water Quality Survey

Item	Intake	After sieve	Aeration tank	Sedimentation tank over flow	Sludge thickener over flow
3 to 4 July 2003					
Water temp (°C)	28.5	27.8	29.8	29.3	26.6
pH	7.2	7.6	7.1	7.5	7.5
BOD (mg/liter)	351.0	401.0	438.0	23.0	13.0
COD (mg/liter)	780.0	820.0	860.0	50.0	30.0
SS (mg/liter)	252.0	253.0	4,750.0	18.0	12.0
VSS (mg/liter)	196.0	227.0	3,750.0	15.0	9.0
T-N (mg/liter)	25.0	25.6	10.3	9.7	10.0
T-KN (mg/liter)	24.5	25.1	8.4	6.2	7.2
NH4-N (mg/liter)	16.8	17.6	4.5	2.3	2.5
NO2-N (mg/liter)	0.4	0.4	1.7	3.3	2.7
NO3-N (mg/liter)	0.090	0.180	0.206	0.190	0.102
Cl- (mg/liter)	280.2	304.0	233.7	292.7	288.1
DO (mg/liter)	1.0	5.5	1.9	1.0	1.0
14 to 15 July 2003					
Water temp (°C)	7.3	6.8	7.0	5.7	6.0
pH	232.0	249.0	169.0	20.0	20.0
BOD (mg/liter)	480.0	576.0	211.0	48.0	29.0
COD (mg/liter)	207.0	390.0	4,300.0	26.0	11.0
SS (mg/liter)	203.0	355.0	3,250.0	8.0	6.0
VSS (mg/liter)	41.3	36.5	10.7	9.9	7.9
T-N (mg/liter)	38.4	33.4	7.9	5.8	4.2
T-KN (mg/liter)	22.4	21.3	3.2	2.8	2.1
NH4-N (mg/liter)	2.8	2.9	2.6	4.1	3.6
NO2-N (mg/liter)	0.092	0.165	0.206	0.025	0.102
NO3-N (mg/liter)	741.5	696.8	288.5	309.9	276.9
Cl- (mg/liter)	1.0	4.5	2.4	1.1	2.8
DO (mg/liter)	7.3	6.8	7.0	5.7	6.0
20 to 21 July 2003					
Water temp (°C)	29.2	29.5	30.8	31.4	25.3
pH	6.6	6.1	6.1	6.1	7.0
BOD (mg/liter)	480.0	400.0	252.0	20.0	40.0
COD (mg/liter)	816.0	757.0	252.0	20.0	78.0
SS (mg/liter)	383.0	1,135.0	5,000.0	19.0	7.0
VSS (mg/liter)	333.0	940.0	3,725.0	15.0	3.0
T-N (mg/liter)	42.9	40.6	16.8	16.1	14.2
T-KN (mg/liter)	41.3	39.2	12.4	10.1	9.3
NH4-N (mg/liter)	19.3	25.2	7.9	7.2	6.2
NO2-N (mg/liter)	1.6	1.3	4.2	5.8	4.8
NO3-N (mg/liter)	0.010	0.130	0.207	0.198	0.093
Cl- (mg/liter)	452.2	328.4	298.6	378.2	233.3
DO (mg/liter)	1.5	5.0	1.9	0.9	1.0

B.1.3.2 Sludge

Results of the sludge survey are shown below.

Table B-5: Results of Sludge Survey

	3 to 4/July	14 to 15 July	20 to 21 July
0 min	100%	100%	100%
5 min	98%	97%	97%
10 min	97%	92%	94%
20 min	87%	77%	84%
30 min	70%	63%	78%
40 min	59%	58%	68%
50 min	53%	54%	62%
60 min	51%	51%	59%
120min	40%	39%	43%
180min	38%	39%	37%
MLSS (mg/l)	4,750	4,300	5,000
SVI	147.4	146.5	156

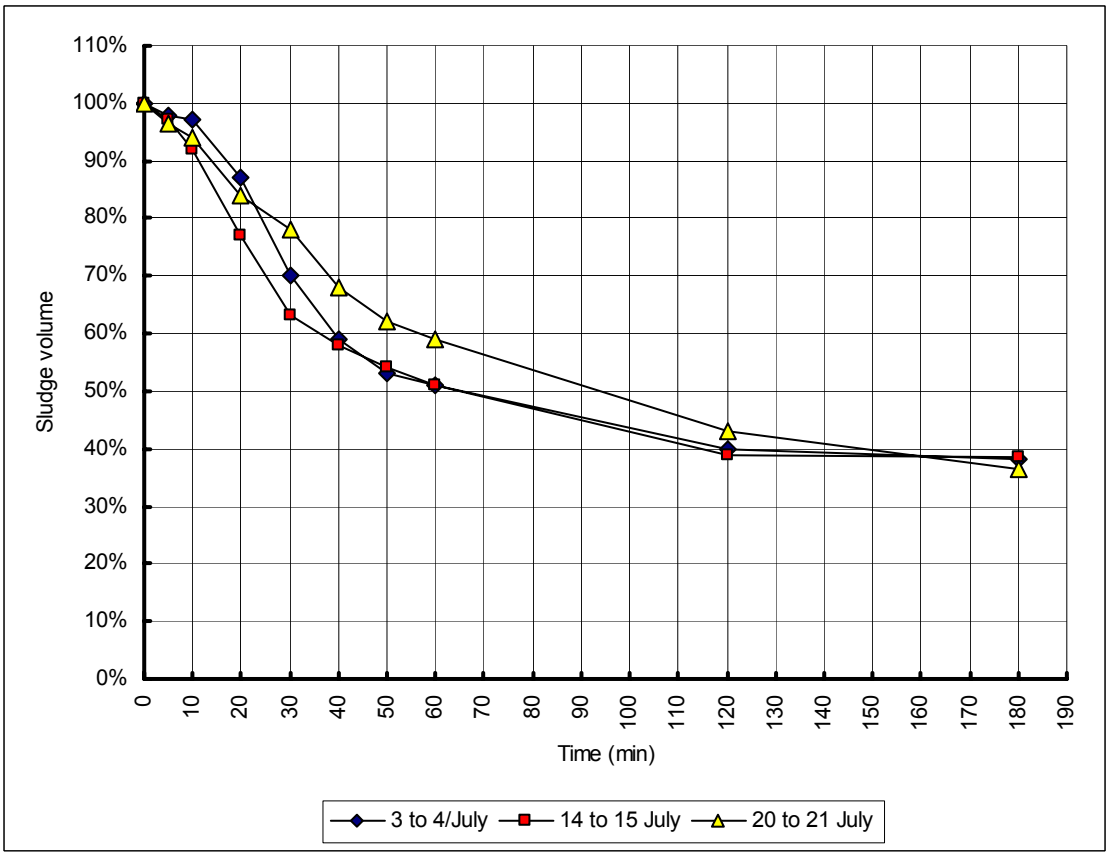

Figure B-2: Sedimentation Rate of Activated Sludge (Aeration Tank)

B.1.3.3 Flow Volume

The results of the flow volume survey are shown below.

Table B-6: Daily Flow Amount

Date	Flow amount (m3/day)	Flow amount (liter/sec)
4/July/2003	3,123.8	26.16
15/July/2003	3,689.3	42.70
21/July/2003	3,438.7	39.80
Average	3,417.3	39.5

Source: operation records at the sewerage treatment plant in Playa del Carmen

Table B-7: Hourly Intake Amount (Average Value) and Coefficient of Hourly Variation

Time	Hourly flow (liter/sec)	Coefficient of hourly variation
1:00	22.0	0.6
2:00	22.0	0.6
3:00	22.0	0.6
4:00	22.0	0.6
5:00	22.0	0.6
6:00	123.0	3.1
7:00	85.0	2.2
8:00	80.0	2.0
9:00	150.0	3.8
10:00	35.0	0.9
11:00	27.5	0.7
12:00	28.5	0.7
13:00	28.5	0.7
14:00	35.0	0.9
15:00	10.5	0.3
16:00	25.5	0.6
17:00	40.5	1.0
18:00	33.3	0.8
19:00	26.0	0.7
20:00	16.3	0.4
21:00	26.5	0.7
22:00	18.0	0.5
23:00	22.0	0.6
0:00	22.0	0.6
Average	39.3	-

Source: results of the flow volume survey and operation records at the sewerage treatment plant in Playa del Carmen

Table B-8: Hourly Return Sludge Flow Amount

Date / Time	7/3 to 4	7/14 to 15	7/20 to 21	Average
1:00	31.7	73.0	43.0	49.2
2:00	31.7	73.0	43.0	49.2
3:00	31.7	73.0	43.0	49.2
4:00	31.7	73.0	43.0	49.2
5:00	31.7	73.0	43.0	49.2
6:00	31.7	73.0	43.0	49.2
7:00	32.2	58.0	32.0	40.7
8:00	32.3	58.0	32.0	40.8
9:00	32.3	58.0	32.0	40.8
10:00	43.8	57.0	45.0	48.6
11:00	31.9	71.0	43.0	48.6
12:00	28.8	71.0	45.0	48.3
13:00	28.8	71.0	43.0	47.6
14:00	28.8	71.0	43.0	47.6
15:00	28.8	71.0	43.0	47.6
16:00	28.8	71.0	43.0	47.6
17:00	25.4	77.0	43.0	48.5
18:00	32.5	73.0	43.0	49.5
19:00	32.0	73.0	43.0	49.3
20:00	32.0	73.0	43.0	49.3
21:00	32.1	73.0	43.0	49.4
22:00	32.1	73.0	43.0	49.4
23:00	31.7	73.0	43.0	49.2
0:00	31.7	73.0	43.0	49.2
Average (liter/sec)	31.5	70.1	41.8	47.8
Daily amount (m3/day)	2,722.3	6,058.8	3,610.8	4,130.6

Source: results of the flow volume survey and operation records at the sewerage treatment plant in Playa del Carmen

B.1.3.4 Pictures

The pictures below show operational status of the sewerage treatment plant in Playa del Carmen.

	
Intake Water	Sieved Water
	
Aeration Tank	Sedimentation Tank
	
Sludge Thickener	Sludge Analysis (measure SV)

B.1.4 Findings

B.1.4.1 Design Data of the Sewerage Treatment Plant in Playa del Carmen

The sewerage treatment plant in Playa del Carmen was modified in 2002. Design data used for the modification is shown in the table below.

Table B-9: Major Design Data of Playa del Carmen Sewerage Treatment Plant

Item	Contents		Remarks
Design capacity	Minimum flow	22.00 liter/sec	1,900 m3/day
	Average flow	45.00 liter/sec	3,888 m3/day
	Maximum flow	68.00 liter/sec	5,875 m3/day
Grit chamber	Average flow	45.00 liter/sec	3,888 m3/day
	Maximum flow	68.00 liter/sec	5,875 m3/day
	Surface area	1.59 m2	surface loading: for max. flow 3,595 m3/m2/day for average. flow 2,447 m3/m2/day
	Tank volume	1.91 m3	detention time: for max. flow 28 sec for average flow 42 sec
Aeration tank	Nos. of tan k	2	
	Volume/ nos.	1,260 m3	water depth : 4.0 m
	Total volume	2,520 m3	
Aeration blower	Type	Lobe blower	
	Nos.	3 (1 reserve)	
	Capacity	18.07 m3/min	
	Operation pressure	0.49 kg/cm2	
Sedimentation tank	Nos. of tank	4	
	Surface area/ nos.	40.95 m2	long 6.5 m, wide : 6.3 m
	Surface loading	23.7 m3/m2/day	for average flow
		35.9 m3/m2/day	for maximum flow
	Water depth	4.87 m	
	Length of over flow weir	25.2 m/tank	
	Weir loading	38.6 m3/m/day	for average flow
		58.3 m3/m/day	for maximum flow
	Incline module	60 degree	
Sludge return pump	Nos. of pump	4 (2 reserve)	Centrifugal vertical type
	Capacity	23 liter/sec/nos.	Rated return ratio 102% Maximum return ratio 204%
Disinfection tank	Volume	81 m3	
	Detention time	30 min	for average flow
		20 min	for maximum flow
	Chlorination	Chlorine gas	

Source: CAPA (INDICE DE ESPECIFICACIÓN DE EQUIPOS PARA REHABILITACIÓN INTEGRAL DE LA PLANTA DE TRATAMIENTO DE AGUAS RESIDUALES DE PLAYA DEL CARMEN, PROGRAMAS DE CAPACITACION E INTEGRACIÓN DE MANUALES DE OPERACIÓN)

Table B-10: Design Water Quality

Item	Intake water	Treated water
BOD	250 mg/liter	30 mg/liter
COD	500 mg/liter	-
SS	250 mg/liter	40 mg/liter
VSS	190 mg/liter	-
Grease and oil	50 mg/liter	15 mg/liter
Faecal coliform	-	1000 NMP/100 ml
Total nitrogen	-	15 mg/liter
Total phosphors	-	5 mg/liter
pH	-	5 to 10

Source: CAPA ((INDICE DE ESPECIFICACIÓN DE EQUIPOS PARA LA REHABILITACIÓN INTEGRAL DE LA PLANTA DE TRATAMIENTO DE AGUAS RESIDUALES DE PLAYA DEL CARMEN, PROGRAMAS DE CAPACITACION E INTEGRACIÓN DE MANUALES DE OPERACIÓN)

B.1.4.2 Flow Pattern and Required Regulation Amount

As biological treatment method is sensitive to fluctuation of inflow and water quality, such fluctuation should be minimized in order sufficiently to treat wastewater. Domestic wastewater does not change its quality drastically. However, amount of inflow changes considerably by the hour. For coping with the fluctuation of inflow, its pattern should be known first.

The figure below shows flow pattern in the treatment plant that is estimated by the inflow survey for 3 days and operating records of the plant. Coefficient of variation (ratio between hourly inflow and average inflow for 24 hours) reaches a peak during 6:00 and 9:00 in the morning.

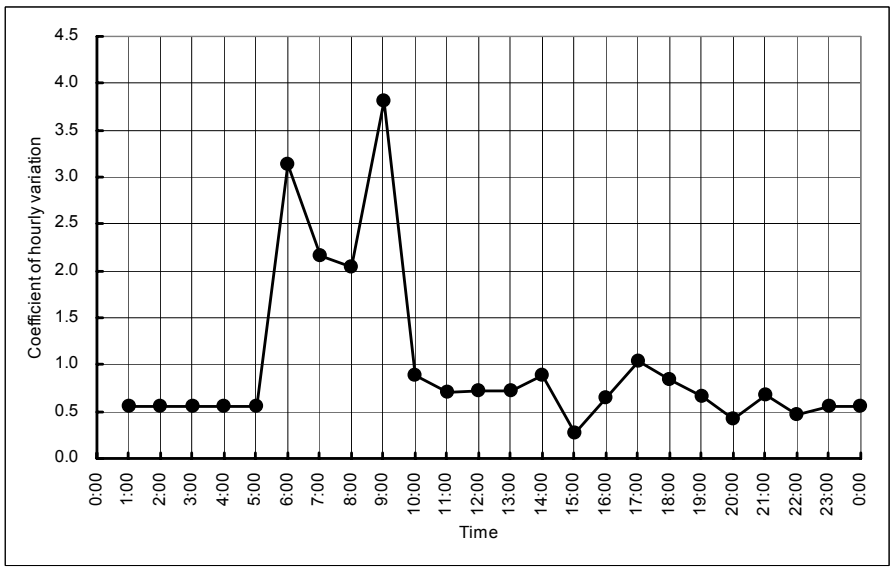

Figure B-3: Flow Pattern of Playa del Carmen Sewerage Treatment Plant

During the survey, average inflow for 24 hours was 39.3 liter/sec and the peak inflow was recorded at 9:00 a.m. as 150 liter/sec. The peak inflow was 3.3 times the rated average treatment capacity of the plant, 45 liter/sec, and 2.2 times the maximum treatment capacity, 68 liter/sec.

Required regulation amounts were calculated in case of the rated average treatment capacity, 45 liter/sec, and the maximum treatment capacity, 68 liter/sec. Average inflow is assumed as the same amount as the survey result, 45 liter/sec. The required regulation amounts are to be 1,157 m^3 in case of the average treatment capacity and 826.6 m^3 in case of the maximum treatment capacity, and detention times are to be 7.2 hours and 5.1 hours respectively, as shown in the tables below.

Table B-11: Required Regulation Amount (treatment amount: 45 liter/sec)

Time	Hourly flow (m3/hour)	Treatment Capacity (m3/hour)	Excess amount (m3/hour)	Required regulation amount (m3)
1:00	90.7	162.0	-71.3	285.0
2:00	90.7	162.0	-71.3	213.7
3:00	90.7	162.0	-71.3	142.4
4:00	90.7	162.0	-71.3	71.1
5:00	90.7	162.0	-71.3	-0.2
6:00	507.2	162.0	345.2	345.2
7:00	350.3	162.0	188.3	533.5
8:00	329.8	162.0	167.8	701.3
9:00	618.5	162.0	456.5	1,157.8
10:00	144.4	162.0	-17.6	1,140.2
11:00	113.4	162.0	-48.6	1,091.6
12:00	117.4	162.0	-44.6	1,047.0
13:00	117.4	162.0	-44.6	1,002.4
14:00	144.4	162.0	-17.6	984.8
15:00	43.2	162.0	-118.8	866.0
16:00	105.1	162.0	-56.9	809.1
17:00	167.0	162.0	5.0	814.1
18:00	137.2	162.0	-24.8	789.3
19:00	107.3	162.0	-54.7	734.6
20:00	67.0	162.0	-95.0	639.6
21:00	109.1	162.0	-52.9	586.7
22:00	74.2	162.0	-87.8	498.9
23:00	90.7	162.0	-71.3	427.6
0:00	90.7	162.0	-71.3	356.3

Table B-12: Required Regulation Amount (treatment amount: 68 liter/sec)

Time	Hourly flow (m3/hour)	Treatment Capacity (m3/hour)	Excess amount (m3/hour)	Required regulation amount (m3)
1:00	90.7	244.8	-154.1	-1,371.0
2:00	90.7	244.8	-154.1	-1,525.1
3:00	90.7	244.8	-154.1	-1,679.2
4:00	90.7	244.8	-154.1	-1,833.3
5:00	90.7	244.8	-154.1	-1,987.4
6:00	507.2	244.8	262.4	262.4
7:00	350.3	244.8	105.5	367.9
8:00	329.8	244.8	85.0	452.9
9:00	618.5	244.8	373.7	826.6
10:00	144.4	244.8	-100.4	726.2
11:00	113.4	244.8	-131.4	594.8
12:00	117.4	244.8	-127.4	467.4
13:00	117.4	244.8	-127.4	340.0
14:00	144.4	244.8	-100.4	239.6
15:00	43.2	244.8	-201.6	38.0
16:00	105.1	244.8	-139.7	-101.7
17:00	167.0	244.8	-77.8	-179.5
18:00	137.2	244.8	-107.6	-287.1
19:00	107.3	244.8	-137.5	-424.6
20:00	67.0	244.8	-177.8	-602.4
21:00	109.1	244.8	-135.7	-738.1
22:00	74.2	244.8	-170.6	-908.7
23:00	90.7	244.8	-154.1	-1,062.8
0:00	90.7	244.8	-154.1	-1,216.9

Table B-13: Required Regulation Amount

Treatment capacity		Required regulation tank	
		volume (m3)	Detention time for average flow amount(hour)
Average	45 liter/sec	1,157.8	7.2
Maximum	68 liter/sec	826.6	5.1

B.1.4.3 Treated Water Quality

The table below compares the results of water quality analysis and designed water quality. As the table shows, the plant worked well. No problem was found in the aspect of treated water quality.

Table B-14: Comparison of Treated Water Quality (measured and designed)

Item	Treated water (actual)	Designed(target)
Water temp (°C)	29.9	-
pH	6.4	5 to 10
BOD (mg/liter)	21.0	30
COD (mg/liter)	39.3	-
SS (mg/liter)	21.0	40
VSS (mg/liter)	12.7	-
T-N (mg/liter)	11.9	15
T-KN (mg/liter)	7.4	-
NH4-N (mg/liter)	4.1	-
NO2-N (mg/liter)	4.4	-
NO3-N (mg/liter)	0.138	-
Cl- (mg/liter)	326.9	-
DO (mg/liter)	1.0	-

B.1.4.4 Treatment Capacity and Issues

As mentioned above, no problem was found in the aspect of treated water quality. However, the average inflow at the survey was 39.5 liter/sec that was below the design values (45 liter/sec of the average treatment capacity; 68 liter/sec of the maximum treatment capacity). This section considers issues that may happen in case that inflow reaches the design values.

a. Evaluation of present process operation parameter

Aeration tank and sedimentation tank center in the sewerage treatment system. In the aeration tank, wastewater and activated sludge are well mixed; air is supplied; organic matters such as BOD are decomposed by oxidation and/or absorbed by the activated sludge. Then, the activate sludge is separated from the treated wastewater in the sedimentation tank.

Microorganisms that decompose nitrogen exist in the plant, in addition to ones break down BOD. They can work in a narrower range of condition that requires careful operation, i.e., lower BOD-SS loading than that for only BOD removal. It is considered from the design loading and the target values of treated water quality that the plant would aim to remove nitrogen in addition to BOD.

Table B-15 compares process parameters between design and actual. As it shows, actual parameters of BOD-SS loading, surface loading and weir loading were below the design parameters, although the actual BOD concentration of inflow was higher than the designed. This was achieved by raising MLSS concentration. In order to keep MLSS concentration high in the aeration tank, return sludge needs to be incrassated or increased.

Table B-16 compares process parameters of return sludge between design and actual. Actual return rates exceed the design ones expect on 3-4 July. Although the actual return sludge concentration is higher than the design, BOD-SS loading is kept below the design by

returning sludge more than the design. This implies that a large amount of sludge needs to be returned to maintain the BOD-SS loading when inflow increases.

Table B-15: Comparison of Process Parameter (aeration and sedimentation tanks)

Item	Design (Average)	Design (Maximum)	3 to 4 July	14 to 15 July	20 to 21 July
Daily flow (m3/day)	3,888	5,875	3,124	3,689	3,439
Daily flow (liter/sec)	45	68	36.2	42.7	39.8
BOD conc.(mg/liter)	250	250	401.0	249	400
Aeration tank					
Aeration tank volume (m3)	2,520	2,520	2,520	2,520	2,520
MLSS (mg/liter)	3,000	3,000	4,750	4,300	5,000
Total SS amount (kg)	7,560.0	7,560.0	11,970.0	10,836.0	12,600.0
BOD-volume loading (kg/m3/day)	0.39	0.58	0.50	0.36	0.55
BOD-SS loading (BOD-kg/ss-kg/day)	0.13	0.19	0.10	0.08	0.11
Detention time (hr)	15.6	10.3	19.4	16.4	17.6
Aeration amount (m3/min.)	36.2	36.2	36.2	36.2	36.2
Aeration am../ water flow	13.4	8.9	16.7	14.1	15.2
Sedimentation tank					
Volume (m3)	800	800	800	800	800
Surface area (m2)	164	164	164	164	164
Length of weir (m)	100.8	100.8	100.8	100.8	100.8
Detention time (hr)	4.9	3.3	6.1	5.2	5.6
Surface loading (m3/m2/day)	23.7	35.8	19.0	22.5	21.0
Weir loading (m3/m/day)	38.6	58.3	31.0	36.6	34.1

Table B-16: Comparison of Process Parameter (return sludge)

Item	Design (Average)	Design (Maximum)	3 to 4 July	14 to 15 July	20 to 21 July
Return amount (m3/day)	3,974	3,974	2,722.3	6,058.8	3,610.8
Return rate (%)	102.2%	67.6%	87.1%	164.2%	105.0%
SVI	-	-	147.4	146.5	156
Input SS (kg/m3)	0.21	0.21	0.235	0.364	1.116
MLSS (kg/m3)	3.000	3.000	4.750	4.300	5.000
Input SS (kg/day)	816.5	1,233.8	734.1	1,342.9	3,837.6
Return SS (kg/day)	23,586.0	29,547.0	27,769.0	41,916.8	35,247.5
Return sludge conc. (kg/m3)	5.935	7.435	10.201	6.918	9.762
Return sludge conc. (mg/liter)	5,935	7,435	10,201	6,918	9,762

b. In case of maximum design flow

This section considers what would happen if inflow constantly reaches to the maximum design capacity, 68 liter/sec.

b.1 Upper limit of BOD-SS loading

In case of only BOD removal, the maximum BOD-SS loading is 0.4 BOD-kg/SS-kg/day and required detention time in the aeration time is about 6 hours. If nitrogen removal is considered, those values will change depending on water quality and temperature of inflow.

Table B-17 shows relation between nitrogen removal ratio and BOD-SS loading based on the results of the survey. And, Figure B-4 schematizes the relation. Then, the relation can be shown by the following formula.

$$y = 0.0591x^{-1.0392}$$

where:

y: Nitrogen removal ratio

x : BOD-SS Loading

Required removal ratio of the plant is 56% as the design water quality is 15 mg/liter of nitrogen and the actual average nitrogen concentration of inflow was 32.4 mg/litter. According to the formula above, 0.115 kg/kg/day of BOD-SS loading corresponds to 56% of nitrogen removal ratio. And, this value is lower than the maximum BOD-SS loading of 0.4 kg/kg/day. Consequently, the BOD-SS loading of 0.115 kg/kg/day is to be the maximum for the plant.

Table B-17: Relation between BOD-SS Loading and Nitrogen Removal Ratio

Item	3 to 4/July	14 to 15 July	20 to 21 July
BOD-SS loading (BOD-kg/ss-kg/day)	0.10	0.08	0.11
Nitrogen removal ratio	0.62	0.83	0.60

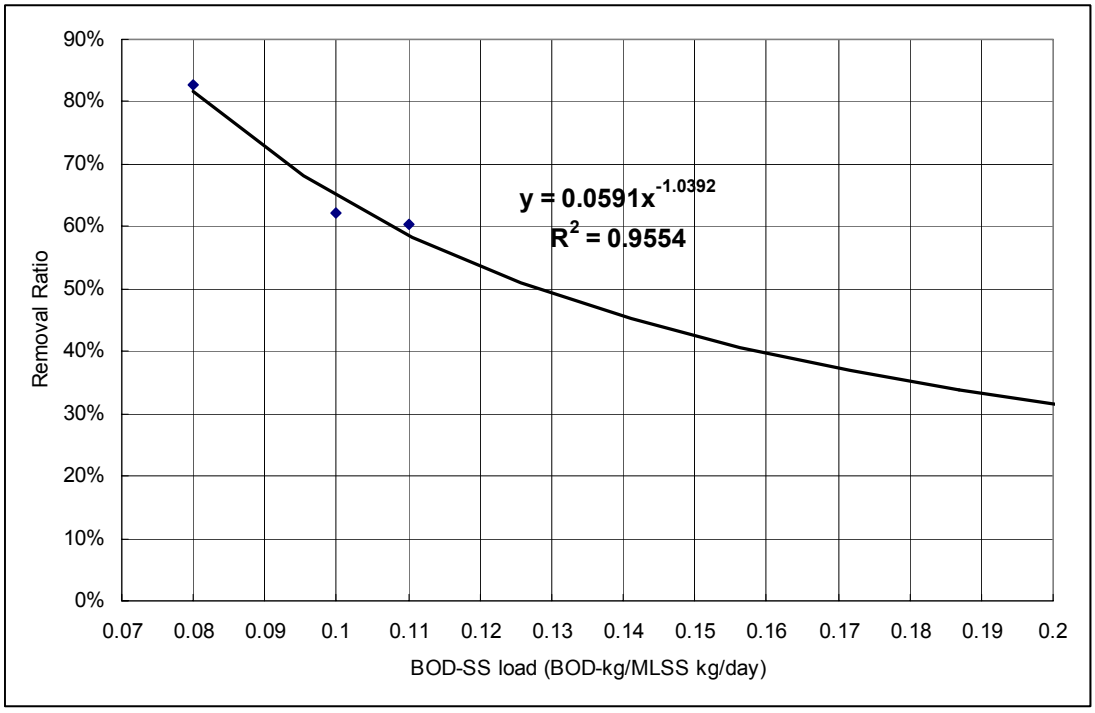

Figure B-4: Relation whit Between BOD-SS Loading and Nitrogen Removal Ratio

b.2 Examination of estimated operational status of the plant

This section examines estimated operational status of the plant under the following two cases.

- Case 1 : to treat 68 liter/sec of wastewater constantly with 0.115 kg/kg/day of BOD-SS loading
- Case 2 : to operate the plant with aiming at removing only BOD; this is the same conditions as ones for the original design

The table below shows operation parameters in the two cases.

Table B-18: Operation Parameters in the Two Cases

Operation Parameters	Case 1	Case 2
Daily average flow (liter/sec)	68	68
Daily flow (m3/day)	5,875	5,875
BOD conc.(mg/liter)	350.0	350.0
Aeration tank		
Aeration tank volume (m3)	2,520	2,520
MLSS (mg/liter)	7,100	3,000
Total SS amount (kg)	17,892.0	7,560.0
BOD-VOL loading	0.82	0.82
BOD-SS loading	0.115	0.272
Detention time (hr)	10.3	10.3
Aeration volume (m3/min.)	36.2	36.2
Flow/Air	8.9	8.9
Sedimentation tank		
Volume (m3)	800	800
Surface area (m2)	164	164
Length of weir (m)	100.8	100.8
Detention time (hr)	3.3	3.3
Surface loading (m3/m2/day)	35.8	35.8
Weir loading (m3/m/day)	58.3	58.3
Return sludge		
Return amount (m3/day)	7,948	3,974
Return rate (%)	135.3%	67.6%
Input SS (kg/m3)	0.57	0.57
MLSS (kg/m3)	7.100	3.000
Input SS (kg/day)	3,358.5	3,358.5
Total SS (kg/day)	98,143.3	29,547.0
Return sludge conc. (kg/m3)	12.348	7.435
Return sludge conc. (mg/liter)	12,348	7,435

b.2.1 Case 1

In order to remove nitrogen adequately as well as BOD, MLSS concentration should be kept 7,100 mg/liter and over. For this, concentration of the return sludge has to be 12,348 mg/liter and over. However, it is difficult to realize this condition due to limited capacity of devices such as pumps for returning sludge and compressors for supplying air.

b.2.2 Case 2

There will be no problem in this case, as the condition is for the original design. However, it is difficult to remove nitrogen.

b.3 Conclusions

According to the examination above, it can be said that:

- The maximum treatment capacity of the plant when considering removal of nitrogen as well as BOD is to be 45 liter/sec.
- It is possible to treat wastewater of 68 liter/sec, if removal of nitrogen is not considered.

Consequently, a regulation tank is necessary for removing nitrogen as well as BOD. Recommended capacity of the tank is 1,158 m^3 and over.

B.2 Social and Public Opinion Survey

B.2.1 Objectives

The survey aims to grasp information regarding public living conditions and awareness on environmental sanitation. It has also as objective to obtain qualitative information on community organizations and their capabilities.

B.2.2 Methodology

For this study, in each of the three municipalities was selected one community from an urban area and one from a local area, i.e. 6 communities in total were selected. Next, 20 households were selected as samples in each community. Consequently, 120 households were selected for the questionnaire survey.

Meanwhile, a group of each community was selected and interviewed. 6 groups were surveyed in total.

B.2.3 Results

B.2.3.1 Households

The survey was carried out in July 2003 by the Instituto Tecnológico de Chetumal under supervision of the S/T. Samples and summary of results are presented below.

a. Samples

As urban communities, Chetumal, Felipe Carrillo Puerto City and Playa del Carmen were selected. Meanwhile, Mahahual, Chunhuas and Akumal were picked up as rural communities.

b. Results

b.1 Family and environment

b.1.1 Family

- This survey was applied to 54% women and 46% men.
- Television is the most important media, followed by radio broadcasts and newspaper.
- Family is composed by 52% parents and children older than 18, 14% young people aged 12-18, 32% children aged 0-11 and a small part of other relatives. We can assume that 66% is economic active community.

- 80% Houses are their own or they are paying for them. People have been living in those houses for 8 years on average. 58% people are from other places and 42% are from Quintana Roo. That shows high immigration into the localities asked on the survey.

- 97% water supply is rendered by CAPA. 89% said it was unsafe, has many doubts or needs to be boiled. That is why 96% drinks bottled water spending about $226.00 monthly on it.

b.1.2 Health conditions

- 43% is not covered by social security service, 57% is covered by this service, and 60% out of this 57% uses social security service. 63% considers social security services are good but 37% considers them not good. They say it is because they have problems with external consulting, secondly because the service doesn't provide enough medicines and finally because hospitalization service is deficient.

- 34% said their families had suffered from parasites and/or frequent diarrhea the last 5 years. They said they had spent $1070.00 annually on this disease additional to social security services. 37% said their children younger than 5 had suffered from this kind of diseases. 7% said any of their children had died as a result of these diseases.

b.1.3 Education

- 75% said their children had environmental matters in their curricula. The topics covered on this subjects are water consumption and waste collection and recycling.

b.1.4 Knowledge and practice of hygiene habits

- 89% of hygiene habits is taught at school. They said that washing their hands before and after defecating is practiced at 99%. 64% said they had flies near them when preparing their meals or eating.

b.1.5 Home economics

- The average of people working for supporting home income is 2 people per family.

- 32% are merchants, 13% domestic jobs, 12% artisans. In the survey results there is a 31% of other jobs, considering in this group fishermen, since one of the surveyed communities lives mainly on fishing activities.

- 32% of the average working hours is 34-40 hours, 15% 25-32 hours and 10% 41-48 hours per week.

- The highest expenses are 34% on food, followed by 12% on rent, 8% on health services and bottled water and 14% on water, electricity, sewage, drinking water and solid waste collection.

b.1.6 Willingness to pay, ability to pay and other services

- 77% Families consider CAPA service is unsatisfactory or sometimes satisfactory, they said service is frequently suspended and pressure in pipes is low. Families pay $113.00 per month for water supply service. 45% considers water supply fee is acceptable or low. 59% considers water supply service is high or very high.

- 2 of the surveyed communities don't have sewage service, for instance 55% are not connected and 45% are connected to sewage system. 57% said they are not connected because there is not sewage service available and 36% said they are not connected because their septic tanks worked well. If the service was available, 93% said they would be willing to pay $30-$50 per month for the service. 42% of the people who don't have connection to sewage system said they would consider to connect would be to protect their families. 37% said they would connect to sewage system to protect the environment.

- Concerning to solid waste collection, 95% said they had this service. 46% is satisfied or very satisfied with solid waste collection service. 54% people are unsatisfied or sometimes satisfied with solid waste collection service. From this 54% people, 90% is willing to pay for a better service. 75% would pay $10-$20, 25% would pay $50-$75 per month for a better solid waste collection service.

b.2 Knowledge on environmental issues

b.2.1 Knowledge on environment

- There is a great interest in protecting the environment since 98% said they are interested in it. They mentioned that it is important to live in a clean environment and to preserve natural resources for future generations. They said that the benefit they would obtain from preserving the environment would be healthy people. They are also aware that public participation is necessary to protect the environment. They consider that it is important that the authorities inform the community and intensify environment curricula on schools.

b.2.2 Awareness on beautification

- 95% people said they are proud of their cities. However, they consider that solid waste management is not appropriate. They also mentioned that there was solid

waste scattered on the streets. A small percentage mentioned water pollution problems, coral reefs damages and lack of urban development plans accomplishment. People suggest some activities to beautify their cities such as no littering, sweep in front of their houses and recycling.

- Needs for improvement in discharge facilities of domestic effluents and night soil (including knowledge on disease transmission)
- 97% families have drainage in their houses. 54% has septic tanks and 35% said they are connected to cesspools. People who contracts night soil cleaning service pay about $200.00 for it. They said they are satisfied with this service, but saying it is expensive.

b.2.3 Needs for solid waste collection and disposal

- Most of the people eliminate solid waste by using municipal solid waste collection service. They collect solid wastes in plastic bags, cardboard boxes or containers. 41% has solid waste collection service three times a week, 25% once a week, 21% twice a week and 13% everyday. 60% has complaints about this service, they are collection frequency, collection hours, collectors leave wastes scattered on the streets and collectors' behavior.

b.2.4 Willingness to participate in community activities

- Participation is low in community organizations. People who take part in them say they work on environment or civic purposes. The most important point is that 98% is willing to participate in activities towards protecting the environment.

B.2.3.2 Groups

a. Samples

As urban communities, Chetumal, Felipe Carrillo Puerto City and Playa del Carmen were selected. Meanwhile, Mahahual, Chunhuas and Akumal were picked up as rural communities.

b. Results

b.1 General

- People have been living in their houses for about 20 years on average.

b.2 Drinking water supply service rendered by CAPA

- Drinking water supplied by CAPA is considered: 5% Safe; 15% Doubtful; 50% Unsafe; 30% It needs to be boiled.
- CAPA water supply service is: 30% Satisfactory; 40% Sometimes satisfactory; 30% Unsatisfactory.
- People said that CAPA water supply service unsatisfactory because: 41% Service is frequently suspended; 12% Low pressure in pipes; 6%Water with chlorine flavour; 41% Water with odor and color.
- Fee for Drinking water service rendered by CAPA is considered: 15% Very high; 30% High; 45% Acceptable; 10% Low

b.3 Sewage and sanitation system

- 100% think that a sewage system is necessary in the city
- People said that a sewage system is necessary in the city because: 29% It is necessary to protect the environment; 20% It is necessary to protect family's health; 13% It is necessary to preserve natural resources for the future generations; 16% It is necessary to avoid polluted water borne diseases; 22% It is necessary to preserve beaches, rivers, lagoons, coral reefs, etc., to promote tourism and create more jobs.
- 100% believe that subsurface water contamination is getting worse because they don't have a sewage system.
- 85% People said that their organization could collaborate in persuading the community to connect their houses to the sewage system and pay for such service.

b.4 Solid waste collection service

People said that solid waste collection service in the community was available: 20% Everyday; 30% Three times a week; 35% Twice a week; 5% Once a week; 10% The service is not available in the community.

Concerning to satisfaction with solid waste collection service, people said: 5% They are very satisfied; 50% Satisfied; 30% Sometimes satisfied; 15% Unsatisfied.

People's complaints about solid waste collection service were: 37% Collection frequency; 13% Collection punctuality; 25% Collectors scatter solid waste on the streets; 13% Collectors spill solid waste fluids on the streets; 6% Collectors behavior; 6% Collection trucks are not appropriate.

85% People said that their organization could collaborate in persuading the community to accept paying for such service

b.5 Environment protection

- 85% People said that their organization could collaborate in persuading the community to participate in activities towards protecting the environment.
- Their organization would be interested in protecting the environment: 44% To preserve natural resources for future generations; 26% To live in environment clean; 15% To protect wildlife; 13% To have a sustainable development; 2% Because they love their country.
- People think that some of the benefits that they would get from protecting the environment would be: 44% Health; 29% Quality of life; 3% Dignity; 9% Preservation; 15% Better economy.
- People think that encouraging community inhabitants to participate in protecting the environment can be achieved if: 16% authorities prepare information upon environment protection; 9% authorities inform the community; 31% authorities intensify environment curricula on the schools; 6% organize community environment organizations; 13% people promote solidarity among the community; 25%authorities and community prepare a plan.

b.6 Awareness on beautification

- 90% are proud of their localities.
- 10% are not proud of their localities. They said that it was because: 25% There are dumps in their localities; 50% Beaches, rivers, lagoons, and wells are contaminated; 25% Urban Development Plan is not being accomplished.
- People suggested some ways to participate in city beautification, they are: 34% No littering; 9% Sweep front of their houses; 16% Recycle; 7% Prepare compost; 16% Plant trees; 14% Don't waste drinking water; 4% Participate in a civic agenda

b.7 Willingness to participate in community activities

- People considered that the following important topics should be included in environment protection curricula on schools: 9% Drinking water consumption; 23% Cenotes, rivers lakes and lagoons contamination; 12% Septic tanks; 19% Solid waste collection; 9% Solid waste recycling; 5% Compost preparation; 11% Coral reefs preservation; 12% Flora and fauna preservation.

B.2.4 Findings

B.2.4.1 Households

It should be first mentioned that numbers of samples in urban areas are the same as one in rural areas, however, urban population is much bigger than rural on the whole study area. Public services such as water supply, sewerage and solid waste collection are focused on the urban area. Therefore, it can be said that the results reflect situation in rural areas than in urban areas. Furthermore, number of sample was only 120. This samples size is too small to explain the situation over the study area.

However, the results give hints to grasp the present situation of environmental sanitation in the study area. Those are:

- Large portion of the samples drinks bottled water as they feel that tap water is unsafe. Meanwhile, hygiene habits are well taught at school. Almost all samples wash their hands after defecating. However, a considerable percentage suffers from parasites and/or diarrhea.
- Large portion is unsatisfied with water supply service as it is frequently suspended and low pressure. However, about half portion accepts the fee as reasonable. It may suggest that the residents would be more willing to pay for the service, if such technical problems were improved.
- According to investigation so far, the present SWM costs are assumed between 200 and 400 pesos/ton. This means that a family having about 5 members should pay about 30 to 60 pesos per months for the service, if the service is self-sufficient. Meanwhile, a large portion showed their willingness to pay between 10 and 20 pesos. This suggests difficulty to make the service self-sufficient or to apply a new technology requiring more costs.
- A large portion has septic tanks or cesspools and they are like to be satisfied with the system. This may imply difficulty to expand sewer system.

B.2.4.2 Groups

- Interviewed people said that they have been living in the locality where they were asked in the survey for 20 years on average. They consider that the organization in which they are enlisted is incorporated to all society strata.
- 80% consider drinking water supplied by CAPA is Unsafe or It needs to be boiled, 80% drinking water supply service rendered by CAPA is considered Sometimes satisfactory or Unsatisfactory, because Service is frequently suspended and Water with

odor and color; 45% People also think that drinking water service fee is High or very High and 45% Acceptable

- 100% consider that a sewage system is necessary in the city mainly to Protect the environment, Preserve beaches, rivers, lagoons, coral reefs, etc., to promote tourism and create jobs and Protect family's health.
- 100% said that they don't have a sewage system and it is worsening subsurface water contamination. 85% They said that their organization would be able to persuade community inhabitants to accept connecting their houses to sewage system and pay for such service
- Solid waste collection service frequency is 85% Every day, Twice or Three a week, in Chunhuas towns said there are not this service; Satisfaction with Municipal solid waste collection service 55% said Very satisfactory or Satisfactory and 45% sometimes satisfactory or unsatisfactory, reasons Collection frequency and Collectors make unpleasant noise
- People mentioned that their organization would be able to collaborate in persuading the community to accept paying for such service.
- 85% People asked in the survey said that their organization would be able to collaborate in encouraging the community to participate in activities towards protecting the environment, 70% they mentioned that their organization would be interested in protecting the environment to Preserve natural resources for the future generations and Live in a clean environment.
- 88% People consider that the community could get benefits from protecting the environment, mainly: Health, Quality of life and Better economy.
- 86% People think that encouraging community inhabitants to participate in activities towards protecting the environment can be achieved if authorities intensify environment curricula on the schools and authorities and community prepare a plan.
- 90%% are proud of their localities but said that it is necessary to work on solid waste management, take care of beaches and avoid damaging coral reefs.
- 80% People suggested some ways to participate in city beautification. Such suggestions are: No littering, Recycle, To plant trees and Don't waste drinking water.
- 42% People considered that the following important topics should be included in environment protection curricula on schools: Cenotes, rivers lakes and lagoons contamination and Solid waste collection.

Annex C

Present Status of the Environmental Sanitation

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C Present Sanitation Environment

C.1 Othón P. Blanco

C.1.1 Water Quality Monitoring

In Othon P. Blanco, water quality monitoring is carried out by the navy targeting Chetumal Bay and cenotes around Lake Bacalar and by CAPA targeting wells. The navy also conducts periodical monitoring of sea water quality along Yucatan Peninsula and Gulf of Mexico.

Figure C-1: Monitoring Point by Navy

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.1.1.1 Monitoring Results by Navy

This section presents results of monitoring carried out by the navy in Chetumal Bay and Lake Bacalar Area. The following figure and tables show those monitoring points and results.

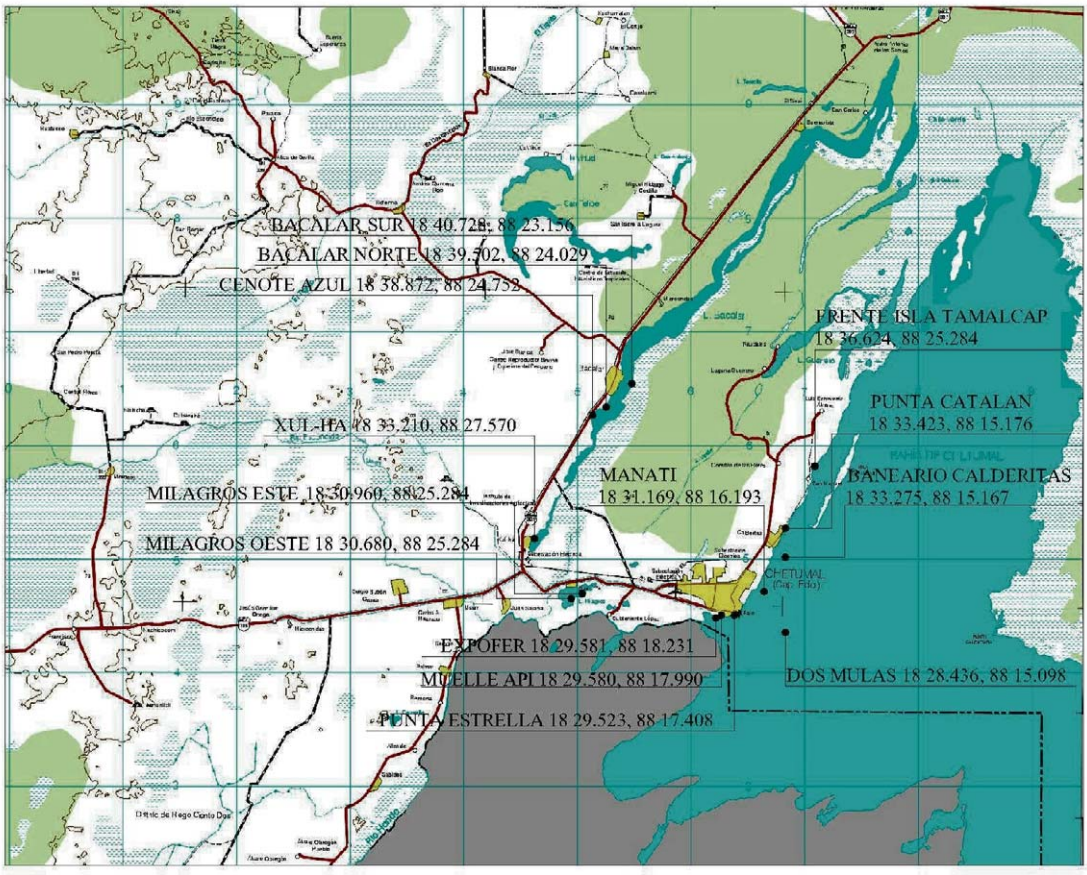

Figure C-2: Location Map of Monitoring Point

Table C-1: Monitoring Result in 2002 (Lagoon & Cenote)

Point	Item	Jan.	Aug.	Oct.	Nov.	Dec.	Average
BACALAR NORTE	Water temperature (Celsius)	27.0	29.5	30.0	30.0	29.0	29.1
	pH	7.15	8.35	7.99	7.98	7.77	7.85
	Salinity (o/oo)	0.0	-	1.0	1.0	4.0	1.5
	DO (mg/litter)	3.36	4.25	4.50	2.50	-	3.65
	NH_4 (mg/litter)	0.077	0.725	0.054	0.054	0.014	0.185
	NO_2 (mg/litter)	0.042	0.061	0.011	0.012	0.008	0.027
	NO_3 (mg/litter)	0.440	0.110	0.393	0.085	0.833	0.372
	$P0_4$ (mg/litter)	0.043	0.128	0.040	0.040	0.106	0.071
	Total coliform (NMP/100ml)	7	<3	<3	<3	<3	7
	Fecal coliform (NMP/100ml)	0	<3	<3	<3	<3	0
CENOTE AZUL	Water temperature (Celsius)	28.0	32.0	30.0	30.3	30.0	30.1
	pH	7.31	8.38	8.38	8.38	7.27	7.94
	Salinity (o/oo)	0.0	-	1.0	1.0	1.0	0.8
	DO (mg/litter)	2.88	4.86	4.50	4.50	-	4.19
	NH_4 (mg/litter)	0.077	0.725	0.187	0.187	0.017	0.239
	NO_2 (mg/litter)	0.038	0.082	0.008	0.012	0.008	0.030
	NO_3 (mg/litter)	0.688	0.014	0.325	0.103	0.669	0.360
	$P0_4$ (mg/litter)	0.043	0.218	0.055	0.055	0.128	0.100
	Total coliform (NMP/100ml)	0	<3	400	400	<3	267
	Fecal coliform (NMP/100ml)	0	<3	<3	<3	<3	0
XUL-HA	Water temperature (Celsius)	28.0	31.0	30.0	30.0	29.0	29.6
	pH	7.30	8.38	8.32	8.32	7.05	7.87
	Salinity (o/oo)	0.0	-	1.0	1.0	2.0	1.0
	DO (mg/litter)	3.04	3.65	4.50	4.50	-	3.92
	NH_4 (mg/litter)	0.089	0.418	0.107	0.107	0.015	0.147
	NO_2 (mg/litter)	0.047	0.017	0.080	0.010	0.004	0.031
	NO_3 (mg/litter)	1.487	0.028	0.109	0.012	0.537	0.435
	$P0_4$ (mg/litter)	0.043	0.104	0.055	0.055	0.106	0.073
	Total coliform (NMP/100ml)	0	21	600	700	<3	330
	Fecal coliform (NMP/100ml)	0	15	400	400	<3	204
MILAGROS ESTE	Water temperature (Celsius)	28.0	31.0	30.0	30.0	28.0	29.4
	pH	7.80	8.61	8.23	8.23	7.92	8.16
	Salinity (o/oo)	0.0	-	2.0	2.0	3.0	1.8
	DO (mg/litter)	3.52	3.65	5.50	5.60	-	4.57
	NH_4 (mg/litter)	0.108	0.153	0.151	0.151	0.012	0.115
	NO_2 (mg/litter)	0.047	0.001	0.065	0.014	0.004	0.026
	NO_3 (mg/litter)	0.301	0.002	0.319	0.100	0.049	0.154
	$P0_4$ (mg/litter)	0.019	0.195	0.055	0.055	0.677	0.200
	Total coliform (NMP/100ml)	0	23	400	400	<3	206
	Fecal coliform (NMP/100ml)	0	9	300	300	<3	152

Source : MARINA

Table C-2: Monitoring Result in 2002 (Costal Area)

	Item	Jan.	Aug.	Oct.	Nov.	Dec.	Average
DOS MULAS	Water temperature (Celsius)	29.5	31.5	30.5	30.5	29.0	30.2
	pH	7.81	8.08	8.44	8.49	8.10	8.18
	Salinity (o/oo)	5.0	-	10.0	10.0	10.0	8.8
	DO (mg/litter)	4.00	4.26	4.50	4.50	-	4.31
	NH_4 (mg/litter)	0.101	0.119	0.139	0.134	0.013	0.101
	NO_2 (mg/litter)	0.047	0.008	0.020	0.012	0.008	0.019
	NO_3 (mg/litter)	0.440	0.034	0.388	0.279	0.007	0.230
	$P0_4$ (mg/litter)	0.043	0.104	0.055	0.055	0.106	0.073
	Total coliform (NMP/100ml)	0	210	<3	<3	<3	105
	Fecal coliform (NMP/100ml)	0	150	<3	<3	<3	75
EXPO FER	Water temperature (Celsius)	29.0	31.0	31.0	31.0	29.0	30.2
	pH	7.81	8.69	8.58	8.58	7.74	8.28
	Salinity (o/oo)	1.0	-	2.0	2.0	5.0	2.5
	DO (mg/litter)	3.36	4.26	5.60	5.60	-	4.70
	NH_4 (mg/litter)	0.095	0.219	0.104	0.104	0.020	0.108
	NO_2 (mg/litter)	0.052	0.004	0.137	0.020	0.012	0.045
	NO_3 (mg/litter)	0.767	0.006	0.619	0.154	0.020	0.313
	$P0_4$ (mg/litter)	0.019	0.043	0.055	0.055	0.512	0.137
	Total coliform (NMP/100ml)	0	11	400	400	23	167
	Fecal coliform (NMP/100ml)	0	7	400	400	0	161
FRENTE ISLA TAMALCAB	Water temperature (Celsius)	29.0	31.5	29.0	29.0	28.0	29.3
	pH	7.79	6.80	8.40	8.40	7.72	7.82
	Salinity (o/oo)	5.0	-	12.0	12.0	12.0	10.3
	DO (mg/litter)	2.72	4.26	4.00	4.00	-	3.74
	NH_4 (mg/litter)	0.131	0.139	0.152	0.162	0.009	0.119
	NO_2 (mg/litter)	0.056	0.008	0.020	0.008	0.004	0.019
	NO_3 (mg/litter)	0.453	0.042	0.388	0.058	0.027	0.194
	$P0_4$ (mg/litter)	0.043	0.171	0.040	0.055	0.539	0.170
	Total coliform (NMP/100ml)	43	23	<3	<3	<3	33
	Fecal coliform (NMP/100ml)	23	9	<3	<3	<3	16
MANATI	Water temperature (Celsius)	28.5	31.5	30.5	30.5	28.0	29.8
	pH	7.81	8.00	8.65	8.85	7.94	8.25
	Salinity (o/oo)	3.0	-	11.0	11.0	11.0	9.0
	DO (mg/litter)	4.32	4.86	4.50	4.50	-	4.55
	NH_4 (mg/litter)	0.095	0.095	0.091	0.091	0.010	0.076
	NO_2 (mg/litter)	0.056	0.017	0.020	0.012	0.008	0.023
	NO_3 (mg/litter)	0.538	0.028	1.092	0.289	0.007	0.391
	$P0_4$ (mg/litter)	0.043	0.062	0.040	0.040	0.150	0.067
	Total coliform (NMP/100ml)	4	43	<3	<3	<3	24
	Fecal coliform (NMP/100ml)	4	23	<3	<3	<3	14

Source : MARINA

Figure C-3 and Figure C-4 show relation between PO4 and NH4 of the coastal water of Chetumal Bay and the freshwater in Lake Bacalar Area.

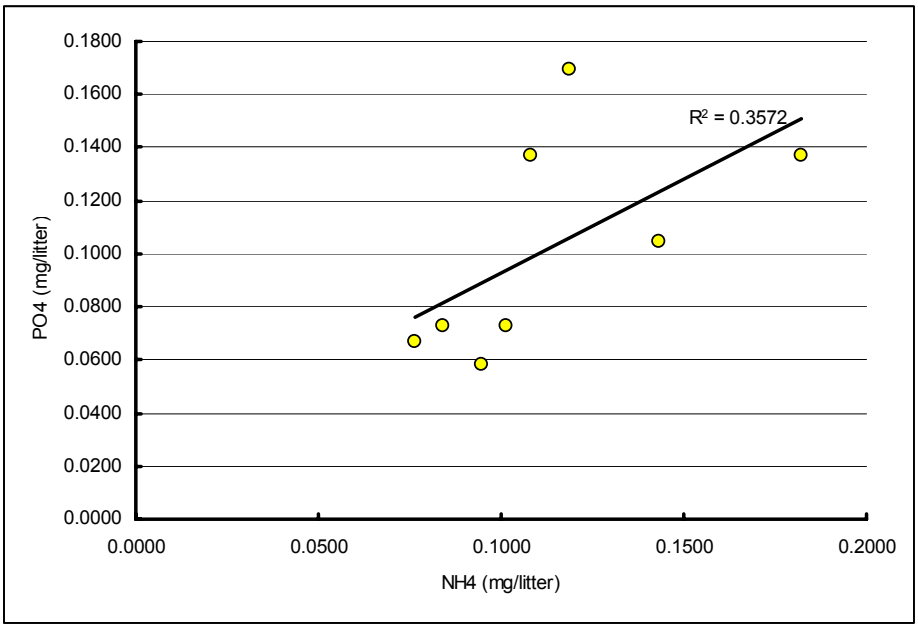

Figure C-3: Relation Between with PO_4 and NH_4 in the Costal Water

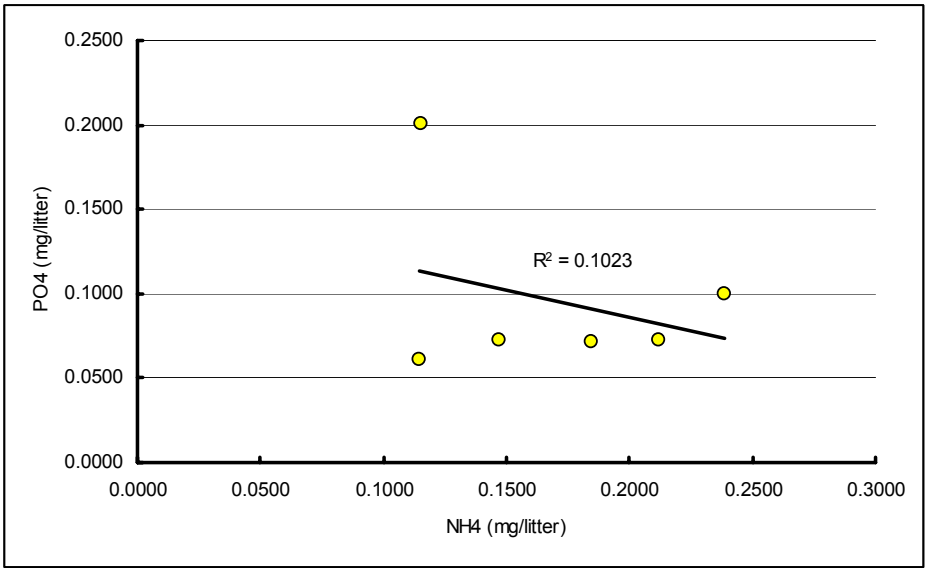

Figure C-4: Relation Between with PO_4 and NH_4 in the Freshwater Area

The analyses above say that relation between NH_4 and PO_4 in the freshwater is remote, meanwhile, they may have a relation in the coastal water. This might imply that pollutants including NH_4 and PO_4 at a constant rate such as domestic wastewater flow in Chetumal Bay.

C.1.1.2 Monitoring Results by CAPA

Table C-3 shows monitoring items and Table C-4 presents monitoring results from 2000 to 2002. The results do not show contamination.

Table C-3: 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-4: Monitoring Results of CAPA's Well

Name of well	Item	Year			
		2000	2001	2002	Average
Buenavista	pH	7.4	7.3	8.0	7.6
	Water temp.	26.1	26.3	25.3	25.9
	EC(µsiems/cm)	4,220	3,610	5,670	4,500
	Turbidity(UTN)	3.0	2.5	2.5	2.7
	Total alkalinity(mg/litter)		395.6	200.0	297.8
	Chlorine(mg/litter)	833.5	922.0	655.6	803.7
	Total hardness(mg/litter)	926.4	1,047.0	890.3	954.6
	Sulphate(mg/litter)			909.3	909.3
	Calcium(mg/litter)			145.5	145.5
	Magnesium(mg/litter)			128.0	128.0
	Total dissolved solid(mg/litter)			2,625.1	2,625.1
Carlos A. Madrazo	pH	7.4		7.4	7.4
	Water temp.			27.5	27.5
	EC(µsiems/cm)	1,318		1,274	1,296
	Turbidity(UTN)	3.0		1.5	2.3
	Total alkalinity(mg/litter)			260.0	260.0
	Chlorine(mg/litter)	51.0		57.0	54.0
	Total hardness(mg/litter)	880.0		437.5	658.8
	Sulphate(mg/litter)			194.3	194.3
	Calcium(mg/litter)			55.0	55.0
	Magnesium(mg/litter)			72.9	72.9
	Total dissolved solid(mg/litter)			744.7	744.7
Chacchoben	pH	7.5		7.2	7.3
	Water temp.			23.9	23.9
	EC(µsiems/cm)	4,010		760	2,385
	Turbidity(UTN)	3.0		5.0	4.0
	Total alkalinity(mg/litter)			90.0	90.0
	Chlorine(mg/litter)	788.4		52.3	420.3
	Total hardness(mg/litter)	668.8		137.5	403.2
	Sulphate(mg/litter)			61.3	61.3
	Calcium(mg/litter)			30.0	30.0
	Magnesium(mg/litter)			15.2	15.2
	Total dissolved solid(mg/litter)			310.0	310.0

C.1.2 Groundwater Management

C.1.2.1 Hydrogeologic Conditions

Geology of Municipality of Othon P. Blanco is composed of Eocene carbonate rocks in the western part and Miocene to Pliocene carbonate rocks in the eastern part. The area is partly covered by Quaternary sediments. Groundwater exists in these carbonate rock aquifers. According to the existing geophysical survey data, thickness of fresh water lens in the coastal area of Chetumal, is estimated to be less than 20m. The seawater intruded in most of the coastal area at 20 to 30m depths. Natural groundwater level is 5 to 10m in the coastal area while in the eastern inland area, it ranges from 20 to 40 m.

C.1.2.2 Extraction and Injection Wells

a. Extraction

According to CNA, number of the registered wells is 1,014, which is largest in the three municipalities (Refer to Table 2.1, Chapter 2.2.1.5). Extraction wells for agricultural purpose make up 65% (658 wells) of the total number. The wells for public water supply are ranked to the second, which makes up 14.5% (147 wells). The public wells are for urban and rural water supply by CAPA.

CAPA Othon P. Blanco currently has 17 production wells, which are being operated. These wells are located in Gonzalez Ortega Ⅰ, Ortega Ⅱ and Xulha. Ortega well fields are located in the western part of Chetumal town. The distance to the coast is approximately 40 km. This two well fields extract groundwater from Eocene aquifers and depths of the well is 70 to 80 m in average. Deepest well is 100 m. The maximum capacity of the wells is 316.7 LPS in Ortega Ⅰ and 339.8 LPS in Ortega Ⅱ, respectively. On the other hand, Xulha well field is located in the area some 20 km from the town and has four (4) operative wells and one (1) not operative. This well field has 10 wells in other times, however, five (5) wells were already abandoned. The maximum capacity of Xulha well field is 173.9 LPS.

Table C-5 shows the well depth, diameter, static water levels and dynamic water levels.

The draw down of the well is approximately 4 to 6 meters except one well (No.13).

Table C-5: Parameters of Wells of CAPA in Othon P. Blanco

Well No.	Depth (m)	Diameter (inch)	SWL	DWL
GONZALEZ ORTEGA Ⅰ				
1	80	12	-	-
2	70	12	28.00	33.52
3	70	12	30.00	35.58
4	70	12	32.30	37.48
5	70	12	26.00	32.00
6	60	12	25.00	28.84
7	80	12	30.80	37.51
GONZALEZ ORTEGA Ⅱ				
8	70	12	29.65	35.11
9	80	12	29.26	34.00
10	80	12	30.83	32.00
11	80	12	31.40	40.00
12	100	12	32.00	40.00
13	70	12	34.00	48.00
XUL HA				
4	80	12	41.70	
7	82	12	41.15	44.00
8	80	12	38.10	43.00
9	80	12	40.00	45.00
10	80	12	42.00	45.00

SWL: Static Water Level DWL: Dynamic Water Level
Source: CAPA Othon P. Blanco

b. Injection well

There are registered 91 injection wells in Othon P.Blanco, of which 82 wells are for service sector. CAPA has two injection wells in its sewage treatment plant, which were constructed 4 years ago, however, they are not being operated because of high artesian pressure of the wells. The depth and screen position is unknown (Figure C-5).

Figure C-5: Injection Well of CAPA in Othon P. Blanco

C.1.2.3 Present Status of Monitoring

There are no CNA monitoring wells in the municipality of Othon P. Blanco. However, CAPA regularly conducts monitoring of water quality. Parameters monitored are, $CaCO_3$, chloride, alkalinity, acid degree, pH, colour, electric conductivity, temperature, turbidity and TDS. According to the data of May 13th, 2003, electric conductivity of the production wells ranges from 835 to 1,724 (micro S/cm) and chloride contents of 70 to 100 mg/litter at a temperature of 27° C. Coliform is also checked at a regular interval.

C.1.3 Wastewater Management

C.1.3.1 Overview of Wastewater Management

a. Present Situation

Only Chetumal is covered by sewer system in urban areas of Othón P. Blanco. Rural areas are hardly covered by the system, although Mahahual is exceptionally provided with the system along with adjoining large scale tourism development. Table C-6 shows outline of the sewer system in Othon P. Blanco.

Table C-6: Outline of Sewer System in Othón P. Blanco

Item		State of Quintana Roo	Othón P. Blanco
1. Basic item			
Area of administrative boundary (km2)		50,843	18,760
Population of administrative boundary		1,233,490	240,971
Service projected area (km2)		76.02	6.35
Water production amount (1,000 m3/year)		112,737.78	27,659.7
Effective (billing) water supply amount (1,000 m3/year)		45,700.42	7,200.32
Water supply population		1,171,816	234,000
Unit water production amount (l/day/person)		263.58	323.8
Effective Unit water supply amount (l/day/person)		106.84	84.3
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	38,851
	Actual	370,955	37,044
On-site system	Plan	-	589(year2002)
	Actual	-	0
Latrine system	Plan	0	0
	Actual	Not available	Not available
No-system	Plan	-	167,338
	Actual	800,861	169,045
3. Off site sewer system			
Responsible authority		C.A.P.A.	
Construction		C.A.PA.	
O & M		ORG. OPER.	
Service area (km2)		62.38	5.81
Service population		370,955	37,044
Number of connections		90,698	8,799
Service coverage rate (population)		30.07	39.23
Length of pipe line		1'088,376	444,528
Number of pump station		-	12
STP intake amount (lps)		1,251.83	20.48
Sewage production per capita		291.6	47.8
Sewage treatment plant (STP)			
Number of STP		16	1
Treatment method		Activated sludge	
Treatment Capacity		1,432	137
Annual average intake amount			
Intake waste quality (Jan. to June/2003)		BOD: COD: S S:	139 393 265
Treated water quality (Jan. to June/2003)		BOD: COD: S S:	1.9 39.9 2.0

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

Table C-7 shows 40% of sewer service coverage in Chetumal based on sewage treatment capacity. However, there are still many houses that do not have connection with sewer pipe. It is estimated that actual sewer service coverage would be much lower than 40 %.

Table C-7: Service Coverage of Sewer System in 2000

Municipality	City	Population	Service coverage		
			Water supply	Sewer line	Sewage treatment capacity
OTHON P. BLANCO	CHETUMAL	118,553	96%	50%	40%
	BACALAR	9,047	88%	0%	0%
	CALDERITAS	4,617	92%	0%	0%
	INGENIO ALVARO OBREGON	3,331	97%	0%	0%
	NICOLAS BRAVO	3,524	92%	0%	0%
	ALVARO OBREGON	3,019	91%	0%	0%
	SERGIO BUTRON CASAS	2,712	98%	0%	0%
	Total	144,803	95%	41%	33%
State total		720,567	95%	57%	73%

Source: CAPA Plan Estratégico APAS 2001-2025

b. Plan

CAPA prepared a strategic plan[1] of wastewater management for the whole Quintana Roo State in 2001. Table C-8 and Table C-9 show implementation and investment plans for Othon P. Blanco respectively from the strategic plan.

Table C-8: Phased Implementation Plan in Urban Area of Othón P. Blanco

Item	2001 to 2005	2006 to 2010	2011 to 2025	Total
Water supply amount (litter/sec)	221	208	618	1,047
Sewer system (ha)	1,103	579	1,736	3,418
Sewage treatment amount (litter/sec)	519	128	384	1,031
Acc. sewage treatment amount (litter/sec)	519	647	1,031	-

Table C-9: Investment Plan for Othón P. Blanco Urban Area (Million pesos)

Item	2001 to 2005	2006 to 2010	2011 to 2025	Total
Water supply	122.4	87.5	261.6	471.5
Sewer line	468.0	93.0	278.0	839.0
Sewage treatment	82.0	26.0	77.0	185.0
Land acquisition	11.0	10.0	31.0	52.0
Total	683.4	216.5	647.6	1,547.5

C.1.3.2 Outline of Sewer System

a. Sewer Line

Othon P. Blanco that is the capital of Quintana Roo State is covered by sewer system. However, it has a problem that number of houses having connection to sewer pipe is small.

It is estimated that about 6,400 residents are covered with the sewer system based on the present treated amount of sewage or 20.48 liter/sec, assuming that water supply unit is 367.52

liter/person/day and 75% of conversion rate from water supply to sewage; this leads to 275.61 liter/person/day of sewage amount; then about 6,400 persons is obtained dividing 20.48 liter/sec by 275.61 liter/day.

The system targets 38,851 residents. However, estimated number of residents covered with the system is only about 6,400. This gives 16.5% of actual service coverage, and the coverage is judged as quite low. A major reason why the coverage is quite low is that many houses are unwilling to connect to the sewer system due to widespread use of septic tanks and financial burden for the connection (2,000 to 5,000 pesos/house). Outflow from the septic tanks percolates into underground, then, cause underground water contamination.

The sewage treatment plant is located in the northern part of the urbanized area of Chetumal. And, 12 relay pumps are distributed over the area due to its flatness.

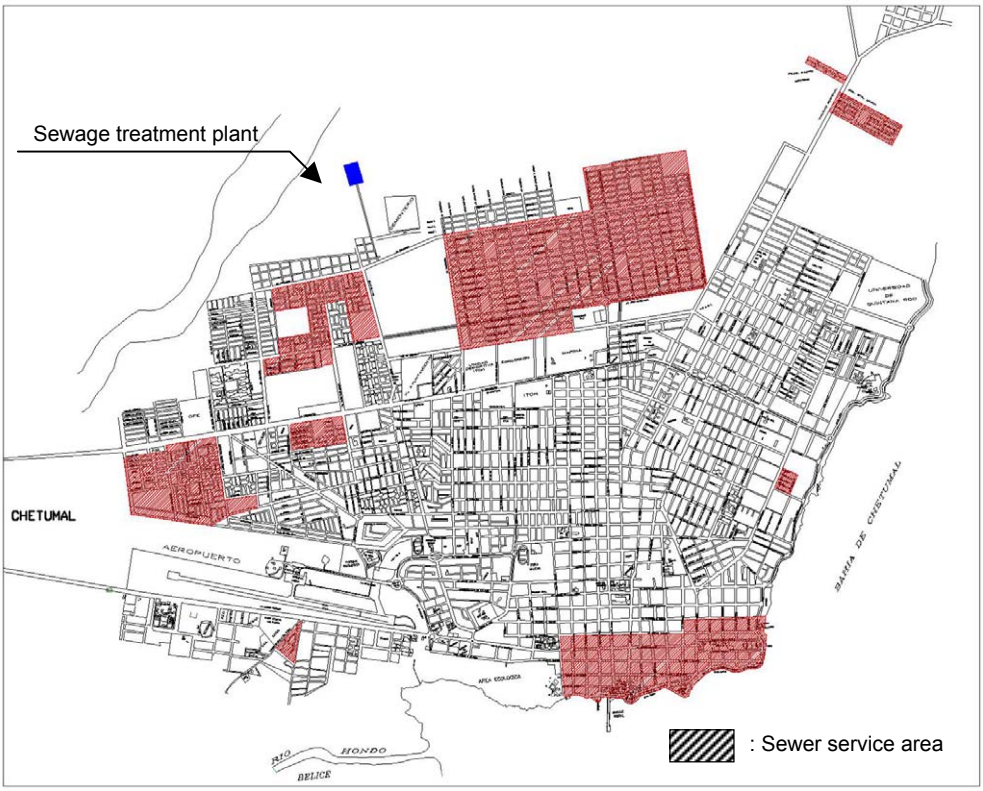

Figure C-6: Sewer Service Area

b. Sewage Treatment

The sewage treatment plant in Chetumal, which was constructed in 1998, has a capacity of 137 liter/sec (11,873m^3/day) at present, although it will have a total capacity of 360 liter/sec (31,104 m^3/day) in the future. However, actual inflow rate is 20.48 liter/sec (1,769m^3/day)

[1] PLAN ESTRATÉGICO DE LOS SERVICIOS AGUA POTABLE, ALCANTRILLADO Y

due to low connection rate to sewer pipe. It is drastically lower than the planned inflow rate. Table C-10 shows outline of the sewage treatment plant in Chetumal.

Table C-10: Outline of Chetumal Sewage Treatment Plant

Item	Parameter
Treatment capacity	137 liter/sec (11,837 m^3/day)
Actual treatment amount	20.48 liter/sec (1,770m^3/day)
Intake water quality	BOD 139mg/liter, COD: 393mg/liter, SS:265 mg/liter
Treated water quality	BOD 1.9mg/liter, COD: 40mg/liter, SS: 2 mg/liter
Treatment method	Activated sludge method

Source: CAPA

Outflow from the plant shows good water quality at present due to the small amount of actual inflow against the designed capacity. However, sewage is discharged without treatment in order to cope with temporal excessive inflow due to time jitter, rainfalls, etc. Although there are two aeration tanks, only one is used for ordinal sewage treatment and another is used as a digester of excess sludge. Figure C-7 shows flow sheet of the plant.

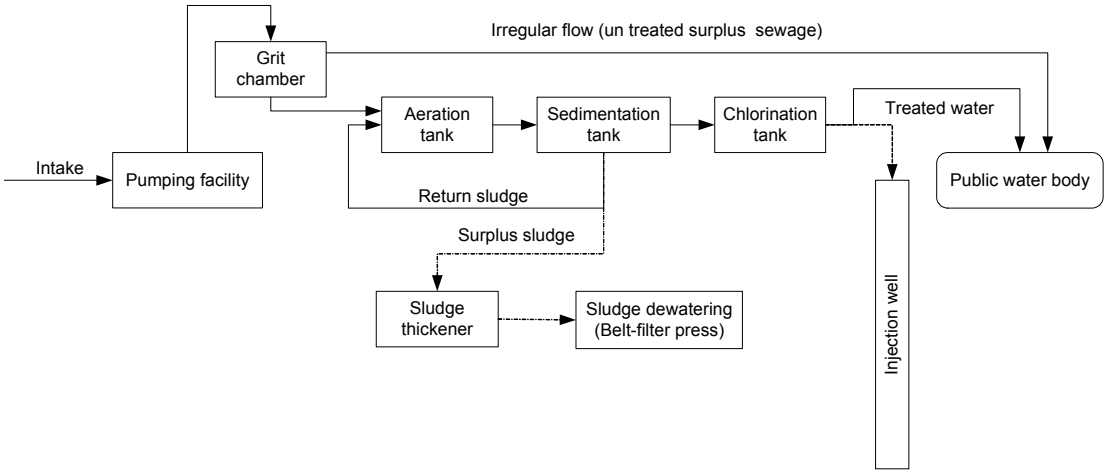

Figure C-7: Flow Sheet of Chetumal Sewerage Treatment Plant

Two injection wells were constructed for discharging treated water to underground at 100m depth. The injection was operated for one year between 1998 and 1999. However, the injection was judged impossible because of difficulty of maintaining injection pressure, etc. Then, the treated water is discharged to an adjoining lagoon. The untreated sewage mentioned above is also discharged to the same point.

SANEAMIENTO 2001-2035, CAPA

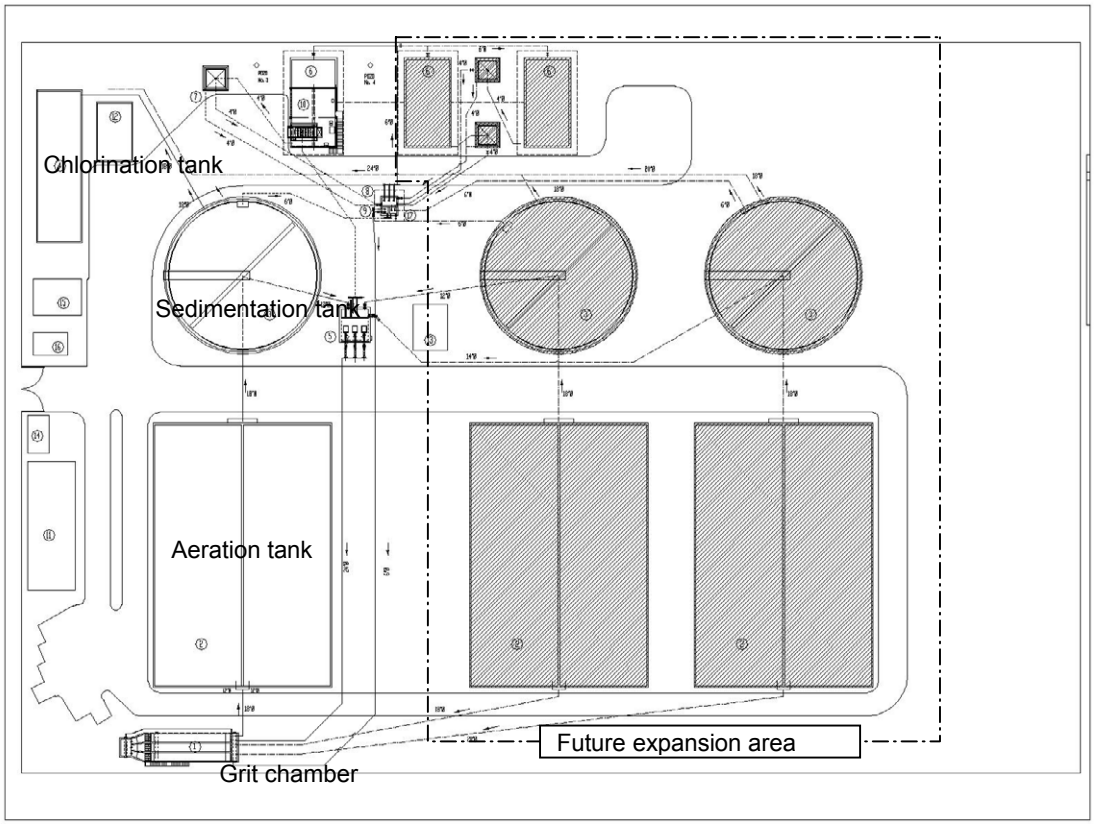

Figure C-8: Layout of Chetumal Sewerage Treatment Plant

C.1.3.3 On-site System

Principal type of on-site system is septic tank. Even in areas where the sewage system is provided, many residents still use the septic tank.

At present, CAPA is constructing a collective on-site system at 4 communities having less than 2,500 residents in the state. In Othon P. Blanco, Subyeninte Lópezs located southwest to Chetumal is one of the 4 communities. Table C-11 shows outline of the collective on-site system. The system applies an-aerobic digestion + filtration treatment method.

Table C-11: 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	Subteniente López	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.

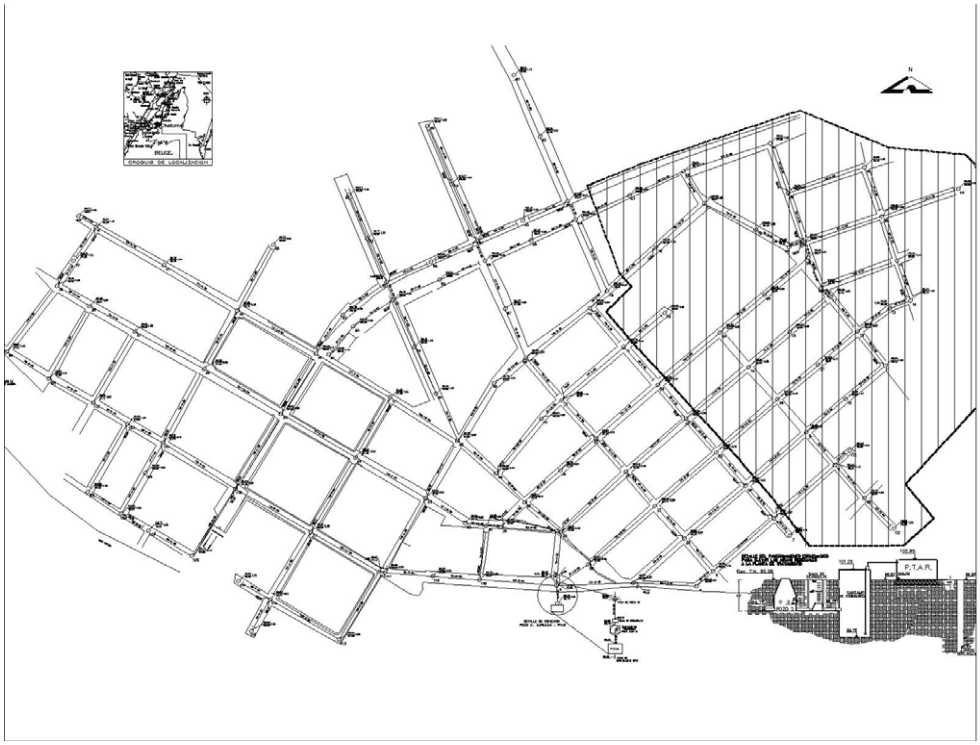

Figure C-9: Sewer Network System in Subteniente López

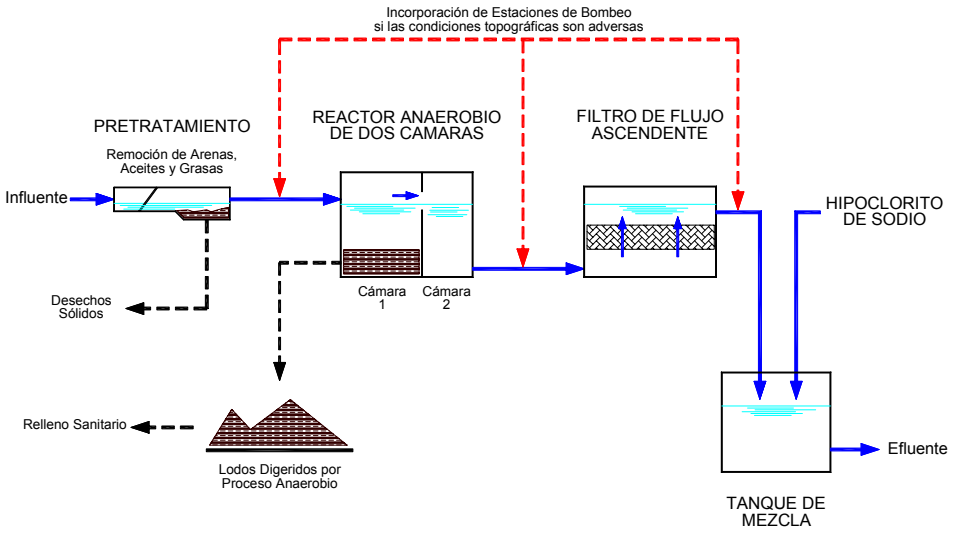

Figure C-10: Flow Sheet of On-site Collective Treatment System

C.1.3.4 Sewerage and Pollutant Sources

Table C-12 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-12: 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-13. Checking figures of Othon P. Blanco, working population in Industry/Manufacturing is small like other municipalities. Consequently, residents and tourists are considered as principal pollutant sources.

Table C-13: 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-14 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[2].

Table C-14: 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

2

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 645,942m^3/year[3] in 2002. Supposing that BOD concentration of inflow is 139 mg/liter and one of outflow is 1.9 mg/liter, this leads 88.6 ton/year of BOD removal amount by wastewater treatment. This BOD removal amount makes up only 1% of the total BOD generation amount. The rest, 99% of the generation amount, is discharged to the environment without treatment.

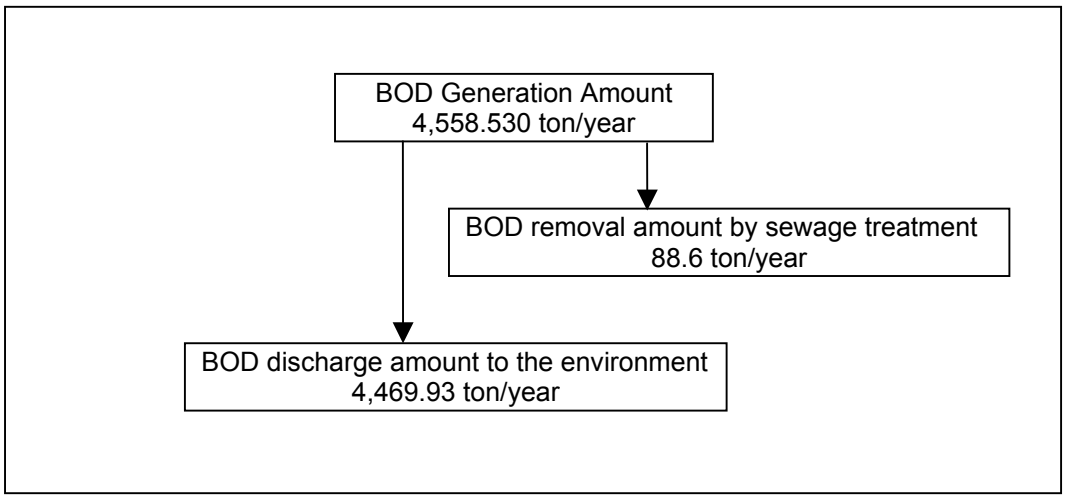

Figure C-11: BOD Balance in Othón P. Blanco Municipality

[3] CAPA

C.1.3.5 Organizational Structure

a. Organizational Improvement

Potable Water and Sewer Commission (CAPA) of Quintana Roo State hired the service of the Mexican firm Alta Dirección Ingenieros y Consultores, SA. de C.V., with the purpose of carrying out a "Technical Assistance on Preparation of Manuals of Organization and of Procedure and Quality", which was completed on September 2002.

Within the activities of the contract, an Organizational Diagnostics was conducted, encompassing aspects concerned with the structure of the organization, commercial, administrative and operation processes which are being used, human resources, material resources, financial resources, and the analysis under the model of better national and international practices in public service (MPNISP).

Some aspects of the recommendations made by this technical assistance have been implemented by CAPA in recent months. Initial results are promising due to the interest and decision of the top management and the cooperation of CAPA´s officers.

b. Organizational Structure of CAPA

CAPA is directed by its Administration Council (see organization chart of CAPA) headed by the Governor of the State, and composed of the Mayors of six Municipalities (Othon P. Blanco, Cozumel, Felipe Carrillo Puerto, José María Morelos, Lázaro Cárdenas and Solidaridad), the Secretary of Urban Development and the Environment as the Secretary, and the Director General of CAPA as the Technical Secretary. The Council sets the policies and strategies of CAPA, approves the budget and tariffs, appointments, contracts through a bidding process, and other important matters.

CAPA main offices in Chetumal serve as headquarters for the top management, support and advisory structure for the whole State. CAPA manages and operates the water supply and sewer and wastewater treatment services in six Municipalities through the Operating Organisms (*Organismos Operativos*), while its North Zone Office (*Delegación Zona Norte*) verifies and controls the concession services in Cancún and Isla Mujeres.

CAPA has seven operating systems: *Othon P. Blanco,* which includes the *Chetumal System,* is in charge of the city of Chetumal and the rural area of the municipality, *Felipe Carrillo Puerto* (city and rural area), *Solidaridad* (cities of Playa del Carmen and Tulúm including the rural area of the municipality), which are included in this Study, in addition to the systems of *Cozumel, José M. Morelos and Lázaro Cárdenas.*

All these systems have the same organizational structure (see organization chart of Othon P. Blanco Operating System) and vary according to the localities they serve.

c. Othon P. Blanco System

The Othon P. Blanco System manages the subsystems of: Chetumal, Río Hondo, Nicolás Bravo, Dos Aguadas, Bacalar and Mahahual.

The structure at the General Management level has three administrative units: Computer Science, Productivity and Quality and Social Communication.

Three assistant management offices:

Assistant Management for Production with three departments: Operation, Loss Recovery and New Connections and New Discharges.

The Operation Department is structured with administrative units having the following functions: Catchment, Conduction, Storage, Collection (wastewater), Treatment (wastewater), and support: Electromechanics and Water Quality.

The Department of Loss Recovery is structured with three functional administrative units.

The Department of Household Connection and Discharge takes care of requests for new connections through two administrative units.

Assistant Management for Commercialization with three department with the functions to manage: Client´s database, Billing and Metering, Control of Overdue Payments and Attention to Clients.

Each department undertakes a control of clients for each of the subsystems.

Assistant Management for Administration and Finance with three departments: Human Resources, Material Resources and Financial Resources.

The Human Resources Department is structured with the functional administrative units of: Payroll, and Training.

The Department of Material Resources with the functional units of: Purchase, Warehouses, and General Services which in turn has the functions of Intendance, Surveillance and Gardening.

C.1.3.6 Financial System

CAPA provides water supply and sewer services in Othon P. Blanco Municipality through the Chetumal system for water supply and sewer services in the city of Chetumal, and the

rural water supply system. The numbers of water supply connections in 2001 were 34,395 in the Chetumal system and 12,874 for the rural water supply system, for a total of 47,269 connections or 54% of the State total. Service coverage was estimated at 95% water supply and 25% sewer service by the Chetumal system, and 88% water supply and 0% sewer service by the rural water supply system.

Households comprised the overwhelming majority of customers with almost 45,000 connections or 95%, followed by 3% of commercial firms, 1.6% of General Services, 0.06% of industrial firms, and 0.08% of hotels. 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.

The water rates being applied by CAPA in June 2003 are shown in the following table.

Table C-15: CAPA Water Rates in June 2003

DOMESTIC WATER RATE			
Consumption Range (m3/month)		Base Rate	Excess Consumption
Lower Bound	Upper Bound	(Pesos/month)	(Pesos/m3)
0	10	35.40	0.00
11	20	38.93	3.54
21	40	88.62	5.27
41	60	193.61	10.56
61	999,999	400.90	26.42
Note: Indexed to the State minimum salary and updated every time the minimum salary changes			
COMMERCIAL WATER RATE			
Consumption Range (m3/month)		Base Rate	Excess Consumption
Lower Bound	Upper Bound	(Pesos/month)	(Pesos/m3)
0	10	36.03	0.00
11	20	59.52	10.80
21	50	159.44	15.49
51	100	632.11	19.58
101	200	1,595.04	28.40
201	999,999	4,430.95	44.44
Note: Indexed to the National Consumer Price Index (NCPI) and updated every time the NCPI changes			
INDUSTRIAL WATER RATE			
Consumption Range (m3/month)		Base Rate	Excess Consumption
Lower Bound	Upper Bound	(Pesos/month)	(Pesos/m3)
0	10	21.62	0.00
11	50	59.75	5.30
51	100	271.47	10.93
101	200	992.91	17.68
201	500	2,761.24	23.09
501	1,000	9,669.72	53.15
1,001	999,999	35,695.55	55.86
Note: Indexed to the National Consumer Price Index (NCPI) and updated every time the NCPI changes			
HOTEL WATER RATE			
Consumption Range (m3/month)		Base Rate	Excess Consumption
Lower Bound	Upper Bound	(Pesos/month)	(Pesos/m3)
0	100	93.59	9.32

101	750	999.10	10.72
751	1,500	7,959.57	16.11
1,501	5,000	24,236.22	21.73
5,001	20,000	100,319.58	26.69
20,001	999,999	500,576.88	29.44
Note: Indexed to the National Consumer Price Index (NCPI) and updated every time the NCPI changes			
WATER RATE FOR GENERAL SERVICES TO THE COMMUNITY			
Consumption Range (m3/month)		Base Rate	Excess Consumption
Lower Bound	Upper Bound	(Pesos/month)	(Pesos/m3)
0	20	75.65	0.00
21	50	79.17	4.04
51	100	201.74	4.43
101	150	419.56	4.72
151	250	661.20	5.14
251	350	1,174.51	5.54
351	500	2,428.66	5.95
501	750	2,631.01	6.43
751	1,000	4,250.97	6.97
1,001	1,500	5,998.57	7.53
1,501	999,999	9,771.07	7.98
Note: Indexed to the National Consumer Price Index (NCPI) and updated every time the NCPI changes			

Source: CAPA

CAPA has the authority to set the water rates as its own decision. Waste water charges are added as 20% over the water consumption. In the case of Othon P. Blanco Municipality, income from water supply between 2000 and 2002 accounted for 80% or more of total income, while income from waste water service comprised only around 3%. 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 27.519 Million cubic meters, and the budgeted expenditures were 59.70 Million Pesos, giving an average cost of 2.17 Pesos per cubic meter of water produced in Othon P. Blanco Municipality. Coverage of waste water services is estimated at 25% in Chetumal, and only 1% of waste water is estimated to be subject to some kind of treatment.

C.1.3.7 Accounting System

CAPA is a decentralized public institution of mixed nature, 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-16: Balance of Chetumal-Othon P. Blanco System (Million Pesos)

INCOME & EXEPEND.	Year 2000		Year 2001		Year 2002	
	Budget	Actual	Budget	Actual	Budget	Actual
INCOME						
Water supply	14.32	14.36	16.81	16.19	18.52	21.77
On-time	7.63	8.21	10.30	9.33	11.18	13.36
Late	6.69	6.15	6.51	6.86	7.34	8.41
Sewer system	0.46	0.50	0.59	0.66	0.72	0.80
On-time	0.28	0.31	0.37	0.39	0.49	0.53
Late	0.18	0.19	0.22	0.27	0.23	0.27
Connection fee	0.70	0.65	0.69	0.47	0.49	0.74
Re-connection fee	0.87	0.14	0.03	0.14	0.07	0.06
LPS (liter per second)	1.51	2.95	1.54	0.21	0.27	2.67
Updating	0.32	0.00	0.00	0.00	0.00	0.00
Surcharges	0.00	0.09	0.00	0.40	0.00	0.00
Fines	0.00	0.00	0.00	0.00	0.00	0.00
Implementation	0.00	0.00	0.00	0.00	0.00	0.00
Other Incomes	0.70	0.71	0.87	0.67	0.84	1.80
Value added tax	0.00	0.66	0.00	0.48	0.00	0.86
Total Income	18.88	20.06	20.53	19.22	20.91	28.70
EXPENDITURES						
Personnel	16.55		22.81		26.69	
Materials & supplies	11.60		6.55		8.52	
General Services	15.09		20.21		21.34	
Aid, subsidy & transfer	0.01		0.01		0.19	
Goods (furniture, equip.)	0.29		0.37		0.15	
Public works	3.85		7.13		1.97	
Contingent expenses	0.00		0.00		1.45	
Public debt	1.19		2.61		1.39	
Total Expenditures	48.58		59.70		61.70	
BALANCE	-29.70		-39.17		-40.79	

Source: CAPA

The above table indicates that the balance of income and expenditures was negative in Othon P. Blanco water supply systems between the years 2000 and 2002. Actual income covered 41% of budgeted expenses in the year 2000, 32% in 2001, and 46.5% in 2002.

C.1.3.8 Social Aspect

The social aspects that may be affected with the management of wastewater in the city of Chetumal are the following.

Social Aspect	Consideration
Coverage of wastewater service	In the city of Chetumal it is 25%. In the rest of the municipality it is 0%
% of houses with infiltration ditch/cesspool (fosas sépticas)	At the municipal level it is 63% of the 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)
Quality of drinking water	Not recommended for drinking. The people use bottled water.
Aquatic areas for recreation	Chetumal Bay receives an aquifer contaminated by the discharge of infiltration ditches/cesspools (fosas sépticas), effluent from the wastewater treatment plant of the city of Chetumal and the discharge of the rainwater drainage system which carries wastewater. Some coastal areas are already banned for swimming due to high contamination.
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, despite the main economic activities being related with commerce and government service. Expenditures on medical care and bottled water go up.

C.1.3.9 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 audio- visual was projected with regard to harmful effects generated by the solid waste. Regarding the wastewater management issues are shown in a very general way the types of pollutants in the aquatic ecosystems. 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).