5.2.6 Results of Simulation

(1) Pueblo Viejo Lagoon

a) Water Current

Water current simulation for Pueblo Viejo Lagoon has been carried out to reproduce the diurnal current variation observed in the current survey (see Figure 5.4 (2)). The water surface elevation at the open boundary (the connection points to Panuco River) is forced by the cosine function with a period of 24 hours and a tidal range of 0.52 m. Figure 5.6 shows the simulated time series of water surface elevation in the rainy season.

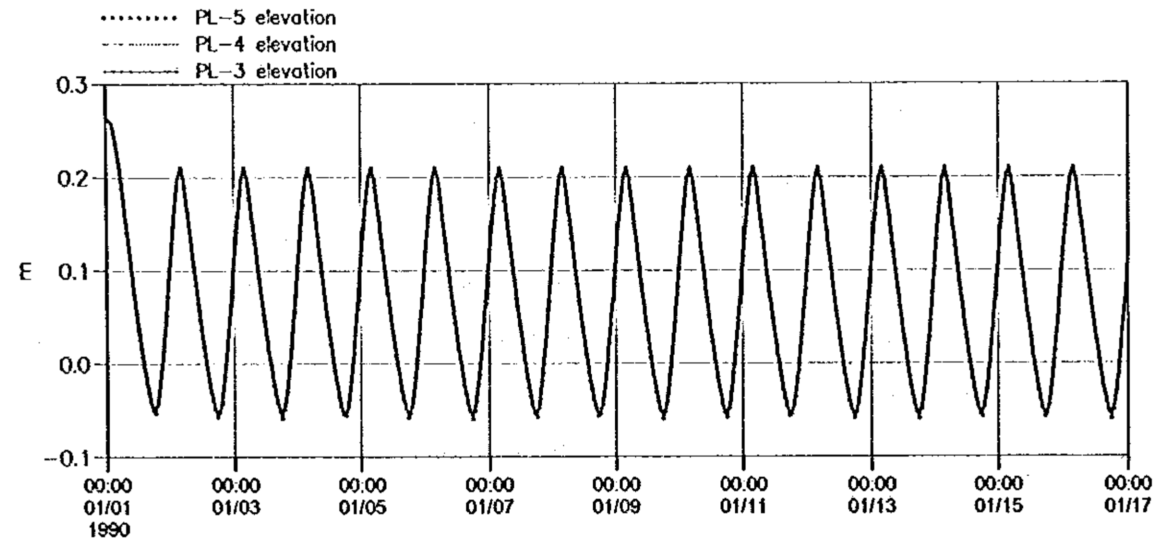


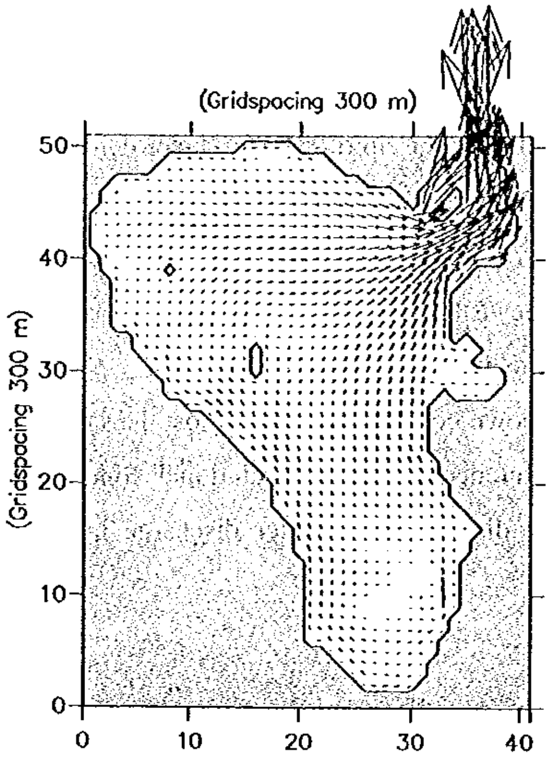
Figure 5.6 Simulated Time Series of Water Surface Elevation in Pueblo Viejo Lagoon in the Rainy Season
The location of three points, PL-3, PL-4 and PL-5, are shown in Figure 4.1(2).

Although the horizontal axis ranges from 00:00 1st to 00:00 16th January 1990, there are no meaning in these particular dates. This merely means that the time period of simulation is 15 days. The time series at the three points, the locations of which are shown in Figure 4.1(2), are almost identical. The ranges of tidal variation are almost same values of 0.26 to 0.27m after the second tidal cycle, indicating the simulation to realize the periodic stationary condition.

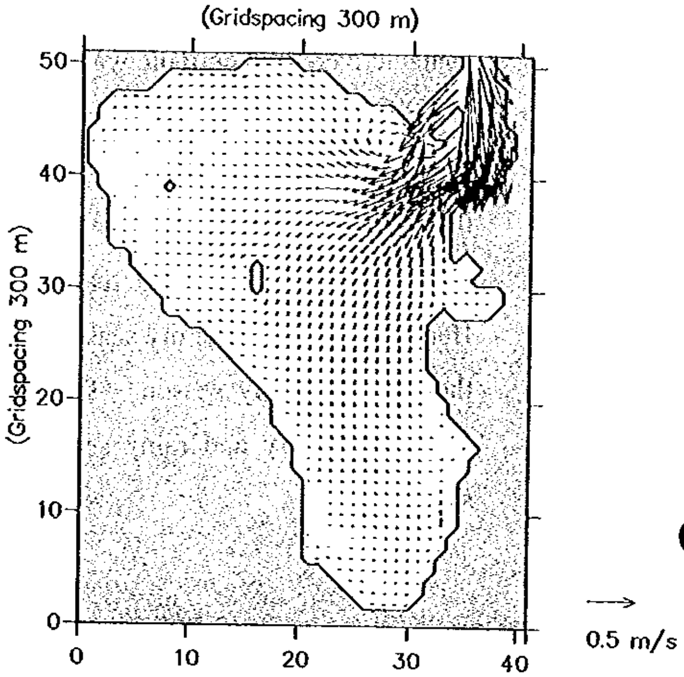
Figure 5.7 shows the simulated current fields for the ebb tide, flood tide and 24 hours mean in the rainy season. Current patterns for the ebb and flood tides are relatively simple and the current velocities are relatively strong only near the open boundary. On the other hand, the current pattern of 24 hours mean shows a relatively complex circulation. Since the posed wind direction is from near ESE, the shallower waters along the coast flows at a NNW direction. Caution should be taken that the velocities in the mean current remains much weaker compared with those in the ebb and flood tide, except near the open boundary.

Figure 5.8 compares the simulated and observed current ellipse. The tidal current is characterized by a periodic water movement, thus the tip of current vector delineates a current ellipse. In Figure 5.8 one can observe that the directions and lengths (velocity amplitudes) of long axis of the current ellipses are almost identical between the simulation and the observation. This means that the current simulation has been able to nearly reproduce the real current fields in Pueblo Viejo Lagoon.

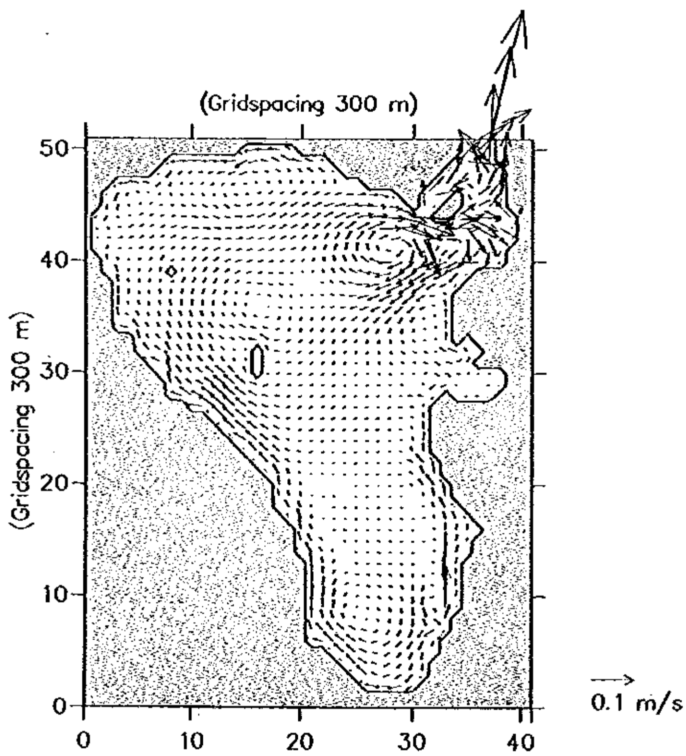
Here, the results in the dry season are not shown because they are almost the same as those in the rainy season. The only difference in the computational conditions between the dry and rainy seasons is the distinction of water discharge in both seasons.



a. Ebb tide



b. Flood tide



c. 24 hours mean

Figure 5.7 Simulated Current Fields in Pueblo Viejo Lagoon at Ebb Tide, Flood Tide and 24-hour Mean in the Rainy Season.

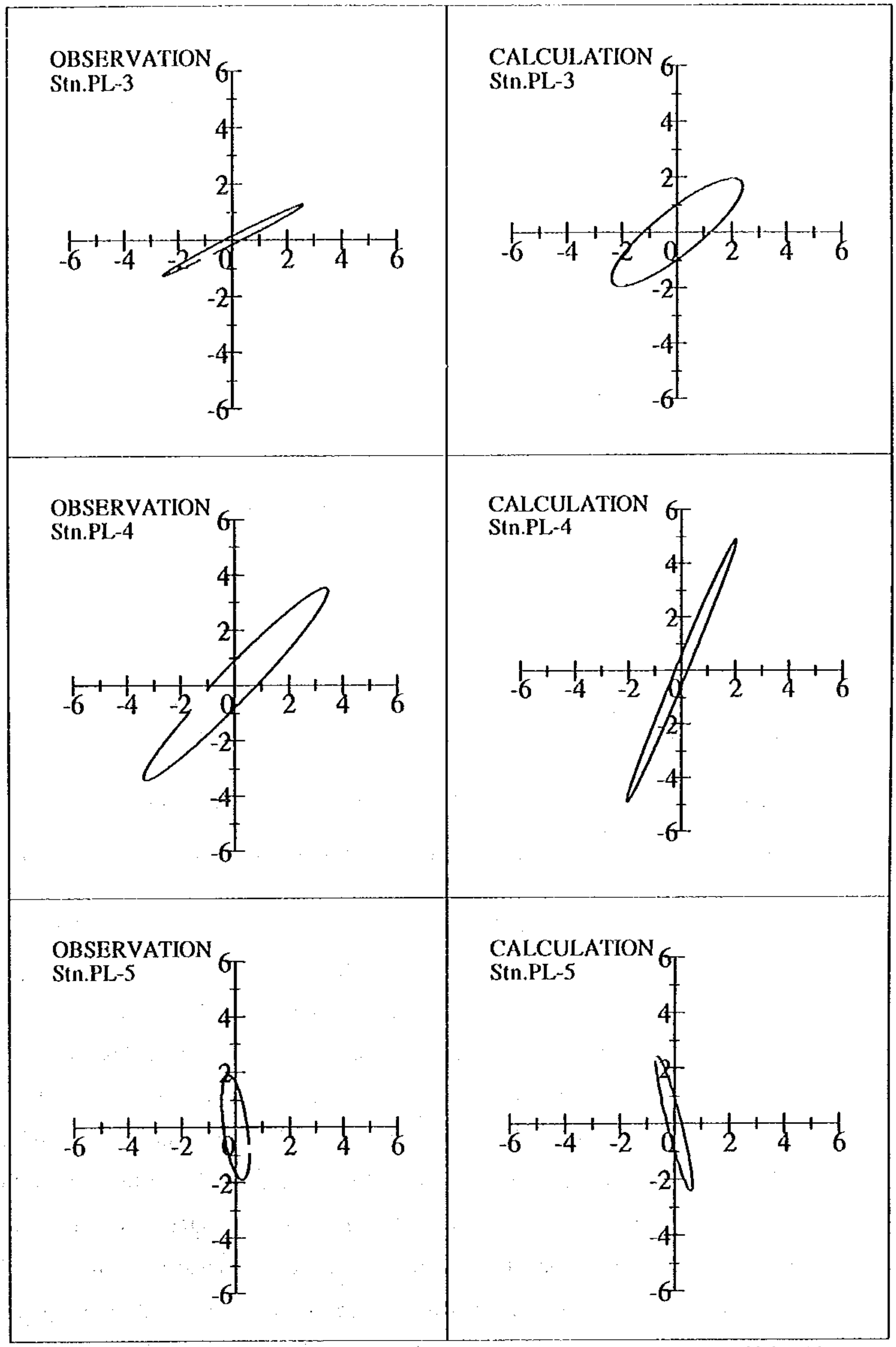


Figure 5.8 Comparison of the Simulated and Observed Current Ellipse

b) Water Quality

Water quality simulations have been carried out for the two items of total-N and COD in dry season and rainy season. Patterns of water quality distribution between the dry and rainy seasons are similar to each other, so that only the results for the rainy season are shown here.

Figure 5.9 shows the simulated time series of COD in the rainy season. There are no meaning in particular dates in the horizontal axis.

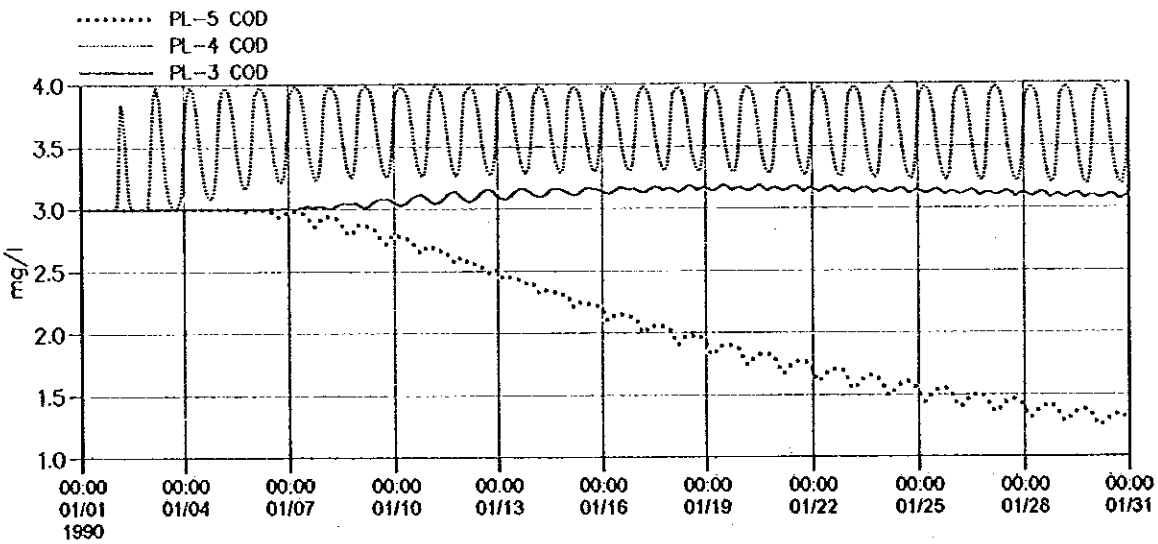
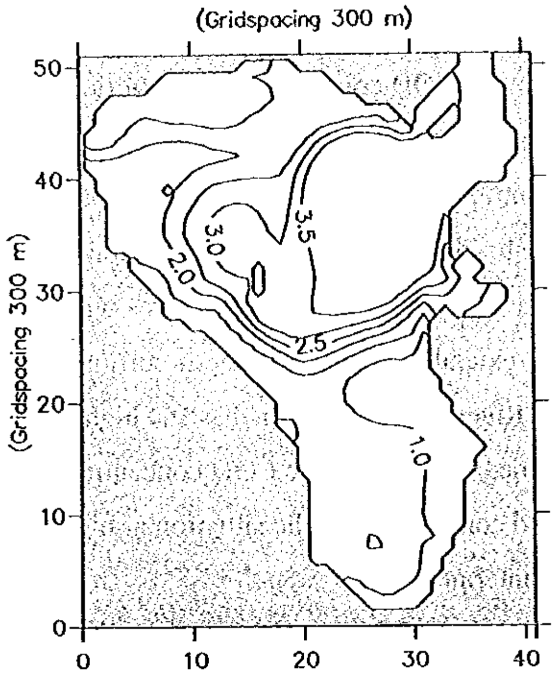


Figure 5.9 Simulated Time Series of COD Concentration in Pueblo Viejo Lagoon in the Rainy Season
The location of three points, PL-3, PL-4 and PL-5, are shown in Figure 4.1(2).

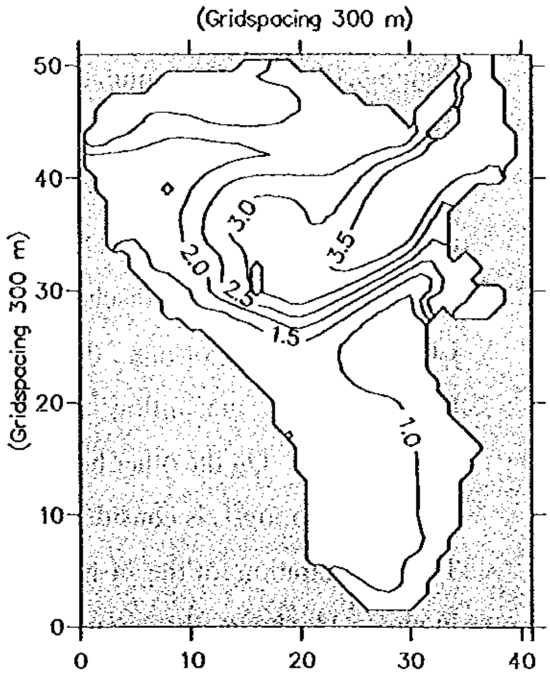
The COD concentration at PL-4, which is the nearest point to the open boundary among the three points, shows a diurnal variation ranging from 3.25 to 4.0 mg/L caused by the tide after around the seventh tidal cycle. This indicates that the simulation nearly realizes the periodic stationary condition around this area. The diurnal variations of COD concentration at other two points are smaller than that at PL-4. The concentration at PL-3 reaches nearly a stationary condition after around the 15th day. However, the concentration at PL-5 located almost at the head of the lagoon monotonously has decreased, although tending to gradually approach a periodic stationary condition. This monotonous decrease of concentration at PL-5 is caused by the discharge from Llave River which flows into the southeastern part of the lagoon. The COD concentration of the discharge is 0.7 mg/L and the water volume discharge rate is 27 m^3/s in the rainy season. Since the COD concentration is considerably smaller than the initial concentration of 3.0 mg/L set in the simulation, so that the concentration at PL-5 gradually decreased due to dilution effects from discharge.

Figure 5.10 shows the simulated distribution of COD concentration at low tide, high tide and 24 hours mean in the rainy season. The concentration of COD is high near the open boundary, with a boundary concentration of 4.0 mg/L set in the simulation, and the concentration of COD is low at the head of the lagoon due to dilution effects caused by the low COD discharge from Llave River. At high tide, an area with high COD concentration of more than 3.5 mg/L extends in the northeastern portion of the lagoon due to the inflow of Panuco River water, which has a high COD concentration. On the other hand, at low tide, an area with the COD concentration of more than 3.5 mg/L is considerably reduced compared with the situation at high tide. The concentration for the 24-hour mean is intermediate.

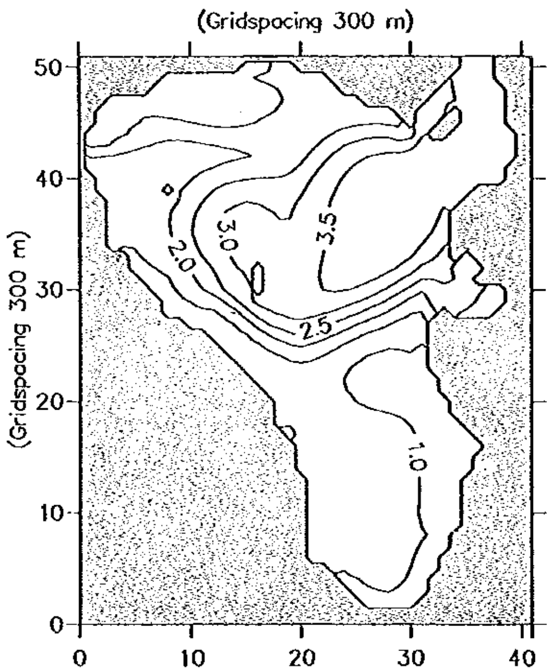
Figure 5.11 shows the simulated distribution of T-N concentration in the rainy season. The concentration is high near the open boundary, reflecting the boundary concentration of 0.7 mg/L set in the simulation, and the concentration is low at the head of the lagoon due to dilution effects caused by the low concentration discharge of 0.13 mg/L from Llave River. At high tide, an area with a high T-N concentration of more than 0.65mg/L extends in the northeastern portion of the lagoon due to the inflow of Panuco River waters, which has a high T-N concentration.



a. High tide



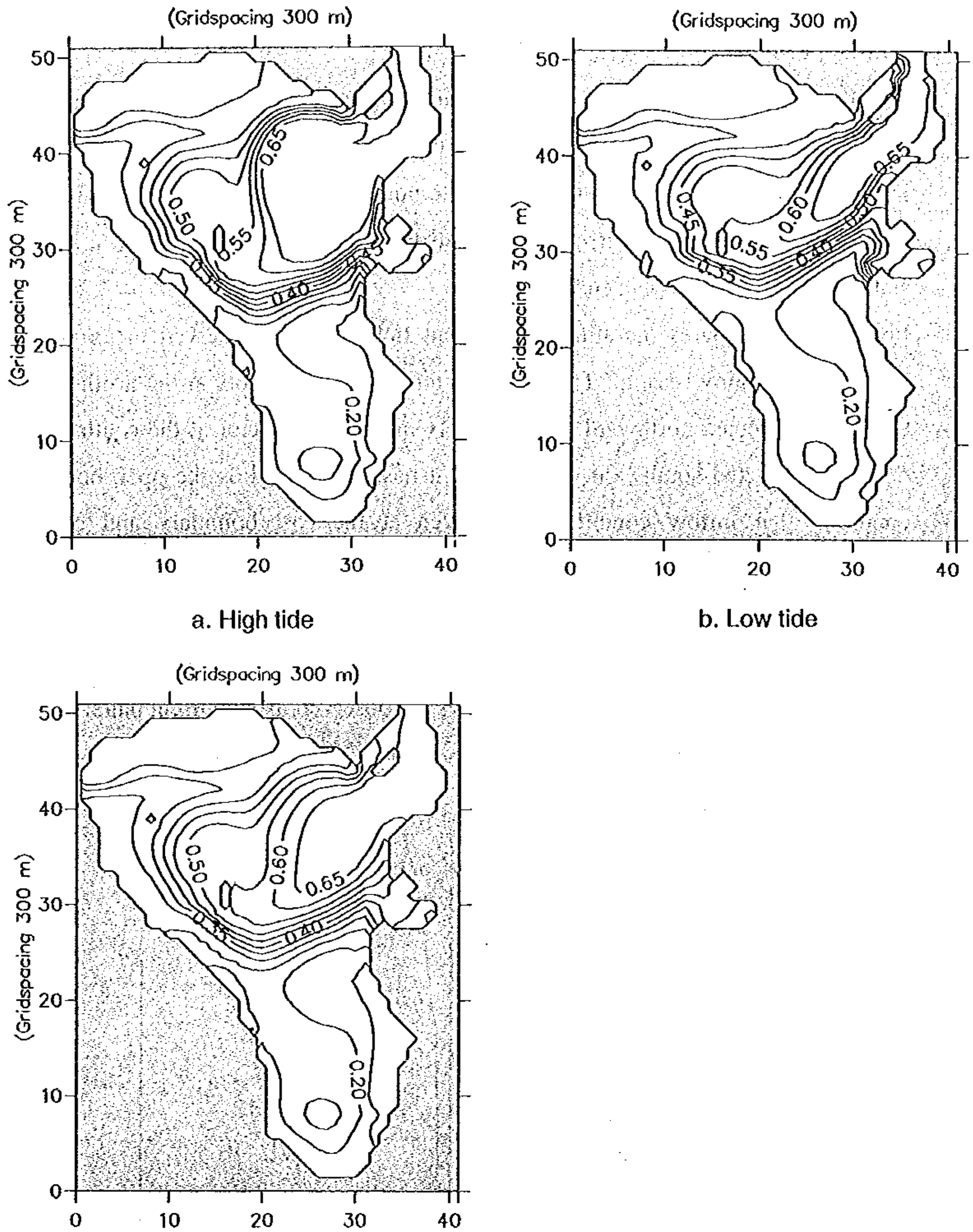
b. Low tide



c. 24 hours mean

Unit:mg/L

Figure 5.10 Simulated Distribution of COD Concentration in Pueblo Viejo Lagoon at High Tide, Low Tide and 24 Hours Mean in the Rainy Season



a. High tide

b. Low tide

c. 24 hours mean

Unit:mg/L

Figure 5.11 Simulated Distribution of T-N Concentration in Pueblo Viejo Lagoon at High Tide, Low Tide and 24 Hours Mean in the Rainy Season

(2) Coastal Water

a) Water Current

Water current simulation for the coastal water has been carried out to reproduce the 15-day mean current because the current in the coastal water is considered to be irregular with no particular periodicity. The boundary condition has been given by forcing the volume transport of water in all the open boundary points at a steady-state to reproduce the mean current pattern.

Figure 5.12 compares the simulated current field and the observed mean current vectors in the rainy season. The observed mean current vectors at the north-side is two points directed northward and, inversely, the current vector at the south-side is one point directed southward. Therefore, it has been posed as the open boundary condition that inflow conditions are given at the east boundary and outflow conditions are set at the north and south boundaries. At the north boundary, the outflow conditions mean that northward volume transport is given, and at the south boundary, southward volume transport is being set. It can be seen in Figure 5.12 that the simulated current field nearly reproduces the observed mean current pattern.

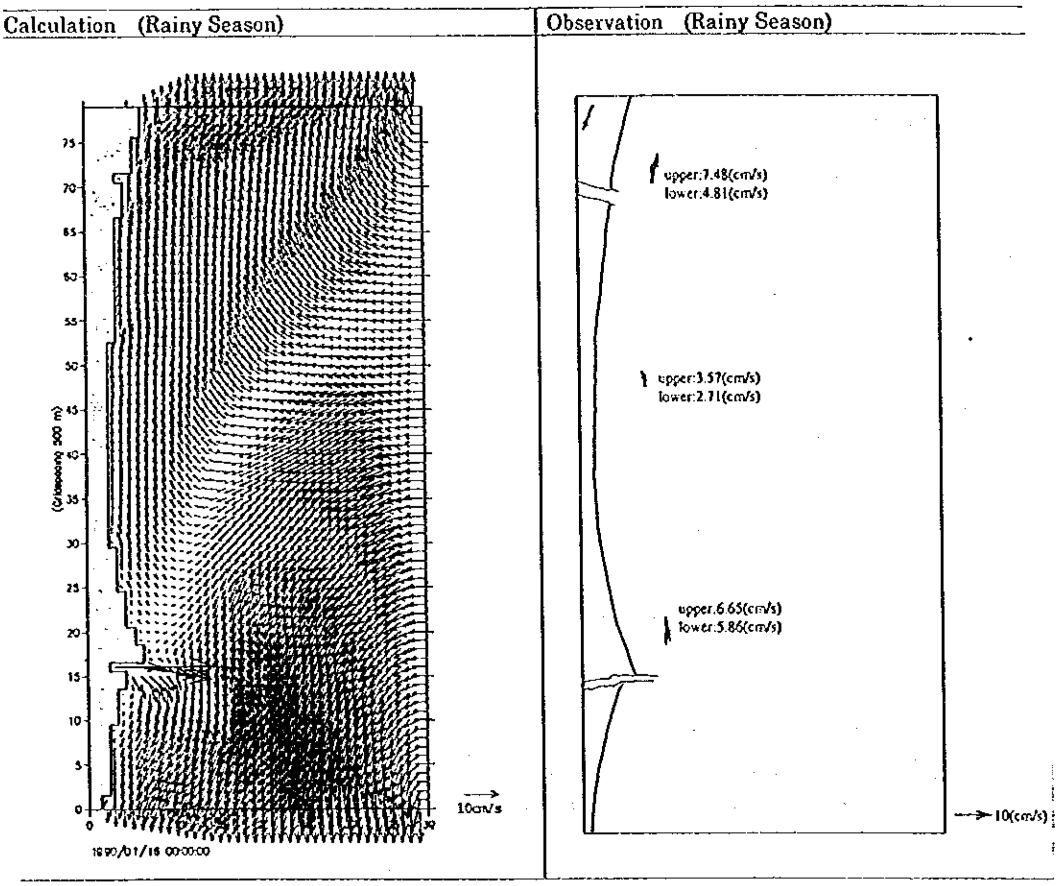


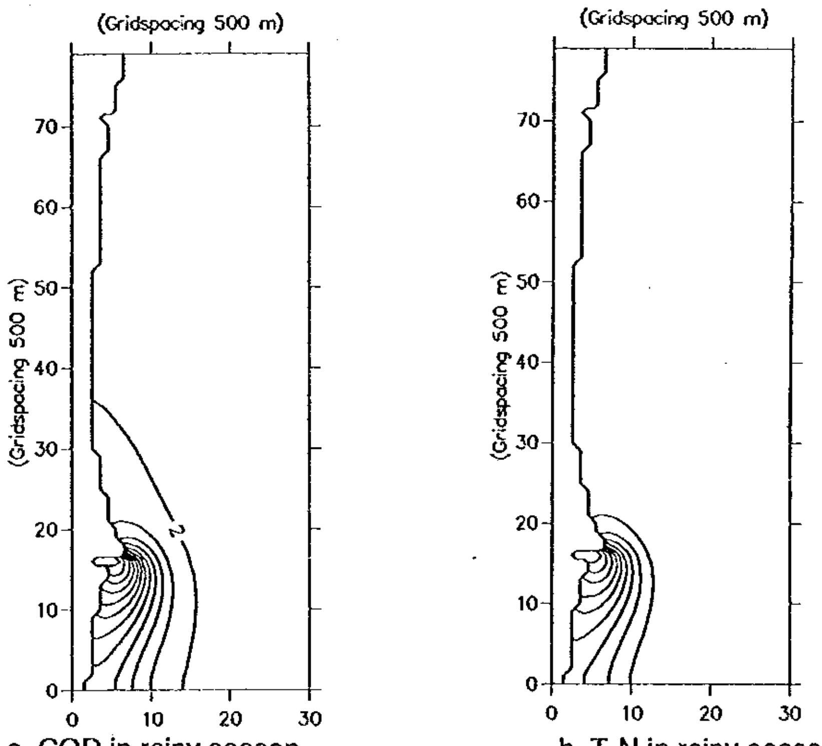
Figure 5.12 Comparison between Simulated Current Field and Observed Mean Current Vectors in the Coastal Waters in the Rainy Season

b) Water Quality

Figure 5.13 shows the simulated distribution of COD concentration in the rainy season. There is no distinction between high tide and low tide in this case because only the mean current is represented as the advection term in the coastal water quality simulation. One can see in Figure 5.13 a. that the water with high COD concentration from the Panuco River spreads mainly southward due to the advection effect of the mean current moving southward around the mouth of Panuco River. The influence of other pollution loads, aside from the discharge from Panuco River, cannot be observed in Figure 5.13 because their collective COD load of about 3 tons/day is considered insignificant compared with the discharge from Panuco River alone, which is 1,750 tons of COD per day.

Figure 5.13 b. shows the simulated distribution of T-N concentration in the rainy season. The distribution of concentration shows that high concentration from the Panuco River spreads mainly southward due to the advection effect of the mean current moving southward around the mouth of Panuco River. This result is similar to that of COD.

Other simulation results not shown herein, namely T-N and COD in the dry season, are found in the Data Book Report.



a. COD in rainy season
b. T-N in rainy season

Figure 5.13 Simulated Distribution of Concentrations in the Coastal Water

In a, the maximum contour line is 24mg/L, the minimum 2mg/L, and the interval 2mg/L.

In b, the maximum contour line is 0.38mg/L, the minimum 0.22mg/L, and the interval 0.02mg/L.

Chapter 6 Planning Policy for Coastal Water Quality Monitoring

6.1 Roles and Objectives of Coastal Water Quality Monitoring

(1) Roles

Mexico's coastal zones are rich with natural resources such as marine products, petroleum, and tourism attractions. They also provide habitats for wildlife as well as water surfaces for navigation. Thus, they present inestimable benefits to the nation. However, human activities in land and water areas have been causing negative impacts to the environment of the coastal areas. Therefore, rational environmental management of the coastal zones is much needed for their sustainable use.

Coastal Water Quality Monitoring is an indispensable element of coastal environmental management. When Coastal Water Quality Monitoring is properly planned with appropriate setting of spatial distribution of monitoring stations, monitoring parameters, monitoring period and frequency, and adequate provisions of human resources, equipment and materials, it can provide the objective information about the existing state of coastal water quality with spatial distribution and the trend of temporal changes in water quality.

Specifically, these data can be used as basis for:

- Evaluating the existing state of water quality according to applicable environmental standards, criteria and guidelines for various uses;
- Prohibiting certain uses of the coastal water or issuing warnings to users, as necessary, depending on the result of above evaluation;
- Identifying likely sources of pollution;
- Evaluating the effects of pollution control measures that have already been implemented;
- Judging the necessity of new/additional pollution control measures to protect or improve the water quality; and
- Developing appropriate water quality simulation models that can explain the mechanism of the existing pollution, and thus predict the future state of water quality corresponding to expected or planned changes of relevant conditions.

Thus, coastal water quality monitoring plays one of the most important roles in the development of a coastal water quality management plan.

Such roles of coastal water quality monitoring are depicted in Figure 6.1.

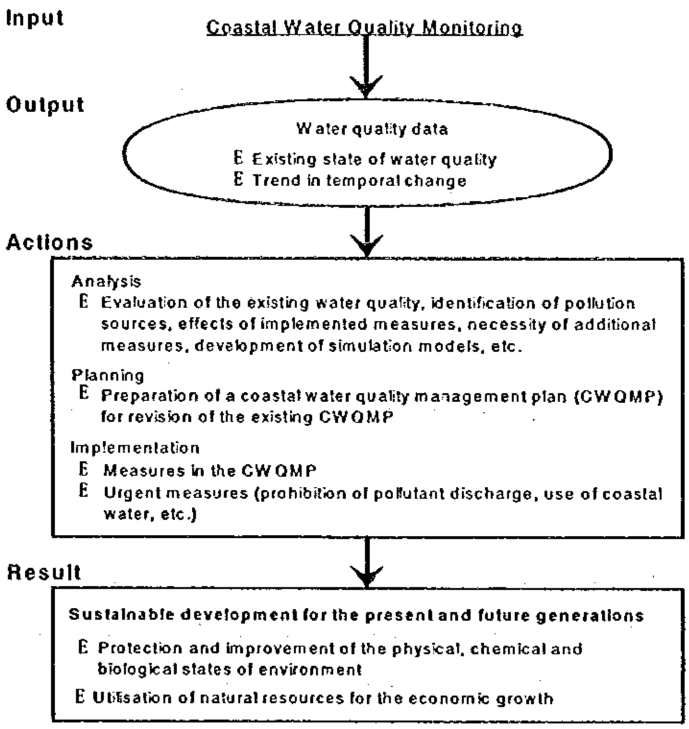


Figure 6.1 Roles of Coastal Water Quality Monitoring

(2) Objectives for Preparation of Water Quality Monitoring Plan

In order to generate monitoring results that can be used for the above-mentioned purposes, the coastal water quality monitoring plan should address the following:

- Development of a technically effective and financially efficient coastal monitoring network;
- Capability-building in sampling, analysis, laboratory management, and data interpretation of the executing body; and
- Improvement of data management system.

6.2 Necessary Conditions of Coastal Water Quality Monitoring

The three key words in Coastal Water Quality Monitoring are: continuous, consistent and extensive.

A continuous monitoring will build a database which can serve to identify environmental changes by comparing the past and present data. A consistent method of sampling and analysis will enable the comparison of data outputs. In principle, therefore, monitoring methods shall be standardized and that they should not be changed often. Covering an extensive monitoring area will enable the comparison of different areas, which is one of the objectives of monitoring work.

6.3 Implementing Agency

The National Water Commission (*Comision Nacional del Agua*), under the Ministry of Environment, Natural Resources and Fishery (*SEMARNAP: Secretaria de Medio Ambiente, Recursos Naturales y Pesca*), as a federal executive power branch, was established under the National Water Law of 1992. According to Article 9 of the National Water Law, *CNA* is responsible for the efficient uses and conservation of water through the appropriate management of water and water areas in the nation. Furthermore, the Federal Government has jurisdiction over the coastal areas of Mexico, and as stated earlier, *CNA* is responsible for the efficient use of water and its conservation. Therefore, *CNA* is duty-bound to monitor coastal water quality.

In view of expensive monitoring costs and the need for meticulous monitoring, the following two options are given: *CNA*-Initiative Management Plan and Decentralized Monitoring Program. In both cases, the obtained monitoring data should be shared by *CNA* and State Governments. The options are shown in Figure 6.2, while their advantages and disadvantages are presented in Table 6.1.

The following conditions should be followed according to the respective options:

<u>*CNA*-Initiative Monitoring Program</u>

- Monitoring capability of Regional Laboratories should be improved in the different states.
- Monitoring Site Offices should be established at priority areas.

<u>Decentralized Monitoring Program</u>

- A State Laboratory should be established in each state.
- The capability of State Laboratories should be raised at the necessary level through the registration and accreditation system of Monitoring Laboratory and License System of Ambient Water Quality Analyst.
- *CNA* should manage the State Laboratories and advise the State Governments on laboratory matters.

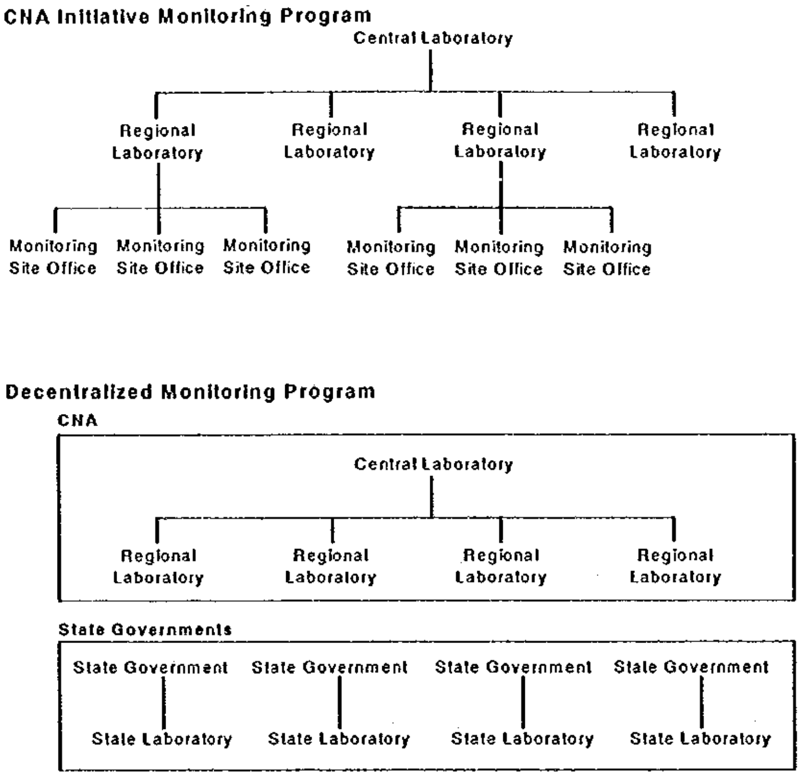


Figure 6.2 Organizational Charts for Options of National Coastal Water Quality Monitoring and Laboratory Network

Table 6.1 Options for Establishment of National Coastal Water Quality Monitoring System

Options	Advantages	Disadvantages
CNA Initiative Program	• *CNA*'s resources can be harnessed	• More equipment and human resources should be secured by *CNA* • Monitoring cost should be borne by *CNA*
Decentralized Monitoring Program	• Monitoring cost can 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

The above two options can be considered by phasing. First, *CNA* will implement coastal water quality monitoring by itself. Then, when state governments are enhanced, they will take over the implementation of coastal water quality monitoring, while *CNA* will manage the state governments and the obtained monitoring data.

CNA-Initiative Monitoring Program is loaded onto *CNA* from the viewpoint of cost. Presently, some of the areas and parameters are being monitored by other agencies such as the Ministry of Navy, Ministry of Communication and Transportation, Ministry of Health and Ministry of Tourism, so that implementation of coastal water quality monitoring can be shared by related agencies, initiated by *CNA*. However, the following conditions should be considered:

- sampling and analysis methods should be standardized based on common technical guidelines; and
- capability for coastal water quality monitoring should be kept well above appropriate levels through quality control.

Some portions of coastal water quality are proposed as shown in Table 6.2.

Table 6.2 Sharing of Coastal Water Quality Monitoring

Related Agencies	Monitoring Areas
CNA	planning, coordination monitoring for industrial areas, lagoons
Ministry of Navy	monitoring for offshore
Ministry of Communication and Transportation	monitoring for seaport
Ministry of Health	monitoring for beach for sea bathing
Institute of National Fishery (INP)	coastal lagoons which are important water areas from view point of fishery resources conservation
Ministry of Tourism	monitoring for tourism sites

6.4 Planning Concept

Coastal Water Quality Monitoring Program aims to develop and improve monitoring capability in order that the following are achieved through implementation of the program (see Figure 6.3):

- provision of usable data,
- improvement of cost performance, and
- attainment of global standards.

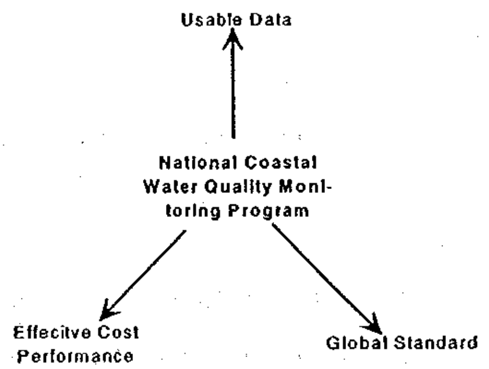


Figure 6.3 Planning Approach for National Coastal Water Quality Monitoring Program

(1) Provision of usable data

As mentioned earlier, coastal water quality monitoring provides information for coastal environmental management. Therefore, the obtained data should not only be accurate and precise; they should also be properly compiled into usable form for environmental management purposes.

(2) Improvement of cost performance

It may seem, in general, that Coastal Water Quality Monitoring does not generate money, and that it requires expensive equipment and trained human resources for adequate environmental monitoring. However, environmental monitoring contributes indirectly to the national economy through the enhancement of environmental management. The term cost performance is interpreted two ways: reduction of cost and improvement of performance:

Reduction of cost

Data from environmental monitoring are used to identify the tendency to change in water quality, and to compare environmental or critical standards. Therefore, there is no need for minute figures requiring the use of high technology equipment.

Sampling and water quality method should be standardized in order that equipment and reagents common to both can be utilized. The cost of environmental monitoring can be reduced through standardization of monitoring method.

Improvement of performance

It can be said that obtained data from monitoring are valuable, if the said data can be used for several purposes. Performance of Coastal Water Quality Monitoring can be improved through provision of information for conservation of ecosystem, management of fishery resources and tourism resources and others. Therefore, data compilation should be considered in Coastal Water Quality Monitoring Program.

(3) Attainment of a global standard

The shorelines of Mexico face the Pacific Ocean, Gulf of Mexico and the Caribbean Sea. Its neighboring countries are the USA and Guatemala in the Pacific side, and the USA and Belize in the Caribbean side. In the future, it will be necessary to provide monitoring data for international concerns. Therefore, sampling and analytical methods should be of international standard so that neighboring countries can use them, and a suitable monitoring system should be developed to enable comparison with international monitoring data.

6.5 Monitoring Components

(1) Monitoring Areas and Samples

Coastal Water Quality Monitoring Program covers water areas in the coastal zone as follows:

- coastal water areas affected by human activities or natural processes from land,
- coastal lagoons,
- rivers, from river mouth to upper stream, until the point where it is affected by sea water, and
- sea ports.

There is no definition of "coastal water" in Mexico. However, it can be defined as coastal water for water quality monitoring 5 to 10 km from the shoreline, depending on shoreline forms. Coastal water quality monitoring provides information for identification of changes caused by pollution from the land, and changes in environment for fishery resources.
Water and sediment samples should be taken from water bodies of the above areas.

(2) Necessary Parameters

Monitoring components measure the quality of water bodies from a chemical aspect. Physical indices, such as hydrological conditions, are not included. Although there is a biological index in monitoring parameters, aquatic organisms, such as fishes, plankton and benthos, are not included. Biological conditions in coastal water are identified indirectly by DO, nitrogen, phosphate and chlorophyll. In the future, however, biological monitoring will be required from the viewpoint of coastal ecosystem so that *CNA* needs to develop biological monitoring skills for plankton, benthos and seagrass, which will take a considerable amount of time.

(3) Arrangement for Monitoring Stations

In principle, coastal water quality monitoring covers the coastal area of the whole nation. However, priority areas for monitoring are recommended. In the first phase, monitoring will be started at priority areas, then expanded to other areas. The following priority areas are recommended:

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

(4) Monitoring Frequency

It is required to take note of seasonal changes and accumulation of pollution from the monitoring data. Changes in coastal environment are related to seasonal climate changes. Coastal environmental impact caused by human activities should also be identified through water quality monitoring so that profiling based on seasonal changes of coastal environment can be developed. Parameters that are sensitive to seasonal changes should be monitored. Furthermore, parameters that identify the accumulation of pollution loads should be monitored at distinctive periods, i.e. dry season and rainy season.

Chapter 7 Guidelines for National Coastal Water Quality Monitoring

7.1 Purpose and Use of Guidelines

(1) Purpose of the Guidelines

The Guidelines for National Coastal Water Quality Monitoring advise the methodology on water quality monitoring in Mexican coastal areas nationwide. The Guidelines are based on the coastal water quality monitoring policy discussed in Chapter 6. The National Coastal Water Quality Monitoring is aimed at identifying the tendency of coastal environmental changes caused by human activities and natural processes.

(2) Use of the Guidelines

Although the Study Team has prepared a Coastal Water Quality Monitoring Plan for Tampico Area, as discussed in Chapter 8, the National Coastal Water Quality Monitoring Plan will not be prepared by the Study Team; instead, it will be prepared by *CNA* using the above mentioned Guidelines. *CNA* is to conduct a preliminary field survey, much like the one conducted for the Pilot Monitoring of Tampico Area, and utilize the information from the said survey to come up with the Guidelines. Afterwards *CNA* is to prepare a Coastal Water Quality Monitoring Plan based on the body of data from the preliminary field survey. In this manner, the monitoring coverage area could be expanded to other coastal areas in Mexico.

The preliminary field survey aims to identify the environmental conditions of coastal areas. The result of the preliminary field survey can be used for the design of monitoring stations, monitoring parameters and monitoring frequency, and support decision-making on special monitoring programs. Survey items of the preliminary field survey consist of hydrological condition, water quality, sediment, plankton and benthos.

(3) Structure of the Guidelines

The Guidelines cover the following six components:

- Laboratory Network
- Sampling
- Laboratory Management
- Data Management
- Human Resource Development
- Special Monitoring Plan

The structure of the six components is shown in Figure 7.1. Components of sampling and laboratory management include monitoring equipment management.

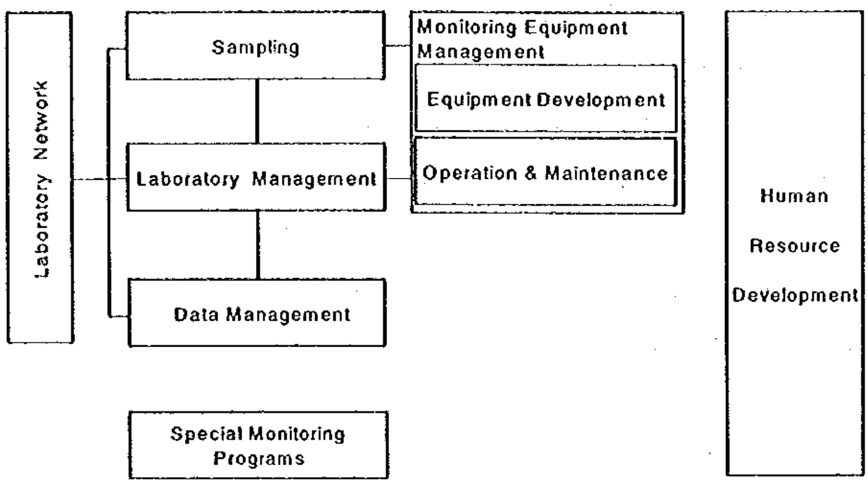


Figure 7.1 Structure of Coastal Water Quality Management Guidelines

7.2 Monitoring Areas

In principle, coastal water quality monitoring covers the coastal areas of Mexico, which include coastal waters, coastal lagoons, rivers (from river mouths to upper streams until the areas affected by seawater), and seaports. It is not reasonable, however, to monitor these coastal areas uniformly, which is the practice at present, from the viewpoint of cost performance. It is more logical to set up priority areas for monitoring. The Study Team recommends that in the first phase, monitoring be started at the priority areas, and later on, expanded nationwide. Also, that the monitoring frequency of the priority areas be higher than the other areas. Following are the recommended priority areas:

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

The priority areas are indicated in Table 7.1 and Figure 7.2.

Table 7.1 Proposed Establishment of Monitoring Site Offices

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	1) Ensenada	Fishery
					2) San Quintin	Fishery
				- Guerrero Negro	3) Santa Rosalia	Fishery
					4) Guerrero	Fishery
					5) Bahia	Fishery
				- La Paz (present State Lab)	6) Los Cabos	Fishery, Tourism
					7) La Paz	Fishery, Tourism
2	2	Hermosillo	0		8) Guyamas*	Fishery
3	3	Culiacan	1		9) Topolobampo*	Fishery
				- Mazatlan	10) Mazatlan	Fishery , Tourism
4	4	Cuernavaca	1	- Lazaro Cardenas	11) Lazaro Cardenas	Fishery, Industry
5	5	Oaxaca	2		12) Puerto Escondido*	Tourism
					13) Puerto Angel*	Fishery
				- Acapulco (present State Lab)	14) Zuhuatanejo	Tourism
					15) Acapulco	Tourism
				- Salina Cruz	16) Salina Cruz	Fishery, Industry
6	8	Guadalajara	2	- Tepic (present State Lab)	17) San Blas	Fishery
					18) Puerto Vallarta	Tourism
				- Colima (present State Lab)	19) Manzanillo	Tourism, Industry
7	9	Tampico	1		20) Tampico*	Industry, Tourism, Fishery
				- La Pesca	21) La Pesca	Fishery
8	10	Xalapa	2		22) Nautla*	Fishery
					23) Tuxpan*	Fishery
					24) Tecocutla*	Fishery
				- Veracruz	25) Veracruz	Fishery, Tourism
					26) Alvarada	Fishery
				- Forin de las Flores (present State Lab.)	27) Coatzacoalcos	Fishery
					28) Minatitlan	Industry , Fishery
						Industry
9	11	Tuxtla-Gutierrez	2	- Villahermosa (present State Lab.)	29) Mecoacan-Machona	Fishery
				- Tapachula	30) Mar Negro	Fishery
					31) Tapachula	Fishery, Industry
10	12	Merida	2		32) Progreso-Celestum*	Fishery
				- Campeche (present State Lab.)	33) Cd. Del Carmen	Fishery
					34) Laguna de Terminos	Fishery
				- Cancun (present State Lab.)	35) Cancun	Tourism
					36) Isla Mujeres	Fishery , Tourism

Source: JICA Study Team
Note: The sampling and analysis of the Priority Areas* are conducted by each Regional Laboratory.

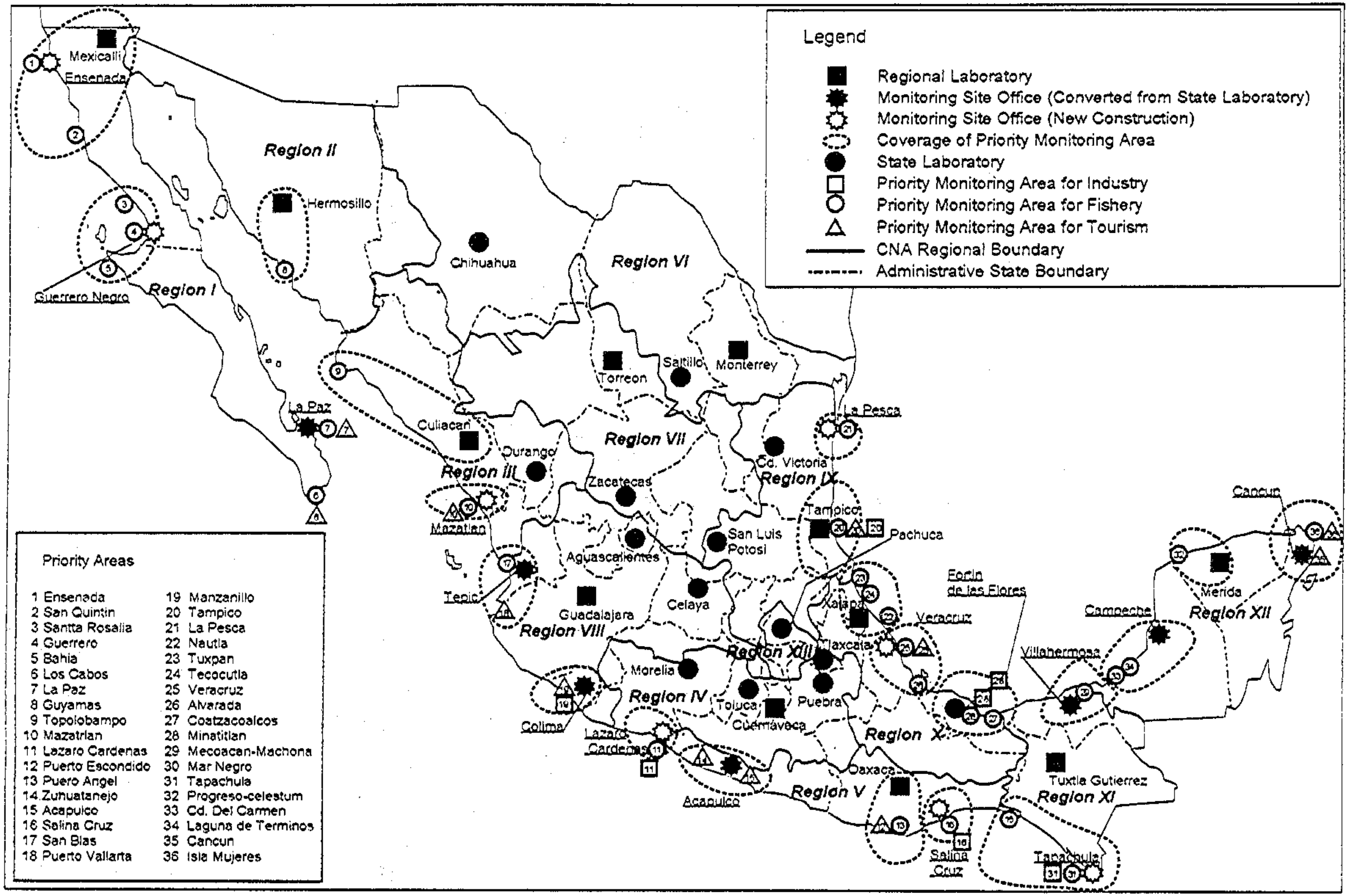


Figure 7.2 Proposed Priority Monitoring Areas and Laboratory Network for Coastal Water Quality Monitoring

7.3 Monitoring and Laboratory Network for Coastal Water Quality Monitoring

(1) Pre-Conditions of Planning

The concept of Monitoring and Laboratory Network for coastal water quality monitoring is prepared based on the assumption that the Core Center for Coastal Water Quality Monitoring will be established as the central office of National Coastal Water Quality Monitoring. The Core Center for Coastal Water Quality Monitoring shall have the following functions:

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

(2) Functions of Organizations

The relevant organizations for coastal water quality monitoring are as follows:

- Central Laboratory
- Core Center for Coastal Water Quality Monitoring
- Regional Laboratory
- Monitoring Site Office

The functions of the above organizations in coastal water quality monitoring are shown in Table 7.2. The Central Laboratory will handle water quality monitoring not only for coastal water but also for fresh water, such as lakes/reservoirs, rivers, and groundwater. On the other hand, the Core Center will only manage coastal water quality monitoring as a part of water quality monitoring. The Central Laboratory will formulate a general water quality monitoring plan, and manage an integrated water quality database on fresh water and coastal water. The Core Center will be responsible for securing the necessary coastal water quality monitoring level of *CNA*, as well as manage the data on coastal areas. It is recommended that the Core Center provide the necessary information on Mexican coastal environment to decision-makers for formulation of coastal management policy. Therefore, the Core Center needs to build its capability to process and assess data, as well as to develop skills on research and development.

The flows of equipment and information should go through the Core Center. Mexico has more than 11,000 km of shoreline, but it is only the Regional Laboratories that monitor the coastal zone nationwide. It is recommended that Monitoring Site Offices be established under Regional Laboratories (see Figure 7.3). A Regional Laboratory can monitor its area of responsibility, including planning of monitoring activities, taking of samples and analysis. In strategic areas, including urban areas, industrial areas, fishing grounds and remote areas where monitoring is also required, Monitoring Site Offices will be set up. Monitoring Site Offices can take and analyze samples at field offices. Sensitive parameters--those which easily produce changes in water quality such as pH and DO, and filtration of SS and chlorophyll-a--can be analyzed by Monitoring Site Offices, where simple laboratory equipment are to be set up. Other parameters are to be sent to a Regional Laboratory from a Monitoring Site Office (see Figure 7.3). It is recommended that 16 Monitoring Site Offices be established at strategic places for coastal water quality monitoring. It is a priority that the eight existing State Laboratories belonging to *CNA* are re-established as Monitoring Site Offices, so that existing *CNA* resources including human resource, building and equipment can be utilized. Proposed locations of Monitoring Site Offices are also shown in Table 7.1 and Figure 7.2.

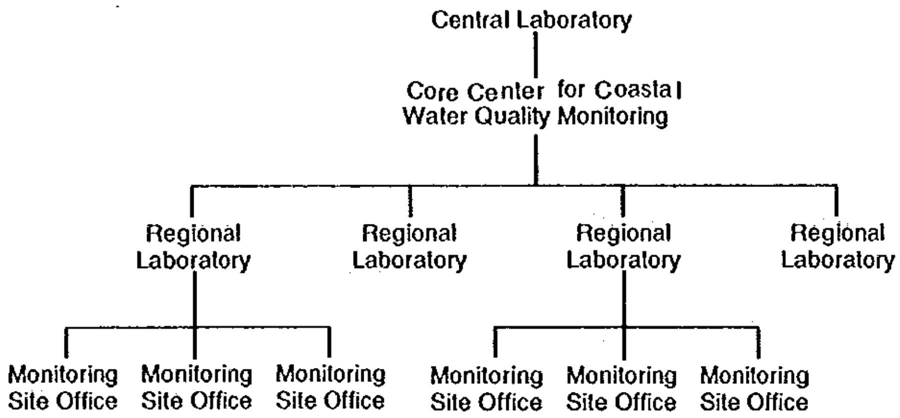


Figure 7.3 Monitoring and Laboratory Network

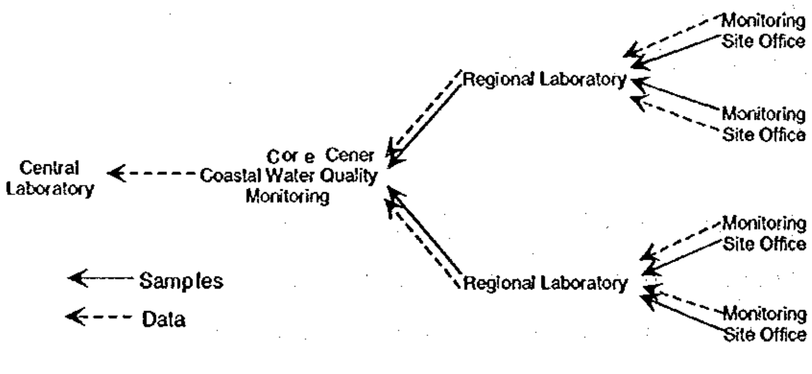


Figure 7.4 Flow of Samples and Monitoring Data

Table 7.2 Functions of Organizations for Coastal Water Quality Monitoring

Organizations	Central Laboratory	Tampico Core Center for Coastal Water Quality Monitoring	Regional Laboratory	Monitoring Site Office
Functions	• to formulate Coastal Water Quality Monitoring Plan • to provide monitoring equipment • to integrate monitoring data	• to provide technical assistance to Regional Offices and Monitoring Site Offices • to compile and evaluate obtain data • to provide environmental information for decision-makers • to train persons who are in charge of coastal water quality monitoring • to implement quality control of Regional Laboratories • to analyze toxic substances and trace substances • to prepare Special Monitoring Programs	• to manage Regional Laboratory • to take samples • to analyze sea water and sediment • to send obtain data to Tampico Core Center • to manage Monitoring Site Offices	• to take samples • to analyze some of basic parameters • to send sample to Regional Laboratory

7.4 Monitoring Components

7.4.1 Sampling

Water bodies are affected by various factors. Furthermore, there is no such thing as uniformity in the various water areas; there are concentration gradients horizontally and vertically which need to be identified.

(1) Sampling Layers

For water quality monitoring, samples are taken from surface water in general. However, vertical profile should be considered especially in the coastal areas and deep lakes. The drawing of water samples from two layers is recommended for Coastal Water Quality Monitoring based on the influence of river water and biological reaction. There is an active layer from the viewpoint of biological process called photosynthesis reaction that has an effect on the surface layer.

As a consequence of the above, the lower layer is set 10 m below surface water, at which point, it is assumed that the water is not overly affected by freshwater and biological processes. However, in the shallow water area not more than 11 m in depth, water samples should be taken 1 m from the seabed and the riverbed because drifting mud could have contaminated the water close to the seabed and riverbed.

Therefore, for sediment sampling, it is important to note that the top sediment has an effect on the lower water layer due to the accumulation of pollution from sea and land. The quality of top sediment provides information on the characteristics of water areas and historical data on pollution.

(2) Monitoring Stations

Distribution of sampling stations will have to depend on shoreline form. There are two ways of distributing sampling stations: by mesh pattern or by radial pattern (see Figure 7.6). The former is suited for a coastal area without river mouth, such as a plain shoreline, and the latter, around a river mouth.

It is recommended that monitoring stations be established to provide background information on monitoring areas, which can then give an indication of a tendency to change by natural process. These stations should be located in areas unaffected by human activities from land, and by river water.

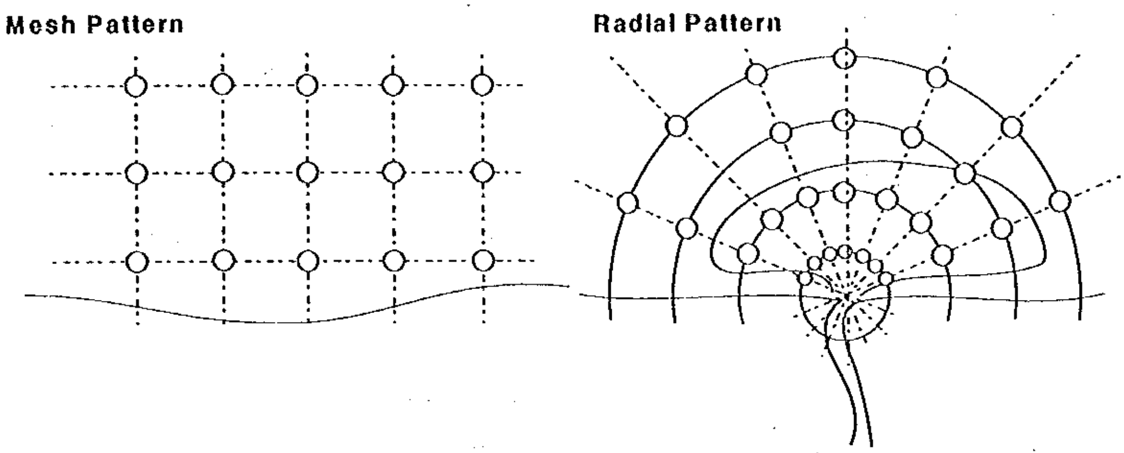


Figure 7.5 Distribution of Monitoring Stations

(3) Monitoring Frequency

The importance of frequency in monitoring is borne out by the fact that environmental changes might not be detected when monitoring is carried out at long intervals. On the other hand, frequent monitoring is very costly. There is a need to strike a balance between performance and cost when deciding on monitoring frequency.

Monitoring frequency also depends on the parameters to be monitored. The monitoring of basic parameters leads to the identification of the characteristics of and seasonal changes in water quality. Meanwhile, monitoring of toxic parameters aims to identify the accumulation of pollution. Therefore, basic parameters of water quality are to be monitored every two months, while toxic parameters are to be monitored twice a year, in dry season and rainy season.

Sediment analysis gives the historical changes in environment and pollution. Sediments do not undergo drastic changes, so that it can also be monitored twice a year, in dry season and rainy season.

7.4.2 Monitoring Parameters

It is important that water quality monitoring is continued and expanded nationwide following a water quality monitoring policy. Therefore, monitoring parameters should be selected based on funding constraints. When environmental changes or pollution are identified through monitoring, a special monitoring program and/or special survey are conducted including specific parameters. For example, in case a high concentration of mercury is identified, alkyl mercury is to be analyzed.

The proposed monitoring parameters for water quality and sediment are shown in Table 7.3. For water quality, monitoring parameters are divided into two: basic parameters and toxic parameters. Basic parameters are also divided into four indices: physical index, basic water quality index, eutrophication index and pollution index (see Figure 7.6). Basic parameters indicate seasonal changes and water pollution caused by human activities such as dumping of organic matter. Analytical methods for water quality and sediment are shown in Chapter 2 of Supporting Report.

Table 7.3 Monitoring Parameters

Sampling	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, sediment particle size distribution, Ignition loss, COD. sulfide
	Toxic Parameters	Cd, Pb, Cu, Zn, T-Hg, As, Cu

Source: JICA Study Team

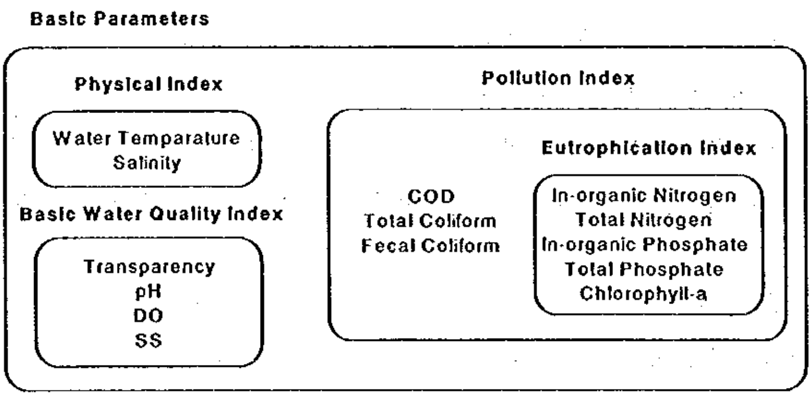


Figure 7.6 Components of Basic Parameters (Water Quality)

7.4.3 Laboratory Management

Laboratory Management covers the following::

- organizational structure,
- building,
- facilities,
- reagent management,
- solid waste management, and
- wastewater management.

(1) Organizational Structure

Three sections shall be established in a Regional Laboratory; namely, Administration Section, Planning Section and Sampling/Analysis Section, as shown in Figure 7.7 and Table 7.4. A Head shall be appointed to supervise a Regional Laboratory. The Administration Section shall be responsible for administrative matters pertaining to the management of the laboratory, including the Monitoring Site Office. The Planning Section, which shall handle monitoring plans and data management for coastal areas, shall prepare and submit Monitoring Reports, among other documents, to the Core Center. The Sampling/Analysis Section shall implement monitoring, including preparation and implementation of monitoring. This section shall also be responsible for the maintenance of monitoring equipment for sampling and analysis.

(2) Building

The proposed design concept of a Regional Laboratory is presented in Table 7.5. The required area for a Regional Laboratory building is 1,000 m^2 with 5 to 6 laboratory rooms, each one measuring about 50 to 60 m^2. Air conditioning should be controlled in order to maintain an appropriate temperature and measurement of dust in the laboratory rooms. Sunlight affects analysis activities and laboratory equipment; therefore, laboratory rooms should be protected from direct sunlight by window shades. Inside laboratory rooms, side tables are to be placed at corners with provision of gas tube and electricity, and supply and drainage of water. The main analytic table at the center of the room should also be provided with the same equipment. Distance between the central main table and corner tables is such that it can accommodate a workspace for two persons.

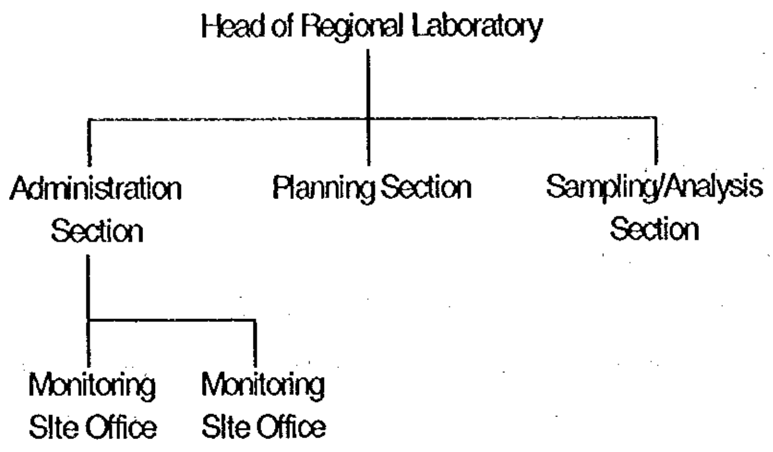


Figure 7.7 Proposed Organizational Chart of a Regional Laboratory

Table 7.4 Functions of the Different Sections in a Regional Laboratory

Sections	Administration Section	Planning Section	Sampling/Analysis Section
Functions	• to manage building and facilities • to manage personnel • to manage budget and accounting • to manage monitoring equipment • to manage laboratory property • to control Monitoring Site Offices	• to prepare a monitoring plan • to compile data • to prepare Monitoring Reports	• to take samples • to analyze sample • to maintain monitoring equipment • to manage quality control

Source: JICA Study Team

Table 7.5 Design Concept of Laboratory Building

Items	Requirement
Size of area	1,000 m^2 and parking area
Room Arrangement	(1) room (s) for analyses of basic parameters (filtration of samples, analyses of COD and DO etc.) (2) room (s) for decomposition of organic substances as a pretreatment of analyses (3) room (s) for extraction processes with solvents (4) room (s) for instrumental analyses (Spectrophotometer, TOC analyzer, auto-analyzer, Atomic absorption spectrometer, Gas chromatograph) (5) room (s) for analyses of basic parameters for sediments (particle size, ignition loss, specific gravity etc.) (6) room (s) for bacteria, biochemical and bacteriological analyses (7) room (s) for microbalances, which are placed on the anti-shock table, under controlled temperature (8) room (s) for storage of samples (9) room (s) for management and staff (10) meeting room (11) library
Laboratory Infrastructure	(1) suitable electricity (2) water supply with appropriate water pressure (3) air conditioner (4) appropriate lighting (avoid direct sunlight from outside)
Laboratory Facilities	(1) laboratory waste bins (for separation of laboratory equipment) (2) laboratory wastewater treatment facilities

Source: JICA Study Team

(3) Reagent Management

Sample are to be analyzed very carefully because a contaminated or deteriorated reagent can be a cause of incorrect data. Some of the analytical reagents are combustible, explosive and harmful. Therefore, analytical reagents should be strictly managed.

a) Storage of reagent

Analytical reagent should be stored in a cool dark place. It should be kept in earthquake-proof shelves or cabinets in a storage room, with readily available fire extinguishers. A Chief of Sampling/Analysis Section should control reagents in stock. The storage room should also be locked at all times.

b) Procedure for receiving analytical reagents from storage

The Chief of Sampling/Analysis Section should approve all requests for reagents from analysts. Any withdrawal of reagents from stock should be properly recorded in a Reagent Management Recording Book. The whole procedure is clearly explained by Figure 7.8.

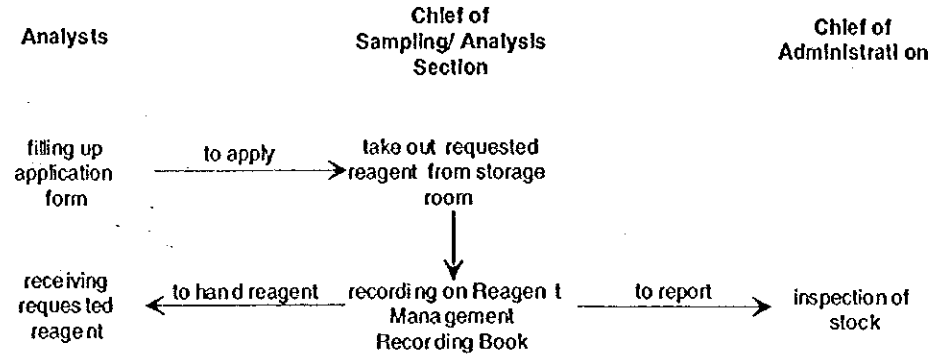


Figure 7.8 Procedure of Request for Analytical Reagent

(4) Wastewater Management and Solid Waste Management

a) Policy of Wastewater Management

It is ironic that after water pollutants are analyzed in laboratories, these same substances are discharged back to the environment. Therefore, in the conduct of analysis, there are two vital points to be considered:

- Limit the use of toxic substances
- Keep the discharge of waste to as minimum as possible

With the above in mind, the following describes the management of pollutants from a chemical laboratory.

Reduction of pollutants

In chemical analysis, various reagents are used, including toxic matter. It is therefore important to reduce the quantity of reagent to be used. A most effective way to reduce the use of reagents is to reduce the amount of sample for analysis. Therefore, it will be necessary to choose a highly sensitive method and equipment.

In this study, ascorbic acid was used rather than tin chloride in the analysis of phosphate phosphorous and total phosphorous. Also, for analysis of COD, the use of mercury chloride was avoided by using the alkaline potassium permanganate method.

Non-discharge of pollutants

The waste substance taken out from the laboratory takes the following three forms:

- Gas,
- Solution, and
- Solid.

Processing corresponding to each form is required.

b) Gaseous waste

Gaseous waste mainly consists of acid steam and offensive odor. An exhaust system should be installed in the laboratory to eliminate odor

c) Wastewater

Wastewater discharged from a laboratory is made up of organic solvent and aqueous solution.

Processing is comparatively simple for the organic solvent, especially for a chemical compound of carbon, hydrogen and oxygen. Although the simplest method is by burning, this poses a threat to human health.

In recent years, studies have indicated that burning organochlorine compounds gives rise to the emission of dioxin, a deadly poison. The processing of these waste materials in a laboratory is quite difficult; appropriate facilities are required. It is necessary that they be stored until they are taken back to the facilities for processing. At the time of storage, it is extremely important to:

- separate waste solvent by kind;
- use an appropriate vessel, preferably glass or metal, which is not easily corroded/damaged;
- stock toxic waste material inside a safe house; and
- mark used volume and stocked volume, as they differ in emission level to the environment.

Processing of aqueous solution should be carried out in proportion to each material contained therein. The solution is normally divided into the following:

- Acid and alkaline water,
- Wastewater including heavy metals,
- Wastewater including other inorganic matter, and
- Wastewater including organic matter.

Procedure of wastewater treatment is described in the Supporting Report.

It is desirable to connect the installation of wastewater treatment systems in order to closely watch and observe the treatment process. However, this requires considerable cost. Though it is desirable that it is installed in a laboratory, fractionation processing by hand is introduced as a present means. In this report, activated sludge treatment system is too complicated to be examined in detail; it requires further examination.

Management of wastewater by type is discussed here independent of any other considerations. A concrete example of wastewater processing is shown in Table 7.6.

Table 7.6 Concrete Example of Wastewater Processing

Type of wastewater	Procedure
Acid solution	Neutralized with alkaline water such as sodium hydroxide.
Alkaline solution	Neutralized with acid water such as hydrochloric acid
Heavy metal solution*	Chemical coprecipitation with another metal compound such as iron chloride.

Source: JICA Study Team
* Mercury is not included.

On wastewater management, attention should be given to the following;

- To record all processes, and
- To self-check wastewater quality.

In a record of wastewater management, the following should be included:

- Date
- Type of wastewater (analytical parameter)
- Volume
- Method of treatment
- Name of person handling treatment and others

Samples of wastewater are to be taken regularly in order to measure its toxicity and to grasp the condition of wastewater. It is also desirable to measure some parameters, such as pH, which is easy to monitor.

d) Solid Waste

Solid waste is generously classified into the following two kinds;

- Remains of solid samples, and
- Sludge from removal process of heavy metals.

Most of the solid samples obtained in the environmental survey can be dumped because of their low concentration of toxic matter, such as heavy metals.

Solid samples, which are pretreated with organic solvent, acid or alkaline solution, can be dumped after washing with water.

It is possible to recycle the sludge without harmful heavy metal as metal resources.

(5) Safety Management for Accidents

Accidents can happen in spite of measures to prevent them. Therefore, the following safety management is required:

- establishment of emergency information network,
- installation of fire extinguishers, and
- regular fire-fighting exercise and emergency evacuation exercise.

7.4.4 Monitoring Equipment

Monitoring equipment is divided into two: sampling equipment and laboratory equipment. They are briefly described as follows:

a) Sampling equipment

Necessary equipment for sampling are shown in Table 7.7. It is important that monitoring is conducted regularly and continuously. Therefore, a plural number of equipment should be prepared at Regional Laboratories and Monitoring Site Offices in case of breakdown and loss of equipment.

Sampling equipment belonging to Monitoring Site Offices is to be managed by Regional Offices. However, Monitoring Site Offices shall be responsible for the daily maintenance of equipment. Regional Laboratories should prepare an Equipment Installation Record, including the date of purchase and record of repair of equipment. A numbering system is to be adopted for equipment management.

After a field survey, equipment should be rinsed by fresh water and/or alcohol, and stored at fixed places.

Table 7.7 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

b) Laboratory equipment

The required basic equipment for water quality monitoring are as follows:

- pure water maker,
- wastewater treatment apparatus, and
- exhaust ventilation system.

For Regional laboratories, the following common laboratory equipment are required:

- incubator,
- dryer oven,
- centrifugal machine,
- auto shaker,
- water bath,
- extraction apparatus,
- filtrated and aspirated apparatus,
- autoclave,
- muffle furnace, and
- ultrasonic cleaner.

Monitoring Site Offices shall analyze sensitive parameters such as pH and DO for water quality and pH and ORP for sediment. Some of the parameters should be pretreated at Monitoring Site Offices, such as SS and chlorophyll-a, so that the following equipment is required:

- pH meter
- DO meter
- ORP meter
- Filtration unit for SS and chlorophyll-a

Laboratory facilities and equipment should be maintained by the use of ledgers. The following ledgers are proposed for management of laboratory facilities and equipment (see Supporting Report):

- List of Facilities and Equipment
- Facilities and Equipment Maintenance Record
- Malfunctions and Repair Record
- Requirement of Maintenance
- Criteria for Regular Inspection Sheet for Facilities and Equipment
- Criteria for Periodic Inspection Sheet for Facilities and Equipment
- Sheet for Maintenance and Inspection Method
- Operation Record for Facilities and Equipment

Daily examination and record of use

Before using a facility and its equipment, a careful examination and necessary adjustment are carried out at the beginning of work; the facility and equipment are then certified as accurate to measure, and the result is documented in a Record of

Use of Facility and Equipment. In case an abnormality is observed in the facility and equipment during the examination at the beginning of work, the facility and equipment will not be used and repair of the facility and equipment are to be sought. At the same time, the results are to be recorded in a Record of Facility and Equipment Maintenance, and reported to the responsible person of Facility and Equipment Maintenance. At the beginning of work, the facility and equipment are cleaned and examined in order to prevent deterioration and to find any abnormality, which is a preventive measure for facility and equipment troubles.

Periodical Examination

At regular intervals or in the case where a responsible person of facility and equipment maintenance consider the examination necessary, the following items are carried out:

- Overhaul, replenishment and replacement of expendable in addition to a daily examination at the beginning of work;
- Confirmation of performance (variance) of analyzers; and
- Recording of results of periodical examination in a Table of Results for Periodic Examination and in Record of Facility and Equipment Examination.

Repair

In the case where it is considered from results in an examination or from troubles in its use that the facility and equipment may have a failure, the manufacturer or its sales agent should be asked to have them repaired, and at the same time the results written in a Facility and Equipment Maintenance Record and reported to the responsible person of facility and equipment maintenance.

Performance Examination

On items which cannot be covered in the periodical examination of a facility and equipment, performance examination should be carried out by the manufacturer or its sales agent in order to get an assessment of condition of the facility and equipment. A facility and equipment should be overhauled as needed in order to keep its condition good and its precision high.

Official Examination

Official Examinations, which are prescribed in related laws and regulations, should be carried out without exception, and results of official examinations are written in a Record of Facility and Equipment Maintenance.

Storage of Record

Record of Facility and Equipment Maintenance is stored during the period when it is held, and the other records are stored for two years.

c) Storage or Setting of Equipment

The facility equipment should always be stored or set in an appropriate place for its use in order to prevent its contamination from indoor environment. A label, on which a record number is written, should be pasted on each piece of equipment as an indication that it is a "maintained equipment."

d) Maintenance of Measuring Apparatus

The precision of frequently used instruments is also certified at need. Standard volumetric instruments (measuring cylinder, pipettes and others), such as JIS, should be used to increase the accuracy of measurements. Washing, drying, and storing of instruments should be done using an appropriate method for each analysis, and it is necessary to keep the various instruments clean in order to prevent contamination of samples.

7.4.5 Data Management

(1) Draw up a Standard Operating Procedure

It is necessary to set up an easy and concrete processing of the following items, and, more importantly, to orient the persons concerned:

- Sampling, preparation and custody of reagent for pretreatment;
- Preparation of analytical reagent and standard substance preparing standard solution, custody and treatment of standard solution;
- Setting and adjustment of measuring conditions for analytical instrument; and
- Recording of whole measuring process.

(2) Maintenance and Evaluation of Instrument Efficiency

a) Standard solution

Guaranteed material is to be used to ensure traceability. It is important that Regional Laboratories utilize a common standard solution in preparing the calibration curve. If the Core Center for Coastal Water Quality can provide a standard solution for use by each Regional Laboratory, the credibility of Regional Laboratory will be raised and obtained data from regional laboratories can be compared.

b) Pretreatment/Condensation

It is necessary to take suitable pretreatment operation since this affects the results of analysis. A collection test is also necessary after addition of solution to confirm the efficiency of previous collection.

c) Adjustment of analytical equipment

Measuring conditions should correspond to samples, and instruments are to be adjusted accordingly. In those cases, it is necessary to confirm the linearity of sensitivity, stability, interference and faculty of adjustment.

(3) Evaluation of Credibility for Measuring Result

a. Detection limit

There is a need to confirm whether the method used is able to clear minimum detection limit before beginning chemical analysis by the following process. If clearance is not possible, it is necessary to increase sample volume or to condense the sample some more.

i) In the case of detection of object substance

Measure seven operation blanks and calculate the amount in blank samples.

Minimum detection limit (DL) = x + 1.94 S

x: mean of blanks, S: standard deviation

ii) In the case of non-detection of object substance

Carry out a collection test 7 times after adding object substance into distilled water at 2-5 times of the lowest concentration for calibration. Calculate minimum detection limit from standard deviation(s)

DL = 1.94 s

b. Operation blank

It is necessary to measure the operation blank in order to confirm the amount of contamination due to sampling, preparing reagent and other handling activities. Also, measuring environment is set without interference for analysis. In case a high blank value is obtained, it leads not only to the downslide of equipment sensitivity but also to decline of credibility of measuring result. Consequently, there is a need to make operation blank value as low as possible and to measure operation blank once every ten samples.

c. Repeat measurement

It is necessary to repeat measurement once every ten samples to confirm that the difference between the two measuring results is below 30% against the average for the measured substances that are over the detection limit. When the difference is larger than 30%, there is a need to check the cause and measure again.

$$(C1-C2) \div (C1+C2)/2 \times 100 < 30$$

d. Daily check on sensitivity of measuring equipment

Change of sensitivity of measuring equipment should be checked by means of measuring test sample of standard solution once a day or once every 10 samples, and confirm that the change of sensitivity is within 20% of previous standard solution. When the change is over 20%, there is a need to find and fix the cause of this discrepancy, and re-test the equipment before measuring actual samples.

e. Addition and collection test

It is necessary to take a collection test 3-5 times with the same samples after adding a suitable amount of known standard solution. It is desirable to have about 10 times concentration for detection limit.

f. Cross-checking

Cross-checking aims to confirm the credibility of laboratories, and strengthen laboratory capability. The Core Center provides samples for cross-checking to Regional Laboratories once or twice a year. Regional laboratories then send data back to the Core Center. The Core Center assesses analysis performance by the cross-checking of data. It is important that there is transparency in the results of cross-checking.

(4) Data Control and Evaluation

a. Reliability of samples

There is a need to confirm whether the samples taken are suitable for the purpose of the survey and are representative of the sampling place.

b. Treatment of abnormal data and lack of data

In case there is a reduction in the sensitivity of measuring apparatus or that the results of repeat measurements vary widely, then the credibility of analysis has become questionable. Measurement should be repeated once more.

c. Recording of measurement operation

It is necessary to record and keep the following information,

- adjustment, operation and readings of instruments and tools used for sampling;
- condition of custody and treatment of sampling bottles;
- sample condition, sampling method, sampling point (location), sampling date;
- observations of samples (Sediment: external appearance, odor, foreign matter in sample, depth of sampling point etc.);
- preparing condition of sample;
- operation and readings of analytical equipment; and
- other important results (dilution ratio, sample volume etc.).

(5) Report for Accuracy Management

It is necessary to record the following information:

- standard operating procedure,
- measuring result of detection limit,
- result of operation blank,
- taking of sample and pretreatment of sample,
- result of collection test after addition,
- change of sensitivity of measuring instrument, and
- whole process of measuring operation.

7.4.6 Human Resource Development

(1) Necessary Skills for Coastal Water Quality Monitoring

Activities of Coastal Water Quality Monitoring are divided into three: sampling, water quality and sediment analysis and data management. Skills necessary for these activities are:

- natural science,
- environmental management,
- water quality monitoring planning,
- appropriate water quality and sediment sampling,
- physical and chemical analysis, and
- data management.

Water quality sampling and data management require knowledge of coastal environment including physical, chemical and biological coastal environment. Sampling activities should also consider coastal environmental conditions. Although modern chemical analyzers have black boxes, laboratory staff members should understand the principle of physical and chemical analysis. Laboratory assistants should be trained for basic skills since they also perform laboratory work. Quality control can ensure reliability, especially quality control within chemical analysts at laboratory, and among laboratories.

Therefore, Coastal Quality Monitoring staff should develop the skills to handle the following concerns on coastal environment including physical oceanography, chemical oceanography and biological oceanography:

- water quality,
- sampling for water quality,
- water quality analysis,
- sediment analysis, and
- statistics and quality control.

(2) Approach for Human Resource Development

There are two approaches for human resource development, such as on-the-job training and off-the-job training, as follows:

a. On-the-job training

Coastal Water Quality Monitoring staff are trained through daily work. For fieldwork, Sampling Teams are organized at Regional Laboratories and Monitoring Site Offices. Sampling team members learn from each other.

In the laboratory, analysts are to be given the opportunity to analyze different parameters using different laboratory equipment. Newcomers are to conduct simple analysis methods on such parameters as pH, DO, SS of water samples, and specific gravity and particle size of sediment. Next, they analyze using a spectrophotometer, then an atomic absorption spectrophotometer or gas chromatograph.

b. Off-the-job training

Off-the-job training programs are not only for analysts but for assistants as well. The training programs should cover coastal environment, sampling methodology, and basic knowledge of chemical analysis for the benefit of assistants.

The proposed Core Center for Coastal Water Quality Monitoring is to function also as a training center for water quality monitoring. The Autonomous University of Baja California has marine science curricula and some other universities have a chemical analysis curriculum. It is recommended that *CNA* contract the University to give lectures on coastal environment to its staff. Water quality and sediment analyses for coastal water and freshwater analyses are almost the same so those technical seminars for chemical analysis can be held with the cooperation of *PROMMA*. Recommended subjects for coastal water quality monitoring are shown in Table 7.8.

Table 7.8 Proposed Topics of the Technical Seminar

Skills	Topics
Monitoring Planning	• monitoring process • methodology of planning • data networking and integration
Field Work	• navigation • operation and maintenance of equipment • observation of hydrological conditions • sampling for water quality • sampling for hydrological conditions
Water Quality Analysis	• seawater quality analysis • sediment analysis • biological analysis • quality control • operation and maintenance of equipment
Simulation Model	• types of simulation models • practice of simulation

Source: JICA Study Team

Chapter 8 Coastal Water Quality Monitoring Plan for the Tampico Area

8.1 Goals

This chapter provides the formulation of a Coastal Water Quality Monitoring Plan for the Tampico Area. The Plan is to be based on the Guidelines for Coastal Water Quality Monitoring discussed in Chapter 7. Ultimately, this Plan will serve as a model for the preparation of coastal water quality monitoring plans for other areas.

As stated in Chapter 7, the Study proposes the establishment of two organizations: 1) Monitoring Laboratory for coastal water quality monitoring and 2) Core Center for National Coastal Water Quality Monitoring. Therefore, this Plan is to include the above two organizations for the Tampico Area.

8.2 Phasing of Development Plan

(1) Target Year

As the enhancement of coastal water quality monitoring capability is not an easy task, it will require a phased development. Therefore, target years have been set up for a phased development as shown in Figure 8.1 and Table 8.1.

There are three phases for development of Tampico Laboratory. By 2002, it will have achieved the capability to monitor basic parameters as routine monitoring work. This includes basic skills for coastal water monitoring. By 2005, Tampico Laboratory will have attained the capability to monitor toxic parameters. Technical skills of Tampico Laboratory staff are to be improved for coastal water quality monitoring. From 2006 to 2010, Tampico Laboratory shall have skilled personnel, and the monitoring know-how of Tampico Laboratory shall expand to other laboratories. Tampico Laboratory shall have the capability to conduct special programs on monitoring. By 2010, it is required that Tampico Laboratory shall have the capability to investigate the causes of coastal environmental problems by trace analysis of new toxic substances.

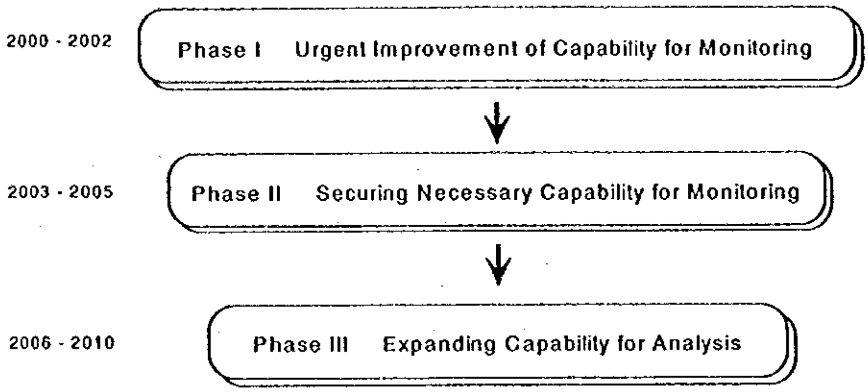


Figure 8.1 Tampico Water Quality Laboratory Development Plan by Target Years

Table 8.1 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

A Core Center for National Coastal Water Quality Monitoring shall be established by 2004, and operated from 2005 with the following schedule:

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

8.3 Tampico Laboratory and the Core Center

There will be two entities related to coastal water quality monitoring: Tampico Laboratory and the Core Center for Coastal Water Quality Monitoring. The Monitoring Laboratory will remain under *CNA* Tamaulipas Regional Office. Meanwhile, the Core Center is to be under *CNA* Central Laboratory, although it will control regional laboratories for coastal water quality monitoring from a technical standpoint, and that will include the Monitoring

Laboratory. They will be two separate organizations sharing the same building/complex, facilities and equipment. Their respective functions are as follows:

a. Monitoring Laboratory for Coastal Quality Monitoring for the Tampico Area

Although Tampico Laboratory has carried out the Pilot Water Quality Monitoring in cooperation with the Study Team, it still does not have enough capability for coastal water quality monitoring work. It is required that the Monitoring Laboratory be enhanced as a model laboratory for coastal water quality monitoring.

b. Core Center for National Water Quality Monitoring Program

As the central office for the National Coastal Water Quality Monitoring Program, it shall have the following functions:

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

Training will be conducted at the Monitoring Laboratory for sampling and water quality skills through daily work.

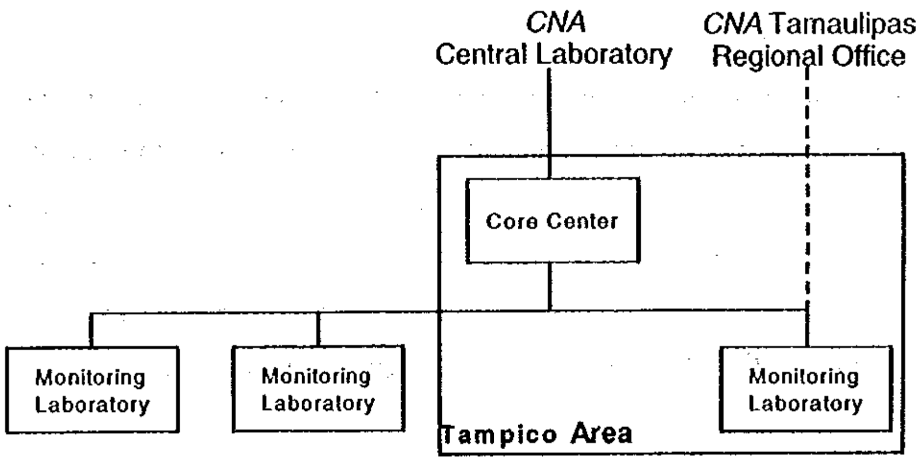


Figure 8.2 Organizational Chart of Water Quality Monitoring Entities

8.4 Sampling and Water Quality Analysis Plan

Methods of sampling and water quality analysis are based on the Guidelines for National Coastal Water Quality Monitoring discussed in Chapter 7.

(1) Monitoring Components

Coastal Water Quality Monitoring consists of the following:

- water quality, and
- sediment quality.

(2) Monitoring Areas and Stations

It is recommended that the following water areas be monitored based on the results of the Pilot Monitoring conducted in 1999.

- coastal water area,
- Panuco River,
- Pueblo Viejo Lagoon, and
- Marismas Lagoon.

The location of monitoring stations and number of monitoring stations are shown in Figures 8.3 and 8.4 and Table 8.2, respectively. Total number of monitoring stations is 26 for water quality including 1 background station in off-shore , and 16 for sediment sampling.

Primary and secondary stations are established. Primary stations (15 stations) are located at typical areas in the monitoring area, and areas affected by pollution. In principle, water and sediment samples are taken at two layers of the primary stations. Toxic parameters are also taken 0.5 m from water surface of the primary stations. Secondary stations (10 stations) are for supplementary identification of horizontal and vertical water-quality distribution patterns. Primary monitoring stations for sediment and water quality are the same.

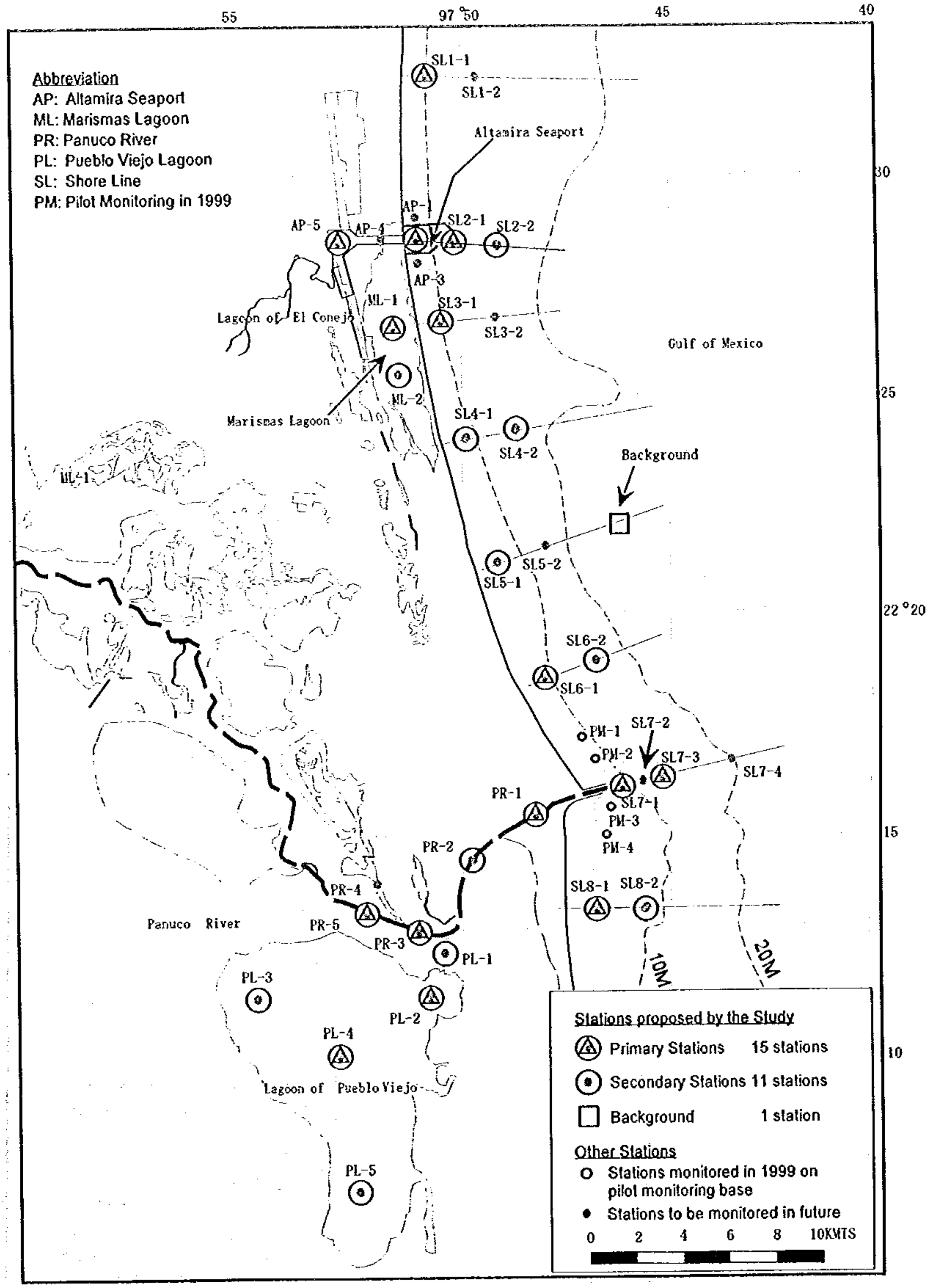


Figure 8.3 Location of Stations in the Tampico Area for Water Quality Monitoring

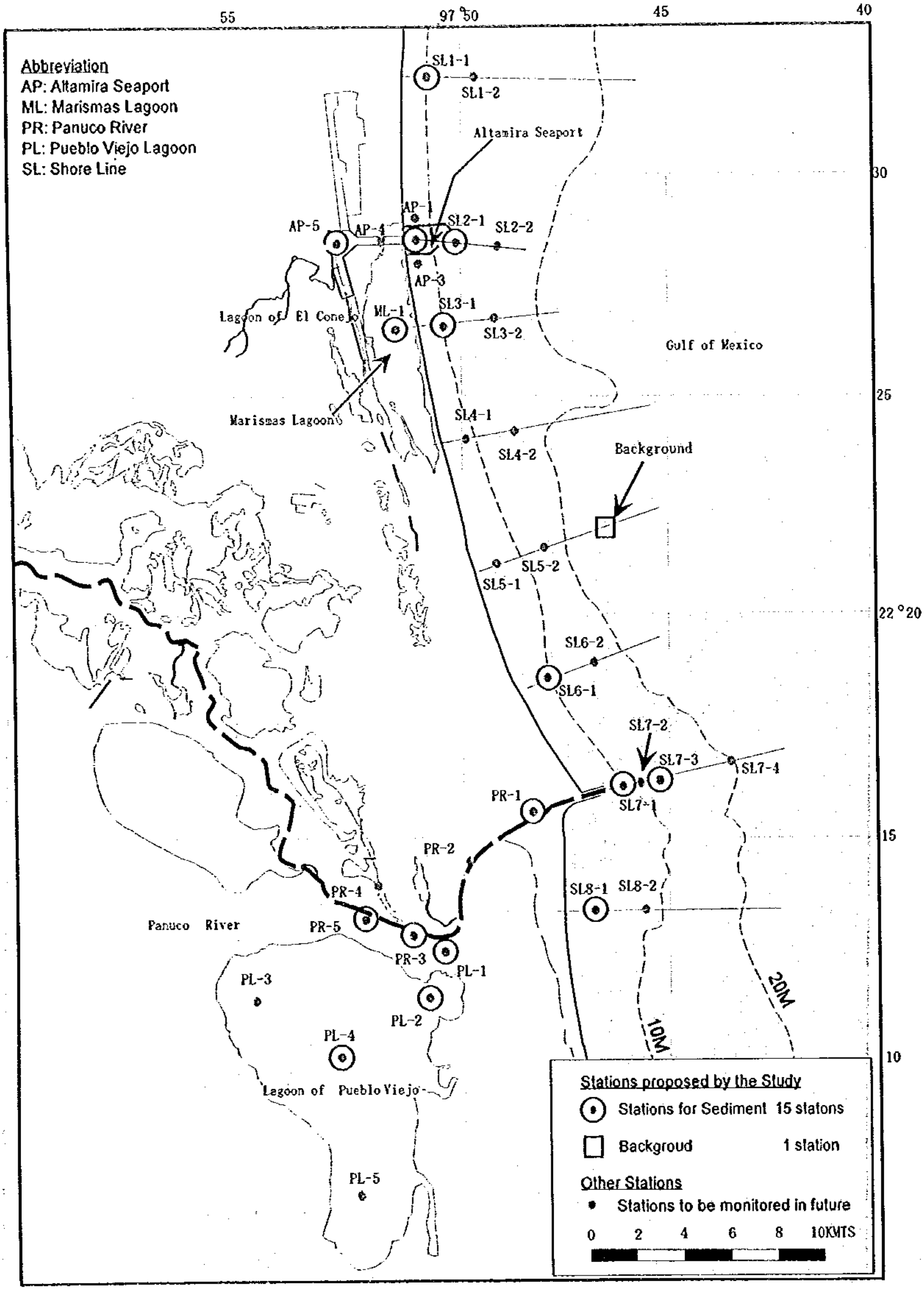


Figure 8.4 Location of Monitoring Stations for Sediment Quality in Tampico Area

Table 8.2 Number of Monitoring Stations in the Tampico Area

	Water Quality							Sediment	
	No. of Stations	Basic Parameters				Harmful Parameters		No. of Stations	all parameters
		6 times/year		2 times/year		2 times/year			2 times/year
		1-Layer	2-Layers	1-Layer	2-Layers	1-Layer	2-Layers		Top Sediment
Coastal Area	**15**	**0**	**9**	**0**	**6**	**9**	**0**	**9**	**9**
Primary Points	9	0	9	0	0	9	0	9	9
Secondary Points	6	0	0	0	6	0	0	-	-
Panuco River	**4**	**0**	**3**	**0**	**1**	**3**	**0**	**3**	**3**
Primary Points	3	0	3	0	0	3	0	3	3
Secondary Points	1	0	0	0	1	0	0	-	-
Pueblo Viejo Lagoon	**4**	**2**	**0**	**2**	**0**	**2**	**0**	**2**	**2**
Primary Points	2	2	0	0	0	2	0	2	2
Secondary Points	2	0	0	2	0	0	0	-	-
Conejo Lagoon	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Primary Points	0	0	0	0	0	0	0	0	0
Secondary Points	0	0	0	0	0	0	0	-	-
Marismas Lagoon	**2**	**1**	**0**	**1**	**0**	**1**	**0**	**1**	**1**
Primary Points	1	1	0	0	0	1	0	1	1
Secondary Points	1	0	0	1	0	0	0	-	-
Background	1	0	1	0	0	0	1	0	0
Total	**25**	**3**	**12**	**3**	**7**	**16**	**0**	**16**	**16**
Primary Points	15	3	12	0	0	16	0	16	16
Secondary Points	10	0	0	3	7	0	0	-	-
No. of Samples	**-**	**3**	**24**	**3**	**14**	**16**	**0**	**16**	**16**

1-Layer Monitoring Stations: 0.5 m below surface

2-Layer Monitoring Stations: 0.5 m and 10 m bleow surface

(3) Monitoring Parameters and Frequency

Monitoring parameters of water quality and sediment are grouped into two: basic parameters and toxic parameters based on the National Water Quality Monitoring. Recommended monitoring parameters are shown in Table 8.3 including a Special Monitoring Program.

Tampico is the site of the largest oil refineries in Mexico. There is a danger that this area will be polluted by leakage of oil and sewage. It is recommended that indicators of oil pollution and water pollution caused by daily human activities be added to the organic monitoring parameters. As indicators of oil pollution, hydrocarbon and hexane extracts should be monitored, the latter at least six times a year (other areas: 2 times/year). Surfactant, as an indicator of water pollution from detergents, should be monitored to determine the inputs from the populated areas. It is expected that the coastal area of Tampico will be polluted by domestic wastewater because of the lack of sewage treatment facilities in Tampico. During the Pilot Monitoring, some amounts of organic chloride pesticides were identified. It is therefore recommended that organic chloride pesticides, such as aldrine, dieldrin, endrien, chlordane and DDT, be monitored until the area is free of environmental problems for at least three years. This is a Special Monitoring Program for Tampico Area.

The monitoring frequency of water and sediment quality of coastal waters is shown in Table 8.4.

Table 8.3 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 (aldrine, 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 8.4 Frequency of Water Quality and Sediment Monitoring

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Water Quality													
Primary Points													
Basic Parameter	O		O		O		O		O		O		6
Harmful Substances			O						O				2
Secondary Points													
Basic Parameter			O						O				2
Harmful Substances													
Sediment													
Basic Parameter			O						O				2
Harmful Substances			O						O				2

8.5 Laboratory Management Plan

8.5.1 Laboratory Personnel Management

Three sections will be established in the Tampico Laboratory. The necessary number of personnel by each section is as follows:

Table 8.5 Necessary Personnel for Tampico Laboratory

Sections	Number of Personnel	
	Experts	Assistants
Head of Laboratory	1	
Administration Section	1	1
Planning Section	1	
Sampling/Water Quality Analysis Section	8	7
Total	11	8

Source: JICA Study Team

8.5.2 Building Management

It was mentioned in Chapter 2 that the existing building of Tampico Laboratory is not appropriate for coastal water quality analysis. It is recommended that Tampico Laboratory be transferred to an appropriate building by 2005. But since the existing building is being used for analysis work, the following are required as temporary measures (also indicated in Figure 8.6):

- installation of faucets and sinks at each room;
- installation of electrical stabiliser;
- improvement of reagent storage room;
- establishment of staff room, meeting room and library;
- additional installation of cabinets for glass apparatus; and
- additional installation of refrigerators for samples.

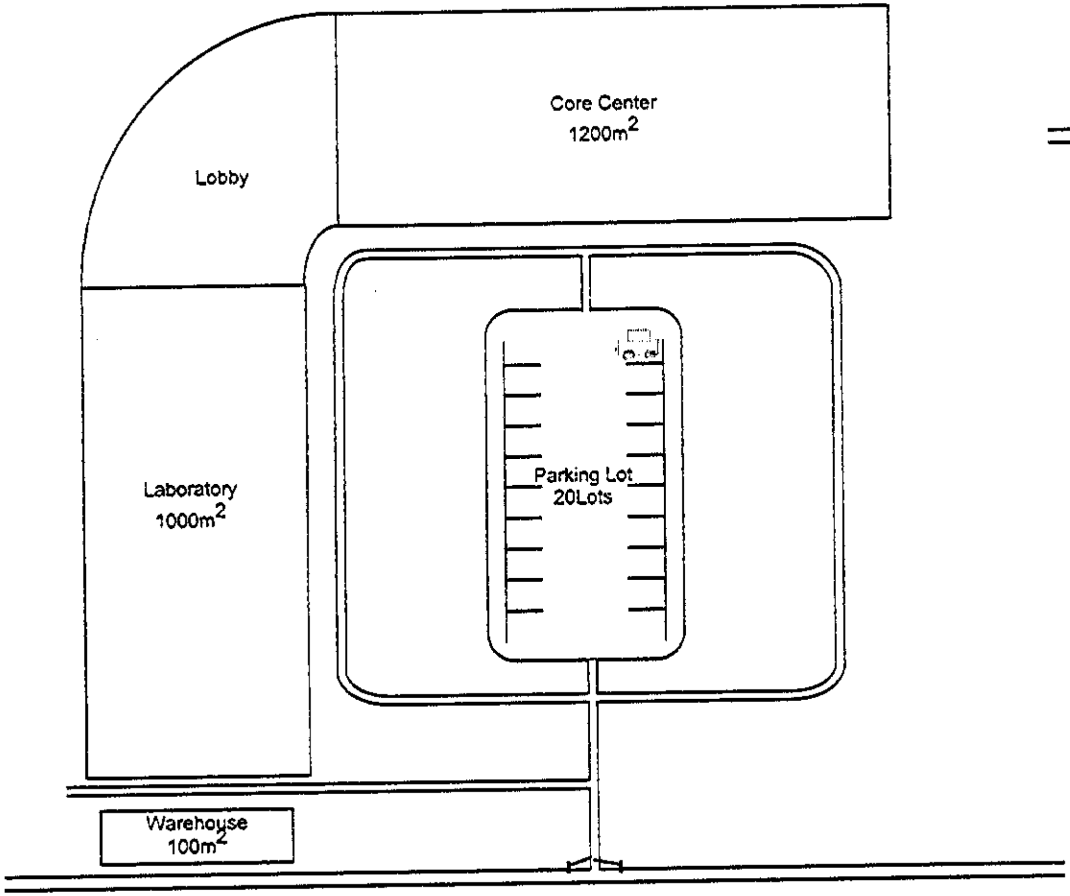
There are two priority areas for coastal water quality monitoring in Golfo Norte Region. One of the priority areas for fishery, La Pesca (Tamaulipas State), is far from Tampico Laboratory so that a Site Monitoring Office should be established.

8.5.3 Equipment and Facility Management

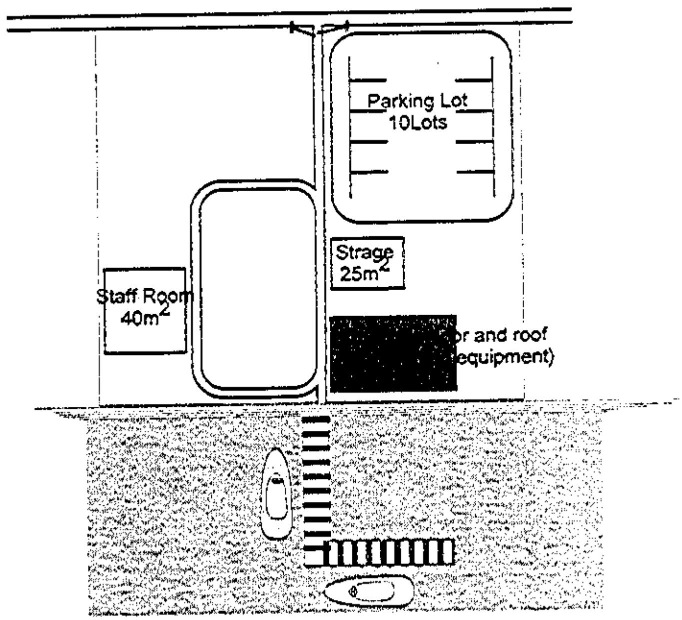
Monitoring activities can be divided into two, namely, sampling and analysis of samples. Monitoring equipment can also be divided into sampling equipment and laboratory equipment. Sampling equipment includes not only samplers but also navigational instruments, sampling containers and radio communication tools. For analysis, laboratory facilities and equipment include basic laboratory facilities, common equipment and specific equipment. The necessary monitoring equipment is shown in Table 8.6. Most of the equipment has been installed at Tampico Laboratory. Those that need to be installed are as follows:

• salinometer (desk type)	1 set
• water thermometer / salinometer for field survey	3 sets
• spectrophotometer (additional)	1 set
• wastewater treatment facility	1 set
• desktop personal computer (for report making)	1 set

A salinometer is used to measure the vertical profiles of STD (Salinity, Temperature and Depth). However, it is quite difficult for each sampling team to have a salinometer for in situ use because of the cost involved. Therefore, it is recommended that samples are taken by water sampler, and analyzed in the laboratory by a salinometer.

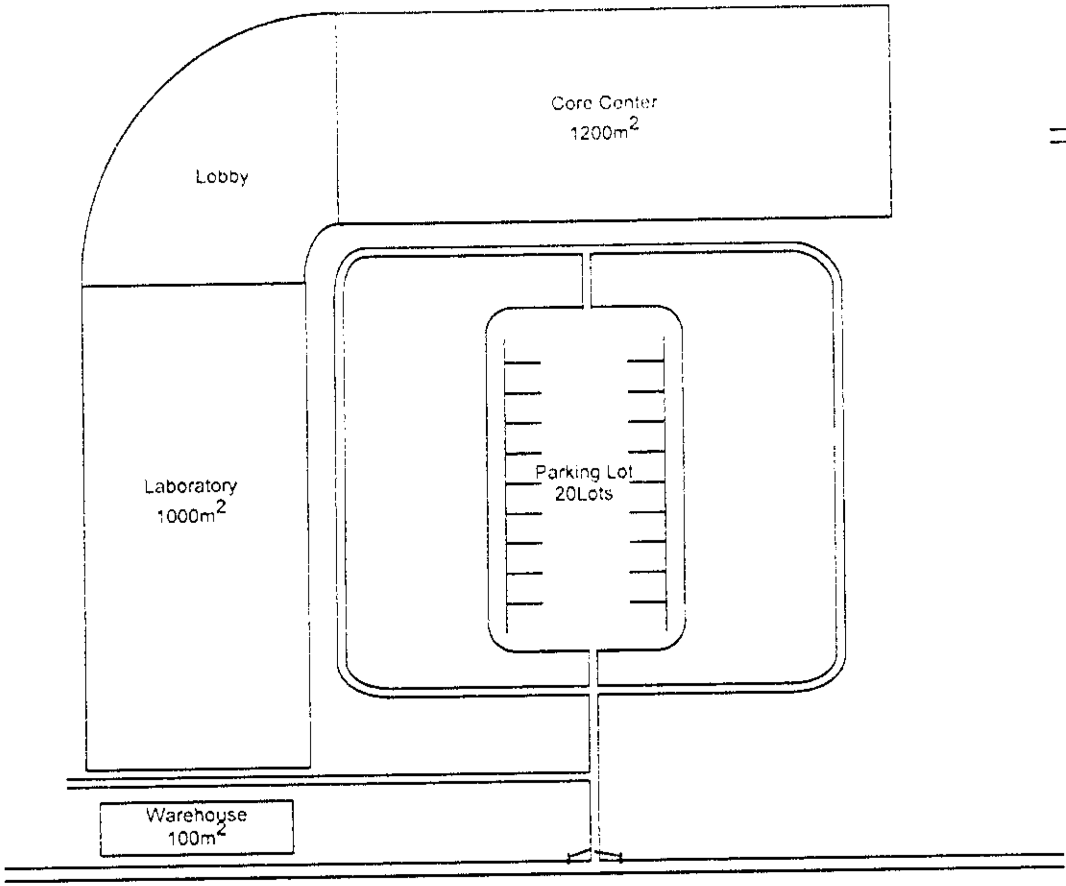


Layout of Tampico Laboratory and the Core Center

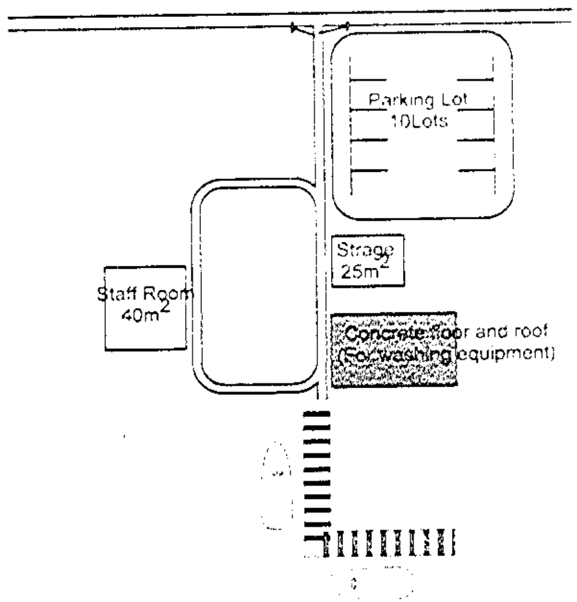


Layout of boathouse belonging to the Core Center

Figure 8.5 Proposed Layout of Tampico Monitoring Laboratory and the Core Center



Layout of Tampico Laboratory and the Core Center



Layout of boathouse belonging to the Core Center

Figure 8.5 Proposed Layout of Tampico Monitoring Laboratory and the Core Center

Table 8.6 Necessary Equipment for Tampico Laboratory

Equipment	Use	Object	Number	Priority
Sampling Equipment				
GPS	navigation		2	A
Radio Communication system	communication		1	A
Van Dorn Water Sampler	sampling for water quality		3	A
Smith-McIntyre Bottom Sampl	sampling for sediment		2	A
Ekman-Berge Dredge	sampling for sediment		2	A
Water Thermometer/Salinom	measuring salinity, temperature		2	A
Analysis Equipment				
Laboratory table	proofing reagent	for extensive uses	6	A
Storage cabinet	tightly shut type	for extensive uses	5	A
Large-sized refrigerator	for preserving samples (6 m3)	for extensive uses	6 m3	A
Large-sized refrigerator	for preserving reagents	for extensive uses	1	A
Large-sized freezer	for preserving samples	for extensive uses	2	A
Large-sized freezer	for preserving reagents	for extensive uses	1	A
House for gas cylinders	outdoor, but to keep closed	for extensive uses	1	A
Draft ventilation unit	one for each testing room	for extensive uses	2	A
Air conditioner	to control the each room condition, cutting dust	for extensive uses		A
Apparatus for treating wastewater of laboratory	treatment of wastewater after analysis	for extensive uses	1	A
Distillation apparatus	one set for each item	cyanide, phenols, T-S(sediment)	4	A
Pipette washer	washing of pipettes, increasing working efficiency	for extensive uses	3	A
Electronic analytical balance	for micro measurement, for reagent, large amount without cover	for extensive uses	2	A
Water bath	keep boiling temperature	COD	2	A
Water bath	keep temperature at 20 to 30℃	pH etc.	2	A
Incubator	for biological analysis	coliform	2	A
Autoclave	digestion of N,P analysis sterilezation	T-N, T-P, coliform	3	A
Centrifugal separator	analyze of chlorophyll-a preparation of sediment	chlorophyll-a, sediment	2	A
filtration sets	for biological analysis, disposable type is better	coliform, biological analysis	3	A
automatic shaker	shake bottles for elution test	elution test	2	B
automatic shaker	shake funnels	hexane extract, pre-treatment of heavy metals, extensive uses	2	A
spectrophotometer	measure level (concentration) of several parameters , more than 2	nitrogen, phosphrous, for measuring by spectrophotometer	2	A
standard screen for soil	screening soil	sediment size distribution	4	A
automatic shaker for screen	screening soil	sediment size distribution	2	A
hydride vapor generator	measure Arsenic	As	2	B
Platinum crucible	for alkaline digestion	Cr	20	B
Kuderna-Danish type concentrator	for pre-treatment of samples for PCB analysis	PCB, pesticides, pretreatment of solid sample(sediment etc.)	4	B
Reflax condenser	for pre-treatment of samples for Mercury analysis	Hg for digestion	4	B
Soxhlet extractor	extraction of organic compounds in solid samples	Pesticides (aldrin, endrin, dieldrn etc.) in solid sample (for example sediment)	4	B
Gradient trap (apparatus for purge trap method)	for analysis of VOC (for example trichloroethylene)	trichloroethylene, tetrachloroetylene, etc.	2	B
Gas chromatograph-ECD	for micro-analysis of organic matters		1	B
Gas chromatograph-FPD	for micro-analysis of organic matters		1	B
Data Compilation				
Computer System	for data processing		1	A
Database software	for data processing		1	A
Printer	for data processing		1	A

8.6 Core Center for Coastal Water Quality Monitoring

8.6.1 Functions of Core Center

The Core Center for National Coastal Water Quality Monitoring Program shall perform the following functions:

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

8.6.2 Organization of Core Center

The Core Center for Coastal Water Quality Monitoring shall have six sections as shown in Figure 8.6 and listed as follows:

- Administration Section
- Planning Section
- Laboratory Network Management Section
- Data Management Section
- Facilities and Equipment Section
- Training Section

The functions of each section are indicated in Table 8.7.

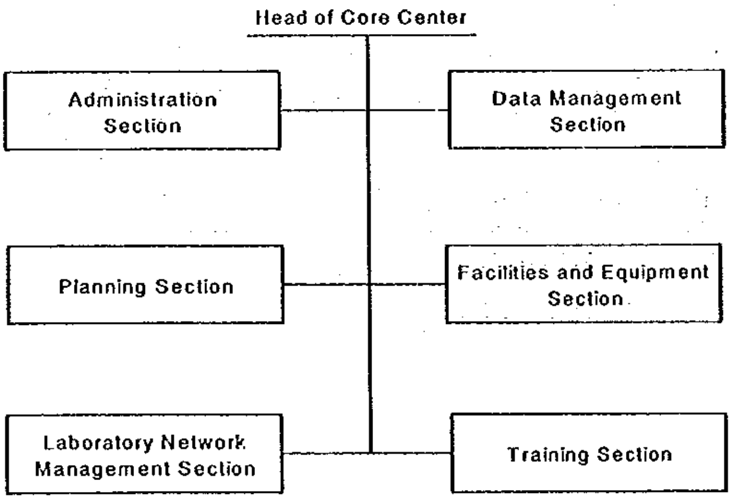


Figure 8.6 Organization of Core Center for National Coastal Water Quality Monitoring

Table 8.7 Functions of the Different Sections of the Core 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

8.6.3 Design Concept of Building

It is desirable that the Core Center be established within the same area of Tampico Monitoring Laboratory, so that they can share monitoring facilities and equipment. It has been mentioned that the Core Center shall function as reference laboratory, data management center and training center. These functions are to be integrated into the Core Center excluding the boathouse. The boathouse may be established on the shore or riverside of Panuco River.

In the construction of the Core Center, a water quality laboratory is required including preparation of analytical standard solutions for water quality analysis and preparation of samples to cross-check for accuracy control among regional laboratories. A data processing room is also required for data management. Data processing includes maintenance of coastal water quality database and Geographic Information System (GIS) database. Training rooms for coastal water quality monitoring and lecture rooms with audio-visual equipment are required with capacities of 15 to 20 persons. Lecture rooms can be used not only for training purposes but also for meetings related to coastal water quality monitoring and coastal environmental management. Laboratory rooms belonging to Tampico Monitoring Laboratory can be shared for training purposes of *CNA* staff. A building design concept of the Core Center is presented in Table 8.8.

Table 8.8 Design Concept of the Core Center for Coastal Water Quality Monitoring

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

Source: JICA Study Team
*: to be shared with Tampico Regional Laboratory

8.6.4 Facilities and Equipment

The necessary facilities and equipment for the Core Center are shown in Table 8.9. Some of the monitoring facilities and equipment can be shared with Tampico Regional Laboratory. The boat used for field surveys belonging to the Core Center will also be used for monitoring activities by Tampico Laboratory.

Table 8.9 Facilities and Equipment of Core Center for Coastal Water Quality Monitoring

Sections	Facilities and Equipment	
Administration Section	personal computer	2 sets
	boat for field survey (10 tons)	1 boast
Planning Section	personal computer	3 sets
	computer for data processing	1 set
	computer accessories	1 set
Laboratory Network Management Section	laboratory equipment	shared with Tampico Lab
	personal computer	3 sets
Data Management Section	personal computer	3 sets
	computer for data processing	1 set
	computer accessories	1 set
	data base software	1 set
	GIS soft ware	1 set
Facilities and Equipment Section	tools for repair	1 set
	personal computer	2 sets
Training Section	personal computer	2 sets
	OHP	2 sets
	screen	2 sets
	video camera	1 set
	video cassette recorder	2 sets
	audio set	2 sets

Source: JICA Study Team

Chapter 9 Project Implementation

9.1 The Proposed Project

9.1.1 Outline of the Project Components

(1) Project Components

The proposed project is divided into the following two components:

- Establishment of coastal water quality monitoring network, and
- Development of Tampico Coastal Water Quality Laboratory and the Core Center.

(2) Outline of the Project

a) Background

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 project be focused initially on the following priority areas, which have high risks of water contamination:

- Industrial Areas
- Tourism Areas
- Fisheries Areas

The present Tampico Laboratory analyzes the water quality of all the above mentioned priority areas. However, it still suffers from the following problems according to the findings of the pilot coastal water quality monitoring in 1999:

- Lack of basic facilities;
- Inadequate laboratory equipment; and,
- Lack of human resources for coastal water quality monitoring.

Therefore, it is expected that the present Tampico Laboratory could be developed effectively following the experience from the pilot coastal water quality monitoring.

b) Objectives

The main objectives of the proposed project are:

- to develop an effective and efficient coastal water quality monitoring network; and,
- to redevelop the Tampico Laboratory and to establish a Core Center of coastal water quality monitoring.

c) Implementing Agencies

CNA has mainly conducted freshwater quality monitoring in Mexico; coastal water quality monitoring should also be initiated by *CNA*. But in terms of the present implementing agencies for coastal water quality, some of the monitoring areas and parameters are being monitored by the other agencies such as the Ministry of Navy, Ministry of Communication and Transportation, Ministry of Health and Ministry of Tourism. These agencies have some experience and budget for coastal water quality monitoring. Therefore, 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 monitoring costs by *CNA*.

Because the Mexican Government has not decided on the involvement of other agencies in coastal water quality monitoring, *CNA* should mainly be responsible for this activity.

9.1.2 Expected Benefits

The proposed project is expected to contribute to the improvement of cost performance for coastal water quality monitoring in Mexico and, at the same time, more effectively provide the following important information to decision makers:

- Detection of any signs of deterioration in coastal water quality; and,
- Evaluation of effectiveness of a coastal water quality management policy.

In terms of the Tampico Laboratory and the Core Center component, it is expected that the following elements could be improved:

- Planning capability for coastal water quality monitoring;
- Data management capability for coastal water quality monitoring; and
- Training capability for coastal water quality monitoring.

9.1.3 Project Cost Estimate

Table 9.1 shows the overall cost for establishment of coastal water quality monitoring network. Table 9.2 shows the overall cost for development of Tampico Coastal Water Quality Laboratory and the Core Center.

Table 9.1 Cost Estimation for Coastal Water Quality Monitoring Network

Unit: N$ million

Cost Category	Overall Cost	Annual Cost (from 2005 to 2010)
Initial Cost	91.8	-
Operation & Maintenance Cost	48.5	5.8 / year
Total	140.3	

Source: JICA Study Team

Table 9.2 Cost Estimation for Development of Tampico Laboratory and the Core Center

Unit: N$ million

Cost Category	Tampico Laboratory	Core Center	Total
Initial Cost	13.8	11.6	25.4
Operation & Maintenance Cost	3.5	1.8	5.3
Annual O&M Cost	0.6	0.3	0.9
Total	17.3	13.4	30.7

Source: JICA Study Team

9.2 Establishment of National Coastal Water Quality Monitoring Network

9.2.1 Sub-Components

Figure 7.2 showed the proposed laboratory network for coastal water quality monitoring. This laboratory network consists of the Core Center, Regional Laboratories, and Monitoring Site Offices. Table 7.3 showed the number and the location of the monitoring site offices and the priority areas, excluding the Core Center. The Core Center is described in Section 9.3 Development of Tampico Laboratory and the Core Center.

a) Regional Laboratories

CNA has a two-phase development strategy in terms of the water quality regional laboratory. This strategy takes into consideration the location of each laboratory, as well as their respective monitoring levels, in the establishment of a laboratory network.

The phases of development are as follows:

- The First Phase: Region 2; Region 4; Region 8; Region 9; Region 12;
- The Second Phase: Region 1; Region 3; Region 5; Region 10; Region 11.

It is proposed that the sampling and laboratory equipment/facility in each region should be installed taking into consideration of the *CNA*'s strategy. Table 9.3 shows the proposed equipment installation schedule.

Table 9.3 Proposed Equipment Installation Schedule for Each of the Coastal Regions

Item/Year	Year 2001	Year 2002	Year 2003	Year 2004
Sampling Equipment	All Coastal Regional Laboratory			
Laboratory Equipment for Basic Parameters	- Region 2 - Region 4 - Region 8 - Region 9 - Region 12	- Region 1 - Region 3 - Region 5 - Region 10 - Region 11		
Laboratory Equipment for Toxic Parameters			- Region 2 - Region 4 - Region 8 - Region 9 - Region 12	- Region 1 - Region 3 - Region 5 - Region 10 - Region 11

Source: JICA Study Team
Note: Regions 6 and 7 are not included in coastal water quality monitoring.

The sampling and laboratory equipment for basic parameters and toxic parameters are shown in Table 9.4.

Table 9.4 Proposed Sampling and Laboratory Equipment/Facility of the Regional Laboratories

Equipment	Use and Objectives		Quantity	Unit Price (N$)	Cost (N$)
Sampling Equipment					
GPS	navigation		2	5,000	10,000
Radio Communication System	communication (transceiver set)		1	5,000	5,000
Van Dorn Water Sampler	sampling for water quality	Big-sized (6L)	2	16,000	32,000
		Small-sized (3L)	2	14,000	28,000
Smith-McIntyre Sediment Sampler	sampling for sediment		2	25,000	50,000
Ekman-Berge Sediment Sampler	sampling for sediment		2	15,000	30,000
Water Thermometer/Salinometer	measuring salinity, temperature	throw into type	2	22,000	44,000
Secchi Plate	Measuring Transperency		2	1,000	2,000
Forel Color Indicator	Observation Water Color		2	1,000	2,000
Depth Meter	Measuring Depth (Tape Measure with Mark)		3	1,000	3,000
Life Jacket			20	1,000	20,000
pH Meter	Measuring pH		2	15,000	30,000
ORP Meter	Measuring ORP		2	15,000	30,000
Fitration Unit	For Filtration of SS and Coliform		5	7,000	35,000
	For Making Filtrated sample and Chlorophyll-a with pump		4	25,000	100,000
Iced Box	For Transporting Samples and Survey		5	150	750
		Sampling Equipment		Sub Total	421,750
Laboratory Equipmnt/Facility					
For Basic Parameters					
Large-sized refrigerator	for preserving samples (6 cubic m)	for extensive uses	1	52,300	52,300
Large-sized refrigerator	for preserving reagents	for extensive uses	1	25,000	25,000
Large-sized freezer	for preserving samples	for extensive uses	2	30,000	60,000
Large-sized freezer	for preserving reagents	for extensive uses	1	30,000	30,000
Distillation apparatus	one set for each item with mantel heater	T-S (sediment)	4	3,000	12,000
Piston Buret	For Titration for COD, DO, T-S	DOSI MAT Brand	4	8,800	35,200
Pipette washer	washing of pipettes (for improving working efficiency)	for extensive uses	3	10,000	30,000
Pure Water Maker	For Extensive Use (Washing and Basic Analysis)		2	50,000	100,000
	For Trace Element Analysis		2	50,000	100,000
Ultra sonic cleaner	For washing materials		1	60,000	60,000
Electronic analytical balance	for micro measurement, for reagent,	for extensive uses	2	18,000	36,000
	large amount without cover		2	12,000	24,000
Water bath (Gas heater)	keep boiling temperature	COD	2	30,000	60,000
Water bath (Gas heater)	keep temperature at up to 100 C	Eetensive use	1	30,000	30,000
Incubator	for biological analysis	coliform	2	53,000	106,000
Autoclave	digestion of N, P analysis, sterilazatic	As	3	100,000	300,000
Centrifugal separator	analyze of chlorophyll-a	chlorophyll-a, sediment	1	105,000	105,000
	preparation of sediment		1	105,000	105,000
Fitration Unit	For Filtration of SS and Coliform		5	7,000	35,000
	For Making Filtrated sample and Chlorophyll-a		4	65,000	260,000
Automatic shaker	shake funnels		2	60,000	120,000
Autodispenser	for storage of reagent		5	9,000	45,000
Spectophotometer	measure level (concentration) of	nitrogen,	2	88,000	176,000
Standard sieve for soil	screening soil	sediment size	2	3,080	6,160
Automatic shaker for screen	screening soil	sediment size distributio	1	15,000	15,000
Wastewater Treatement System			1	1,000,000	1,000,000
		For Basic Parametrs		Sub Total	2,927,660
For Toxic Parameters					
Atomic absorption spectrophotomete	Flame method and Grafite method		1	647,500	647,500
Micro Wave Oven	C.M. Brand (same type from GSCA)		1	600,000	600,000
Hydride vapor generator (same brand with Gas chromatograph)	measure Arsenic	As	1	88,000	88,000
Rotary Evaporator	for hexan extracts		2	30,000	60,000
Rotary Evaporator	for analysis of organic compounds		3	30,000	90,000
Reflax condenser	for pre-treatment of samples for Mercury analysis	Hg for digestion	4	65,000	260,000
Mecury redcution unit	for Mercury analysis	For atomic absorption sp	1	4,000	4,000
Soxhlet extractor	extraction of organic compounds	Pesticides	4	30,000	120,000
Soxhlet extractor	in solid samples	Hexan Extract	4	30,000	120,000
Gradient trap (apparatus for purge trap method) (same brand with Gas chromatograph)	for analysis of VOC (for example trichloroethylene)		2	260,000	520,000
Gas chromatograph-ECD	for micro-analysis of organic matters		2	277,500	555,000
Gas chromatograph-FPD	for micro-analysis of organic matters		1	305,250	305,250
Capillary Column	brand number SPB-608 or DB-5 (30		2	4,625	9,250
Capillary Column	brand number SPB-624 or DB-624		2	8,547	17,094
		For Toxic Parametrs		Sub Total	3,396,094
		Laboratory Equipment		Sub Total	6,323,754
				Total	6,745,504

b) Monitoring Site Offices

The proposed Monitoring Site Offices should be developed as shown below (see Table 9.5):

Table 9.5 Development Priority for Each of the Monitoring Site Offices

Starting Year for Operation	Year 2001	Year 2002	Year 2003	Year 2004
Development Priority 1	- La Paz (1) - Acapulco (5) - Tepic (8) - Villahermosa (11) - Campeche (12)			
Development Priority 2		- Colima (13) - Fortin de las Flores (10) - Tapachula (11) - Cancun (12)		
Development Priority 3			- Ensenada (1) - Mazatlan (3) - Lazaro Cardenas (4) - Veracruz (10)	
Development Priority 4				- Guerrero Negro (1) - Salina Cruz (5) - La Pesca (9)

Source: JICA Study Team
Note: Number in parentheses denotes the region number.

The location of the Priority Area and the existence of a State Laboratory have been considered in the identification and prioritization of the Monitoring Site Offices (MSO). Existing State Laboratories could be converted into MSOs, and their staff and office building for water quality monitoring could be utilized. In the areas without a State laboratory, such as Ensenada, Guerrero Negro, Mazatlan, Lazaro Cardenas, Salina Cruz, La Pesca, and Veracruz, it would be necessary to build new monitoring site office buildings. Table 9.6 shows the proposed sampling and laboratory equipment of the MSO.

Table 9.6 Proposed Sampling and Laboratory Equipment/Facility of the Monitoring Site Offices

Equipment	Use and Objectives		Quantity	Unit Price (N$)	Cost (N$)
Sampling Equipment					
GPS	Navigation		1	5,000	5,000
Radio Communication System	Communication		1	10,000	10,000
Van Dorn Water Sampler	Sampling for water quality	Big-sized (6L)	2	16,000	32,000
		Small-sized (3L)	2	14,000	28,000
Smith-McIntyre Sediment Sampler	Sampling for sediment		1	25,000	25,000
Ekman-Berge Sediment Sampler	Sampling for sediment		1	15,000	15,000
Forel Color Indicator	Observation of Water Color		2	1,000	2,000
Depth Meter	Measuring Depth (Tape Measure with Mark)		3	1,000	3,000
Life Jacket			10	1,000	10,000
pH Meter	Measuring pH		1	15,000	15,000
Filtration Unit	Filtration of SS and Coliform		5	7,000	35,000
	Making filtrated sample and Chlorophyll-a with pump		4	25,000	100,000
Ice Box	Transporting samples and survey		5	150	750
				Sub Total	280,750
Laboratory Equipment					
Large-sized refrigerator	Preserving samples (6 cu.m)	for extensive use	1	52,300	52,300
Large-sized refrigerator	Preserving reagents	for extensive use	1	25,000	25,000
Filtration Unit	Filtration of SS and Coliform		5	7,000	35,000
	Making Filtrated sample and Chlorophyll-a		4	65,000	260,000
				Sub Total	372,300
				Total	653,050

Source: JICA Study Team

9.2.2 Cost Estimate

a) Basis of Cost Estimate

The cost of this project component is estimated based on the following conditions:

- Engineering cost is assumed at 5.0% of direct construction cost.
- Physical contingency allowance at assumed at 4.0% of direct construction cost.
- All base costs are expressed under the economic conditions prevailing in November 1999.
- Currency exchange rate of US$ 1 = N$ 9.25 = ¥ 105 is assumed.
- All taxes such as V.A.T. and federal taxes are not considered for this estimate.

b) Component Cost

The total cost of this project component is N$ 140.3 million, while the total initial cost is estimated to be N$ 91.8 million. The total O/M cost from 2000 to 2010 is estimated to be N$ 48.5 million. The annual O/M cost from 2005 to 2010 is estimated to be N$ 5.8 million. The bases of cost estimation for a Region 1 Laboratory shown in Table 9.7 applies to each regional laboratory development sub-component. In terms of analysis cost, this is dependent on the number of monitoring samples, which is to be determined based on the type of priority area.

Table 9.7 Bases of Cost Estimation for Region 1 Laboratory

1. Initial Cost	Estimation Base	Unit cost	Quantity	Cost (N$)
(1) Equipment/Facility Cost				
1) Sampling Equipment	See Table 9.3	421,750	1	421,750
2) Laboratory Equipment/Facility	See Table 9.3			
(Basic Parameters)	See Table 9.3	2,927,660	1	2,927,660
(Toxic Parameters)	See Table 9.3	3,396,094	1	3,396,094
			Sub Total	6,745,504
2. Annual O/M Cost	**Estimation Base**	**Unit cost**	**Quantity**	**Cost (N$)**
(1) Sampling Cost				
1) Sampling boat rental fee	Large size	4,500	12	54,000
	Small size	1,700	38	64,600
(2) Analysis Cost				
1) Reagent Cost	Water quality (basic parameters) 888 samples	158,994	1	158,994
	Water quality (toxic parameters) 102 samples	27,390	1	27,390
	Sediment (basic parameter) 102 samples	2,765	1	2,765
	sediment (toxic substances) 102 samples	22,120	1	22,120
2) Consumption Cost for Analyses	Water quality (basic parameters) 100 samples	2,498	8.88	22,182
	Water quality (toxic parameters) 100 samples	6,299	1.02	6,425
	Sediment (basic parameter) 100 samples	8,189	1.02	8,353
	Sediment (toxic substances) 100 samples	1,774	1.02	1,809
(3) Maintenance Cost for Equipment/Facility	3.0 % of the Equipment/Facility cost is for maintenance (Sampling and Basic)	3,349,410	0.03	100,482
	3.0 % of the Equipment/Facility cost is for maintenance (Toxic)	3,396,094	0.03	101,883
			Sub Total	571,004
			Total	7,316,508

Note: 1) This cost includes the analysis costs of the Monitoring Site Offices in the same region.

The sampling by type of priority area per year is identified in Table 9.8. If an area has more than two types of priority areas, the priority area with the most number of sampling stations will be considered as the representative priority area.

Table 9.8 Sampling Determination by Priority Area

Item		Water Quality		Sediment	
Type of Priority Area	Number of Sampling Stations	Basic Parameters	Toxic Parameters	Basic Parameters	Toxic Parameters
Industry	15	15 stations x 2 layers x 6 times = 180	10 stations x 1 layer x 2 times = 20	10 stations x 2 times = 20	10 stations x 2 times = 20
Tourism	12	12 stations x 2 layers x 6 times = 144	8 stations x 1 layer x 2 times = 16	8 stations x 2 times = 16	8 stations x 2 times = 16
Fishery	10	10 stations x 2 layers x 6 times = 120	7 stations x 1 layer x 2 times = 14	7 stations x 2 times = 14	7 stations x 2 times = 14

The detailed cost of this project component is shown in Table 9.9.

9.2.3 Implementation Schedule

The proposed implementation schedule is shown in Table 9.10.

Table 9.9 (1) Component Cost for Establishment of National Coastal Water Quality Monitoring Network

(Unit: thousand N$)

Items/Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
C.N.A Region 1												
a) Regional Laboratory (Mexicali)												
- Installation of sampling equipment		422										422
- Installation of laboratory equipment (basic parameters)			2,930									2,930
- Installation of laboratory equipment (toxic parameters)					3,396							3,396
- Operation (basic parameters)			205	411	411	411	411	411	411	411	411	3,493
- Operation (toxic parameters)					79	159	159	159	159	159	159	1,033
b) Monitoring Site Office												
1) Ensenada (new)												
- Office construction and installation of equipment, etc.				858								858
- Operation				63	127	127	127	127	127	127	127	952
2) Guerrero Negro (new)												
- Office construction and installation of equipment etc.					858							858
- Operation					73	147	147	147	147	147	147	955
3) La Paz (converted from State Laboratory)												
- Installation of equipment, etc.		653										653
- Operation (sampling and basic analysis)		63	127	127	127	127	127	127	127	127	127	1,206
Region 1 Total	0	1,138	3,262	1,459	5,071	971	971	971	971	971	971	16,756
C.N.A Region 2												
a) Regional Laboratory (Hermosillo)												
- Installation of sampling equipment		421										421
- Installation of laboratory equipment (basic parameters)		2,927										2,927
- Installation of laboratory equipment (toxic parameters)				3,396								3,396
- Operation (basic parameters)		126	252	252	252	252	252	252	252	252	252	2,394
- Operation (toxic parameters)				63	126	126	126	126	126	126	126	945
Region 2 Total	0	3,474	252	3,711	378	378	378	378	378	378	378	10,083
C.N.A Region 3												
a) Regional Laboratory (Culiacan)												
- Installation of sampling equipment		421										421
- Installation of laboratory equipment (basic parameters)			2,929									2,929
- Installation of laboratory equipment (toxic parameters)					3,396							3,396
- Operation (basic parameters)			140	281	281	281	281	281	281	281	281	2,388
- Operation (toxic parameters)					66	132	132	132	132	132	132	858
b) Monitoring Site Office												
1) Mazatlan (New)												
- Building construction and installation of equipment etc.				858								858
- Operation				53	107	107	107	107	107	107	107	802
Region 3 Total	0	421	3,069	1,192	3,850	520	520	520	520	520	520	11,652
C.N.A Region 4												
a) Regional Laboratory (Cuernavaca)												
- Installation of sampling equipment		421										421
- Installation of laboratory equipment (basic parameters)		2,927										2,927
- Installation of laboratory equipment (toxic parameters)				3,396								3,396
- Operation (basic parameters)		144	289	289	289	289	289	289	289	289	289	2,745
- Operation (toxic parameters)				76	153	153	153	153	153	153	153	1,147
b) Monitoring Site Office												
1) Lazaro Gardenas (New)												
- Building construction and installation of equipment etc.				858								858
- Operation				53	107	107	107	107	107	107	107	802
Region 4 Total	0	3,492	289	4,672	549	549	549	549	549	549	549	12,296
C.N.A Region 5												
a) Regional Laboratory (Oaxaca)												
- Installation of sampling equipment		421										421
- Installation of laboratory equipment (basic parameters)			2,927									2,927
- Installation of laboratory equipment (toxic parameters)					3,396							3,396
- Operation (basic parameters)			201	403								604
- Operation (toxic parameters)					74	149	149	149	149	149	149	968
b) Monitoring Site Office												
1) Acapulco (covered by present State Laboratory)												
- Installation of equipment, etc.		653										653
- Operation (Sampling and Basic Analysis)		63	127	127	127	127	127	127	127	127	127	1,206
2) Salina Cruz (New)												
- Building construction and installation of equipment etc.					858							858
- Operation					53	107	107	107	107	107	107	695
Region 5 Total	0	1,137	3,255	530	4,508	383	383	383	383	383	383	11,728

Table 9.9 (2) Component Cost for Establishment of National Coastal Water Quality Monitoring Network

(Unit: thousand N$)

Items/Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
C.N.A Region 8												
a) Regional Laboratory (Guadalajara)												
- Installation of sampling equipment		421										421
- Installation of laboratory equipment (basic parameters)		2,927										2,927
- Installation of laboratory equipment (toxic parameters)				3,396								3,396
- Operation (basic parameters)			173	348	348	348	348	348	348	348	348	2,957
- Operation (toxic parameters)				74	148	148	148	148	148	148	148	1,110
b) Monitoring Site Office												
1) Tepic (covered by present State Laboratory)												
- Installation of equipment, etc.		653										653
- Operation (Sampling and Basic Analysis)		63	127	127	127	127	127	127	127	127	127	1,206
2) Colima (covered by present State Laboratory)												
- Installation of equipment, etc.		653										653
- Operation		53	107	107	107	107	107	107	107	107	107	1,016
Region 8 Total	0	4,770	407	4,052	730	730	730	730	730	730	730	14,339
C.N.A Region 9												
a) Regional Laboratory (Present Tampico Laboratory)												
- Operation	403	403	403	403	403							2,015
b) Monitoring Site Office												
1) La Pesca (new)												
- Building construction and installation of equipment etc.					858							858
- Operation					53	107	107	107	107	107	107	695
Region 9 Total	403	403	403	403	1,314	107	107	107	107	107	107	20,782
C.N.A Region 10												
a) Regional Laboratory (Xalapa)												
- Installation of sampling equipment		421										421
- Installation of laboratory equipment (basic parameters)			2,927									2,927
- Installation of laboratory equipment (toxic parameters)					3,396							3,396
- Operation (basic parameters)			157	314	314	314	314	314	314	314	314	2,669
- Operation (toxic parameters)					69	139	139	139	139	139	139	903
b) Monitoring Site Office												
1) Veracruz (new)												
- Building construction and installation of equipment etc.				853								853
- Operation				63	127	127	127	127	127	127	127	952
2) Fortin de las Flores (covered by State Laboratory)												
- Installation of equipment, etc.			653									653
- Operation			63	127	127	127	127	127	127	127	127	1,079
Region 10 Total	0	421	3,800	1,357	4,033	707	707	707	707	707	707	13,853
C.N.A Region 11												
a) Regional Laboratory (Tuxtla Gutierrez)												
- Installation of sampling equipment			421									421
- Installation of laboratory equipment (basic parameters)			2,927									2,927
- Installation of laboratory equipment (toxic parameters)					3,396							3,396
- Operation (basic parameters)			157	314	314	314	314	314	314	314	314	2,669
- Operation (toxic parameters)					69	139	139	139	139	139	139	903
b) Monitoring Site Office												
1) Villahermosa (covered by State Laboratory)												
- Installation of equipment, etc.		653										653
- Operation		53	107	107	107	107	107	107	107	107	107	1,016
2) Tapachula (covered by State Laboratory)												
- Installation of equipment, etc.			653									653
- Operation			53	127	127	127	127	127	127	127	127	1,069
Region 11 Total	0	706	4,318	548	4,013	687	687	687	687	687	687	13,707
C.N.A Region 12												
a) Regional Laboratory (Merida)												
- Installation of sampling equipment		421										421
- Installation of laboratory equipment (basic parameters)		2,927										2,927
- Installation of laboratory equipment (toxic parameters)				3,396								3,396
- Operation (basic parameters)		193	386	386	386	386	386	386	386	386	386	3,667
- Operation (toxic parameters)				77	154	154	154	154	154	154	154	1,155
b) Monitoring Site Office												
1) Campeche (covered by State Laboratory)												
- Installation of equipment, etc.		653										653
- Operation		63	127	127	127	127	127	127	127	127	127	1,206
2) Cancun (covered by State Laboratory)												
- Installation of equipment, etc.			653									653
- Operation			63	127	127	127	127	127	127	127	127	1,079
Region 12 Total	0	4,257	1,229	4,113	794	794	794	794	794	794	794	15,157
Grand Total	403	20,219	20,284	22,037	25,240	5,826	5,826	5,826	5,826	5,826	5,826	140,353

Table 9.10 (1) Implementation Schedule for Establishment of 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 Cardenas (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					···	—	—	—	—	—	—

Table 9.10 (2) Implementation Schedule for Establishment of National Coastal Water Quality Monitoring Network

Items/Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
C.N.A Region 8											
a) Regional Laboratory (Guadalajara)											
- 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) Tepic (converted from present State Laboratory)											
- Installation of equipment, etc.		—									
- Operation		···	—	—	—	—	—	—	—	—	—
2) Colima (converted from present State Laboratory)											
- Installation of equipment, etc.			—								
- Operation			···	—	—	—	—	—	—	—	—
C.N.A Region 9											
a) Regional Laboratory (Tampico Laboratory)											
- Operation	—	—	—	—	—						
b) Monitoring Site Office											
1) La Pesca (New)											
- Building construction and installation of equipment etc.					—						
- Operation					···	—	—	—	—	—	—
C.N.A Region 10											
a) Regional Laboratory (Xalapa)											
- 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) Veracruz (New)											
- Building construction and installation of equipment etc.				—							
- Operation				···	—	—	—	—	—	—	—
2) Fortin de las Flores (converted from State Laboratory)											
- Installation of equipment, etc.			—								
- Operation			···	—	—	—	—	—	—	—	—
C.N.A Region 11											
a) Regional Laboratory (Tuxtla Gutierrez)											
- 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) Villahermosa (converted from present State Laboratory)											
- Installation of equipment, etc.		—									
- Operation		···	—	—	—	—	—	—	—	—	—
2) Tapachula (converted from present State Laboratory)											
- Installation of equipment, etc.			—								
- Operation			···	—	—	—	—	—	—	—	—
C.N.A Region 12											
a) Regional Laboratory (Merida)											
- 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) Campeche (converted from present State Laboratory)											
- Installation of equipment, etc.		—									
- Operation		···	—	—	—	—	—	—	—	—	—
2) Cancun (converted from present State Laboratory)											
- Installation of equipment, etc.			—								
- Operation			···	—	—	—	—	—	—	—	—

9.3 Development of Tampico Laboratory and the Core Center

9.3.1 Sub-Components

The cost of this project can be divided into the following two sub-components:

a) Tampico Laboratory

The Tampico Laboratory should be redeveloped as one of the regional laboratories and is to be located within the same building as the Core Center. The Tampico Laboratory has the following two main functions:

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

b) Core Center

The Core Center should be established in order to control all regional laboratories including the Tampico Laboratory, for coastal water quality monitoring from a technical aspect. The Core Center has the following three main functions:

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

Detailed design for both Tampico Laboratory and the Core Center should commence in 2001, with preliminary operations in 2004. Full operation is slated for 2005.

9.3.2 Cost Estimate

a) Basis of Cost Estimate

The cost of this project component is estimated based on the following conditions:

- Engineering cost is assumed at 5.0% of direct construction cost.
- Physical contingency allowance is assumed at 4.0% of direct construction cost.
- All base costs are expressed under the economic conditions prevailing in November 1999.
- Currency exchange rate of US$ 1 = N$ 9.25 = ¥ 105 is assumed.
- All taxes such as V.A.T. and federal tax are not considered for this estimate.

b) Component Cost

The total initial cost of this component is estimated to be 25.4 million. The annual O/M cost from 2005 to 2010 is estimated to be N$ 0.9 million.

The estimation bases of the Tampico Laboratory and the Core Center sub-components are shown in Tables 9.11 and 9.12 respectively.

Table 9.11 Estimation Bases for Core Center Sub-Component

1. Initial Cost	Estimation Base	Unit cost	Quantity	Cost (N$)
(1) Construction Cost				
1) Main building	Cost based on GSCA estimation per m^2	6,258	1,200	7,509,120
2) Ware house	Cost based on GSCA estimation per m^2	1,971	100	197,120
3) Boat house	Cost based on GSCA estimation per m^2	2,819	65	183,248
4) Land Preparation Cost	Cost based on GSCA estimation per m^2	10	1,500	15,000
5) Engineering Cost	5.0 % of the direct construction cost	7,889,488	0.05	394,474
6) Physical Contingency	4.0 % of the direct construction cost	7,889,488	0.04	315,580
	Construction Total			8,614,542
(2) Equipment/Facility Cost				
1) Sampling Equipment		420,750	1	420,750
2) Management Equipment/Facility		588,000	1	588,000
3) Sampling Boat	N$976,000 x2 ships	1,952,000	1	1,952,000
	Equipment Total			2,960,750
	Initial Cost Sub Total			20,189,834
2. Annual O/M Cost	Estimation base	Unit cost	Quantity	Cost (N$)
(1) Sampling Cost	Not covered by Core Center			-
(2) Analysis Cost				
1) Reagent Cost	water quality (basic parameters) 300 samples	58,848	1	58,848
	water quality (toxic parameters) 300 samples	61,151	1	61,151
	sediment (basic parameter) 300 samples	7,608	1	7,608
	sediment (toxic substances) 300 samples	47,570	1	47,570
2) Consumption Cost for Analyses	water quality (basic parameters) 100 samples	2,498	3	7,494
	water quality (toxic parameters) 100 samples	6,299	3	18,897
	sediment (basic parameter) 100 samples	8,189	3	24,567
	sediment (toxic substances) 100 samples	1,774	3	5,322
(3) Maintenance Cost for Equipment/Facility	3.0 % of the Equipment/Facility cost as for the maintenance	1,008,750	0.03	30,263
(4) Maintenance/Inspection Cost for Sampling Boat	cost based on GSCA's personnel	38,400	1	38,400
(5) Training Cost	cost based on GSCA's a recent technical seminar fee per day per 20 persons	586	10	5,860
	Annual O/M Cost Sub Total			305,980
			Total	20,495,813

Source: JICA Study Team

Table 9.12 Estimation Bases for Tampico Laboratory Sub-Component

1. Initial Cost	Estimation Base	Unit cost	Quantity	Cost (N$)
(1) Construction Cost				
1) Main building	Cost based on CNA estimation per m^2	6,258	1,100	6,883,360
2) Ware house	Cost based on CNA estimation per m^2	1,971	100	197,120
3) Boat house	not covered by Tampico laboratory component			-
4) Land Preparation Cost	Cost based on CNA estimation per m^2	10	1,300	13,000
5) Engineering Cost	5.0 % of the direct construction cost	7,080,480	0.05	354,024
6) Physical Contingency	4.0 % of the direct construction cost	7,080,480	0.04	283,219
	Construction Cost Total			7,730,723
(2) Equipment/Facility Cost				
1) Sampling Equipment	see File (cost-EuipT24)	341,750	1	341,750
2) Laboratory Equipment/Facility	see File (cost-EuipT24)	5,746,254	1	5,746,254
	Equipment Total			6,088,004
			Sub Total	21,549,450
2. Annual O/M Cost	**Estimation base**	**Unit cost**	**Quantity**	**Cost (N$)**
(1) Sampling Cost				
1) Sampling boat rent fee	large size (12 times / year)	4,500	12	54,000
	small size (3x10+ 4x2) times / year	1,700	38	64,600
(2) Analysis Cost				
1) Reagent Cost	water quality (basic parameters) - 300 samples	58,848	1	58,848
	water quality (toxic parameters) - 34 samples	15,795	1	15,795
	sediment (basic parameter) - 64 samples	1,101	1	1,101
	sediment (toxic substances) - 64 samples	13,380	1	13,380
2) Consumption Cost for Analyses	water quality (basic parameters) - 100 samples	2,498	3.00	7,494
	water quality (toxic parameters) 100 samples	6,299	0.34	2,142
	sediment (basic parameter) - 100 samples	8,189	0.34	2,784
	sediment (toxic substances) - 100 samples	1,774	0.34	603
(3) Maintenance Cost (Equipment/Facility)	3.0 % of the Equipment/Facility cost as for the maintenance	6,088,004	0.03	182,640
			Sub Total	403,387
			Total	21,952,838

Note: 1) This cost does not include personal expenses.

2) This construction cost includes design fee, but excluding land acquisition cost.

The detailed cost of this component is shown in Table 9.13.

9.3.3 Implementation Schedule

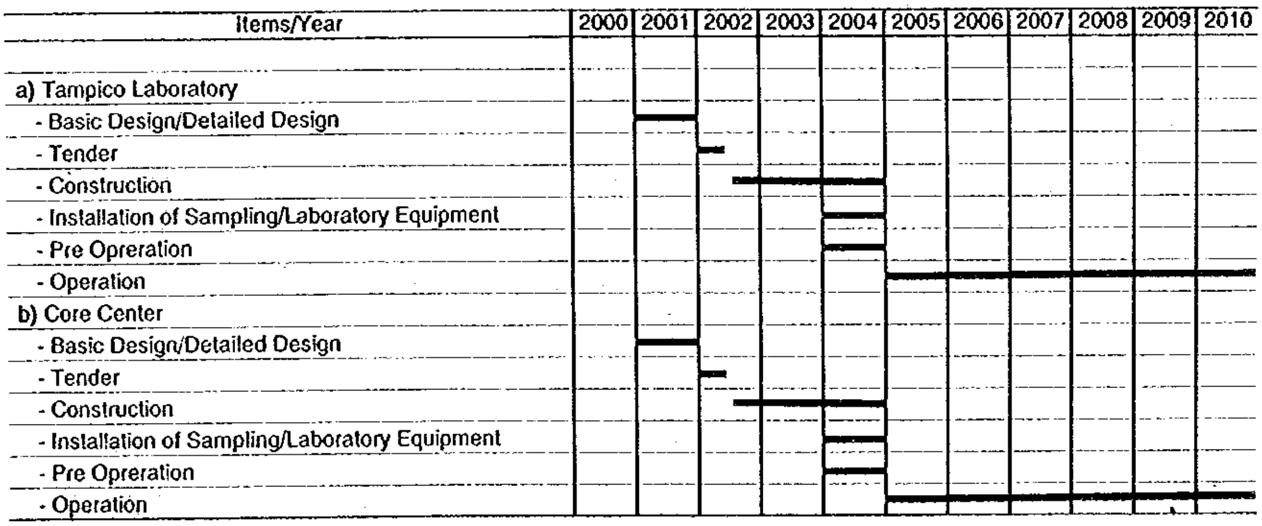
The proposed implementation schedule of this component is shown in Table 9.14.

Table 9.13 Component Cost for Development of Tampico Laboratory and the Core Center

(Unit: thousand N$)

Items/Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
a) Tampico Laboratory											
- Basic Design/Detailed Design		1,932									
- Tender			1,932								
- Construction				1,932	1,932						
- Installation of Sampling/Laboratory Equipment					6,088						
- Pre Operation											
- Operation						591	591	591	591	591	591
b) Core Center											
- Basic Design/Detailed Design		2,153									
- Tender			2,153								
- Construction				2,153	2,153						
- Installation of Sampling/Laboratory Equipment					2,960						
- Pre Operation											
- Operation						305	305	305	305	305	305
Total		4,085	4,085	4,085	13,133	896	896	896	896	896	896

Table 9.14 Implementation Schedule for Development of Tampico Laboratory and the Core Center



9.4 Financial Resources

The proposed project could be applied for a Yen Loan as an environmental project under a Japanese development finance agency. Taking this into consideration, the JICA Study Team could consider the following five basic alternatives of financial resources for the proposed project as follows:

Table 9.15 Basic Alternatives of Financial Resources

	Laboratory / Monitoring Site Office Construction Cost	Sampling / Laboratory Equipment Cost	O/M Cost
Alternative 1	CNA	CNA	CNA
Alternative 2	CNA	A development finance agency*	*CNA*
Alternative 3	A development finance agency	A development finance agency*	*CNA*
Alternative 4	A development finance agency	WB (*PROMMA*)	*CNA*
Alternative 5	WB (*PROMMA*)	WB (*PROMMA*)	*CNA*

Note: Excludes the World Bank (WB)

(1) Alternative 1

The proposed project will be fully financed by *CNA*. This alternative should be considered as one of the alternatives in the near future.

(2) Alternative 2

The proposed project could be financed by *CNA* in terms of the cost of laboratory/monitoring site office construction as well as the O/M cost. The other costs, which include sampling and laboratory equipment cost, could be financed by a development finance agency.

(3) Alternative 3

The laboratory/monitoring site office construction cost and sampling/laboratory equipment cost could be financed by a Japanese development agency. In general, the Japanese development finance agency could cover 60% of the total project cost. The present conditions of this case in Mexico are as follows:

- Interest Rate: 1.8 %
- Repayment Period: 25 years
- Grace Period: 7 years

(4) Alternative 4

The proposed project could be financed by World Bank (WB), which also finances *PROMMA* Since *PROMMA* has an ongoing project on surface water quality monitoring in Mexico, some of their sampling/laboratory equipment could be shared for coastal water quality monitoring use.

(5) Alternative 5

The laboratory and MSO construction cost and sampling/laboratory equipment cost could be financed by WB (*PROMMA*). But *CNA* could finance the O/M cost.