社会開発調査部報告書

JAPAN INTERNATIONAL COOPERATION AGENCY
NATIONAL WATER COMMISSION

THE STUDY ON DEVELOPMENT OF THE NATIONAL WATER QUALITY MONITORING PROGRAM IN COASTAL AREAS IN THE UNITED MEXICAN STATES

FINAL REPORT
(SUMMARY)

March 2000

PACIFIC CONSULTANTS INTERNATIONAL
METOCEAN

The exchange rate applied in this report is

US$ 1.00 = Mexican Peso (N$) = 9.25 = Yen 105.00
(as of the end of November 1999)

PREFACE

In response to a request from the Government of the United Mexican State, the Government of Japan decided to conduct a study on "Development of the National Water Quality Monitoring Program in Coastal Areas" and entrusted the study to the Japan International Cooperation Agency (JICA).

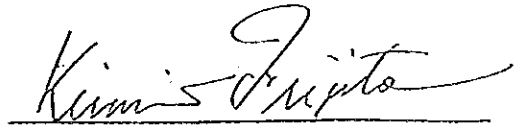
JICA selected and dispatched a study team headed by Dr. Akira UCHIDA of Pacific Consultants International (PCI) and composed of PCI and Shin-Nippon Meteorological and Oceanographical Consultant Co:, Ltd. (METOCEAN) to Mexico 4 times between January 1999 and February 2000. In addition, JICA set up an advisory committee headed by Prof. Takashi HAYASE, Nagasaki University, between January 1999 and March 2000, which examined the study from specialist and technical points of view.

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

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Mexico for their close cooperation extended to the Team.

20 March 2000



Kimio FUJITA
President
Japan International Cooperation Agency

March 2000

Mr.Kimio FUJITA
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit to you the final report entitled "The study on Development of the National Water Quality Monitoring Program in Coastal Areas in the United Mexican States." This report has been prepared by the Study Team in accordance with the contracts signed on January 8,1999 and June 4,1999 between the Japan International Cooperation Agency (JICA) and The Study Team, jointly organized by Pacific Consultants International (PCI) and Shin-Nippon Meteorological and Oceanographical Consultant Co., Ltd. (METOCEAN).

The report describes the study results of developing guidelines for the national water quality monitoring program for coastal areas in Mexico and developing a specific coastal water quality monitoring plan for the Tampico area.

The report consists of the Main Report and Summary Report, both in English and Spanish, Supporting Report and Data Book in English,and Technology Transfer Report in Spanish.

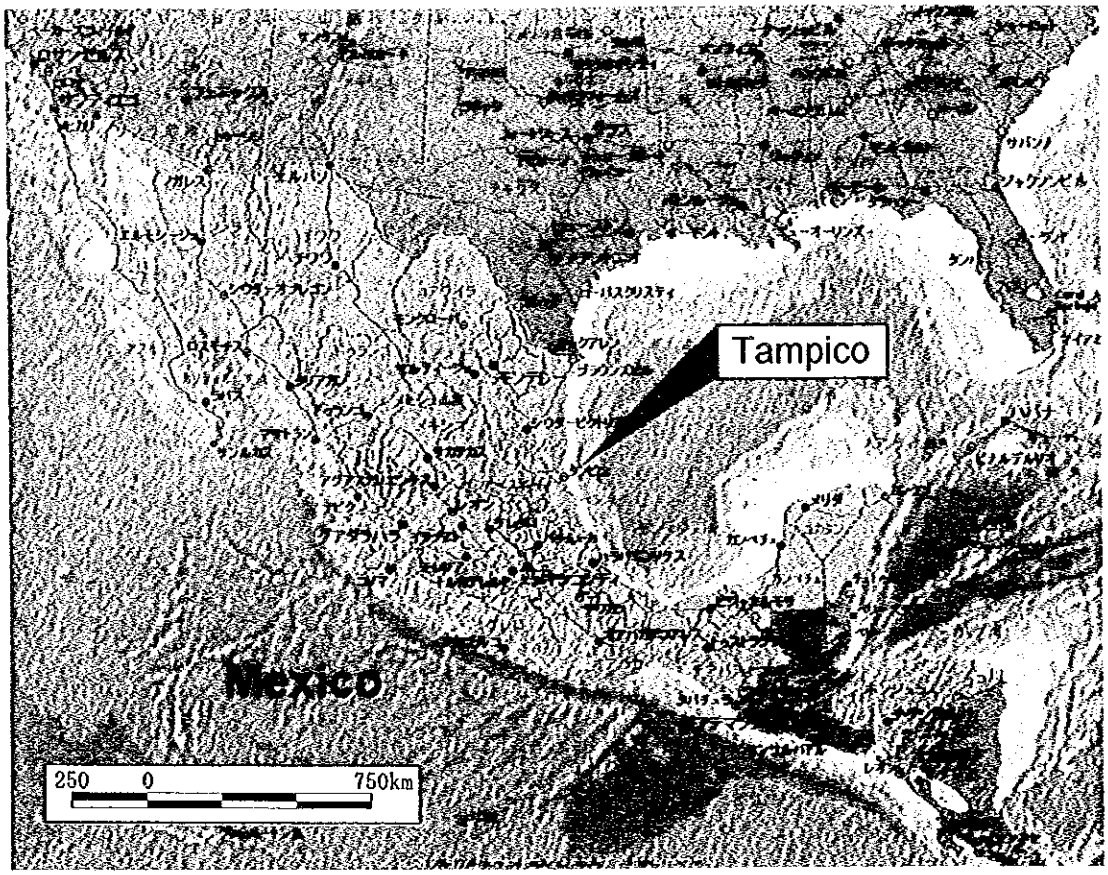
The Main Report presents: i) existing states of coastal environment and water quality monitoring, ii) planning policy for the coastal water quality monitoring, iii) the guidelines for the national coastal water quality monitoring, iv) the coastal water quality monitoring plan for the Tampico area, and v) project implementation schedule. The summary Report presents these results concisely. The Supporting Report describes technical details concerning the methods of coastal water quality monitoring including field surveys, analysis of sea water quality, laboratory management, and data analysis. The Data Book contains detailed information which supports reasoning of developing the monitoring guidelines and the monitoring plan. The Technology Transfer Report describes the various on-the-job and off-the-job training activities carried out in the course of the Study, and their evaluations.

We wish to express grateful acknowledgements to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Environment Agency, Tokyo Metropolitan Government, and Embassy of Japan in Mexico. We also wish to express sincere appreciation to our counterpart, the National Water Commission (CNA) of Mexico. We hope that the proposed plan and guidelines will contribute to the realization of sustainable development of coastal areas in Mexico.

Yours faithfully,

内田顕

Dr. Akira UCHIDA
Team Leader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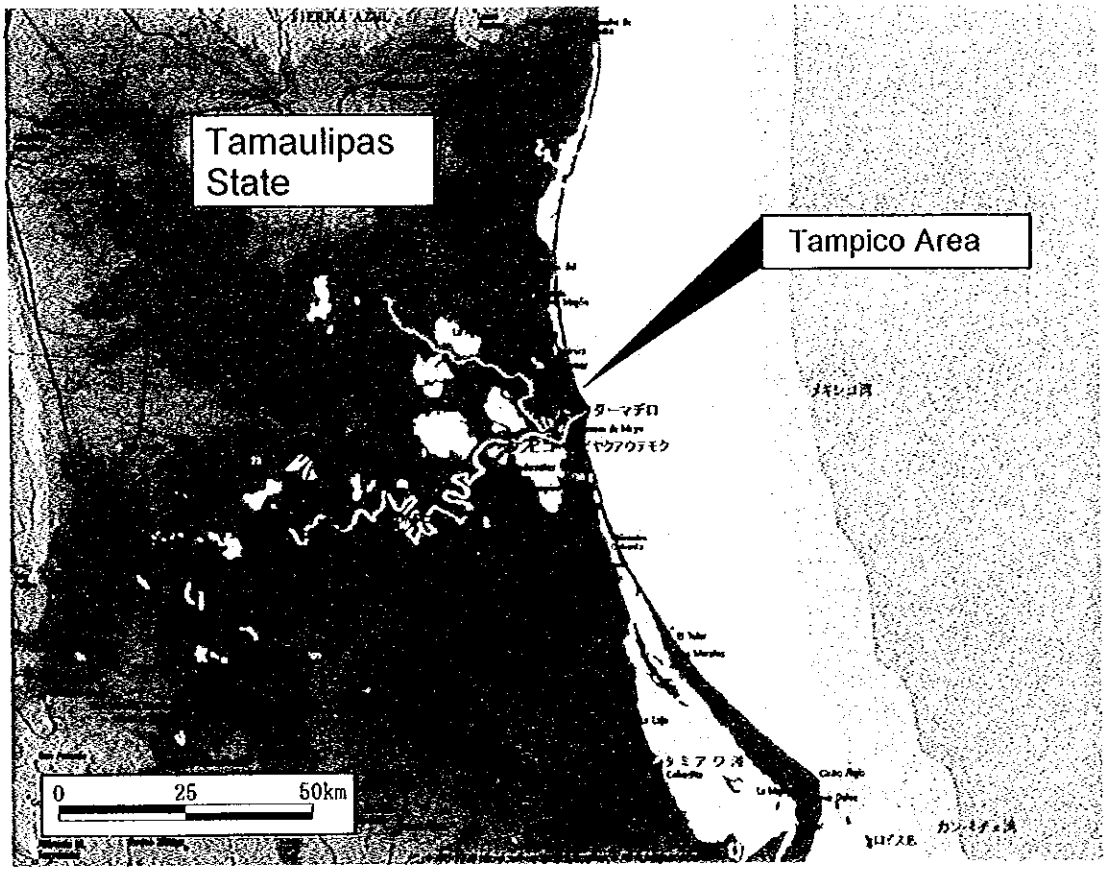
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Tampico Area
0 25 50km

Study Area


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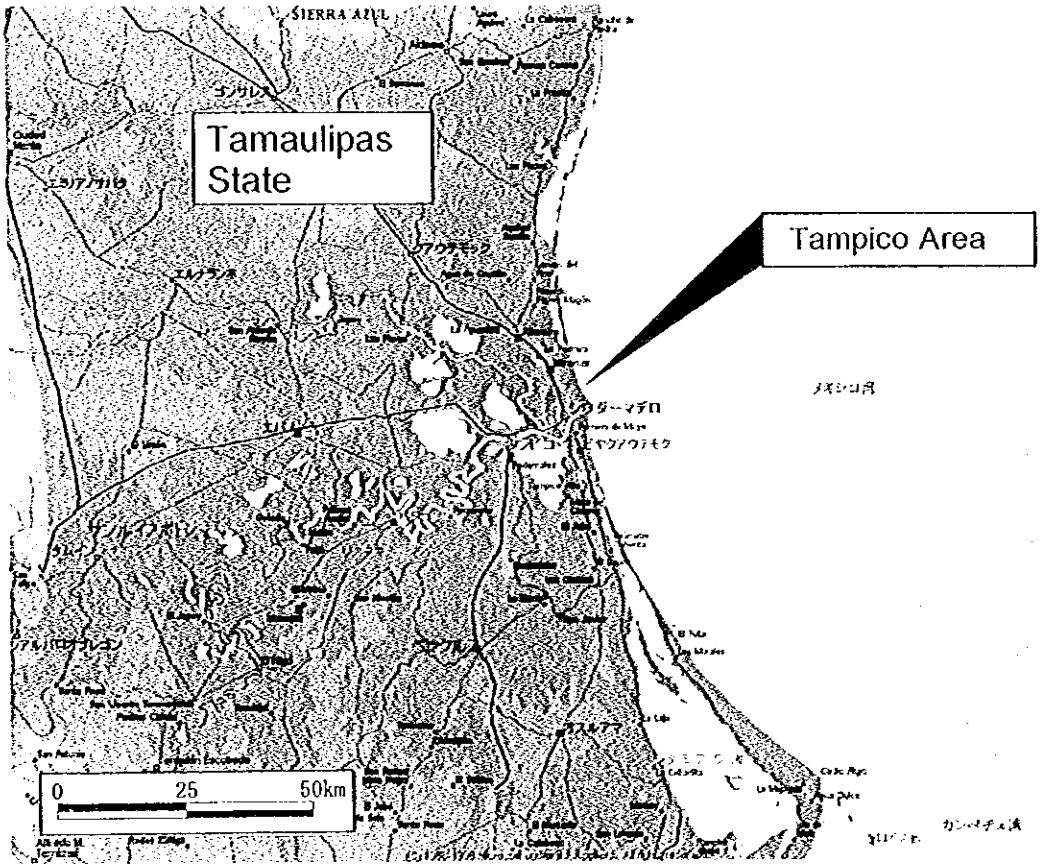
Mexico
250 0 750km


Tamaulipas State
Tampico Area
0 25 50km

Study Area

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List of Terminology/Acronyms

BOD	biochemical oxygen demand
CNA	*Comision Nacional del Agua* (National Water Comission)
COD	chemical oxygen demand
DO	dissolved oxygen
JICA	Japan International Cooperation Agency
NOM	*Norma Oficial Mexicana* (Official Mexican Standard)
ORP	oxidation reduction pond
PROMMA	*Proyecto de Modernizacion del Manejo del Agua* (Modernization of Water Management Project)
SEMARNAP	*Secretaria de Medio Ambiente, Recursos Naturales y Pesca* (Ministry of Environment, Natural Resources and Fisheries)
SS	suspended solids
T-N	total nitrogen
T-P	total phosphate
T-Hg	total mercury
TSS	total suspended solids

Outline of the Study

1. Background of the Study

Mexico has the shoreline of 10,000 km or more with lagoons in about 100 locations (12,500 km2) along the coast. These lagoons are now natural resources important for fishery and tourism. Coastal areas are positioned as important areas for future development in the national development plan. However, coastal water quality has deteriorated under effects of industrial and municipal wastewater discharges.

Under such circumstance, the National Water Commission (*CNA*), Mexico planned a coastal water quality monitoring program under the World Bank loan, proceeding with its development. However, the scope of this program is limited to fresh water bodies, such as rivers, lakes, and groundwater. With this background, it is urgent for Mexico to plan and implement the coastal water quality monitoring.

2. Objectives of the Study

The objectives of the study is to develop the coastal water quality monitoring system that is indispensable for protection of coastal water bodies and for sustainable utilization of natural resources of Mexico. The objectives are:

- To develop a water quality monitoring program for the specific coastal water bodies in the Tampico area, State of Tamaulipas, and to prepare guidelines for the national water quality monitoring program for coastal areas in Mexico; and
- To effect technology transfer to Mexican counterpart personnel in the course of the Study

3. Existing Water Quality Monitoring System

(1) Organization for Water Quality Monitoring

CNA is responsible for efficient use of water and its conservation. Therefore, CNA's duties include water quality monitoring of rivers, lakes, coastal water bodies, and groundwater. For this purpose, CNA has one Central Laboratory in Mexico City and 13 Regional Laboratories, and 20 State Laboratories.

(2) Ongoing Plan for Water Quality Monitoring

CNA has been conducting a project called "Water Management Modernization Project" (abbreviated in Spanish as PROMMA). Started in 1996 under the financial support of the World Bank, PROMMA is an institutional program aimed at strengthening the technical bases required for the sustainable development and management of water resources in the country. The objectives of the program include the following:

- strengthening of human resources,
- modernization of infrastructure for monitoring and data management,
- integration of hydraulic resource management, and
- decentralization of administration, distribution and control of water use.

PROMMA is aimed at water quality monitoring of rivers, lakes, coastal water bodies, and groundwater, however there is no specific plan for coastal water bodies.

(3) Tampico Laboratory

Tampico Laboratory, which is the main target of technology transfer of the study team, is located in the residential area of Madero City. The building constructed as a residence in 1979 was renovated by *CNA* as a laboratory in 1992.

Although most of analyses have been conducted for fresh water samples, some samples of industrial wastewater were analyzed in 1998. No sea water samples were analyzed prior to the Study. Most of the laboratory equipment were bought 15 to 20 years ago. Although the equipment units have been maintained well, there are problems in efficiency and quality control. There is a lack of fixtures and glass tools including pipettes and tubes.

4. Planning Policy for Coastal Water Quality Monitoring

(1) Roles and Objectives of Coastal Water Quality Monitoring

Coastal Water Quality Monitoring is one of the tools for coastal environmental management. The results of analysis provide valuable information to support decision-makers in the following:

1) establishment of an appropriate environmental management plan;
2) amendment of environmental management plan;
3) proper management and use of water and water areas;
4) prevention of environmental deterioration; and
5) control of pollution.

(2) Requirements for Coastal Water Quality Monitoring

Important keywords for coastal water quality monitoring are "continuity", "consistency", and "extensive area." Namely, Monitoring must ensure continuous data acquisition, consistency in sampling and analysis methods, and coverage of extensive area.

(3) Implementing Agency

The National Water Law established in 1992 stipulates that *CNA* is an agency responsible for proper management and use as well as conservation of water and water areas in Mexico. Accordingly, a tool for proper management of water areas, that is, water quality monitoring, is under control of *CNA*.

(4) Monitoring Components

Coastal areas to be monitored are areas affected from human activities on land, coastal lagoons, rivers (from its mouth to the point where river water is affected by seawater), and seaports. For the purpose of monitoring work, coastal waters are defined as the area 5 to 10 km from the shoreline.

In principle, coastal water quality monitoring is to be implemented nationwide. However, since this is impossible considering funding constraints, monitoring work is to be conducted in the following priority areas, and then expanded later on to cover other areas.

- industrial areas
- tourism sites
- fishing grounds/conservation areas for fishery resources
- protected areas/environmental conservation areas

5. Guidelines for National Coastal Water Quality Monitoring

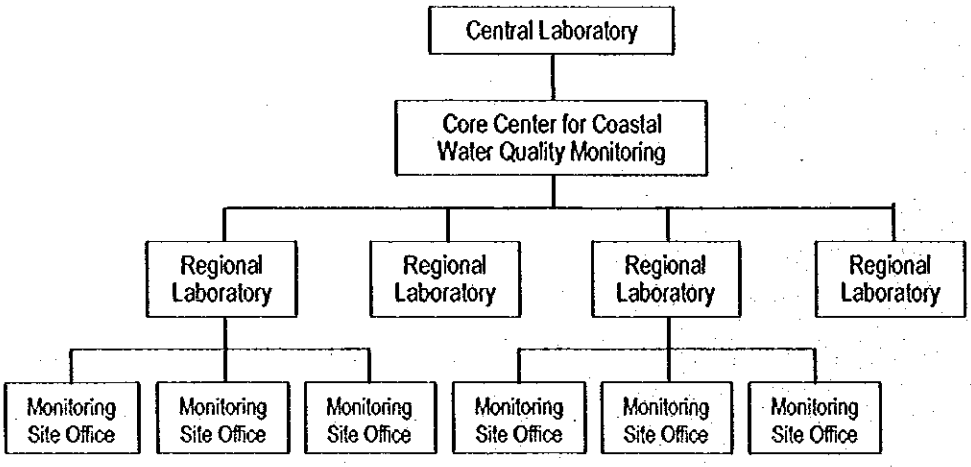
This guideline will provide guidance when *CNA* will develop the coastal water quality monitoring program in the future for areas other than Tampico area. The guideline will consist of the following six components:

- Laboratory Network,
- Sampling.
- Laboratory Management
- Data Management
- Human Resources Development, and
- Special Monitoring Program

(1) Laboratory Network

A laboratory network will consist of the Central Laboratory, Core Center, Regional Laboratories, and Monitoring Site Offices. Each organization plays the following role:

- Central Laboratory : Responsible for coastal and fresh water quality monitoring
- Core Center for Coastal Water Quality Monitoring: Functions as a reference laboratory, data management center, and training center for coastal water quality monitoring while providing the necessary information on Mexico's coastal environment to decision-makers for formulation of coastal management policy.
- Regional Laboratories : Monitor their respective areas, including sampling and analysis.
- Monitoring Site Offices: Established in strategic areas, such as urban areas, industrial areas and fishing grounds, where sampling and analysis of samples that may be readily deteriorated can be made on field.



Monitoring and Laboratory Network

(2) Sampling

Sampling for coastal water quality monitoring is conducted at two layers, considering the influence of river water and biological reaction called photosynthesis. On the other hand, sediment samples are taken from the top of seabeds, since they provide information on water characteristics and pollution trends.

Monitoring parameters include basic parameters to indicate water quality characteristics and seasonal changes and toxic parameters to be used as indices to indicate accumulated pollution.

The monitoring frequency is every two months for basic parameters and twice (dry and wet seasons) a year for toxic parameters in principle.

Monitoring Parameters

Samples	Parameters	
Water Quality	Basic Parameters	Water temperature, salinity, transparency, pH, DO, SS, COD, NO_3-N, NO_2-N, NH_4-N, T-N, PO_4-P, T-P, Chlorophyll-a, Total Coliform, Fecal Coliform
	Toxic Parameters	Hexane Extracts, Cd, Pb, Cu, Zn. T-Hg, As, Cr^{+6}
Sediment	Basic Parameters	ORP, particle size distribution, ignition loss, COD, sulfide
	Toxic Parameters	Cd, Pb, Cu, Zn, T-Hg, As, Cu

(3) Laboratory Management

Laboratory management is a collective term to indicate the organizational structure, building, equipment and facilities, reagent management, solid waste disposal, and wastewater treatment of regional laboratories.

Sampling and analysis equipment used in monitoring must be subjected to daily and periodical tests and controlled with the specified registry.

(4) Data Management

In order to enhance the reliability of monitoring data, it is essential to implement development of the standard work process, maintenance and performance evaluation of specified equipment, and proper pre-treatment.

(5) Human Resources Development

Improvement of technology necessary for coastal water quality monitoring requires not only sampling and water quality analysis skills, but also knowledge of the coastal environment in general. These skills and knowledge can be acquired through on-the-job training in daily activities and through off-the-job training, such as a seminar, etc.

6. Coastal Water Quality Monitoring Plan for the Tampico Area

(1) Phasing of Development Plan

Tampico Laboratory shall be developed in phases, spanning 10 years.

Targets of Phased Development of Tampico Laboratory

Phase I 2000—2002	Monitoring equipment will be developed to enable continuous monitoring. Sampling skill and basic parameter analysis will be implemented continuously as daily activities.
Phase II 2003—2005	Toxic parameter analysis will be implemented as a daily activity. The existing Tampico laboratory will be transferred from the existing building to the one appropriate for analysis activities.
Phase III 2006—2010	New type toxic material will be identified when such problem causes any coastal environmental problems. Biological accumulation test will be implemented as a daily activity.

(2) Construction of the Tampico Core Center

The Core Center will be annexed to Tampico Laboratory and put into operation by the year 2005.

(3) Tampico Coastal Area Monitoring Plan

Water bodies to be monitored

- Coastal water area
- Panuco River
- Pueblo Viejo Lagoon
- Marismas Lagoon

In the above water areas, 26 monitoring stations for water sampling and 16 for sediment sampling will be provided.

Monitoring parameters

As the Tampico Area includes urban areas and the large oil refinery terminal, parameters to

act as indices for municipal wastewater discharges and oil pollution were added to those specified in the coastal water quality monitoring guideline.

Monitoring Parameters for the Tampico Area

Samples		Parameters
Water Quality	Basic Parameters	6 times/year: water temperature, salinity, transparency, pH, DO, SS, COD, NH_4-N, NO_2-N NO_3-N, T-N, PO_4-P, T-P, Chlorophyll-a, Total Coliform, Fecal Coliform
	Harmful Parameters	2 times/year: Cd, Pb, Cu, Zn, T-Hg, As, Cr^{6+}
	Special Monitoring Program	6 times/year: Hexane Extracts 2 times/year: Hydro carbon, Surfactant, Organic chloride pesticide (aldrin, dieldrin, endrien, chlordane, DDT)
Sediment	Basic Parameters	2 times/year: ORP, sediment particle size distribution, Ignition loss, COD. sulfide
	Harmful Parameters	2 times/year: Cd, Pb, Cu, Zn, T-Hg, As

7. Project Costs

(1) Establishment of the national coastal water quality monitoring network

Cost Estimation of the Coastal Water Quality Monitoring Network

Unit: Million Mexican pesos

Cost Component	Cost (2001-2010)
Initial investment	91.8
O&M cost	48.5
Total	140.3

(2) Development of the Tampico Laboratory and Core Center

Cost Estimation for Development of the Tampico Laboratory and Core Center

Unit : Million Mexican pesos

Cost Component	Tampico Laboratory		Core Center		Total	
Initial investment	13.8		11.6		25.4	
O&M cost	3.5	0.6/year	1.8	0.3/year	5.3	0.9/year
Total	17.3		13.4		30.7	

1. Introduction

1.1. Background of the Study

In Mexico, protection of coastal zones and sustainable utilization of natural resources in these zones are some of the key factors for the healthy economic development of the country. Therefore, the proper management of coastal water quality will greatly benefit the nation. Coastal Water Quality Monitoring (CWQM) is a fundamental element of coastal water quality management. Although development of a comprehensive national water quality monitoring system for the coastal zones is much needed in Mexico, the country has no sufficient experience in developing such system.

Under such circumstance, the Government of Mexico requested technical cooperation from the Government of Japan in preparation of a coastal water quality monitoring program. Consequently, the Japan International Cooperation Agency (JICA) undertook the Study, and the Scope of Work for the Study was agreed upon between JICA and the National Water Commission (*CNA)* of Mexico on August 4, 1998.

1.2. Objectives of the Study

The objectives of the Study are:

1) To develop a water quality monitoring program for the specific coastal water bodies in the Tampico Area, State of Tamaulipas, and to prepare guidelines for the national water quality monitoring program for coastal areas in Mexico; and
2) To effect technology transfer to the Mexican counterpart personnel in the course of the Study.

1.3. Study Area

The Study Area for the development of coastal water quality monitoring program included the following water bodies (see also Figure 2.1):

1) A section of Panuco River from the river mouth to the confluence with its tributary Tamesi River;
2) Pueblo Viejo Lagoon;
3) Coastal sea area along the shoreline from the mouth of Panuco River to the Altamira Industrial Zone;
4) Altamira Seaport; and
5) Marismas Lagoon.

In the Scope of Work, it was Conejo Lagoon, and not Marismas Lagoon, that was included as one of the object water bodies for which a water quality monitoring program is to be developed and a pilot monitoring is to be conducted in the Study. However, in consultation with the Mexican counterparts at the later stage, it was decided to replace Conejo Lagoon with Marismas Lagoon in the monitoring program since the latter was considered as more important in terms of usage of water area and the stream running between Conejo Lagoon and Marismas Lagoon.

For preparation of guidelines for the national water quality program for coastal areas, the whole coastal areas in Mexico were taken into consideration. However, the term "Study Area" refers to the above-listed water bodies and their watershed areas within the Tampico Area.

The Tampico Area, in this report, refers to the area consisting of administrative areas of the cities of Tampico, Madero and Altamira in the State of Tamaulipas and those of the municipalites of Panuco, Pueblo Viejo and Tampico Alto in the State of Veracruz.

1.4. Implementation of the Study

(1) Study Organization

The organization for the implementation of the Study is as follows.

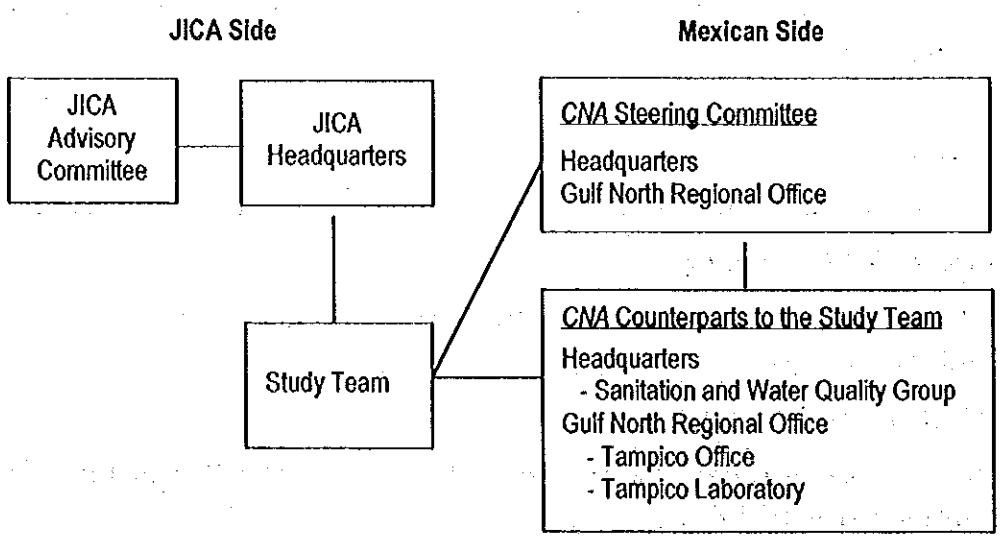


Figure 1.1 Study Organization

(2) Study Activities

The Study was conducted in Mexico and Japan from January 1999 to March 2000. The Study works were carried out largely in Mexico, while the work periods in Japan were devoted mostly to the preparation of reports. Figure 1.1 shows the overall activities performed by the Study Team in cooperation with the Mexican counterparts during the work periods in Mexico. As starting point, the Study Team collected data relative to coastal quality conditions in the national level, and specifically in Tampico Area. In addition, the existing monitoring system was also investigated. A Coastal Water Quality Monitoring Plan for Tampico Area was prepared based on the coastal environmental profile and the pilot monitoring for Tampico Area. The Study Team also prepared guidelines for the National Coastal Water Quality Monitoring by *CNA*. Lastly, technology transfer was effected through seminars conducted during the course of the Study, as shown in Table 1.1.

Table 1.1 Major Study Activities in Mexico

Stage	Seminar / Training
Site Work I (end January – end March, 1999)	• Training on preliminary field survey (Tampico) • First technical seminar on coastal water quality monitoring (Mexico City) • Introduction of the Study at the World Water Day Conference (Tampico)
Site Work II (mid June - beginning September, 1999)	• Meeting for evaluation of the result of the coastal water quality monitoring conducted by *CNA* in May (Tampico) • Technical seminar for hydrological survey (Tampico) • Second technical seminar on coastal water quality monitoring (Tampico) • Technical seminar on water quality simulation (Mexico City)
Site Work III (mid August - end November, 1999)	• Technical seminar on water quality sampling (Tampico) • Technology Transfer Seminar (Mexico City)

Source: JICA Study Team

1.5. Organization of the Reports

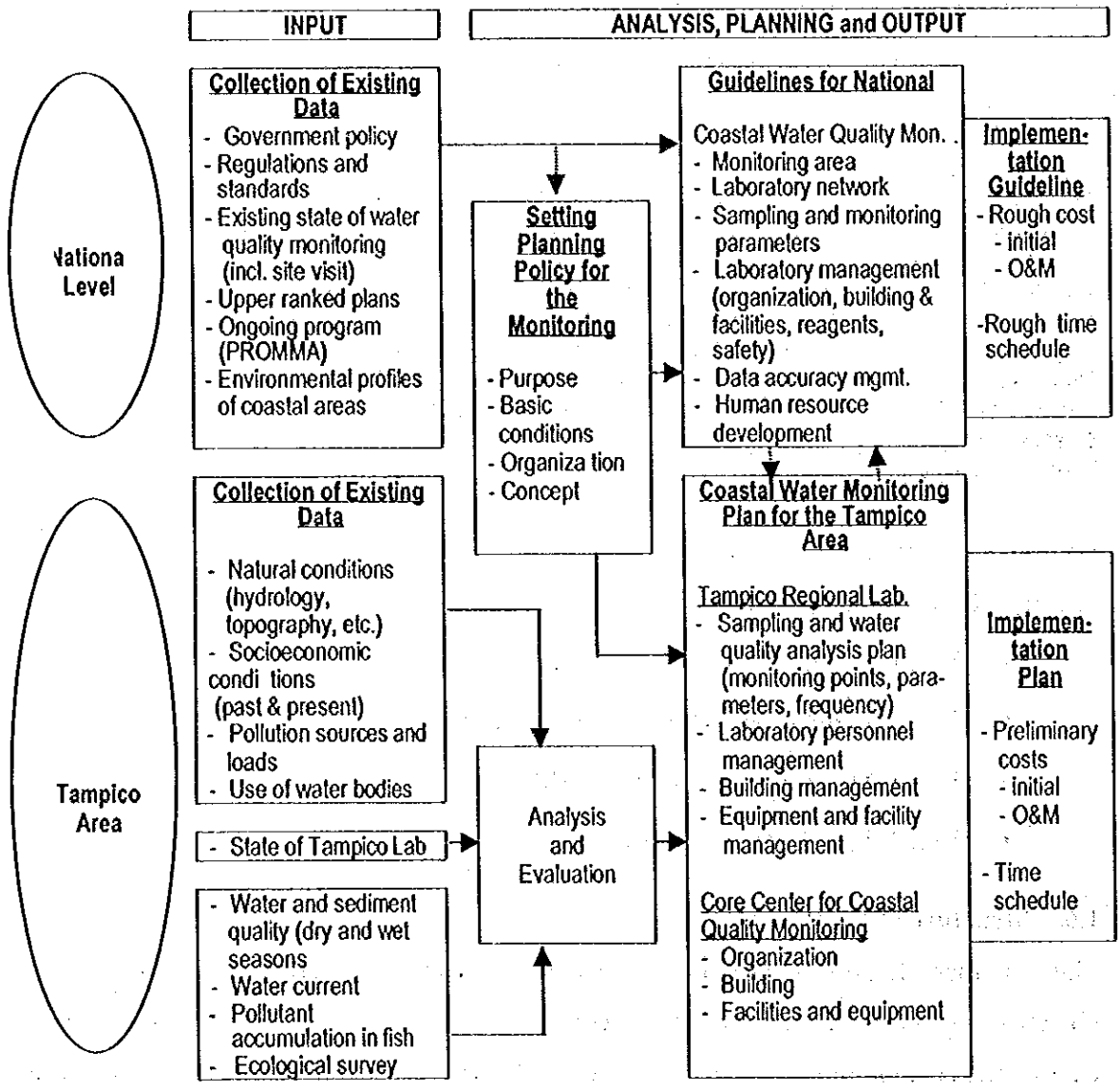
The Final Report is composed of four separate volumes, as follows:

- Vol. 1 Summary (English and Spanish)
- Vol. 2 Main Report (English and Spanish)
- Vol. 3 Supporting Report (English)
- Vol. 4 Data Book (English)

1.6. Structure of the Report

This Summary Report consists of six chapters. Chapter 1 describes the background and objectives of the Study, and its work activities as well. Chapter 2 provides the existing environmental conditions in Tampico Area and the Mexican water quality monitoring system at present. Findings from this exercise were used as the basis of coastal water quality

monitoring planning. In Chapter 3, a planning policy for National Coastal Water Quality Monitoring is presented, while Chapter 4 discusses the Guidelines for National Coastal Water Quality Monitoring. The Guidelines are to serve as planning reference for expansion of the monitoring areas in Mexico. Chapter 5 provides the coastal water quality monitoring plan for Tampico Area based on the Guidelines for National Coastal Water Quality Monitoring of Chapter 4. This plan can be used for formulation of coastal water quality monitoring plan by *CNA* for other areas. Finally, Chapter 6 proposes two implementation plans, with their respective schedules and cost estimates. One proposal is to establish a National Coastal Water Quality Monitoring based on Chapter 4. The other is the implementation of coastal water quality monitoring for Tampico Area including the establishment of a Core Center.



Source: JICA Study Team

Figure 1.2 General Structure of the Study

2. Existing Conditions

This chapter is a compilation of the existing environmental conditions in Tampico Area that will be covered in the monitoring plan, and the present water quality monitoring system as well. Environmental conditions of Tampico Area are considered in the formulation of a monitoring plan for the said area. It is necessary that CNA conduct the same study for formulation of monitoring plans for other areas.

2.1 Natural Conditions Around Tampico Area

(1) Topography and Climate

The Tampico Area is located in the center of a broad plain bounded by mountain ranges to its north, west, and south directions. As shown in Figure 2.1, the eastern side of the plain faces to the Gulf of Mexico, where a straight coastline extends in the south-north direction. There are many freshwater and brackish water lagoons in the low land areas around Tampico. The largest brackish lagoon in the area is Pueblo Viejo Lagoon having a surface area of about 100 km^2. Many freshwater lagoons located northwest of Tampico City are protected from the salt intrusion by a number of dikes constructed on lower sections of the Tamesi River system.

In Tampico, the annual average temperature is 24.8°C, the highest monthly average is 28.8°C in June and August, and the lowest is 18.7°C in January. The average annual rainfall in Tampico is 1,118 mm, and the average monthly rainfall ranges from 15.7 mm (March) to 269.6 mm (September). The average annual evaporation is 1,457 mm being significantly higher than the rainfall. The excess of evaporation over precipitation is largest in April or May before the rainy season, and the excess of rainfall is largest in September in the rainy season. The annual rainfall during the last twenty years ranged between 602 mm in 1982 and 1,632 mm in 1993.

(2) Oceanography

The continental shelf of the Tampico coast is relatively narrow; the water depth exceeds 100 m at 50 km offshore. Reefs and tidal inlets develop along the shore, representing the dominance of littoral drift. The tidal range is relatively small; the forecasted maximum high tide and the minimum low tide in 1999 were 64 cm and 30 cm above the Mean Low Water Level (MLWL) respectively. The diurnal tide dominates over the semi-diurnal tide.

The synoptic currents in the Gulf of Mexico are clockwise. The current at 50 - 100 km off the

Tampico shore is northward, but the dominant direction of near-shore currents is southward. The mean wave height in the Tampico Area falls between 0.6 and 0.8 m with the mean wave period being 6 - 7 seconds. On the occasions of hurricane, waves of 5.0 to 6.0 m high with the period of 11 - 13 seconds can be observed in the Tampico Area.

(3) Hydrology

There are three major watersheds in the Tampico Area as shown in Figure 2.1: Altamira Industrial Port area, Conejo Lagoon and Marismas Lagoon area, and Panuco River area.
The Panuco River watershed area consists of the following parts: 1) Upstream part of Panuco River, 2) Tamesi River and surrounding freshwater lagoons, and 3) Estuary of Panuco River including Costa Lagoon, Pueblo Viejo Lagoon, and Chijol channel.

The annual mean water discharge from the upstream part of Panuco River is 421 m^3/s. The minimum monthly discharge is 120.41 m^3/s in May and the maximum is 1,095 m^3/s in September. In the part of Tamesi River and the freshwater lagoons, the water storage amounts to 438,000,000 m^3. The lagoon freshwater is supplied to the cities of Tampico, Madero, Altamira, Panuco and Gonzalez for the industrial, communal and agricultural uses. Panuco River exchanges water with Costa Lagoon, Pueblo Viejo Lagoon, Carpintero Lagoon, and Chijol channel by tidal flows.

The Altamira Industrial Port area (about 66 km^2) has only one natural stream called Garrapatas, which flows into the seaport. The height of this watershed area is less than 30 meters above sea level.

In the Conejo Lagoon and Marismas Lagoon area, there are several other small lagoons, but no natural stream flows into this area. Conejo Lagoon has a surface area of about 1.6 km^2 and a catchment area of about 5.8 km^2 while Marismas Lagoon has a surface area of 39.6 km^2 with its volume exceeding 9,500,000 m^3. The lagoon is divided into three parts by an industrial road and the Altamira Seaport. Although it is separated from the Gulf of Mexico by a sandbank without any connection to the sea, the lagoon water is saline. Only the outflow from Conejo Lagoon supplies water to Marismas Lagoon.

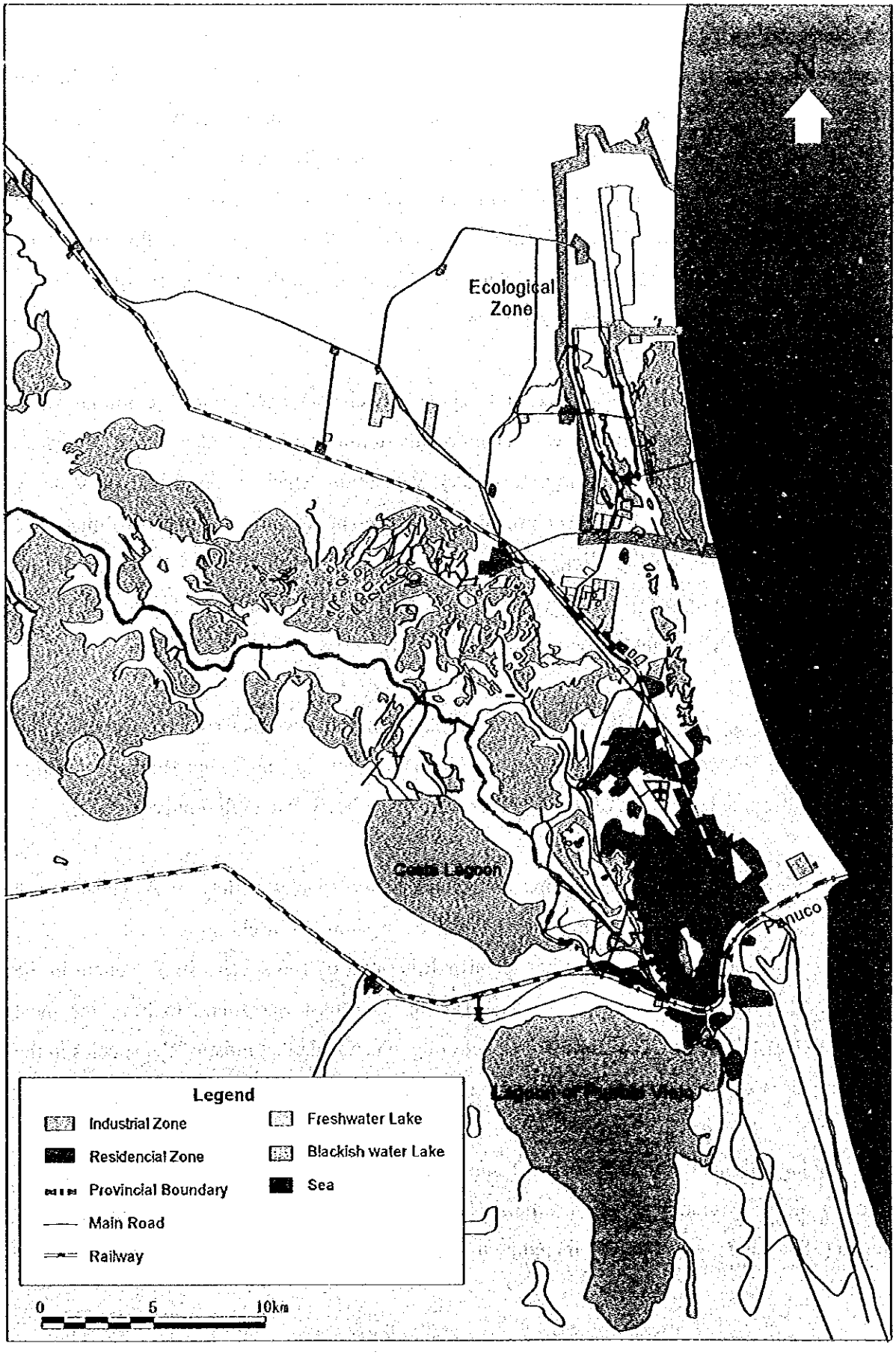


Figure 2.1 Watersheds Around the Tampico Area

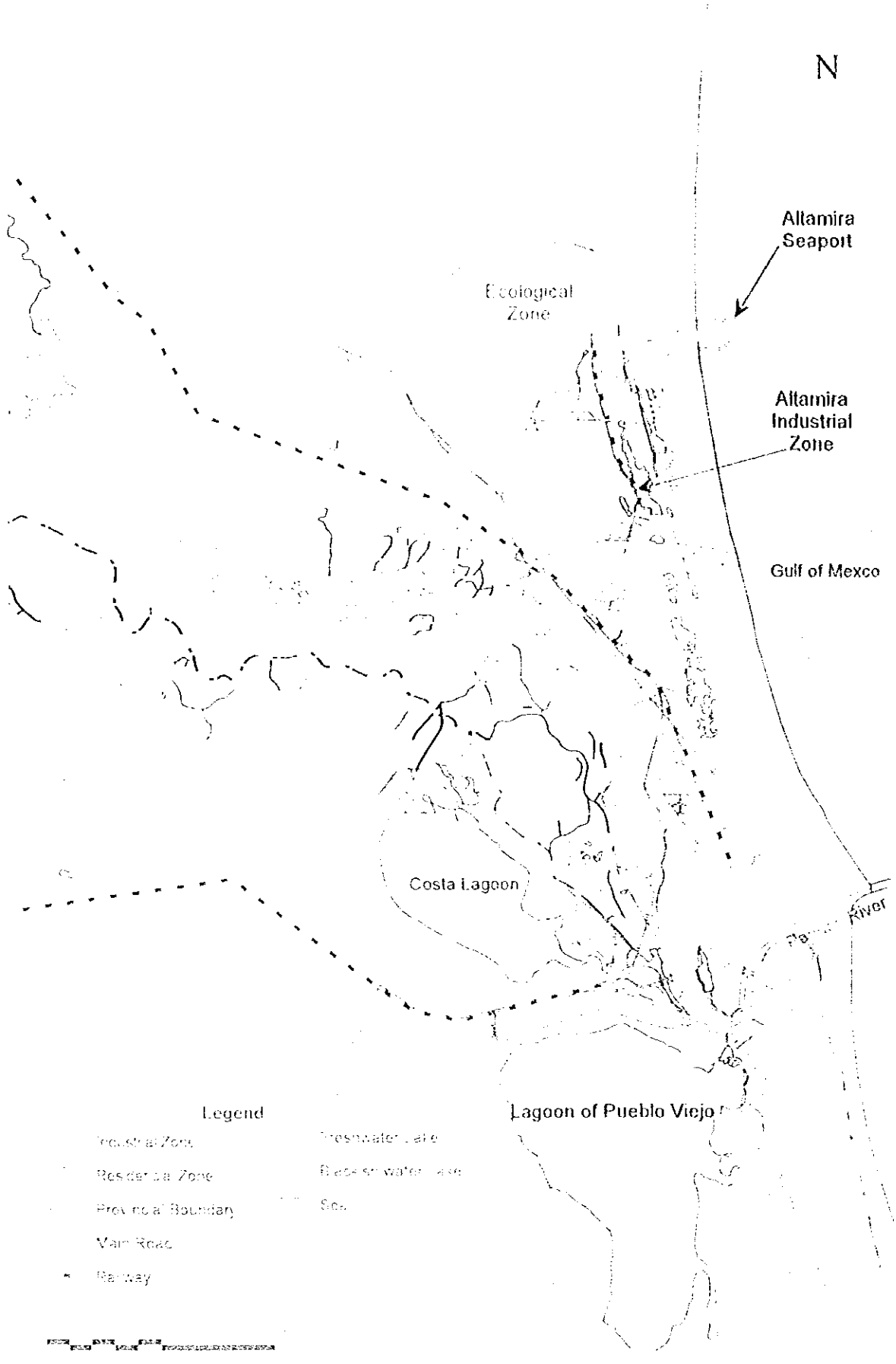


Figure 2.1 Watersheds Around the Tampico Area

(4) Ecology

Information concerning ecology such as species composition and distribution is very limited in this area, not to speak of the evidential information about the impact of water pollution on the local ecology. Under this situation, the JICA Study Team, in cooperation with the University of Noreste, carried out a biological survey in the Tampico Area. The survey included field observations in the rainy season of 1999 and a bibliography survey on zooplankton, phytoplankton, benthos, nektons (fish), aquatic birds, and higher aquatic plants in the area. The results are summarized below.

The natural vegetation in the Tampico Area is generally characterized by low deciduous forest, mangrove, and salt marsh covered with a community dominated by vascular plants. However, the majority of the area comprises secondary vegetation which is perturbed or strongly influenced by human activities. The principal aquatic plant community consists of mangrove species, especially in Pueblo Viejo Lagoon. In the estuary of the Panuco River, hardly no higher plants were observed but macroscopic algae. The survey identified 110 higher plants, but none to be protected under the relevant national norm (NOM-59).

The most diverse and abundant classes of zooplankton and phytoplankton are Copepod and Chrysophyta respectively. In the Pueblo Viejo Lagoon, the phytoplankton species that indicate eutrophic conditions of water bodies were also observed at high relative density.

Benthos identified in sediment samples showed that the species variety of Polychaeta was high in the coastal area off Miramar Beach close to a wastewater discharging point.

The investigation of nekton fauna has identified the total of 166 species in 52 genera in the water bodies in the Tampico Area. The Tampico seacoast was found to have the most diversified fish species. The survey in Conejo Lagoon showed that most of the species in the lagoon were exotic ones introduced mainly from Africa.

Coastal lagoons and estuaries in the Tampico Area provide an important habitat also for aquatic birds. Although it was not the season of bird migration, diverse and abundant bird fauna (28 species) was observed including three species that are listed in NOM-59.

2.2 Socioeconomic Conditions in the Tampico Area

(1) Population

The total population of the Tampico Area is about 720,000 as shown in Table 2.1, of which about 564,000 (78%) is in the Tamaulipas State.

Table 2.1 Population of the Tampico Area

State	City and Municipality	Population in 1995	Annual Growth Rate 1990-1995 (%)
	Tampico City	278,933	0.45
Tamaulipas	Madero City	171,091	1.30
	Altamira City	113,810	6.62
	Panuco Municipality	93,414	2.60
Veracruz	Pueblo Viejo Municipality	48,054	3.60
	Tampico Alto Municipality	14,009	-
Total		719,311	-

(2) Industry

Main industries in the Tampico Area are oil refining, petrochemical and chemical industries. These industrial plants are located mainly in the Tampico-Madero-Altamira corridor near the coast. In addition to a large PEMEX refinery, there are 18 chemical and petrochemical plants, which together produced about 2.3 million tons of diverse chemical and petrochemical products in 1996. Assembling and food industries are also important ones in the manufacturing sector.

A variety of fish resources are available in the Tampico Area for near-shore and inland fishery. Typical commercial fish species in Tampico City are shrimp, white mullet, and crab. In Madero City, tilapia, shrimp, and oyster are the representative fishery products. Pueblo Viejo Lagoon is one of the main oyster production grounds in Tamaulipas State. The annual fishery production in the Tampico Area during the period 1990 - 1998 was between 9,590 ton (1990) and 14,214 ton (1995).

Except for the urban areas and wetlands areas, terrestrial lands in the Tampico Area are mainly used as croplands and pasturelands. The main agricultural products in the Tampico Area are cotton, sorghum, corn, soybeans, pepper and tomato. Many farmers raise cattle and chicken especially in the southern municipalities of the area. The annual total livestock production in 1996 exceeded 70 thousand tons in which beef is a major product.

Tourism is also an important industry in the Tampico Area. Miramar Beach and Altamira Beach have a potential for tourism development. There are hotels of international standard near the Miramar Beach and in other parts of the area. There is also a high potential of eco-tourism development owing to rich natural resources. Calm and wide beaches and countless lagoons with diverse wildlife attract nature-oriented tourists.

2.3 Water Quality

Water quality of the water bodies in the Study Area are characterized below based on the evaluation of the results of the pilot monitoring conducted in the dry and wet seasons in 1999.

(1) Tampico Seacoast

Near the Mouth of Panuco River

River water causing high degrees of turbidity and bacterial contamination in the rainy season had directly affected the quality of water around the mouth of Panuco River. In one part, high concentrations of mercury were found in sediment samples and tissue samples of the Gurrubata fish.

North Area

The quality of seawater was normal although water transparency was a little low.

Altamira Seaport

No significant feature of water quality was noted, except for the bottom water of the inner port, where oxygen deficiency was observed in the rainy season.

(2) Panuco River

The water has high turbidity. Concentrations of bacteria and organic matter are also high. In addition, the mercury content was high in the sediment samples and tissue samples of the Gurrubata fish, which inhabits the river.

(3) Pueblo Viejo Lagoon

The Panuco River has a remarkable influence on the water quality of the northeast area of the lagoon. The water quality exhibits the same characteristics as that of Panuco River: high turbidity, high levels of organic and bacterial contamination, and high concentration of mercury in sediment and its accumulation in the Gurrubata fish.

(4) Conejo Lagoon

Among the observed water areas, Conejo Lagoon recorded the highest values for many basic pollution parameters. The lagoon is highly eutrophic and polluted by organic matters. However, Tilapia and Bagre, which are found in the lagoon, did not have any abnormal accumulation of heavy metals and toxic organic compounds in their tissues.

2.4 Water Pollution Sources

Industrial and municipal wastewater discharges exert significant impacts on the quality of water bodies and the coastal ecosystem in the Tampico Area. It has been estimated that the total organic pollution load (in terms of COD) of identifiable (point source) municipal and industrial wastewater discharges amounts to some 56 tons/day, of which the municipal wastewater accounts for 42 tons/day (74%). There is a plan to construct a public wastewater treatment plant, which is expected to reduce the COD load in the future by some 9 tons/day. There are many houses not connected to sewers, including those in the watershed of Pueblo Viejo Lagoon, and illegal houses along the lower Panuco River.

Wastewater having high concentrations of iron from a chemical plant is discharged into the sea off Miramar Beach through an ocean outfall. Impacts of this discharge on the environment have not been sufficiently investigated as yet.

The present method of solid waste disposal may be polluting soil and groundwater. The wastes are collected without separation into different types and are dumped at designated or illegal disposal sites, which are located close to Panuco River in Tampico City and the northern part of the Altamira City. No treatment is applied to the dumped wastes. Impacts of this issue, however, have not yet been investigated.

2.5 Present Water Quality Monitoring System

(1) Organization

CNA is responsible for the efficient use of water and its conservation. Therefore, *CNA's* duties include water quality monitoring of inland and coastal waters. Specifically, this task belongs to the Water Quality and Sanitation Group in the Technical Subdirectorate of *CNA*. Presently, *CNA* has one Central Laboratory in Mexico City and 13 Regional Laboratories. The Tampico Laboratory is the Regional Laboratory of the *CNA* Gulf North Region. However, these laboratories, including Tampico Laboratory, have been engaged in the

monitoring of freshwater exclusively, and they lack the skill and equipment required in sampling and analysis of coastal waters.

The Ministry of Navy conducts some monitoring works on coastal waters within their scope of responsibility. But monitoring is not done regularly and is limited to basic parameters.

(2) Ongoing Plan for Water Quality Monitoring - *PROMMA*

CNA has been conducting a project called "Water Management Modernization Project" (abbreviated in Spanish as *PROMMA*). Started in 1996 under the financial support of the World Bank, the *PROMMA* is an institutional program aimed at strengthening the technical bases required for the sustainable development and management of water resources in the country. The objectives of the program include the following:

- strengthening of human resources,
- modernization of infrastructure for monitoring and data management,
- integration of hydraulic resource management, and
- decentralization of administration, distribution and control of water use.

The sub-components of *PROMMA* that are most relevant to the present Study are Modernization of the National Monitoring Network of Water Quality, and Modernization of the National Laboratory Network.

The National Monitoring Network of Water Quality is proposed to include the following components:

Primary Network: This network aims to assess periodically the conditions of water bodies that have regional importance in terms of water use and susceptibility to pollution. It will indicate a long-term trend of water quality changes. Monitoring of this network for freshwater have started in 1999.

Secondary Network: This network aims to identify pollution of water bodies that are receiving wastewater discharges from industries, municipalities, and agriculture. Monitoring items are mostly toxic substances. Priority sites in this network have not been completely decided as yet.

There are two other components called "Special Studies" and "Hydroecological Emergencies." Table 2.2 shows the recommended number of monitoring stations for the Primary Network.

The total number of primary monitoring stations is 402, of which 98 are designated for coastal waters. Monitoring sites of coastal waters have not been decided as yet. Currently recommended water quality parameters to be monitored in freshwater system are BOD (or COD), NH_3-N, NO_3-N, PO_4-P, conductivity, DO, TSS, and fecal coliform bacteria.

Table 2.2 Number of Primary Monitoring Stations Recommended by PROMMA

Category of Water Body	Number of Monitoring Stations
Surface Water	**201**
rivers	143
streams and brooks	3
dam	29
lakes and lagoons	20
channels and discharges	6
Groundwater	**103**
Coastal Water	**98**
bays and port	52
lagoons	22
isles	3
estuaries, capes and points	21
Total	**402**

Source: CNA

Modernization of the National Laboratory Network, another important component of the *PROMMA*, aims to accomplish the following three objectives:

- to standardize, operate and sustain a laboratory network in order to develop studies and projects for management and conservation of hydraulic resources in the country,
- to secure the analytical requirement for operation of the National Monitoring Network and water quality studies, and
- to obtain usable data that are accurate, precise, verifiable and trustworthy.

The original plan of the National Laboratory Network is to have one Central Laboratory, 13 Regional Laboratories, and 20 State Laboratories. But due funding constraints, the idea of State Laboratories has been eliminated. *CNA* plans to introduce mobile laboratories instead.

(3) Tampico Laboratory

Tampico Laboratory is located in the residential area of Madero City. The building constructed as a residence in 1979 was renovated by *CNA* as a laboratory in 1992.

There are 19 personnel including the Head of Laboratory. Seven members have a background in chemical engineering or chemistry, two in pharmacology, and 10 members are high school

graduates. The analytical staff is grouped into 5 as shown in Table 2.3.

Although most of analyses have been conducted for freshwater samples, some samples of industrial wastewater were analyzed in 1998. No seawater samples were analyzed prior to the present Study.

Table 2.3 Responsibility of Analytical Groups of Tampico Water Quality Laboratory

Analytical Group	Major Parameters in Charge
Physical-Chemical	pH, Conductivity, Turbidity, Color, Oil and Grease, SS, Mineral salts, Hardness, Alkalinity, Sulphates
Organic Matter	DO, BOD, COD
Nutrient Salt	Inorganic Nitrogen, Total Nitrogen, Inorganic Phosphorus
Toxic and Harmful Substances	Methylene Bule Active Substances (MBAS), Chromium hexavalent, Phenol
Bacteria	Coliform bacteria

Source: *CNA*

Most of the laboratory equipment was bought 15 to 20 years ago. Although the equipment units have been maintained well, there are problems in efficiency and quality control. There is a lack of fixtures and glass tools including pipettes and tubes. JICA procured some new analytical units including an atomic absorption spectrophotometer, a gas chromatography, a spectrophotometer, and a total organic carbon analyzer for the conduct of the present Study.

3. Planning Policy for Coastal Water Quality Monitoring

This chapter describes the planning policy for coastal water quality monitoring, including the implementing agency, necessary conditions and planning concept, and monitoring components.

3.1 Roles and Objectives of Coastal Water Quality Monitoring

Coastal Water Quality Monitoring is one of the tools for coastal environmental management. It consists of sampling and analysis performed using accepted protocols and quality control procedures. The results of analysis can provide valuable information to support decision-makers on the following:

1) establishment of an appropriate environmental management plan;
2) amendment of environmental management plan;
3) proper management and use of water and water areas;
4) prevention of environmental deterioration; and
5) control of pollution.

Specifically, the data derived from coastal water quality monitoring can be the basis for evaluating the existing state of water quality according to applicable environmental standards and guidelines. Simulation models can be developed that can explain the mechanism of existing pollution in water bodies and enable forecasting of future states of water quality vis-à-vis some applied scenarios. The obtained data can also be used to identify possible sources of pollution and allow for a more strict compliance of environmental laws. Additionally, pollution control measures can be prepared to address immediate concerns. A total picture of the different roles of coastal water quality monitoring is presented in Figure 3.1.

3.2 Necessary Conditions of Coastal Water Quality Monitoring

Continuous and consistent are the first two key words of coastal water quality monitoring. The build-up of database on coastal water quality conditions can be realized by continuous monitoring activities. Thus, backed up by actual monitoring data, a more efficient and effective comparison between past and present data could be carried out. It is also important to realize the need for consistency of sampling and analysis methods. Linking this key aspect with continuity, the use of consistent methods will enable facility in comparison of

data. It is also noteworthy to mention that the selected sampling and analysis methods should coincide with worldwide standards to enable an international comparison of data, especially with those of neighboring countries. The third key word is extensive. This refers to the coverage area of monitoring work and its benefits, once again, relate to comparison, this time with other monitoring areas. These key words of continuous, consistent, and extensive coverage are the necessary conditions to Coastal Water Quality Monitoring.

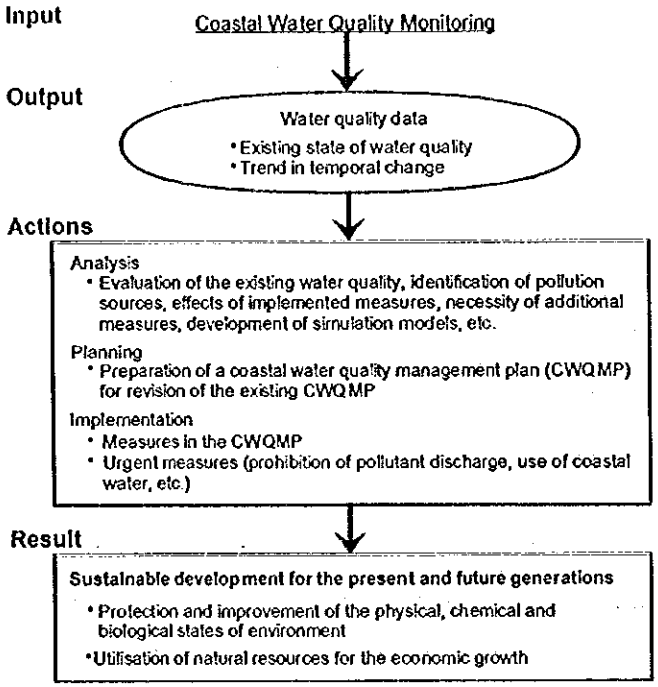


Figure 3.1 Roles of Coastal Water Quality Monitoring

3.3 Implementing Agency

The National Water Commission (*Comision Nacional del Agua*, or *CNA*), by virtue of National Water Law of 1992, has become the caretaker of water usage and water conservation by the appropriate management of water and water areas throughout the nation. *CNA* is under the jurisdiction of the Ministry of Environment, Natural Resources and Fisheries (*Secretaria de Medio Ambiente, Recursos Naturales y Pesca* or *SEMARNAP*), a federal executive branch.

Monitoring of coastal water quality is one of the responsibilities of *CNA*. However, because of funding constraints, there are two options available to them, as follows:

1) CNA-Initiative Monitoring Program
2) Decentralized Monitoring Program

In the first option, *CNA* will spearhead the improvement of Regional Laboratories in the different states, as well as the establishment of Monitoring Site Offices in strategic locations. The second option involves the establishment of State Laboratories belonging to the State Governments, and improvement of their capability by requiring accreditation of monitoring laboratories and the licensing of analysts. Table 3.1 outlines the advantages and disadvantages of these two options, while the proposed organization charts are depicted in Figure 3.2. In line with the Mexican government's decentralization policy, the Study Team proposes a phased turn over of responsibility, i.e. from *CNA* to state governments. *CNA* could initially implement coastal water quality monitoring, and then, the state governments can take over the work once their capabilities are enhanced in the future.

Table 3.1 Decision Table for Selection of Options on National Coastal Water Quality Laboratory and Monitoring Network

Options	Advantages	Disadvantages
CNA-Initiative Program	• *CNA*'s resources can be harnessed	• More equipment and human resources will be needed • *CNA* will shoulder monitoring costs.
Decentralized Monitoring Program	• Monitoring cost will be shared by *CNA* and State Governments • States' characteristics can be considered for environmental monitoring	• Current State Governments are not technically capable • Financial capacity of State Governments is weak

Source: JICA Study Team

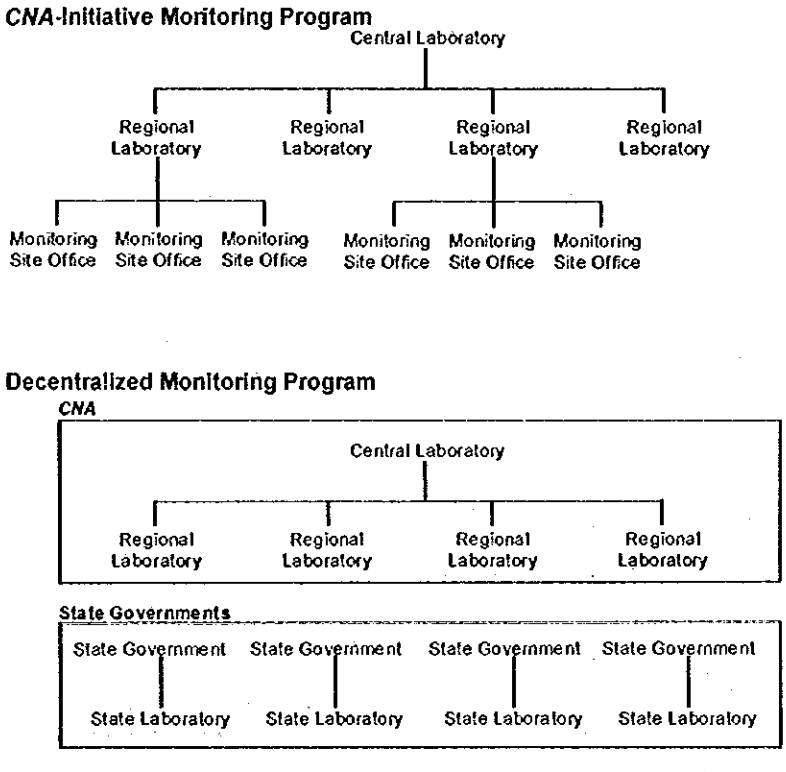


Figure 3.2 Organizational Charts for Options of National Coastal Water Quality Monitoring and Laboratory Network

Presently, there are other agencies that undertake sampling and analysis work, such as the Ministry of Navy, Ministry of Communications and Transportation, Ministry of Health and Ministry of Tourism. Such being the case, the implementation of coastal water quality monitoring could be shared with these agencies, as indicated in Table 3.2. This arrangement is to be led by *CNA* to ensure that standard operating procedures in sampling and analysis are followed and to emphasize the need for capability building on coastal water quality monitoring.

Table 3.2 Delineation of Responsibilities of Relevant Agencies on Coastal Water Quality Monitoring

Related Agencies	Responsibility
CNA	▪ planning and coordination ▪ monitoring of industrial areas and lagoons
Ministry of Navy	▪ monitoring of offshore
Ministry of Communication and Transportation	▪ monitoring of seaport
Ministry of Health	▪ monitoring of beach, e.g. sea bathing
Institute of National Fishery (INP)	▪ monitoring of coastal lagoons for fishery resources conservation
Ministry of Tourism	▪ monitoring of tourism sites

Source: JICA Study Team

3.4 Planning Concept

The coastal water quality-monitoring program shall endeavor to develop and improve monitoring capability in order to *generate usable data*, *improve cost performance* and *attain global standards*.

Usable data means accurate, precise and properly compiled data for environmental management. Improvement of cost performance involves two things: cost reduction and improved performance. Cost reduction is achieved by standardizing monitoring methods. In addition, data periodically collected can be used to identify any tendencies of change in water quality. The obtained data can also be used for the conservation of the ecosystem and the management of fishery resources, tourism resources, and others. There is a need to develop international sampling and analytical methods to enable the comparison of monitoring data with those of other countries.

3.5 Monitoring Components

The following describes the components of water quality monitoring as defined by the Coastal Water Quality Monitoring Program:

(1) Monitoring Areas and Samples

Water and sediment samples will be taken from coastal water areas affected by human activities on land, coastal lagoons, rivers (from river mouth until the upstream end, up to the point where it is affected by seawater), and seaports. For the purpose of monitoring work, coastal waters is defined as the area 5 to 10 km from the shoreline.

(2) Monitoring Parameters

Samples taken during monitoring work will be used to measure the chemical conditions of the water areas. Biological conditions in coastal waters are identified indirectly by DO, nitrogen, phosphate and chlorophyll. In the future, biological parameters will be measured.

(3) Monitoring Stations

In principle, coastal water quality monitoring is to be implemented nationwide. However, since this is impossible considering funding constraints, it is recommended that monitoring work be conducted in the following priority areas, to be expanded later on to cover other areas.

- industrial areas
- tourism sites
- fishing grounds/conservation areas for fishery resources, and
- protected areas/environmental conservation areas

(4) Monitoring Frequency

Monitoring frequency depends on the parameters to be measured. Parameters that are sensitive to seasonal changes are to be periodically monitored such as DO, organic matters and nutrient salts, and those that identify the accumulation of pollution load including heavy metals should be measured twice a week in the dry season and wet season.

4. Guidelines for National Coastal Water Quality Monitoring

This chapter presents the Guidelines for National Coastal Water Quality Monitoring based on the planning policy discussed in Chapter 3. The guidelines can be applied for formulation of coastal water quality monitoring for other areas. Coastal Water Quality Monitoring Plan can be formulated with the guidelines and preliminary field survey.

4.1 Coverage of Guidelines

The guidelines for Coastal Water Quality Monitoring shall cover the following six components:

- Monitoring and Laboratory Network
- Sampling
- Laboratory Management
- Data Management
- Human Resource Development
- Special Monitoring Program

Structure of the above mentioned components is depicted in Figure 4.1 and a brief explanation is provided below.

4.2 Proposed Guidelines for Coastal Water Quality Monitoring

(1) Monitoring and Laboratory Network

A laboratory network for coastal water quality monitoring is proposed for establishment based on the existing laboratory network of *CNA* in order to avoid drastic changes, which can lead to administrative conflict. The different organizations that will form the laboratory network are the Central Laboratory, the Core Center, Regional Laboratories, and Monitoring Site Offices. The Central Laboratory shall formulate a general water quality-monitoring plan for both coastal water and freshwater quality monitoring, and manage an integrated water quality database for the same. The Core Center for Coastal Water Quality Monitoring shall provide the necessary information on Mexico's coastal environment to decision-makers for formulation of coastal management policies. Figure 4.2 provides the setup of this monitoring and laboratory network.

Meanwhile, Regional Laboratories shall monitor their respective areas, including sampling and analysis. Setting-up of Monitoring Site Offices are proposed in strategic areas, such as urban areas, industrial areas and fishing grounds, where *in situ* sampling and analysis can be conducted.

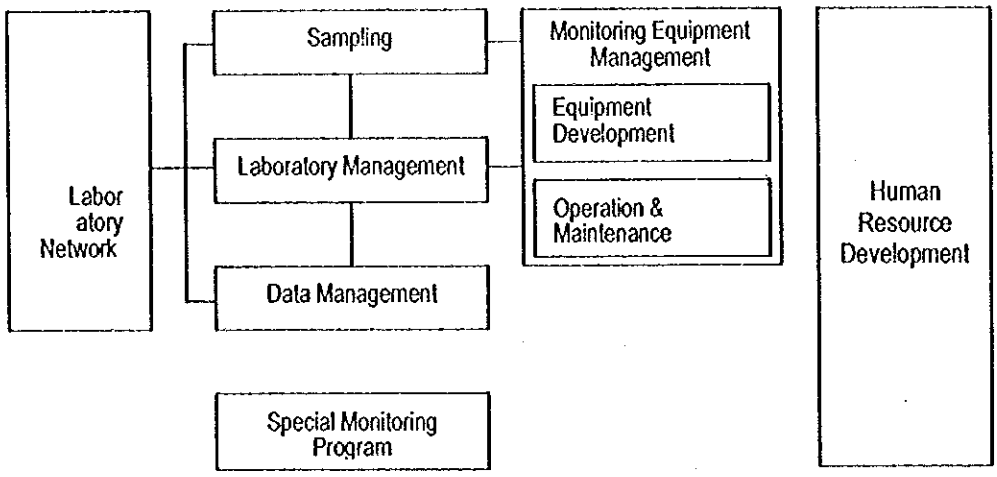


Figure 4.1 Structure of Guidelines for Coastal Water Quality Monitoring

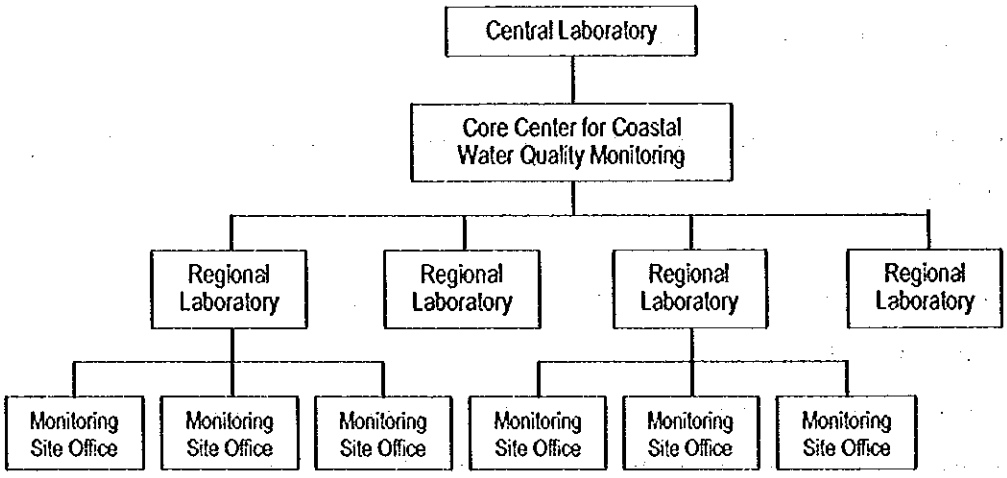


Figure 4.2 Monitoring and Laboratory Network

(2) Sampling

The Study Team determined the sampling methodology of water quality monitoring as follows:

- Sampling Layers: Sampling for coastal water quality monitoring is conducted at two layers of surface water, considering the influence of river water and biological reaction called photosynthesis. On the other hand, sediment samples are taken from the top of seabeds, since they provide information on water characteristics and pollution trends.

- Monitoring Stations: The distribution of water quality monitoring sampling stations depends on shoreline form. There are two types of distribution patterns used: mesh pattern and radial pattern. The radial distribution pattern is suitable around the mouth of a river.
- Monitoring Parameters: There are two types of monitoring parameters to be analyzed: basic parameters and toxic parameters. Basic parameters identify the characteristics of and seasonal changes in water quality, while toxic parameters indicate the accumulation of pollutants (see Table 4.1).
- Monitoring Frequency: Basic parameters of water quality are to be monitored every two months while toxic parameters of water quality and basic and toxic parameters of sediment are to be measured twice a year, in dry and rainy seasons.

Table 4.1 Monitoring Parameters

Samples		Parameters
Water Quality	Basic Parameters	Water temperature, salinity, transparency, pH, DO, SS, COD, NO_3-N, NO_2-N, NH_4-N, T-N, PO_4-P, T-P, Chlorophyll-a, Total Coliform, Fecal Coliform
	Toxic Parameters	Hexane Extracts, Cd, Pb, Cu, Zn. T-Hg, As, Cr^{+6}
Sediment	Basic Parameters	ORP, particle size distribution, ignition loss, COD, sulfide
	Toxic Parameters	Cd, Pb, Cu, Zn, T-Hg, As, Cu

Source: JICA Study Team

(3) Laboratory Management

Laboratory management is a collective term to indicate the organizational structure, building, equipment and facilities, reagent management, solid waste management and wastewater management of regional laboratories.

The offices to be found in a Regional Laboratory are the Administration Section, Planning Section and Sampling/Analysis Section. These shall be housed in a building occupying 1,000 sq.m., with 5 to 6 laboratory rooms, each measuring 50 to 60 sqm.

The monitoring equipment for coastal water quality monitoring can be divided into two types: sampling equipment and laboratory equipment. The necessary equipment for sampling is listed in Table 4.2.

Table 4.2 List of Field Survey Equipment

Field	Equipment
General	life jacket, GPS, compass, depth meter, ice box
Water Sampling	Forel Color Indicator, Secchi disc, pH meter, Van Dorn water sampler, plastic funnel, sampling bottles
Sediment Sampling	Ekman-Berge Sediment Sampler, Smith-McIntyre Sediment Sampler, Sampling bottle

Source: JICA Study Team

Daily and periodic examination of equipment should be carried out. Results of examination should be properly recorded in prescribed forms. Any indication of failure or defect in the facility or equipment should be reported to the responsible person.

Various reagents are used in analysis. They are highly toxic and combustible and should be handled with extreme care. Furthermore, they should be kept in a cool dark room and locked up when unused. Any reagent withdrawal should be approved and properly recorded. The use of toxic substances and their subsequent discharge must be limited to the extent possible. One way to do this is to reduce the amount of sample for analysis. For this purpose, the use of highly sensitive equipment would be necessary. It is also important to keep a record of all analysis processes, to include, among other thing, the date, analytical parameter, volume, method of treatment, and the name of the person in charge.

Solid waste from laboratories should be separated by kind and placed in appropriate containers, which are not susceptible to corrosion or any other form of damage. It is necessary that they be properly stored until such time that they could be processed.

There should be an emergency information network to ably cope with accidents in the premises. Fire extinguishers should be readily available. It is important to conduct safety drills, such as fire drills and emergency evacuation exercises.

(4) Data Management

The first step to proper management of data is to make sure that each concerned individually is completely oriented as regards their assigned tasks. Towards this end, it is necessary to set up a standard operating process that is clear and easy to follow.

Meanwhile, the credibility of data can be secured by carrying out such measures as maintenance and evaluation of efficiency of instruments, pretreatment of samples, if necessary, and adjustment of analytical equipment. Also, cross-checking is to be conducted to confirm the credibility of laboratories. It is important that results of analysis are recorded.

(5) Human Resource Development

Water quality monitoring activities include sampling and water and sediment analysis, while

data management requires knowledge of the physical, biological and chemical processes of coastal environment. Because of this, coastal water quality monitoring personnel should possess the skills necessary to do their respective work.

There are two approaches for human resource development: on-the-job training and off-the-job training. As the former indicates, skills are learned while on field or through daily work in the laboratory by observations, questions, and information sharing. Off-the-job training involves lectures and seminars. The Core Center can function as a training center for water quality monitoring. Some personnel may be sent to the University of Baja California to study marine science, or the university may be tapped to give a lecture on coastal environment. *PROMMA* may also be counted upon to provide assistance.

5. Coastal Water Quality Monitoring Plan for the Tampico Area

Coastal Water Quality Monitoring Plan for Tampico Area is presented in this chapter. The formulation of this plan is based on monitoring guidelines, as discussed in Chapter 4, with the results of Pilot Monitoring in Tampico Area.

The Coastal Water Quality Monitoring Plan for the Tampico Area will serve as a model for the preparation of coastal water quality monitoring plans for other areas in the Mexican States. There will be two important organizations on coastal water quality monitoring. One is the Tampico Laboratory and the other is the Core Center for National Coastal Water Quality Monitoring.

5.1 Phasing of Development Plan

Tampico Laboratory shall be developed into three phases, spanning 10 years. This is explained by Figure 5.1 below and the targets for each period are given in Table 5.1:

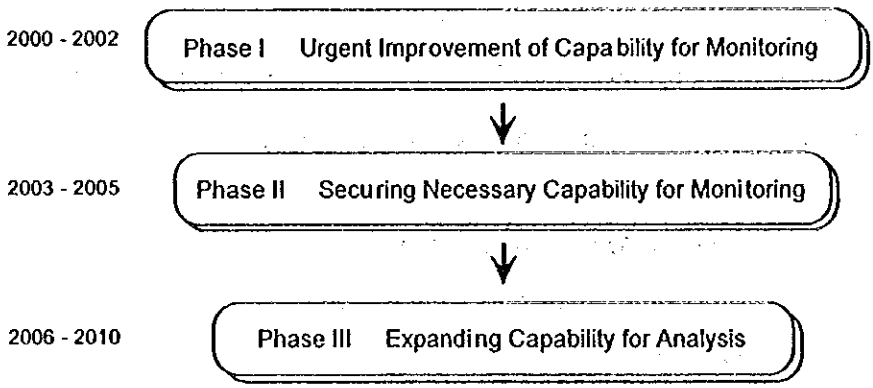


Figure 5.1 Development of Tampico Water Quality Laboratory by Target Years

The Core Center for National Coastal Water Quality Monitoring shall be established by 2004 and operational by 2005 with the following schedule:

- Basic Design : year 2001
- Detail Design : year 2001
- Construction Work: 2002 – 2004
- Pre-Operation : 2004
- Operation : from 2005

Table 5.1 Target of Development of Tampico Laboratory as a Monitoring Laboratory

Phase I 2000 -2002	Monitoring activities will be established as routine work. In order to conduct monitoring periodically and continually, fundamental facilities should be improved such as formation of monitoring team and analysis team, and appropriate number of appropriate equipment. It is required that sampling skill should be established, and at least basic parameters should be monitored.
Phase II 2003 - 2005	Micro-analysis, including those of harmful substances, should be analyzed under quality control. At the end of Phase II, general skill for coastal monitoring should be established. It may be reasonable that Tampico Laboratory will be transferred to an appropriate building until Phase II.
Phase III 2006 - 2010	Phase III tackles a new type of coastal environmental problems such as those caused by new toxic substances, traces of which have accumulated in marine life and human bodies.

Source: JICA Study Team

5.2 Tampico Laboratory and the Core Center

Tampico Laboratory shall be restructured to appropriately perform its responsibilities as a laboratory for coastal water quality monitoring. In this regard, laboratory technicians should regularly attend capability-building programs.

The Core Center shall serve as the central office for the National Water Quality Monitoring Program. Specifically, it shall serve as:

- reference laboratory for coastal water quality monitoring;
- data management center for coastal water quality monitoring; and
- training center for coastal water quality monitoring.

5.3 Sampling and Water Quality Analysis Plan

It is recommended that the following areas be monitored based on the results of the Pilot Monitoring for the Tampico Area in 1999.

- coastal water area
- Panuco River
- Pueblo Viejo Lagoon
- Marismas Lagoon

Water quality monitoring will involve sampling of water and sediment. In total, 26 monitoring stations for water sampling and 16 for sediment sampling will be set up as shown in Figures 5.1 and 5.2 and listed in Table 5.2. Primary stations are located in typical areas and in areas affected by pollution. Secondary stations are for supplementary identification of the horizontal and vertical water quality distribution patterns.

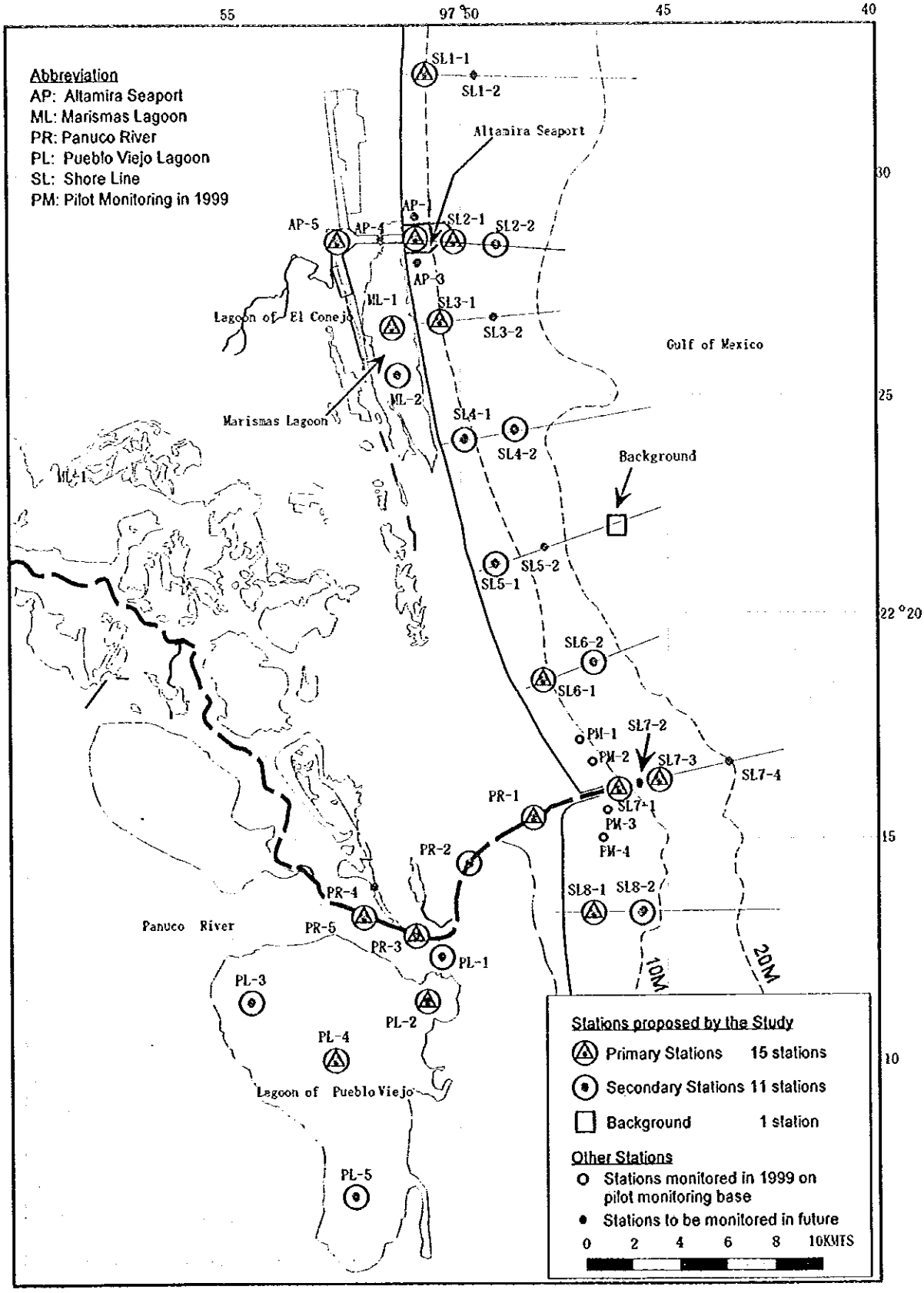


Figure 5.2 Location of Monitoring Stations in the Tampico Area

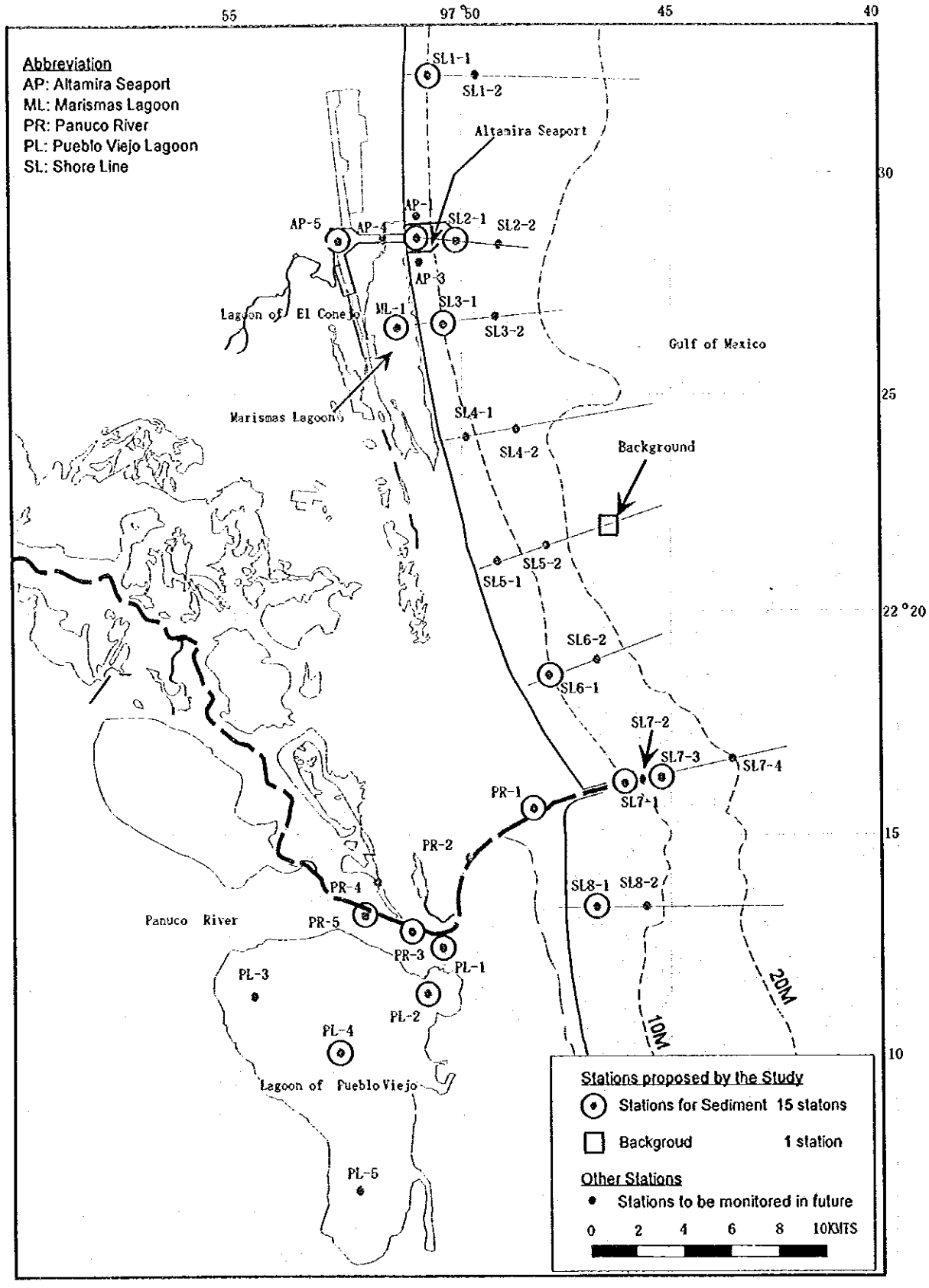


Figure 5.3 Location of Monitoring Stations for Sediment in the Tamplco Area

Table 5.2 Number of Monitoring Stations in the Tampico Area

Monitoring Areas	Water Quality							Sediment	
	No. of Stations	Basic Parameters				Harmful Parameters		No. of Stations	All para. 2x/yr.
		6 times/year		2 times/year		2 times/year			
		1 layer	2 layers	1 layer	2 layers	1 layer	2 layers		Top sed.
Coastal Area	16	0	10	0	6	10	0	10	10
Primary	10	0	10	0	0	10	0	10	10
Secondary	6	0	0	0	6	0	0	-	-
Panuco River	4	0	3	0	1	3	0	3	3
Primary	3	0	3	0	0	3	0	3	3
Secondary	1	0	0	0	1	0	0	-	-
P. Viejo Lagoon	4	2	0	2	0	2	0	2	2
Primary	2	2	0	0	0	2	0	2	2
Secondary	2	0	0	2	0	0	0	-	-
Conejo Lagoon	0	0	0	0	0	0	0	0	0
Primary	0	0	0	0	0	0	0	0	0
Secondary	0	0	0	0	0	0	0	-	-
Marismas Lagoon	2	1	0	1	0	1	0	1	1
Primary	1	1	0	0	0	1	0	1	1
Secondary	1	0	0	1	0	0	0	-	-
Total	26	3	13	3	7	16	0	16	16
Primary	16	3	13	0	0	16	0	16	16
Secondary	10	0	0	3	7	0	0	-	-
No. of Samples	-	3	26	3	14	16	0	16	16

Source: JICA Study Team

Note: One layer monitoring stations: 0.5 m below surface
Two layers monitoring stations: 0.5 m and 10 m below surface

Monitoring frequency depends on the parameters to be measured. By monitoring basic parameters, the characteristics of and seasonal changes in water quality are identified, while monitoring of toxic parameters aim to indicate the accumulation of pollution. Since Tampico is site of the largest oil refineries in Mexico, there is always the threat of oil leakage and other pollution concerns. Therefore, basic parameters are to be monitored every two months while toxic parameters are to be monitored, during the dry season and rainy season. Tables 5.3 and 5.4 list the monitoring parameters and monitoring frequency for the Tampico Area respectively. In addition, as a Special Monitoring Program for the Tampico Area, it is recommended that organic chloride pesticides such as aldrine, dieldrin, endrien be monitored until no trace of the said substances is found for at least three years.

Table 5.3 Monitoring Parameters for the Tampico Area

Samples		Parameters
Water Quality	Basic Parameters	6 times/year: water temperature, salinity, transparency, pH, DO, SS, COD, NH_4-N, NO_2-N NO_3-N, T-N, PO_4-P, T-P, Chlorophyll-a, Total Coliform, Fecal Coliform
	Harmful Parameters	2 times/year: Cd, Pb, Cu, Zn, T-Hg, As, Cr^{6+}
	Special Monitoring Program	6 times/year: Hexane Extracts 2 times/year: Hydro carbon, Surfactant, Organic chloride pesticide (aldrin, dieldrin, endrien, chlordane, DDT)
Sediment	Basic Parameters	2 times/year: ORP, sediment particle size distribution, Ignition loss, COD. sulfide
	Harmful Parameters	2 times/year: Cd, Pb, Cu, Zn, T-Hg, As

Source: JICA Study Team

Table 5.4 Frequency of Water Quality and Sediment Monitoring for the Tampico Area

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total.
Water Quality													
Primary Points													
Basic Parameters	O		O		O		O		O		O		6
Harmful Parameters			O						O				2
Secondary Points													
Basic Parameters			O						O				2
Harmful Substances													
Sediment													
Basic Parameters			O						O				2
Harmful Substances			O						O				2

Source: JICA Study Team

5.4 Laboratory Management Plan

The Laboratory Management Plan covers the following components:

(1) Laboratory Personnel Management

The new Tampico Laboratory shall have three sections: Administration, Planning, and Sampling/Water Quality Analysis. Including the Laboratory Head, the total number of experts is 11, with 8 assistants.

(2) Building Management

It is recommended that Tampico Laboratory transfer to a new building by 2005. But since the existing building is still being used for analysis work, several items are proposed, such as installation of sink and faucet, electrical stabilizer, and cabinets, improvement of storage room for reagents, establishment of staff / meeting room and library, and additional refrigerators for reagents.

(3) Equipment and Facility Management

As previously mentioned, there are two types of laboratory equipment: sampling equipment and analysis equipment. Most of the necessary equipment is already installed at the Tampico Laboratory. However, there are still some required equipment lacking, such as salinometer, water thermometer, spectrophotometer and desktop computer. A wastewater treatment system is also needed.

5.5 Core Center for Coastal Water Quality Monitoring

The Core Center for Coastal Water Quality Monitoring shall comprise six sections as follows:

Administration, Planning, Laboratory Network Management, Data Management, Facilities and Equipment, and Training, as shown in Figure 5.4 with the functions indicated in Table 5.5. It shall have facilities for data processing and training. Data processing shall include maintenance of coastal water quality database and GIS data. Training rooms shall include audio-visual rooms and lecture rooms.

It is desirable that the Core Center and the Monitoring Laboratory be housed in one building or complex, so that they can share facilities and equipment. A building design concept is shown in Table 5.6.

Meanwhile, management of the boathouse, which is a combination office and storage structure, shall not fall under the responsibility of the Core Center.

Table 5.5 Functions of the Different Sections of the CorPe Center

Sections	Administration Section	Planning Section	Laboratory Network Management Section
Functions	• to manage building and facilities • to manage personnel • to manage budget and accounting • to manage monitoring equipment • to manage laboratory property	• to prepare plan for coastal water quality monitoring • to provide monitoring program • to prepare Monitoring Report • to provide necessary information for water area management and pollution control for decision-maker	• to coordinate laboratory network for coastal water quality monitoring • to implement accuracy control for coastal water quality monitoring in CNA • to assist in technical aspects regarding implementation of sampling and operation of laboratory
Sections	Data Management Section	Facilities and Equipment Section	Training Section
Functions	• to collect monitoring data from Regional Laboratories • to compile monitoring data • to establish and maintain database system • to prepare Monitoring Report • to send monitoring data and Monitoring Report	• to manage monitoring equipment and laboratory facilities • to prepare Facility and Equipment Plan • to purchase facilities and equipment • to provide facilities and equipment to Regional Laboratories • to assist in technical aspects regarding operation and maintenance of monitoring equipment • to repair monitoring equipment • to study monitoring facilities and equipment • to design laboratory facilities	• to prepare training programs • to implement training programs • to prepare training materials

Source: JICA Study Team

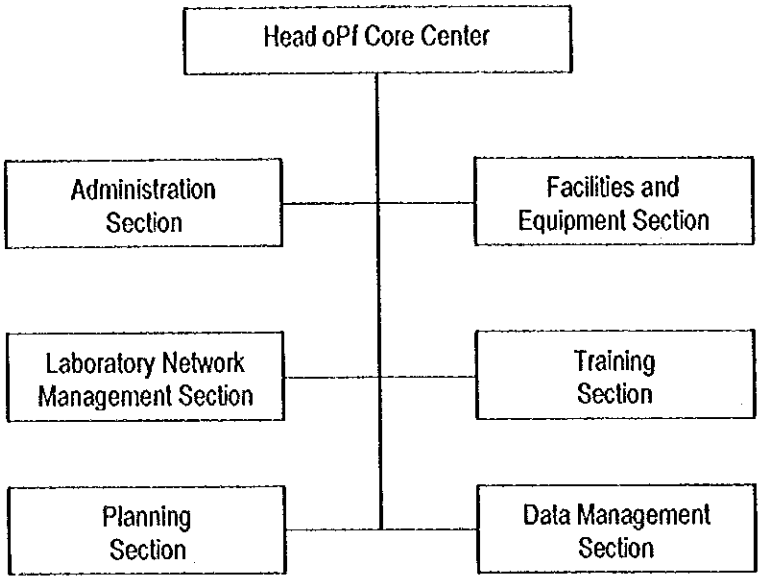


Figure 5.4 Organization of Core Center for National Coastal Water Quality Monitoring

Table 5.6 Design Concept of the Core Center for Coastal Water Quality Monitoring

Items	Requirement		
Main Building 1,200 m^2 (RC 2 floors)	administration room staff room computer room lecture room analytical room* equipment storage room conference room library car park	1 room 6 rooms 1 room 3 rooms 2 rooms 1 room 1 room 20 cars	80 m^2 80 m^2 X 6 rooms 50 m^2 50 m^2 X 3 rooms 40 m^2 X 2 80 m^2 80 m^2
Warehouse 100 m^2 (Prefabricated building)	storage of sampling equipment repair shop	1 room 1 room	40 m^2 60 m^2
Building Facilities	appropriate electric power water supply system air conditioner sewage treatment system (septic tank)		
Boathouse (on shore, Prefabricated building)	staff room storage room pier car park	1 room 1 room 1 for 10 cars	40 m^2 25 m^2

Source: JICA Study Team

*: to be shared with Tampico Regional Laboratory

6. Project Implementation

In this chapter, the following projects are proposed for implementation based on discussions in Chapters 4 and 5 respectively: 1) a National Coastal Water Quality Monitoring, and 2) Coastal Water Quality Monitoring for Tampico Area. The latter includes the establishment of the Core Center for National Coastal Water Quality Monitoring. Also included in this chapter are the proposed implementation schedules and project cost estimates.

6.1 The Proposed Project

In principle, this coastal water quality-monitoring network should cover the whole coastal areas of Mexico. But a simultaneous implementation of coastal areas nationwide would be difficult owing to Mexico's present financial situation as well as the existing performance of coastal water quality monitoring work. A phased implementation would be required. Therefore, it is proposed that the proposed project be focused initially on the following priority areas, which have high risks of water contamination:

- Industrial Areas
- Tourism Areas
- Fisheries Areas

(1) Project Components

The proposed project is divided into the following two project components:

1) Establishment of the National Coastal Water Quality Monitoring Network, and
2) Establishment of the new Tampico Monitoring Laboratory and the Core Center for Coastal Water Quality Monitoring.

(2) Objectives

The main objectives of the proposed projects are to:

- Develop an effective and efficient coastal water quality monitoring network; and
- Restructure the existing Tampico Laboratory to address the dual needs of a monitoring laboratory and a center for coastal water quality monitoring.

(3) Implementing Agencies

The implementation of the proposed project could be a joined undertaking by *CNA* and the related agencies to effectively use the monitoring data and to mitigate the burden of

involvement of other agencies in coastal water quality monitoring, *CNA* should mainly be responsible for this proposed project.

6.2 Establishment of National Coastal Water Quality Monitoring Network

(1) Project Composition

Figure 6.1 shows the proposed national laboratory network for coastal water quality monitoring consisting of the Core Center, Regional Laboratories, and Monitoring Site Offices. Table 6.1 shows the number and location of the Regional Laboratories and Monitoring Site Offices in the Priority Areas.

Table 6.1 Proposed Monitoring Site Offices in the Priority Areas

No.	Region No.	Coastal Regional Laboratory	No of Monitoring Site Offices	Monitoring Site Offices	Priority Areas	Characteristics of Priority Areas
1	1	Mexicali	3	- Ensenada - Guerrero Negro - La Paz (Present State Lab)	1) Ensenada 2) San Quintin 3) Santa Rosalia 4) Guerrero 5) Bahia 6) Los Cabos 7) La Paz	Fishery Fishery Fishery Fishery Fishery Fishery, Tourism Fishery, Tourism
2	2	Hermosillo	0		8) Guyamas*	Fishery
3	3	Culiacan	1	- Mazatlan	9) Topolobampo* 10) Mazatlan	Fishery Fishery, Tourism
4	4	Cuernavaca	1	- Lazaro Cardenas	11) Lazaro Cardenas	Fishery, Industry
5	5	Oaxaca	2	- Acapulco (Present State Lab) - Salina Cruz	12) Puerto Escondido* 13) Puerto Angel* 14) Zuhuatanejo 15)Acapulco 16) Salina Cruz	Tourism Fishery Tourism Tourism Fishery, Industry
6	8	Guadalajara	2	-Tepic (Present State Lab) - Colima (Present State Lab)	17) San Blas 18) Puerto Vallarta 19) Manzanillo	Fishery Tourism Tourism, Industry
7	9	Tampico	1	- La Pesca	20) Tampico* 21) La Pesca	Industry, Tourism, Fishery Fishery
8	10	Xalapa	2	- Veracruz -Forin de las Flores (Present State Lab.)	22) Nautla* 23) Tuxpan* 24) Tecocutla* 25) Veracruz 26) Alvarada 27) Coatzacoalcos 28) Minatitlan	Fishery Fishery Fishery Fishery, Tourism Fishery Fishery Industry, Fishery Industry
9	11	Tuxtla-Gutierrez	2	- Villahermosa (Present State Lab.) - Tapachula	29) Mecoacan-Machona 30) Mar Negro 31) Tapachula	Fishery Fishery Fishery, Industry
10	12	Merida	2	- Campeche (Present State Lab.) – Cancun (Present State Lab.)	32) Progreso-Celestum* 33) Cd. Del Carmen 34) Laguna de Terminos 35) Cancun 36) Isla Mujeres	Fishery Fishery Fishery Tourism Fishery, Tourism

Source: JICA Study Team

Note: Sampling and analysis of the Priority Areas* are conducted by each Regional Laboratory.

(2) Cost Estimate

The total cost of this project component is N$ 140.3 as shown below. This cost is exclusive of any taxes and is estimated under the economic conditions prevailing in November 1999.

Table 6.2 Cost Estimation of Coastal Water Quality Network

Unit: N$ million

Cost Component	Total Amount (2001-2010)	Remarks
Initial cost	91.8	
O&M cost	48.5	O&M cost from 2005 to 2010 is approx. 5.8 million/year
Total	140.3	

Source: JICA Study Team

(3) Implementation Schedule

The proposed implementation schedule of this component is shown in Figure 6.2.

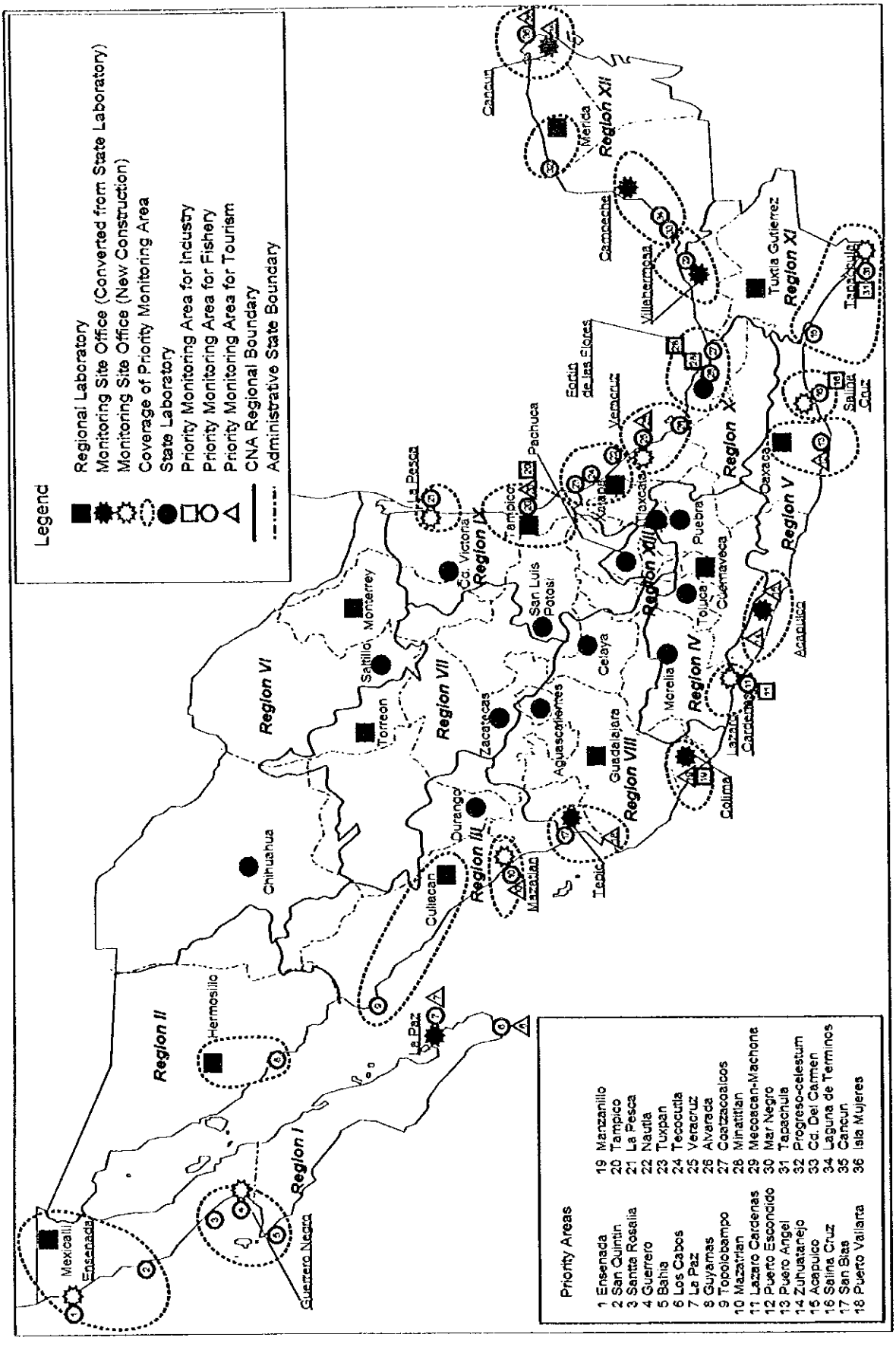


Figure 6.1 Proposed National Coastal Water Quality Monitoring Network

Items/Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
C.N.A Region 1											
a) Regional Laboratory (Mexicali)											
- Installation of sampling equipment											
- Installation of laboratory equipment (basic parameters)											
- Installation of laboratory equipment (toxic parameters)											
- Operation (basic parameters)											
- Operation (toxic parameters)											
b) Monitoring Site Office											
1) Ensenada (New)											
- Building construction and installation of equipment etc.											
- Operation											
2) Guerrero Negro(New)											
- Building construction and installation of equipment etc.											
- Operation											
3) La Paz (converted from present State Laboratory)											
- Installation of equipment, etc.											
- Operation											
C.N.A Region 2											
a) Regional Laboratory (Hermosillo)											
- Installation of sampling equipment											
- Installation of laboratory equipment (basic parameters)											
- Installation of laboratory equipment (toxic parameters)											
- Operation (basic parameters)											
- Operation (toxic parameters)											
C.N.A Region 3											
a) Regional Laboratory (Culiacan)											
- Installation of sampling equipment											
- Installation of laboratory equipment (basic parameters)											
- Installation of laboratory equipment (toxic parameters)											
- Operation (basic parameters)											
- Operation (toxic parameters)											
b) Monitoring Site Office											
1) Mazatlan (New)											
- Building construction and installation of equipment etc.											
- Operation											
C.N.A Region 4											
a) Regional Laboratory (Cuernavaca)											
- Installation of sampling equipment											
- Installation of laboratory equipment (basic parameters)											
- Installation of laboratory equipment (toxic parameters)											
- Operation (basic parameters)											
- Operation (toxic parameters)											
b) Monitoring Site Office											
1) Lazaro Gardenas (New)											
- Building construction and installation of equipment etc.											
- Operation											
C.N.A Region 5											
a) Regional Laboratory (Oaxaca)											
- Installation of sampling equipment											
- Installation of laboratory equipment (basic parameters)											
- Installation of laboratory equipment (toxic parameters)											
- Operation (basic parameters)											
- Operation (toxic parameters)											
b) Monitoring Site Office											
1) Acapulco (converted from present State Laboratory)											
- Installation of equipment, etc.											
- Operation											
2) Salina Cruz (New)											
- Building construction and installation of equipment etc.											
- Operation											

Figure 6.2 (1) Implementation Schedule for Establishment of National Coastal Water Quality Monitoring Network

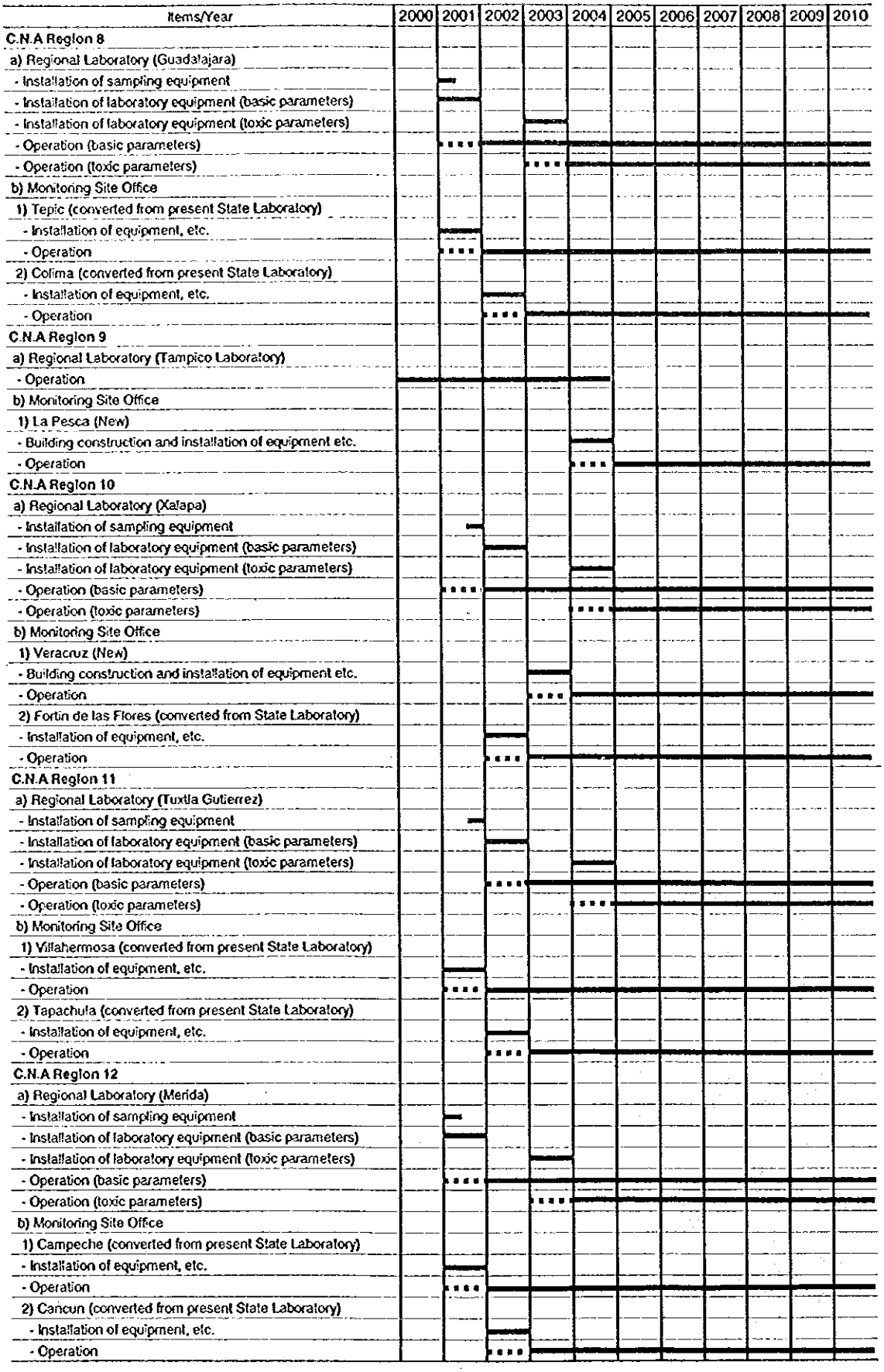


Figure 6.2 (2) Implementation Schedule for Establishment of National Coastal Water Quality Monitoring Network

6.3 Development of the Tampico Regional Laboratory and the Core Center

(1) Project Component

This project component is divided into the following two sub-components:

1) Tampico Laboratory

Tampico Laboratory shall be redeveloped as one of the regional laboratories and is to be located within the same building or complex as the Core Center. It shall have the following two sub-components:

- Improvement of coastal water sampling and analysis in Region 9; and
- Training of technicians through ordinary coastal water sampling and analysis.

2) Core Center

The Core Center shall have control over all regional laboratories, including the Tampico Regional Laboratory, on the technical aspects of coastal water quality monitoring. The Core Center shall serve as:

- Reference laboratory for coastal water quality;
- Data management center for coastal water quality monitoring; and,
- Training center for coastal water quality monitoring.

(2) Cost Estimate

The total initial cost of this component is estimated to be 25.3 million as shown in Table 6.3. The annual O/M cost from 2005 to 2010 is estimated to be N$ 0.8 million. This cost is exclusive of any taxes and is estimated under the economic conditions prevailing in November 1999.

Table 6.3 Cost Estimation for Development of Tampico Laboratory and Core Center

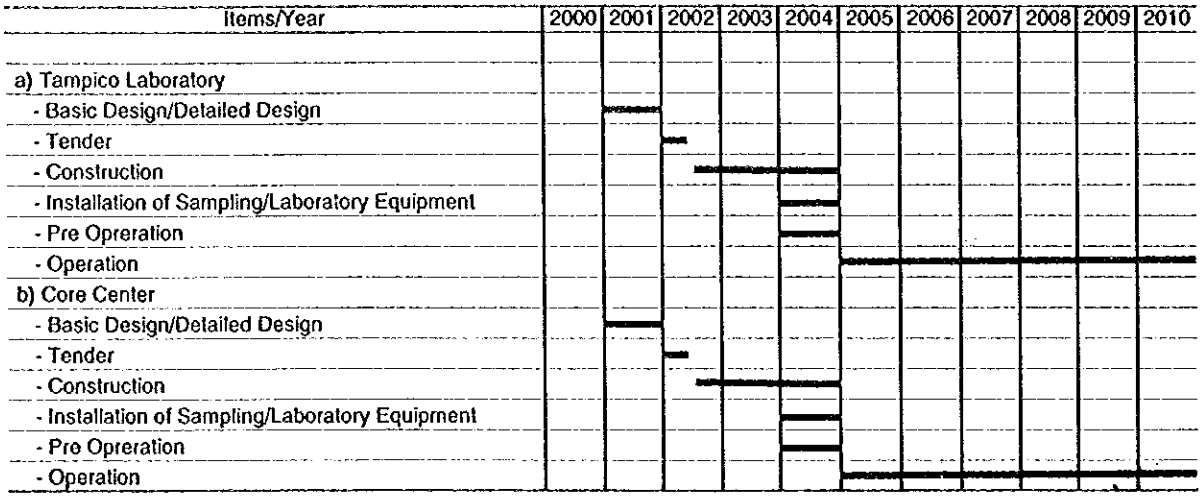
Unit: N$ million

Cost Component	Tampico Lab.		Core Center		Total	
Initial cost	13.8		11.6		25.4	
O&M cost	3.5	0.6/year	1.8	0.3/year	5.3	0.9/year
Total	17.3		13.4		30.7	

Source: JICA Study Team

(3) Implementation Schedule

The proposed implementation schedule of this component is shown in Figure 6.3.



Source: JICA Study Team

Figure 6.3 Implementation Schedule for Development of Tampico Laboratory and the Core Center