The comparison of the alternatives is shown in Table 1.3.2. Though these alternatives have various advantages and disadvantages as mentioned in the Table, there is no decisive difference between them in the Master Plan itself with the target year 2005. However, taking account of construction works including the works based on the Short-term Plan, Case 1 has a great advantage by using the existing land possessed by EMPORNAC as the site for the new container terminal. Moreover,in the first stage, reclaimed land will be created using dredged materials which can then be used for the second stage with sufficient time to stabilize the reclaimed soft soil. Thus, Case 1 is selected as the optimum plan.

1.3.8 Navigation Aids Planning

(1) Navigation aids

To secure the safety of navigation at sea, establishment of navigation aids and other relevant facilities is necessary. Visual and electronic navigation aids are complementary. Neither one is sufficient by itself. The visual range is limited and affected by weather, while the electronic range is extended and not affected by the weather.

The number of visual aids and electronic aids to navigation in the Long-term Plan is as follows:

a) Visual Navigation Aids

1)	Safe Water Marks	2
2)	Lateral Marks	14
3)	Cardinal Marks	3
4)	Isolated Danger Marks	4
5)	Lighthouse	3

b) Electronic Navigation Aids

Radar beacon stations are planned primarily for the entrance channel and its vicinity.

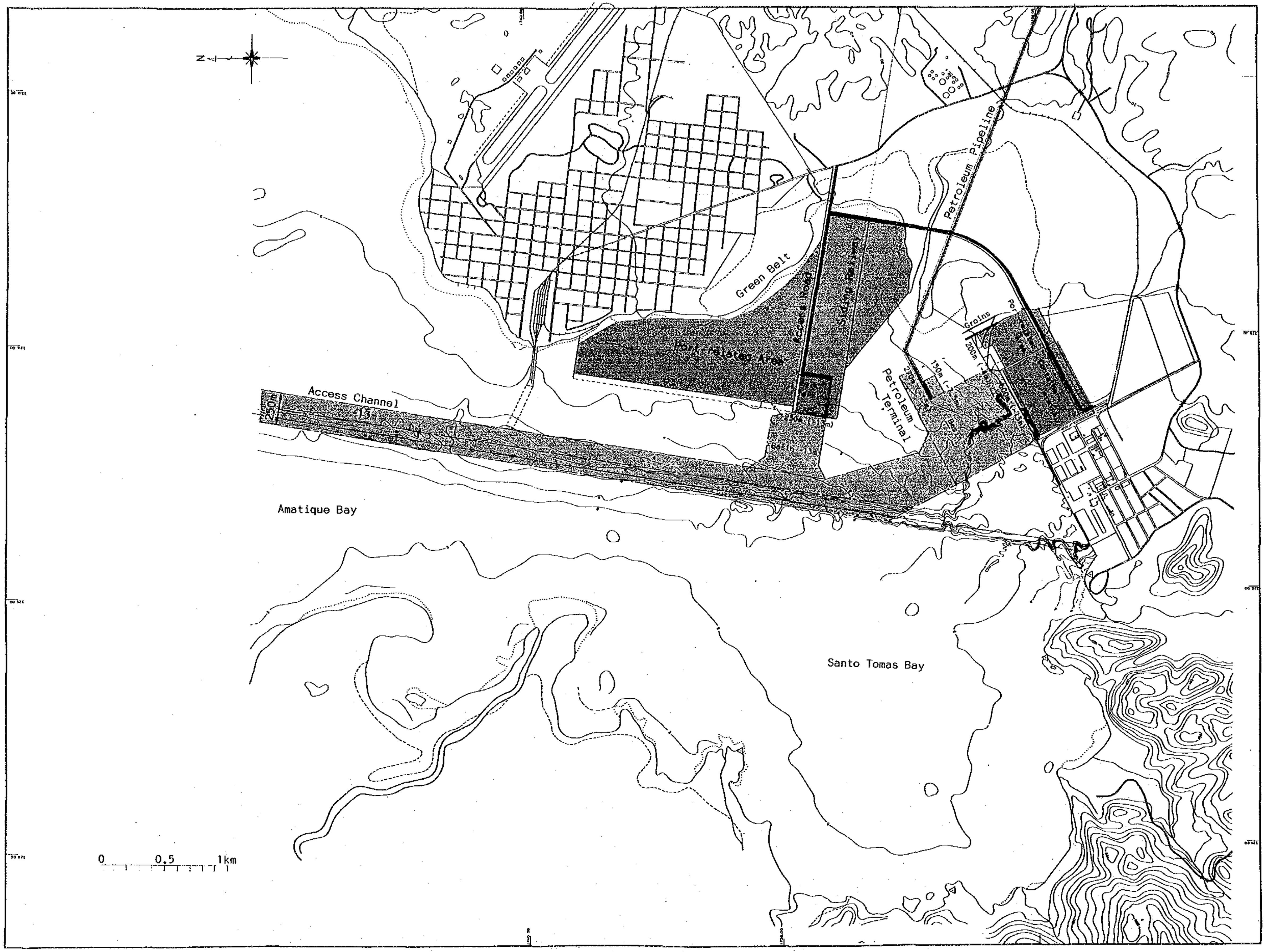


Fig. 1.3.2 Alternative Layout Plan -- Case 1

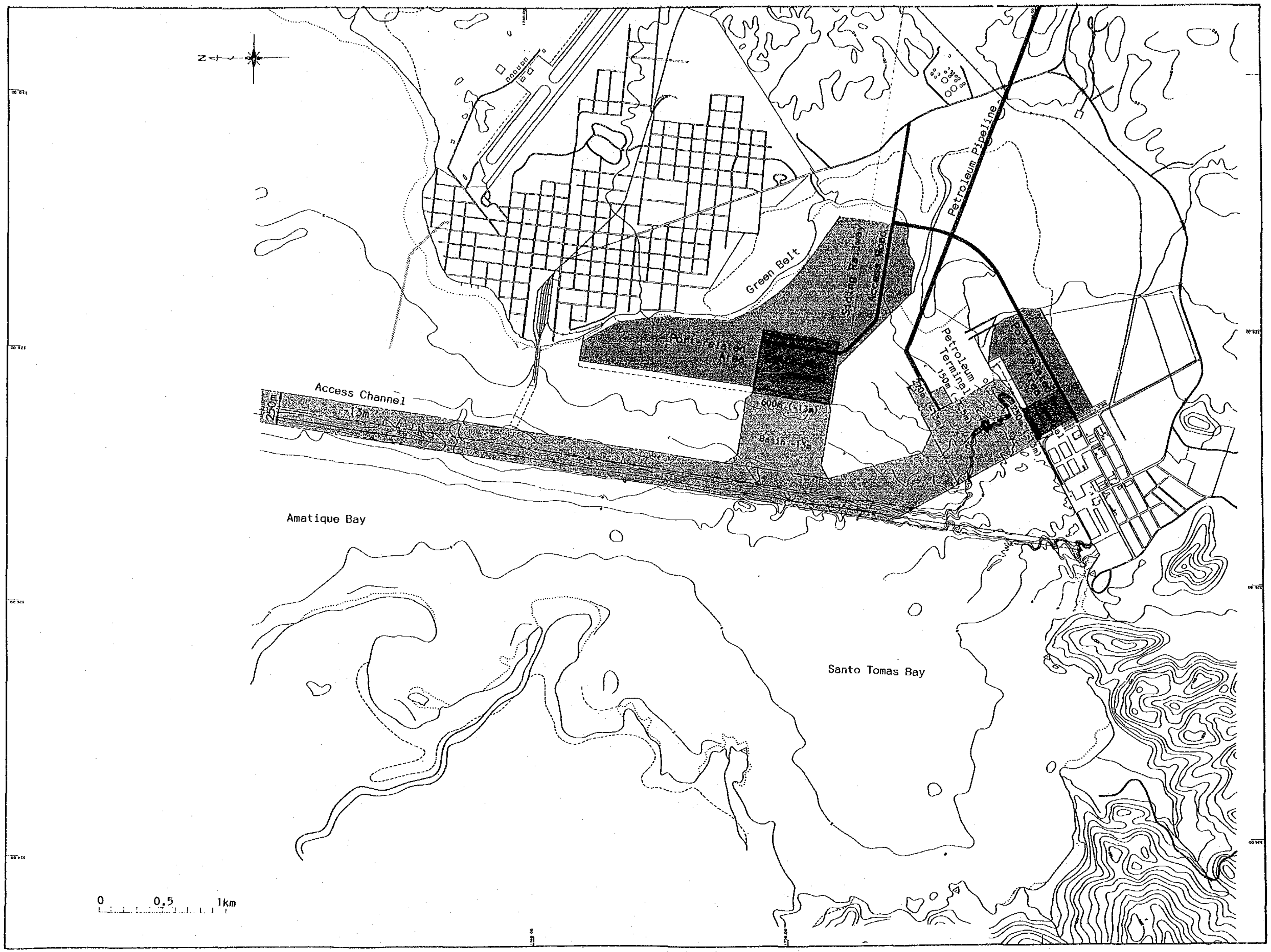


Fig. 1.3.3 Alternative Layout Plan -- Case 2

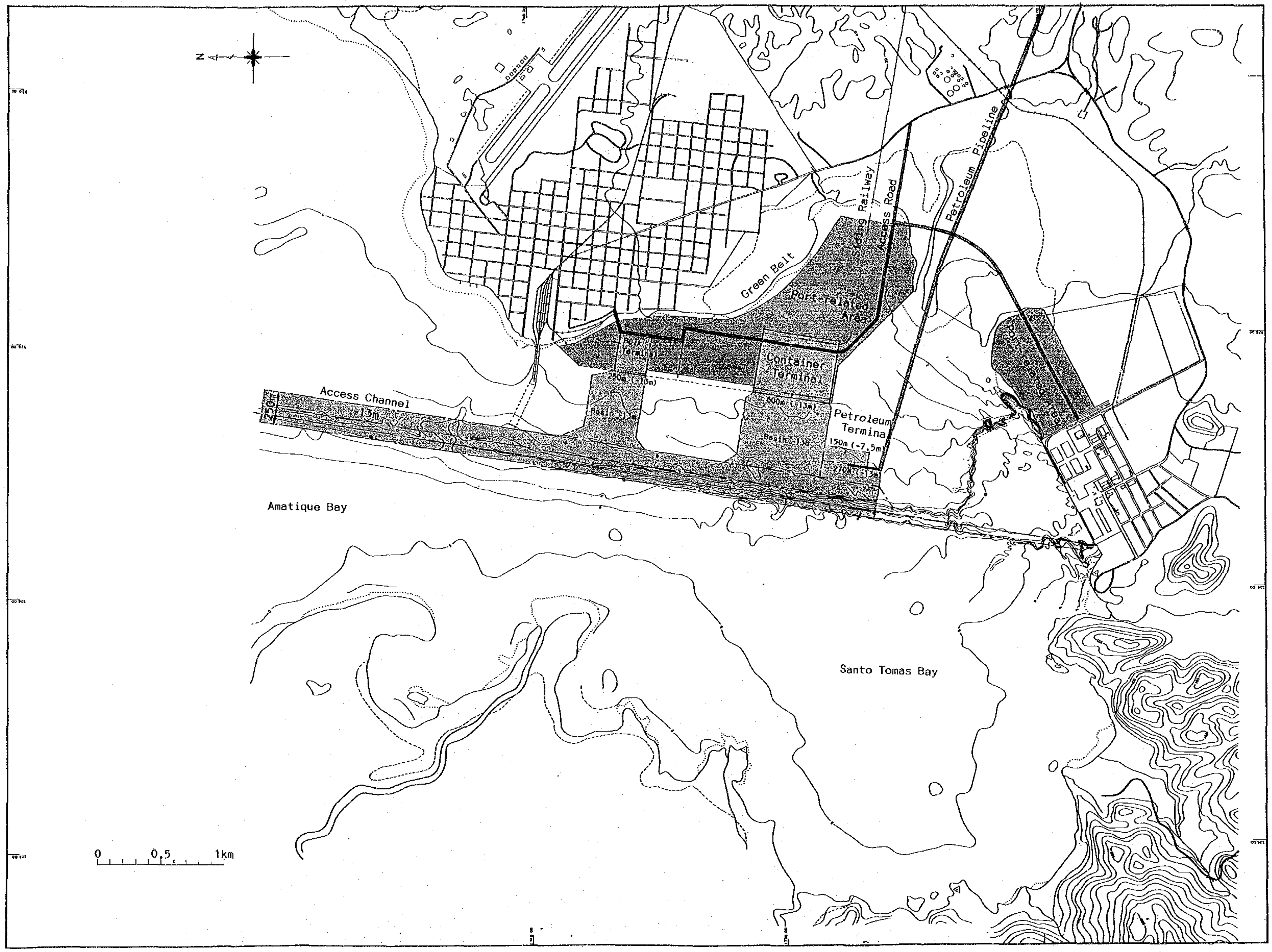


Fig. 1.3.4 Alternative Layout Plan -- Case 3

Table 1.3.2 Comparison of the Alternative Layout Plans of the Master Plan

Item	Case 1	Case 2	Case 3	Case 4
1. Acquisition of sites for the Container and Bulk Terminals	It is not necessary to acquire the site for the proposed container terminal since that is already possessed by EMPORNAC. However, there is no sufficient space behind the site for port-related industries or business due to the location of ZOLIC. On the other hand, the site for the bulk terminal must be reclaimed using dredged materials from the access channel and basins. As the dredged materials seem to be soft, after reclamation, soil stabilization will be needed.	The site for the proposed container terminal must be reclaimed using dredged materials. After reclamation, soil stabilization will be needed. On the other hand, the site for the bulk terminal is already possessed by EMPORNAC.	The sites for the proposed container and bulk terminals must be reclaimed using dredged materials. After reclamation, soil stabilization will be needed. The area neighboring the existing terminal will remain unused.	
2. Construction Cost Excluding Cost for the Petroleum Terminal	456 Mil. Quetzales	454 Mil. Quetzales	430 Mil. Quetzales	
3. Port Administration and Operation	At the site for the container terminal neighboring the existing terminal, only two berths can be constructed due to the limited area. Hence, additional container berths required beyond the target year 2005 will be separated from the proposed first stage container terminal which will be constructed east of the Cacao River.	Additional container and bulk berths required beyond the target year 2005 can be constructed adjacent to the respective proposed first stage terminals. Thus, each of the terminals can be administrated and operated as a single unit, even in the far future.	The same as Case 2.	
4. Handling of Dangerous Cargoes	Dangerous cargoes will be separated from other cargoes by construcing a new petroleum terminal.	The same as Case 1.	The same as Case 1.	Dangerous cargoes will be separated from other cargoes by constructing a new petroleum terminal. As the distance between the terminal and existing or planned storage tanks located near the existing port is great, this case is costly compared with the other alternatives.

(2) Need for Administrative Structure for Maintenance

At present, because of the lack of an appropriate administrative structure, efficient maintenance is not conducted even for routine services, and emergency services for immediate remedy of sudden failures are also not sufficient. The deployment of the total buoy replacement maintenance system on a biannual base is proposed to maintain reliable effective operational performance of the lighted buoys.

1.3.9 Dredging Plan

(1) Channel and Basin Dredging

The existing channel is not sufficiently wide for navigation of vessels. Therefore, the existing channel will be dredged to increase its depth and width.

To minimize the obstruction to navigation of vessels during the dredging work, the channel will be relocated 90m east of the existing channel.

Basins in front of the new wharf, oil berth and bulk terminal shall also be dredged.

(2) Dredging

a) Dredging volume

The dredging volume of the channel and basins for the planned water depth is shown in Table 1.3.3

Table 1.3.3 Dredging Volume of Channel and Basins

Depth	Channel	Container	Bulk	Total
11.0m	3,100,000m^3	3,100,000 m^3	940,000 m^3	7,140,000 m^3
12.0	6,500,000	5,500,000	1,330,000	13,330,000
13.0	9,300,000	6,800,000	2,130,000	18,230,000
14.0	14,900,000	8,000,000	2,780,000	25,680,000

The channel and basins shall be dredged to a depth of -13m below C.D.L under the master plan and -11m below C.D.L under the short-term plan considering the dredging volume and the draft of calling vessels.

b) Disposal of dredged materials

Dredged materials should not be dumped into open water areas. Revetments should be constructed to prevent the spread of the dredged materials into the water.

1.3.10 Cost Estimation

The estimated costs of facilities and equipment under the master plan of the new port are shown in Table 1.3.4.

Table 1.3.4 Construction Cost

Unit: Million Quetzales

Item	Case 1	Case 2	Case 3
1. Container Terminal	265.68	238.32	238.32
2. Bulk Terminal	99.13	124.41	96.86
3. Oil Terminal	31.42	31.42	42.54
4. Common Facilities	91.32	91.32	94.91
Total	487.55	485.47	472.63

1.4 PORT MANAGEMENT AND OPERATION

1.4.1 Port Management and Operation System

EMPORNAC is the sole body responsible for the planning, construction, management and operation of the port. In developed countries, both the public and private sectors play important roles to ensure smooth and efficient activities in and around port areas. The structure of the port management body at each port is slightly different depending on historical, socio-economical and institutional factors.

A worldwide tendency has been observed whereby the participation of the private sector is increasing, especially in the field of port operation. While cargo volume is not so great, one organization may be able to provide all the required services at a port. However, port activities develop year by year. In the near future the scale of the port activities at Santo Tomas may exceed the moderate size which can be efficiently managed by one organization.

Public sector management has advantages as well as disadvantages. Port facilities including water areas are regarded as public property, or social infrastructure. Thus the administration of port facilities should strictly follow the national interest. In addition, since the initial investment for port facilities is huge and requires a long recovery period, only the public sector can bear such a heavy burden. Furthermore, the public sector can enjoy lower interest rates utilizing foreign aid loans.

However, as the public sector lacks the profit motive, there are sometimes problems such as rigid organization, slow decision making, fixed budget and inefficient performance.

In order to realize smooth and effective cargo flow in the port area, the participation of the private sector in the field of port operation should be considered in the near future. It is quite reasonable to let the private sector participate in some activities step by step. At any rate, it is advisable for EMPORNAC to study a privatization plan.

1.4.2 Handling Systems

There are many different systems to transport containers from the quaywall to the marshaling yard, and to stack containers in the yard.

The main handling systems are as follows;

a) Chassis system
b) Straddle carrier system
c) Tire-mounted transfer crane system

Based on studies on the efficiency, investment and operation costs, storage capacity, operation control and expandability for each handling system, the tire-mounted transfer crane system is desirable at the Port However the straddle carrier system is preferable at the port of Santo Tomas de Castilla considering the existing handling system.

1.4.3 Terminal Operation

(1) Container terminal

As for the management and operation systems for the new container terminal under the Master plan, the following three types are considered.

a) Public sector management and operation of the container terminal,
b) Public sector management and operation of areas behind the apron such as the marshaling yard, and private sector operation of other facilities.
c) Private sector management and operation of the entire terminal, with the basic infrastructure leased by the public sector.

(2) Petroleum terminal

As for the new petroleum terminal, the following systems are considered.

a) EMPORNAC executes all of the works

EMPORNAC constructs all of the facilities which will be required for the petroleum terminal including the loading and unloading facilities, and manages and operates the terminal.

b) EMPORNAC prepares the infrastructure, and users prepare other facilities such as loading and unloading facilities and then operate the terminal.

c) The private sector constructs all of the facilities

The private sector constructs all of the facilities for exclusive use, and manages and operates the terminal.

On the other hand, as for the management and operation systems of the existing terminals for break bulk and solid bulk, the present systems seem to be appropriate.

1.4.4 Maintenance of Cargo Handling Machines

All maintenance work is carried out by EMPORNAC. However, as mentioned in Chapter 3, the condition of the existing machines is not so good due to certain problems in the maintenance section despite their great efforts.

EMPORNAC's maintenance system consists of regular checks including oil changes, changing brake shoes, etc. and repair of damaged machinery. In Japan, a daily check is carried out and parts are changed at regular intervals. Therefore the operating ratio is raised by minimizing downtime. EMPORNAC should commence a study to formulate the most effective maintenance system as soon as possible.

1.4.5 Computerized Automated Container Terminal

Responding to the increase of container cargoes, it will become more difficult to carry out all the operations manually. Container terminals of international standard size can handle more than 100,000 T.E.U. per year. To prevent confusion at the terminal and improve handling efficiency, it is crucial to introduce a computer system to assist terminal operations.

The computerization of container terminals may be divided into four steps as follows:

a) Plan and Management Control System
b) Yard Operation Control System
c) Crane Operation Control System
d) Automation System

The computerization of the container terminal at the port should proceed according to these four steps.

2 SHORT-TERM PLAN

2.1 SHORT-TERM PLAN FOR THE PORT DEVELOPMENT

2.1.1 The Basic Concept of the Short-term Plan

The Short-term Plan is prepared as a first stage plan with a target year of 1995 for the development of the port of Santo Tomas de Castilla. The Short-term Plan is made within the framework of the Master Plan.

In order to formulate the Short-term plan, the use plan of the existing terminal is studied. From the standpoint of safe operations and considering the increasing volume of dangerous cargoes handled at the Port, it is advisable to construct a new petroleum terminal in the first stage. On the other hand, judging from the present high rate of berth occupancy at the existing terminal and the future increase of cargo volume, even if petroleum cargoes are shifted to a new terminal, it will be impossible to handle all the remaining cargoes at only the existing facilities in the future. Furthermore, it would not be economical to use the existing terminal for container ships because the existing terminal cannot accommodate full container vessels. As for the handling of solid bulk cargoes in the year 1995, there are three alternatives: preparation of new cranes with a larger capacity at the existing terminal, use of the present cargo handling system at the existing terminal and construction of a new terminal equipped with larger cranes. The former alternative is selected as the optimum case from the economic point of view. From the above, the following new terminals are planned in the Short-term Plan:

- Container Terminal
- Petroleum Terminal

When planning the container terminal, the optimum number of berths and water depth are examined using the same method adopted in Section 1.3.2.

2.1.2 Required Scale of New Terminals

(1) Container Terminal

The number of containers to be handled at the new container terminal in the year 1995 is forecast as 116,000 TEU.

The optimum number of berths is calculated by water depth by using the same method presented in Section 1.3.2. Herein, two alternative water depths, -9 meters and -11 meters, are considered. The optimum number of berths by alternative water depth is one in both cases. The optimum required water depth is selected by comparing total costs including access channel dredging cost. The total transportation costs are summed up and compared between the two alternative cases. Thus, in the year 1995, 11 meters is selected as the optimum water depth. For the same reasons mentioned in Section 1.3.2, it is also advisable to construct a quaywall which will be able to bear deepening of the waters immediately adjacent to the quaywall from 11 meters to 13 meters in the future. Through the above examination, a container terminal with the following dimensions and facilities is considered economical:

Water Depth: 11 meters
Berth Length: 250 meters
No. of Container Gantry Cranes: 2

In this case, the terminal can serve only one container ship at a time. From this case, a derivative alternative can be considered. Without changing the water depth, superstructures and cargo handling facilities from the base case, the following alternative is proposed to be examined:

Water Depth: 11 meters
Berth Length: 500 meters
No. of Container Gantry Cranes: 2

In this alternative case, two container ships can berth at the same time. Though the container gantry cranes can serve only one ship at the same time, the other ship can receive other services such as mooring and unmooring, preparation of cargo handling, preparation and procedures of departure and draft check. Hence, in the alternative case, ship waiting time at the Port will be saved compared with the base case. Judging from the comparison between the two cases, 500 meters is proposed as the optimum berth length in the year 1995.

In the above examination, it is proposed to prepare two container gantry cranes without considering the case where a crane may become unusable due to regular maintenance or repair. Taking account of this, the necessity of an additional crane is examined. In the case where only two gantry cranes will be prepared, there will be heavy congestion in those periods when one crane is under regular maintenance or repair. On the other hand, in the case when an additional crane will be prepared, even if one crane is unusable, there will be no congestion and ship waiting cost can be reduced during ordinary times by using all three cranes. According to the comparison between the two cases, three gantry cranes are proposed in the year 1995.

As for the cargo handling system at the container yard, three systems, straddle carrier, transfer crane and chassis systems, are considered and these systems have various merits and demerits. Taking into account that straddle carriers are being used at the existing terminal, and to make the most use of EMPORNAC's experienced personnel and the existing machines, the straddle carrier system is proposed for the new container yard.

According to the above, the required dimensions and facilities of the new container terminal are computed and summarized as follows:

- Water Depth: 11 Meters
- Berth Length: 500 Meters
- Apron: 500 Meters x 40 Meters
- Marshaling Yard: 500 Meters x 116 Meters
- Container Freight Station: 143 Meters x 40 Meters
- Terminal Office: 30 Meters x 25 Meters
- Repair Shop: 40 Meters x 25 Meters
- Van Pool: 216 Meters x 70 Meters
- Railway Yard: 480 Meters x 60 Meters
- Number of Cargo Handling Machines: Container Gantry Cranes: 3
  Straddle Carriers: 8*
  Forklift: 1

*Two straddle carriers are expected to be shifted from the existing terminal.

(2) Petroleum Terminal

As noted in Section 2.1.1, a new petroleum terminal is planned to be constructed apart from the existing terminal and the new container terminal for securing safe port operations. According to the demand forecast, the volume of cargoes to be carried by petroleum tankers through the Port in 1995 is estimated as 1,616,000 metric tons.

For the cargo volume, one berth with a water depth of 11 meters is proposed. The berth occupancy ratio is estimated as 0.59 in the year 1995.

2.1.3 Dimensions of the Access Channel and Basins

Judging from the forecast traffic through the access channel, less than five ships daily on average, the target width of the channel for only one-way traffic will be sufficient in the year 1995. The target water depth of the channel in the same year is determined in Section 2.1.2. Thus, the target dimensions of the access channel to be created are shown as follows:

Water Depth: 11 Meters
Width : 90 Meters

Basins in front of the proposed terminals are considered assuming the use of tug boats when mooring and unmooring. A circle with a diameter double the maximum L.O.A. of calling vessels is considered as the minimum area of the basins.

2.1.4 Layout of the New Terminals and the Access Channel

The required terminals proposed in Section 2.1.2 including container and petroleum terminals are located according to the Master Plan. Thus, the container terminal and the petroleum terminal are located east of the existing terminal and off the mouth of the Cacao River, respectively.

A new access channel is planned alongside the existing access channel. Specifically, the center line of the new channel will run parallel to and 100 meters east of the center line of the existing channel. Alternatively, the new channel could also be dredged just by deepening the existing channel. However, the waters adjacent to the existing channel are deep enough and there is not much difference in the dredging cost between the two cases. Moreover, in the latter case, dredging works at the existing channel would hinder the traffic of ships, and consequently the dredging works would be costly. Hence, the latter case is not adopted.

A layout plan of the port facilities under the Short-term Plan is shown in Fig. 2.1.1.

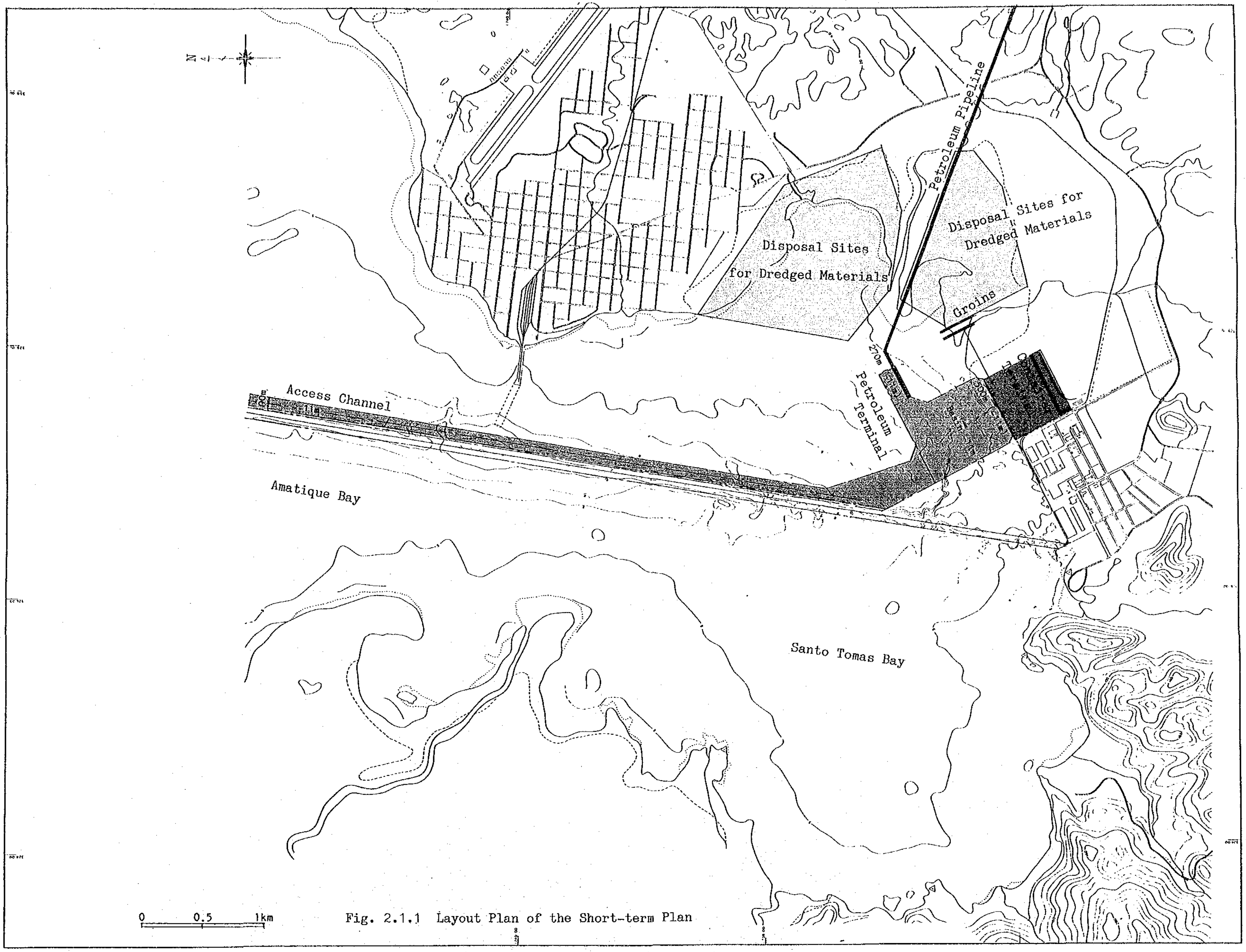


Fig. 2.1.1 Layout Plan of the Short-term Plan

2.1.5 Layout of the Required Facilities of the Container Terminal

The new container terminal will be located east of the existing terminal. Since ZOLIC is located behind the site for the container terminal, the maximum depth which can be planned is 500 meters. However, the necessary depth of the site in the year 1995 is less than 500 meters. The remaining area is reserved for future expansion beyond the target year of the Short-term Plan. The required facilities proposed in Section 2.1.2 are arranged taking account of the future expansion. The layout plan is shown in Fig. 2.1.2.

Judging from the reserved area for the marshaling yard, the cargo handling capacity of the container terminal to be constructed east of the existing terminal is estimated as 199,000 TEU per annum.

2.1.6 Navigation Aids

For the creation of the new access channel and basin, new navigation aids, two lateral marks and three cardinal marks will be required. Furthermore, to secure safe navigation at the mouth of the Amatique Bay, a safe water mark is planned to be installed in the waters.

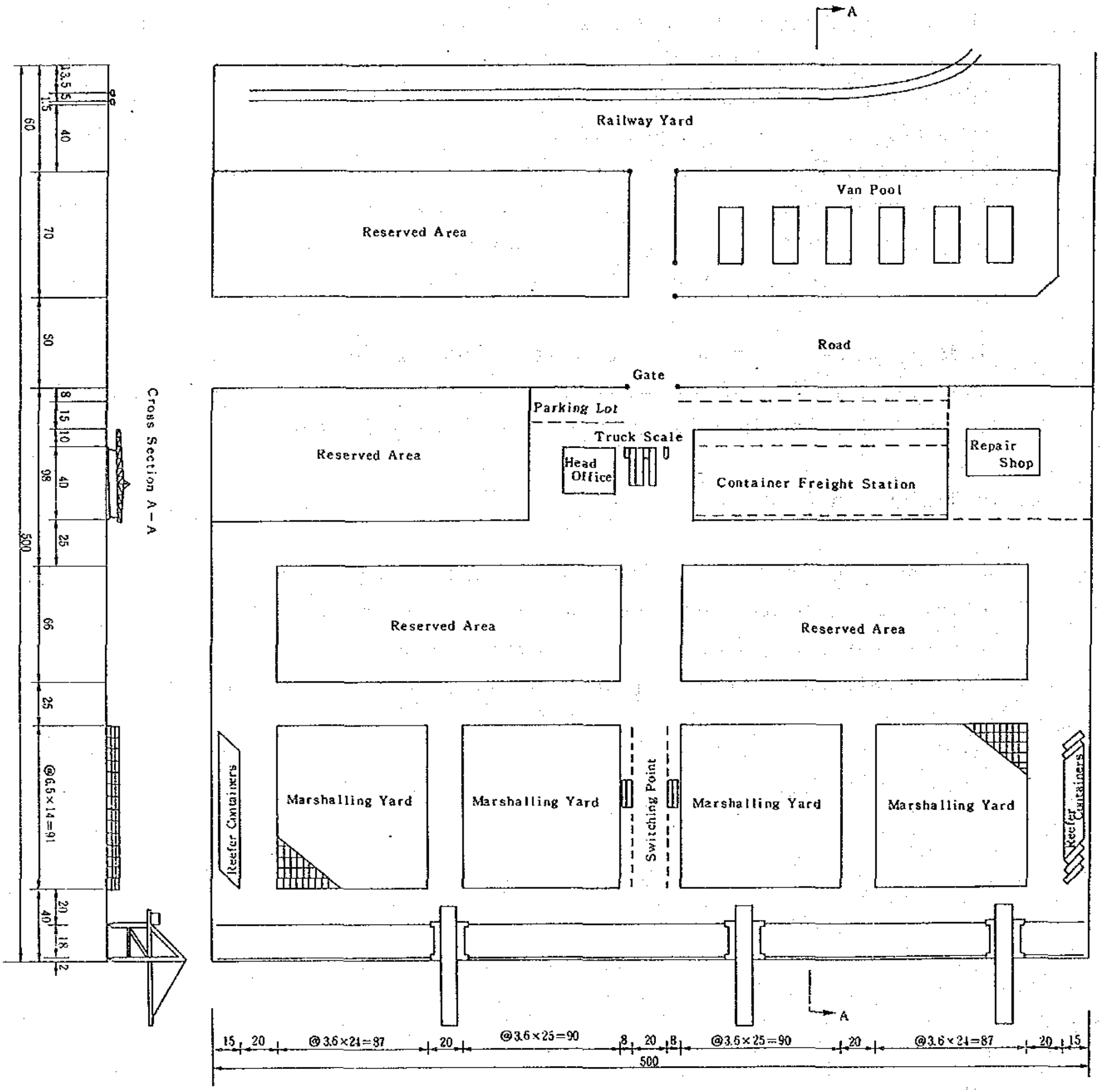


Fig. 2.1.2 Layout Plan of the Facilities of the Container Terminal

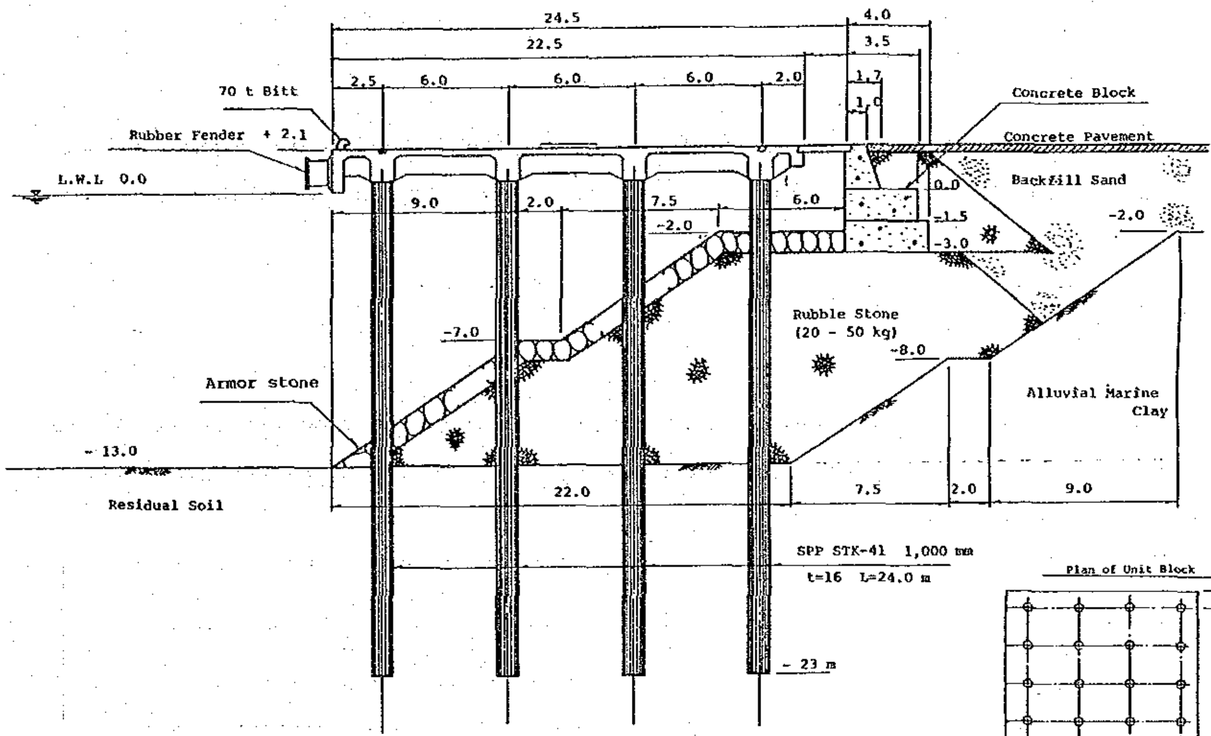
2.2 Design, Construction and Cost Estimation

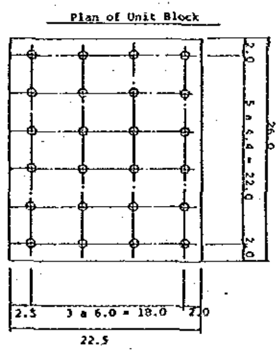
2.2.1 Design of Main Structures

(1) Wharf

A comparative analysis on the structural types for the wharf is carried out. The open deck type with steel pipe piles is considered preferable. Fig 2.2.1 shows the standard cross section of the wharf.

Fig 2.2.1 Standard Cross Section of the Wharf





(2) Oil Berth

A dolphin type pier is planned 500 m away from the other port facilities to minimize potential damage from any accident involving the inflammable cargoes.

(3) Container Yards and Roads

The yards are paved taking into consideration the soil conditions and the planned use of each yard.

(4) Navigation Channel and Basins

The new channel, 90 meters in width, will be located 90 m east of the existing channel. Both the channel and the basins are 11 meters in depth below C.D.L.

(5) Buildings

Designs are prepared for the main buildings including the container freight station, the port office, and the maintenance shop.

(6) Related Facilities

Related facilities include the drainage system, the water supply system, the electric power supply facilities, the lighting system and cargo handling equipment.

2.2.2 Construction planning

The construction plan and construction schedule are devised based on the port plan and the port facillity design. Fig 2.2.2 shows the proposed construction schedule.

Items	1.st year	2 nd year	3 rd year
Temporary works	======		
Container berth			
Dredging	============	=========================	=======
Civil works			
Wharf	============	=========================	=============
Reclamation	============	========	
Container yards	===	=========================	=============
Road	===	=========================	========
Drainage		====================	=====
Railway		===	==========
Buildings			
Office		====================	=============
C.F.S		====================	=============
Workshop		============	========
Sub-station			===========
Gate house and fence		=============	
Utilities			
Water supply			==================
Power supply			==================
Lighting			=========
Machinery			=========
Oil berth			
Dredging	===============	===	
Dolphin	===	===================	
Jetty		=============	==
Existing berth			=========
Navigation Channel			
Navigation aids			=========
Dredging		==============	==========

Fig 2.2.2 Proposed Construction Schedule

2.2.3 Cost Estimation

(1) Estimation conditions

Construction costs are estimated in accordance with the following conditions.

a) The costs are based on the market prices as of January 1988.
b) Unit prices of construction materials are based on the data obtained through the site survey.
c) Taxes such as import duties and enterprise taxes are not included at all.
d) Land rents and compensations related to this project are not included.
e) The exchange rates between the Guatemalan quetzale, Japanese yen and U.S. dollar are assumed as follows.
   US$1.0 = Q2.58 = ¥129

(2) Approximate construction cost

The approximate construction cost of the Short-term Plan is shown in Table 2.2.1

Table 2.2.1 Construction Cost

Items	Foreign	Local	Total
Temporary works	3,515,000	1,456,000	4,971,000
Container berth			
Basin dredging	16,120,000	5,580,000	21,700,000
Civil works	36,706,400	42,947,400	79,653,800
Buildings	5,980,400	7,192,100	13,172,500
Utility	7,014,000	1,816,900	8,830,900
Machinery	42,970,400	119,400	43,089,800
Sub total	108,791,200	57,655,800	166,447,000
Oil berth	21,775,000	5,096,000	26,871,000
Existing berth	5,760,000	107,000	5,867,000
Navigation channel	10,032,000	3,496,000	13,528,000
Total	149,873,200	67,810,800	217,684,000
Enginering fee	8,968,000	3,379,000	12,347,000
Contingency	13,203,000	7,108,000	20,311,000
Total	172,044,200	78,297,800	250,342,000

Unit: Quetzale

2.3 PORT MANAGEMENT AND OPERATION

2.3.1 General

The main elements of proper port management and operation systems are appropriate form and structure of the port administrative body, efficient port operations, a sound financial system using modern accounting methods, a reasonable level of port dues, accurate port statistics, skillful promotion and publicity, and regional cooperation with neighboring ports. Here, an administration and operation system for the container terminal at the port of Santo Tomas de Castilla is proposed as follows.

2.3.2 Management Body

(1) New Management Organization

The new terminal's administrative body should be separated from existing ones and have an independent accounting system. The organizational structure should be clear and simple, and the new organization should have a sufficient number of skilled officers and workers.

(2) Container Terminal Operation Method

Efficiency of operation and quality of the terminal service are governed by the selection of the container handling system and the kinds and numbers of cargo handling machinery equipped at the container terminal.

As mentioned in Part 1 Section 9.3.3, container handling systems are classified by the handling machinery installed such as the chassis system, the straddle carrier system and the transfer crane system, and each system has various merits and demerits.

The straddle carrier system is proposed for the new container terminal because EMPORNAC has experience using this system at the present terminal.

2.3.3 Containers and Containerized Cargo Flow in the Terminal

The following container flow is an outline of the proposed container terminal operation system.

(1) Import Container Operation Procedure

Containers unloaded from ships are placed on the apron according to the "unloading sequence list" drawn from the "import stowage plan", and transferred to the yard by straddle carrier and stacked in two layers.

The containers should be stacked according to the "yard stacking plan". Schematic representations of the yard stacking plans are usually available in the terminal control center.

(2) Export Container Operation Procedure

Full containers for export are received at the gate and moved to the marshaling yard directly. Export containers should be stacked in the marshaling yard, again in accordance with "the yard stacking plan", to confirm the container number to be loaded, and to allow drafting of the "loading sequence list".

The export containers are moved under the gantry crane according to the "loading sequence list" and loaded on ship.

2.3.4 Container Terminal Operation System

(1) Facility Utilization System

As for the utilization system of port facilities at the container terminal, three systems, namely open use, priority use and exclusive use, are considered. The open use system is proposed for the new container terminal at the initial stage of operation, considering the socio-economic condition in Guatemala.

(2) Management and Operation System

As for the management and operation system at the terminal, three systems are considered and these systems have various merits and demerits. Considering the present situation, management and operation of almost all the facilities by EMPORNAC is proposed for the new container terminal operation. But van pool operation should be handed over to the private sector.

(3) Privatization of Terminal Operation

In order to realize smooth and effective cargo handling in the terminal, it is quite reasonable to let the private sector participate in some activities step by step in the near future.
In making the privatization plan, the following viewpoints will be considered.

i) Cargo handling efficiency should be raised by private sector participation.
ii) In the future, profit will increase by raising productivity.
iii) Privatization will proceed step by step.

The following works may be easy to privatize in the early stages:

- Van pool lease
- Maintenance shop works
- C.F.S works

2.3.5 Organization of Container Terminal

(1) Organization

The numbers and functions of workers which will be required for effective performance of the container terminal operations depends on various factors at the port. The proposed organization and number of workers at the container terminal are assumed based on modifications from the Japanese standard.

Section	Number
Operation management	25
Control of container terminal	22
Operation of cargo handling	134
Container freight station	95
Maintenance and repair	30
Grand Total	306

(2) Training

It is recommended that EMPORNAC should investigate the operational systems of container terminals in developed ports, so as to provide detailed training on container terminal operation procedures to the staff and workers.

The key staff members responsible for yard operation should be trained by workers at actual jobs at already developed container terminals. As for the engineers who will be responsible for maintenance and repair of highly complex cargo handling equipment, they should also be trained at an already developed terminal. The workers who will operate container handling machinery should be trained at an operating terminal, if possible.

It is proposed that such machinery should be purchased well in advance of the terminal's opening for hands-on training at the site.

2.3.6 Computerized works at the container terminal

The port of Santo Tomas de Castilla will be attractive for regular container services by providing a system matching the high requirements for information flow. The shippers want information from other ports of trade, and stowage planning has to be executed before the ships arrive. Shipping companies require quick dispatch of their ships. Many container terminal operators have developed computer programs for their terminal operations to meet such requirements.

Several of the above items will utilize the computer system.

2.3.7 Container Handling Tariff

A simplified tariff will be better for both users and for the accounting section of the terminal, so it is proposed that the composite type of tariff be used as much as possible to meet actual operational needs.

The charges should be calculated based on construction cost, purchase cost and actual personnel and maintenance cost. Then the new tariff rate should be checked to see whether it can be accepted by users considering the present tariff and the improved service level of the new system.

2.3.8 Petroleum Terminal

(1) Operation System

At present, petroleum such as crude petroleum, refined oil and propane gas are loaded and unloaded at No.6 berth. But in order to minimize the possible damage from accidents, the new oil terminal should be constructed apart from the existing terminal (See Part 1 Section 8.2.4). There are three possible development and management methods for the new terminal as noted below.

i) EMPORNAC executes all of the works

EMPORNAC constructs all of the facilities which will be required for the petroleum terminal including loading and unloading facilities, and manages and operates the terminal.

ii) EMPORNAC prepares the infrastructure, and users prepare other facilities such as loading and unloading facilities, and then operate the terminal.

iii) All of the facilities are constructed by the private sector

Private companies construct all of the facilities for exclusive use, and manage and operate the terminal.

Case (ii) above is proposed for the new petroleum terminal.

(2) Allocation of Construction Cost

The infrastructure will be constructed by EMPORNAC and leased to private sector firms, and the pipeline and loading-unloading facilities will be prepared by the private sector firms.

2.4 ECONOMIC ANALYSIS

2.4.1 Purpose and Methodology of the Economic Analysis

The purpose of the economic analysis is to appraise the economic feasibility of the Short-term Plan for the port development from the viewpoint of the national economy. Thus, the analysis focuses on whether the net benefits of this development project exceed those which could be derived from other investment opportunities in the Republic of Guatemala (e.g. the opportunity cost of capital). All benefits and costs in the economic analysis are evaluated using economic prices based on the border price concept. The economic internal rate of return (EIRR) based on the cost-benefit analysis is used to appraise the feasibility of this project. The EIRR is calculated using the following formula:

$$\sum_{i=0}^{n} \frac{Bi - Ci}{(1 + r)^{i}} = 0$$

where, Bi : Benefits in the i-th year
Ci : Costs in the i-th year
r : Discount rate
n : Period of the project life

2.4.2 "Without Case"

In the cost-benefit analysis, both the benefits and the project costs are defined as the difference between the "Without" the project and the "With" the project cases. In this study, the following conditions are adopted as the "Without" case.

(1) Considering ship staying conditions at the Port, the cargo volume may exceed the maximum cargo handling capacity of the port by the year 1991.

(2) The additional cargo volume after the year 1991 would have to be handled at alternative ports. However, the following cargoes are selected to be handled at the alternative ports considering the characteristics of the cargoes.

a) Container cargo
b) Furgon (Ro-Ro) cargo
c) Dry cargo (except bananas)

(3) The cargo exceeding the port capacity will be transported on land, mainly by trucks, from the alternative ports to Guatemala City.

2.4.3 Prerequisites of the economic analysis

In order to estimate the costs and benefits under the "With" and "Without" cases, the following prerequisites are assumed for the analysis.

(1) The cargo not transferred to the alternative ports will be handled at the Port. Although no additional investment will be made to enlarge the existing port facilities, the required funds will be provided to maintain the existing facilities at their current level of service.

(2) The alternative ports under the "Without" case are selected as the ports of Cortes, Acajutla and Quetzal, and these ports have enough capacity to handle the overflow cargo from the port of Santo Tomas de Castilla.

(3) The land transportation capacity from the alternative ports is also assumed to be sufficient.

(4) Under the "With" case, the short-term plan for the port development will be implemented from the year 1990 and the new container terminal and petroleum terminal will start operations in 1993.

2.4.4 Economic Prices

For the economic analysis, prices are expressed in economic prices rather than market prices, based on the border price concept. The border prices (economic prices) are calculated by eliminating transfer items, such as taxes, subsidies, etc.

2.4.5 Benefits of the Project

In line with the objectives of the development and the significance of the Short-term Plan for the development of the port, the following items are identified as major benefits arising from the short-term development from the viewpoint of the national economy.

a) Savings in ships' staying costs
b) Savings in transportation costs by ships
c) Savings in transportation costs by alternative routes
d) Promotion of regional economic development
e) Increase in employment opportunities and incomes
f) Reduction of damage from accidents at the port

It would be difficult to evaluate all these benefits in monetary terms, but here the following items are considered countable and the monetary benefits of these items are calculated.

a) Savings in ships' staying costs
b) Savings in transportation costs by ships
c) Savings in transportation costs by alternative routes

2.4.6 Costs of the Project

The costs arising from the implementation of this project are as follows:

(1) Construction Costs
(2) Maintenance Costs
(3) Operation Costs
    a) Personnel costs
    b) Administration costs
    c) Other costs
(4) Replacement Costs for Handling Equipment

2.4.7 Evaluation

(1) Results of the EIRR

The lifespans of the various port facilities and infrastructures vary. Here, the average lifetime of the facilities, 30 years, is taken as the project lifetime. The cost-benefit analysis is carried out starting in 1990 and ending in 2022.

The results of the calculation of the EIRR are as follows:

Alternative Case 1 : EIRR = 23.4 %
Alternative Case 2 : EIRR = 20.1 %
Alternative Case 3 : EIRR = 19.5 %

(2) Sensitivity Analyses

In order to estimate the variation of the EIRR, sensitivity analyses are made for three cases for each alternative and the results are as follows:

Case	Alter-1	Alter-2	Alter-3
Base	23.4	20.1	19.5
A	21.9	18.7	18.1
B	20.2	16.9	16.4
C	18.9	15.7	15.1

Case A : The construction costs increase by 10 %
Case B : The forecast cargo volume decreases by 10 %
Case C : The construction costs increase by 10 % and the cargo volume decreases by 10 % simultaneously

2.4.8 Conclusion

From the above calculations, the EIRR of this project is more than 19.5 %. The results of the EIRR calculation, only taking into account the major three quantitative benefits, show a return of more than 15 % under every probable case. Therefore, this Short-term Development Project is feasible from the viewpoint of the national economy.

2.5 FINANCIAL ANALYSIS

2.5.1 Purpose and Methodology of Financial Analysis

(1) Purpose

The purpose of the financial analysis is to ascertain the impact of the present project on the financial condition of the port management body and to examine the profitability of the project itself, to determine whether or not the project is sound from the financial viewpoint.

(2) Methodology of the Financial Analysis

The investment effects of this project are analyzed by the following two methods.

a) Analysis by financial statements

The financial viability of the management body is appraised based on the projected financial statements (income statement, statement of source and application of funds) and analyses of the statements and fund raising conditions.

b) Analysis by discount cash flow

The profitability of the project itself is analyzed by the financial internal rate of return (FIRR) using the discount cash flow method (D.C.F.). The FIRR is a discount ratio which makes the net present value of the cash flow (revenue minus cost) equal to zero.

2.5.2 Prerequisites for Financial Analysis

The following points are assumed for the analysis:

a) All of the port activities of EMPORNAC are analyzed.
b) The accounting is carried out under the business accounting system.
c) The financial analysis covers the period from 1990 to 2019.
d) The funds necessary to execute this project are to be raised as follows:

- Domestic currency portion: Government funds (Government subsidy and EMPORNAC's reserves)

- Foreign currency portion: Soft loan from a foreign country.

e) The revenue is calculated based on the current port tariff rate authorized by the Guatemalan government and the new container handling tariff which is proposed by the study team.

f) The fixed assets consist of the existing facilities and the additional investment. Depreciation is calculated using the straight line method, considering the residual value.

2.5.3 Revenues

As indicated in the above assumptions, the revenue is calculated using EMPORNAC's tariff rates and the proposed container handling charges. The types of dues and charges are as follows.

a) Ship charges
   Port dues, Pilotage, Tug boat fee, Mooring-Unmooring charges
b) Berthage
c) Water supply
d) Cargo handling charge
e) Storage charge
f) Others

2.5.4 Expenditure

The expenditure is calculated as follows:

a) Personnel cost and administration cost
b) Maintenance and repair cost
c) Fuel expenses
d) Replacement cost
e) Depreciation expense
f) Interest on long-term loans

2.5.5 Results of Financial Analysis

(1) Evaluation of Financial Ratios

a) Working Ratio

The working ratio is very good compared with that of ports in Europe, North America and Australia.

b) Operating Ratio

Like the working ratio, the operating ratio has a very favorable value.

c) Debt Service Coverage

The high value of this ratio shows that there will be no problem in repaying the loans.

(2) Evaluation by Discount Cash Flow (DCF)

In evaluating the financial profitability of the project, the financial internal rate of return (FIRR) using the discount cash flow (DCF) method is used. In this project, 69% of the overall construction cost (i.e. the foreign portion) is assumed to be raised by a soft loan. The FIRR is required to exceed the weighted average interest rate for all the project funds. Judging from this point of view, this project can be regarded as feasible, since the FIRR of the project is 7.37%, well above the weighted average interest rate.

(3) Result

As shown by the foregoing financial ratios and by the FIRR, there are no problems in balancing revenues and expenditures or in raising funds. With the new investments the financial soundness of the port management body is easily secured and the financial viability clearly demonstrated.

2.5.6 Sensitivity Analysis

(1) Identification of Cases

Sensitivity Analysis is executed for the following cases;

Case A cargo handling volume decreases by 10%
Case B port tariff increases by 10%

(2) Result

The calculation results are Case A 5.15% and Case B 8.06%. Every FIRR exceeds the lower limit. The results of the sensitivity analysis prove that each would be feasible.

(3) Conclusion

From the viewpoint of the profitability of the project itself and the financial viability of the management body, this project can be regarded as feasible.

INTRODUCTION

INTRODUCTION

(1) Background

The Republic of Guatemala is primarily an agricultural country. Agricultural products and processed goods are Guatemala's main exports, and they are shipped mostly to the United States, Central and South America, Western Europe and Japan through the five principal ports: Santo Tomas de Castilla and Puerto Barrios on the Atlantic Ocean and San Jose, Champerico and Quetzal on the Pacific Ocean.

As Guatemala has major ports on both the Atlantic and the Pacific Ocean coasts, the nation is in a good position to conduct maritime trade. The port of Quetzal was opened in 1983 as the first deep seaport on the *Pacific Ocean coast of Guatemala. On the other hand, on the Atlantic* coast, the Port of Santo Tomas de Castilla serves as the main terminal for the trade between Guatemala and the eastern coast of the the United States and Western Europe. The volume of cargo handled at this port in 1986 was around 2.3 million metric tons.

Santo Tomas de Castilla is thus the biggest port in Guatemala in terms of cargo throughput. The Port accounted for approximately sixty percent of the total national maritime cargo throughout at Santo Tomas over the last five years, with the average annual growth rate of 7.8% indicating a steady increase of cargo flow.

Construction work at the Port of Santo Tomas began in the mid-1950's and the Port was designed as the first modern seaport in Guatemala at that time. However, the water depth along the 914 meter quaywall is only 9 meters, and thus the facilities are insufficient to accommodate vessels larger than 10,000 DWT, which have become common in international maritime transport. Moreover, the cargo handling areas are small, and the cargo handling equipment is old. Thus the cargo handling system is relatively inefficient, and it is difficult to adapt the current facilities to modern innovations in cargo handling including increased containerization.

(2) Circumstances

Under these circumstances, the Government of Guatemala requested the

Government of Japan to conduct a feasibility study on the development project of the Port mainly aiming at the following objectives:

- Expansion of quaywalls to increase berthing capacity,
- Deepening and expansion of the access channel and basin for larger vessels,
- Improvement and installation of land facilities including container yards, silos for bulk cargoes such as grains and land transportation terminals in the port district,
- Improvement and renewal of cargo-handling equipment,
- *Construction of facilities for port administration.*

In response to the request, the Government of Japan decided to conduct the Study on the Development Project of the Port of Santo Tomas de Castilla. Based on the agreement between both Governments, JICA organized a study team headed by Mr. Keiichi Miyota, Executive Director, OCDI and the study team executed the study from June of 1987 to June of 1988.

(3) Objectives of the Study

The objectives of the study are to prepare a Master Plan for the development of the Port for the period up to the year 2005, and to conduct technical, economic and financial feasibility studies on a Short-term Development Plan for the target year 1995 based on the Master Plan.

(4) Study Schedule

The study was conducted as follows:

1) First field survey, presentation of the Inception Report	: June - August,	1987
2) Presentation of the Progress Report	: August,	1987
3) Preparation of the Interim Report	: Sep. - Nov.,	1987
4) Presentation of the Interim Report	: November,	1987
5) Preparation of the Draft Final Report	: December, - March,	1988
6) Presentation of the Draft Final Report	: March,	1988
7) Preparation of the Final Report	: May - June	1988
8) Submission of the Final Report	: July	1988

(5) Organization of the study team

The Japanese study team was comprised of 10 specialists from OCDI, YEC and a representative of JICA as follows:

Title	Name		Responsibility	
Study Team				
Team Leader	Keiichi	MIYOTA	Overall Management	(OCDI)
Co-leader	Yugo	OHTSUKI	Port Planning	(OCDI)
Specialist	Nobuyuki	MANABE	Port Administration and Operation, Financial Analysis	(OCDI)
Specialist	Takashi	YAMAMOTO	Demand Forecast, Economic Analysis	(OCDI)
Specialist	Mitsuo	IGARASHI	Navigational Channel Planning	(OCDI)
Specialist	Shuji	SEKIGUCHI	Design and Cost Estimation	(YEC)
Specialist	Katsutoshi	SUZUKI	Natural Conditions (Soil investigation)	(YEC)
Specialist	Shuichi	ONDA	Natural Conditions (Sounding survey I)	(YEC)
Specialist	Ryoichi	MINAMI	Natural Conditions (Sounding survey II)	(YEC)
Interpreter	Sachiyo	SANO	Interpreter	(OCDI)
Coordinater				
	Kenichi	KOJIMA	Coordination	(JICA)
	Toshiichi	MINATANI	Coordination	(JICA)

(6) List of EMPORNAC's counterparts

Ing. Antonio Garicia	(Chief of Engineering Department)
Lic. Jose Roland Alivato	(Director of Financial Division)
Ing. Carlos Quinto	(Director of Mechanical Department)
Ing. Roland Chorosajev	(Director of Port Operation Division)
Sr. Hugo Sierra	(Chief of Comercial Division)
Sr. Rigoberto Chavarria Panlencia	(Sub-Director of Port Operation Division)
Sr. Andres Hora Lyanceva	(Sub-Director of Maritime Operation Division)

PART I MASTER PLAN

CHAPTER 1 OUTLINE OF GUATEMALA

1.1 Socioeconomic Condition of Guatemala

1.1.1 Geography

The Republic of Guatemala is located in the northern part of Central America between north latitude 13°44' - 18°30' and west longitude 87°24'-92°14'. Guatemala faces the Republic of Mexico to the west, northwest and north, the Atlantic Ocean, the Republic of Honduras and El Salvador to the east, and the Pacific Ocean to the south. The area of Guatemala is 108,889 sq.km (excluding the 22,900 sq.km of Belize) which is one-third the total area of Japan. Guatemala has two major mountain ranges with many volcanos, the Sierra Madre and the Sierra Cuchumatanes, which run from the west coast to the southeast through Chiquimula and Izabal. Half of the country is mountainous, and the areas between 1,000-1,500 meters have abundant fertile soil and a moderate climate, and many people live in these areas.

Guatemala belongs to the tropical zone geographically. However, the climate varies with the height of the land, and is tropical in coastal areas (average 25°C - 30°C) and temperate in the highlands (average 15°C - 20°C). Guatemala is well'suited for the production of agricultural crops such as coffee, bananas, cotton and sugar. The average annual rainfall varies from 1,000 mm to 3,000 m with the rainy season from May to October and the dry season from November to April. The abundant rainfall and fertile soil greatly benefit the production of agricultural products.

Table 1.1.1 Meteorological Data

Location	Temperature (°C)		Rainfall (mm)
	Max.	Min.	
El Progreso	35.0	19.5	774
Puerto Barrios	30.0	21.9	2,990
Guatemala City	24.9	19.1	895

1.1.2 Demography

According to the ninth national census conducted by Direccion General de Estadistica in 1981, the total population of Guatemala is 6,054 thousand persons with 3,016 thousand males and 3,038 thousand females. The past growth rate of the census population of Guatemala is presented in Table 1.1.2.

Table 1.1.2 Census Population of Guatemala

Census	Year	Population	Growth Rate (%/year)
I	1778	396,149	----
II	1880	1,224,602	1.11
III	1893	1,501,145	1.58
IV	1921	2,004,900	1.04
V	1940	2,400,000	0.95
VI	1950	2,790,868	1.52
VII	1964	4,284,473	3.11
VIII	1973	5,160,221	2.09
IX	1981	6,054,227	2.02

source : Censos Nacionales, DGE, 1981
Estudios Sociales

The census figures show a relatively low growth rate until the 1940's. The population increased rapidly at a rate of 3.11% per year from 1950-1964, but the growth rate has been decreasing ever since. The last four censuses are used in this study. These censuses, however, are not entirely accurate, as pointed out by several statistical agencies. It seems that there are many people who are not counted in these censuses. In 1985, Secretaria General del Consejo Nacional de Planificacion Economica (SEGEPLAN) and Centro Latinoamericano de Demografia (CELADE) estimate the total population of Guatemala focusing on fertility, mortality and international migration. As a result of the study, it is estimated that the omitted population totaled 5.42%, 3.78%, 10.32% and 13.75% in 1950, 1964, 1973 and 1981, respectively. The adjusted population in these census years is thus estimated as shown in Table 1.1.3.

Table 1.1.3 Estimated Population of Guatemala

Year	Census	Estimation	Growth Rale (%/year)
1950	2,790,868	2,968,976	----
1964	4,284,473	4,441,603	2.92
1973	5,160,221	5,698,802	2.81
1981	6,054,227	7,113,391	2.81

Source : Estimaciones y Proyecciones de Poblacion 1950-2025, SEGEPLAN

According to this estimation, the population of Guatemala in 1986 is 8,195 thousand persons with 4,143 thousand males and 4,052 thousand females. The people who live in rural areas account for about 61% of the total population, and half of the total population are illiterate.

(1) Regional Population

The estimated regional population by department is presented in Table 1.1.4. This table shows that more than 20 percent of the total population live in the Department of Guatemala which is the center of the political and economic activity of the Republic.

As for the population density, the Department of Guatemala shows a high density of 822 persons per sq. km in comparison with the average of 75 persons per sq. km. The concentration of population into the urban areas has a close relation with economic activities. Workers migrate into urban areas, looking for job opportunities and better salaries. The concentration of population into urban areas is clear from the table, especially in the Departments of Guatemala and Quetzaltenango.

Furthermore, these areas have geographical advantages as centers of economic activity.

Table 1.1.4 Regional Population, 1986

Department	Population	Percent (%)	Area (km2)	Density(p/km2)
Guatemala	1,747,542	21.32	2,126	882
El Progreso	98,166	1.20	1,922	51
Sacatepequez	155,435	1.90	465	334
Chimaltenango	298,139	3.64	1,979	151
Escuintla	467,321	5.70	4,384	107
Santa Rosa	241,962	2.95	2,955	82
Solola	207,353	2.53	1,061	195
Totonicapan	258,092	3.15	1,061	234
Quetzaltenango	485,657	5.93	2,088	233
Suchitepequez	316,112	3.86	2,510	126
Retalhuleu	206,129	2.51	1,856	111
San Marcos	609,049	7.44	3,791	161
Huehuetenango	609,049	7.44	7,403	82
Quiche	491,700	6.00	8,378	59
Baja Verapaz	161,472	1.97	3,124	52
Alta Verapaz	506,800	6.18	8,686	58
Peten	192,767	2.35	35,854	5
Izabal	278,597	3.40	9,038	31
Zacapa	147,425	1.80	2,690	55
Chiquimula	227,752	2.78	2,376	96
Jalapa	168,593	2.06	2,064	82
Jutiapa	318,824	3.89	3,219	99
Republic of Guatemala	8,195,117	100.0	108,889	75

Source : Proyecciones Departamentales de Poblacion 1980-2000, SEGEPLAN and INE

(2) Economically Active Population and Employment

The change of population and the Economically Active population (EAP) during the past 11 years is shown in Table 1.1.5.

Table 1.1.5 Economically Active Population

Year	Population (thousand persons)		DR
	Total	EAP	
1975	6,023	1,856	224
1976	6,191	1,192	224
1977	6,364	1,970	223
1978	6,542	2,024	223
1979	6,726	2,080	223
1980	6,917	2,138	224
1981	7,003	2,196	224
1982	7,315	2,257	224
1983	7,524	2,319	224
1984	7,740	2,382	225
1985	7,963	2,449	225

Source : SEGEPLAN, CELADE and Banco de Guatemala
Note : EAP indicates the EAP 10 years old or older
DR indicates Dependency Ratio

There is no significant change in the Dependency Ratio (DR), which means that the growth rate of the EAP is almost the same as that of the total population. However the EAP by age group is changing. According to the study by SEGEPLAN, the participation rate of 10-14 year olds in the total EAP accounts for 6% in 1981, down from 8% in 1950. The reason for the decrease is the higher school attendance of 10-14 year olds. One-third of the total EAP, however, are young people less than 25 years old, and more than 85% of the total 85% of the total EAP are male. Furthermore, people who live in urban areas account for 41.8% of the EAP, up from 32.8% and 32.1% in 1973 and 1964, respectively. Especially, 25.7% of the total EAP live in the Department of Guatemala, showing the concentration of the EAP in the leading district.

The sectoral employment is presented in Table 1.1.6. In terms of the number of workers, the agriculture sector leads the nation. However, the share of this sector has decreased sharply since 1980. This phenomena is caused by a combination of two factors; the first is that when the minimum wage for agricultural workers was raised by the government the employers decreased the number of workers to limit their production cost. The second is the decrease in the world prices for agricultural products which has led to a depression of the export agricultural sector which is reflected in the employment situation. The fact that the abrupt decrease of employment in the agricultural sector caused a decrease in total employment shows that the employment situation in Guatemala conspicuously depends on the agricultural sector.

Table 1.1.6 Sectoral Employment

(in percentages)

Sector	1970	11975	1980	1985
Agriculture	46.2	50.0	49.4	37.0
Mining	0.7	0.5	0.5	0.3
Industry	15,5	11.9	11.0	12.4
Construction	4.8	4.0	3.7	2.2
Electricity	1.1	1.1	1.8	2.1
Commercial	8.2	7.3	7.8	9.2
Transport & Commu.	2.0	2.1	2.9	3.2
Other Service	21.5	23.1	23.0	33.6
Total employment	448,276	520,696	755,542	631,654

Source : Boletin Estadistico, Banco de Guatemala

1.1.3 Economy

(1) Guatemalan economy

Prior to the 1980's, Guatemala enjoyed decades of steady economic growth. This era abruptly ended in 1980-1981 due to a combination of factors including the worldwide economic recession and regional and internal political problems which effectively impeded both private and public sector investment in the economy.

The Gross Domestic Product (GDP) during the past 10 years is shown in Table 1.1.7. The table shows that GDP growth in real terms turned negative in 1981 and has continued to decrease ever since. The per capita GDP in 1985 is less than it was in 1975 due to the rapid growth of the population and the consequent growth in the number of the unemployed. Especially, the stagnation of production in the agricultural and industrial sectors contributed to the depression of the Guatemalan economy. There are three main reasons for the stagnation of the Guatemalan economy as follows:

a) Decrease in external demand due to global economic stagnation
b) Decrease of the price of agricultural products in the world market
c) Decrease in internal demand due to inflation

Agriculture is predominant in the economic structure of Guatemala. The agricultural sector still accounts for 25% of the GDP, while the industrial sector accounts for 16% and the commercial sector 25%. The sectoral structure shows that industry is still underdeveloped. However, the GDP share of the commercial sector is greater than in other Central American countries. Thus, in comparison with other countries in the region the share of the industrial sector is low and the share of the commercial sector is high. As for the regional economy, the GDP of Guatemala accounts for 38% of the total GDP of Central America followed by Costa Rica with 21% in 1985. The per capita GDP in Guatemala, however, is about 60% of that in Costa Rica. The agricultural sector in Guatemala accounts for 40% of the total agricultural sector GDP of all Central America, and the industrial and commercial sectors account for 35% and 50%, respectively, of the regional totals.

Table 1.1.7 Gross Domestic Product at constant 1958 prices

(unit : million Quetzales)

Sector	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Agriculture	660	690	717	739	760	772	781	758	745	757	750
Mining	2	3	3	5	9	15	9	11	9	8	6
Industry	356	393	436	464	490	517	501	475	466	468	467
Construction	44	76	86	89	94	98	117	103	76	54	49
Electricity	33	35	44	49	52	53	53	52	52	54	56
Commercial	649	704	769	802	825	839	844	797	764	773	745
Transport & Communi.	151	165	178	190	199	216	211	201	200	206	209
Other Service	458	461	491	522	566	597	612	620	628	634	643
GDP	2,353	2,527	2,724	2,860	2,995	3,107	3,128	3,017	2,940	2,954	2,925
GDP per capita	391	408	428	437	445	449	440	412	391	382	367

Source : Boletion Estadistico, Banco de Guatemala

Annual Growth Rate (%)

	1975-1980	1980-1985
GDP	5.7	-1.2
GDP per capita	2.8	-4.0

(2) International Trade Balance

The international trade of Guatemala follows the typical pattern of most developing countries, with exports of agricultural products and primary goods such as coffee, cotton, bananas, cardamom, sugar, meat, nickel and crude oil, and imports of capital goods, durable goods and consumption goods such as fertilizer, petroleum products, chemical goods, machinery and equipment.

The international trade balance during the past 11 years is shown in Table 1.1.8.

Table 1.1.8 International Trade Balance

(unit : million Quetzales)

Year	Export (FOB)	Import (CIF)	Balance	GDP	E+I / GDP
1975	624	732	-108	3,646	37.2 %
1976	760	839	-79	4,365	36.6 %
1977	1,160	1,053	107	5,481	40.4 %
1978	1,089	1,286	-197	6,071	39.1 %
1979	1,241	1,504	-263	6,903	39.8 %
1980	1,520	1,598	-79	7,879	39.6 %
1981	1,226	1,673	-447	8,608	33.7 %
1982	1,120	1,388	-268	8,717	28.8 %
1983	1,159	1,135	24	9,050	25.3 %
1984	1,122	1,278	-156	9,470	25.3 %
1985	1,021	1,175	-154	11,130	19.7 %

Source : Boletin Estadistica, banco de Guatemala

The economic depression in Guatemala after 1980 suppressed the international trade, and the ratio of export and import to GDP radically dropped from 40% to 20%. This sudden drop was due to the decrease in the export of coffee, which is the major export earner, the rapid price changes in the world market, and the decrease of internal demand for imported materials and manufacturing goods due to inflation.

Major export commodities shown in Table 1.1.9 are coffee, cotton, bananas, cardamom and sugar, with shares of 40.3%, 5.9%, 6.1%, 5.8% and 4.3% in total exports respectively. These five major export commodities account for more than 60% of total export earnings. However, these agricultural products are sensitive to natural conditions, especially climate. The total export earnings of Guatemala are influenced by the volatile price of coffee in the world market because of the nation's high dependency on coffee exports.

Table 1.1.9 Shares of Major Export Commodities (by value)

(unit : percent)

	1981	1982	1983	1984	1985
Coffee	24.0	32.0	30.2	32.1	40.9
Cotton	10.7	7.0	4.0	6.3	5.9
Bananas	4.2	5.6	3.5	5.1	6.1
Cardamom	2.8	2.7	2.7	5.3	5.8
Sugar	6.9	2.4	10.9	6.6	4.3
Meat	2.4	1.4	1.3	1.0	0.9
Crude oil	1.8	4.1	5.2	3.0	1.2
Others	47.2	44.8	42.2	40.6	35.5

Source : Boletin Estadistico, Banco de Guatemala

The major import commodity group shown in Table 1.1.10 is petroleum products (fuel and lubricants) which accounts for more than 20% of total imports even though Guatemala exports crude oil. Other Leading imports are chemical goods and materials, and equipment needed for industry and manufacturing including durable goods accounts for 60% of total imports.

Table 1.1.10 Shares of Major Import Commodities (by value)

(unit : percent)

	1981	1982	1983	1984	1985
Fuel & Lubricants	22.6	21.8	22.6	23.7	23.1
Chemical Products	18.6	19.4	22.7	23.2	23.0
Materials	19.2	18.7	20.5	18.5	16.6
Machinery & Trans.	21.1	21.6	14.7	16.4	19.0
Manufacturing	8.1	8.0	7.0	6.7	5.1
Others	10.4	10.5	12.5	11.5	13.2

Source : Boletin Estadistico, Banco de Guatemala

The most important trading partner of Guatemala is the United States for both exports and imports, followed by other Central American countries, especially El Salvador, West Germany, Mexico, Venezuela and Japan as presented in Table 1.1.11. The export share of the United States increased more than 10 points in 5 years, and the Central American countries lost their share. As for imports, the United States leads other countries followed by Mexico. Thus the share of the trade among the Central American countries is gradually decreasing and the economy of Guatemala is becoming more dependent on the economy of the United States.

Table 1.1.11 Foreign Trade by Major Country

(unit : percent)

	1981	1982	1983	1984	1985
Export					
U.S.A.	25.2	27.0	34.5	37.2	35.9
El Salvador	15.3	17.0	14.1	15.7	11.8
Costa Rica	4.7	4.6	4.5	4.9	4.4
West Germany	8.2	7.0	5.4	5.5	7.4
Mexico	5.3	3.1	1.3	1.2	1.2
Venezuela	0.2	0.6	---	0.6	---
Japan	4.9	5.0	3.4	4.4	3.3
Other	36.2	35.6	36.8	30.5	36.0
Import					
U.S.A.	33.5	30.7	31.6	30.9	37.0
El Salvador	6.1	8.5	9.1	7.6	4.1
Costa Rica	3.4	4.2	7.2	5.0	2.7
West Germany	6.4	5.6	5.0	5.9	7.4
Mexico	7.7	7.4	7.8	9.1	10.6
Venezuela	6.8	5.9	9.0	8.1	6.7
Japan	7.7	5.2	4.9	5.5	5.8
Other	28.4	32.5	25.4	27.9	25.7

Source : Boletin Estadistico, Banco de Guatemala

1.1.4 Transport

(1) Maritime Transport

There are five major ports in Guatemala. Three are located on the Pacific Ocean and the other two face the Atlantic Ocean. Because of the historical importance of the trade with European countries, the largest ports face the Atlantic Ocean, i.e. the port of Santo Tomas de Castilla and

Puerto Barrios. Since the operation of the port of Quetzal started in 1983, maritime transport via the Pacific Ocean has become one of the major trade routes. Total maritime transport in 1985 is 3,877 thousand tons with 2,736 thousand tons of import and 1,141 thousand tons of export according to the foreign trade statistics (Institute Nacional de Estadistica). In accordance with the development of maritime transport including increasing vessel size, exclusive cargo vessels, containerization, etc., the ports of Santo Tomas de Castilla and Quetzal are able to receive modern fleets, although some facilities and equipment are not yet in place.

(2) *Railway Transport*

The Guatemala railway has a long history of more than one hundred years. The main route is from Puerto Barrios to San Jose through Guatemala City, with two branch lines connecting to Mexico and El Salvador, and the railway has a total length of 694 km (374.6 miles) and is operated by FEGUA. However, due to the superannuation of facilities and the competition with trucks the transport volume has gradually decreased. The transport performance improved a little bit in recent years, and the railways carried 647 thousand tons and 4,804 thousand passengers in 1986.

(3) Road Transport

Guatemala has a permanent road network spread over the Republic with a total length of 11,665 km which is composed of 2,978 km of paved road and 8,687 km of unpaved road in 1986. The main corridor is the route from San Jose to Puerto Barrios passing through Guatemala City (CA-9) and from Mexico to El Salvador passing through the City (CA-1). Administratively, the roads are classified into four groups: Centro American, national, departmental and rural. According to the traffic movement survey for CA-1, CA-2 and CA=9 in 1984, 2,308 million ton-km of cargo and 4,437 million passenger-km of passengers are transported on these roads each year.

(4) Air transport

There is a national airline Aviateca with international routes from the international airport La Aurora located in Guatemala City to Merida, Miami, New Orleans, Houston and Mexico D.F. Aviateca carries tourists and air cargo, and also has a domestic route to Flores (Department of Peten), near the famous sightseeing place Tikal. There are also foreign airlines flying to Guatemala with routes to the United States, Central American Countries and Europe. The foreign airlines are as follows:

PAN AMERICAN	(USA)
IBERIA	(SPAIN)
KLM	(HOLLAND)
MEXICANA DE AVIACION	(MEXICO)
TACA	(EL SALVADOR)
LACSA	(COSTA RICA)
SAHSA	(HONDURAS)
COPA	(PANAMA)
SAM	(COLOMBIA)

1.2 National Development Plan

The Guatemalan economy had enjoyed steady growth; however the economy began to contract in 1980. In recent years, it seems that the Guatemalan economy may begin to recover from the negative growth. In order to reconstruct the damaged economy and improve the social conditions related to nutrition, employment, education, etc., the Government of Guatemala developed the National Development Plan 1987-1991 in 1986.

The development plan, based on a review of the current situation, presents five general development strategies through a series of development steps as follows:

------ General Development Strategy ------

1) Restructuring, expansion and diversification of the national economy
2) Decentralization of economy and politics
3) Organization and participation of the people
4) Modification of national goals
5) Unification of the nation

Based on the general development strategy, the macroeconomic scenario in the target year 1991 is presented with the target annual growth rates as follows:

a)	Gross Domestic Product	3.5 %
b)	Per Capita Income	0.5 %
c)	Private Consumption	2.8 %
d)	Government Consumption	5.5 %
e)	Private Investment	4.7 %
f)	Government Investment	8.2 %
g)	Exportation	7.7 %
h)	Importation	6.0 %
i)	Price Increase	10.0 %
j)	Unemployment	8.0 %

The target growth rate of GDP during the development period is 3.5% annually. However, the growth rate of the per capita income is 0.5% due to the high growth rate of the population and inflation.

In order to achieve and sustain the economic growth, two major factors are considered as crucial. The first is to increase export earnings. As for the export commodities, the diversification of agricultural products, which are sensitive to the change of climate and other natural conditions, and the emphasis on the introduction of processing and manufacturing industries are emphasized to increase exports and to reconstruct the export industry. The second factor is to increase income in real terms. The increase of the income level induces private consumption, thus promoting the production of consumption goods. At the same time, political problems such as institutional and social problems, government stability, improvement of the private investment environment and increased public investment are also discussed. This development plan attempts to solve the most serious problem, unemployment in Guatemala, by the reconstruction of the Guatemalan economy, and to lead Guatemala to become the center of the Central American economy.

CHAPTER 2 NATURAL CONDITIONS

2.1 Meteorology

Meteorological analysis is required for port planning, the maneuvering of vessels, cargo handling and construction works. Meteorological data were collected from the following stations.

(1) Instituto Nacional de Sismologia, Volcanologia, Meteorologia e Hidrologia (INSIVUMEH)

a)	Code No.	8.1.4
b)	Name of station	Puerto Barrios
c)	Latitude	15-44'-16" N
d)	Longitude	88-35'-30" W
e)	Observation period	1973-1984 (for eleven years) (observed every hour)

(2) Aeropuerto Barrios

a)	Observation period	1968-1973 (for five years) (observed once a day)

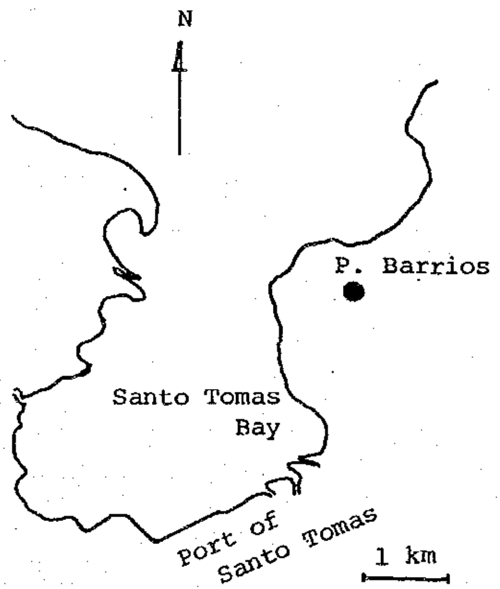


Fig.2.1.1 Location of Meteorological Station

2.1.1 Winds

(1) Characteristics

The important general characteristics of the winds are as follows:

a) Table 2.1.1 and Fig. 2.1.2 show the frequency of wind velocity. The frequency of calmness is twenty-four percent (24%) and the frequency of wind velocity less than 5.1 m/sec is seventy-five percent (75%), so it is generally very calm.

Table 2.1.1 Frequency of Wind Velocity

V / DIRECTION	10.0> kt	11.0 - 15.0	16.0 - 20.0	21.0 - 25.0	26.0 - 30.0	31.0<	TOTAL	%
	5.250	1.406	201	19	3	1		
N	76%	20	3	1	0	0	6.880	35
	610	212	59	7	0	0		
NNE	69%	24	7	0	0	0	888	5
	1.079	358	101	5	1	0		
NE	70%	23	7	0	0	0	1.544	8
	405	131	44	1	1	0		
ENE	70%	22	8	0	0	0	582	3
	1.141	154	27	4	1	0		
E	86%	12	2	0	0	0	1.327	7
	331	10	2	0	0	0		
ESE	97%	3	0	0	0	0	343	2
	44	4	4	0	0	0		
SE	84%	8	8	0	0	0	52	0
	183	9	4	0	0	0		
SSE	93%	5	2	0	0	0	198	1
	453	36	9	4	4	0		
S	90%	7	1	1	1	0	503	3
	118	6	4	0	0	0		
SSW	92%	5	3	0	0	0	128	1
	165	7	3	1	1	0		
SW	93%	5	2	0	0	0	177	1
	202	44	9	0	0	5		
WSW	78%	17	3	0	0	2	264	1
	2.214	620	354	89	40	16		
W	66%	19	11	3	1	0	3.333	17
	379	114	27	0	0	0		
WNW	73%	22	5	0	0	0	521	3
	818	120	16	0	0	0		
NW	86%	13	1	0	0	0	956	5
	1.243	450	42	2	2	0		
NNW	71%	26	3	0	0	0	1.739	8
TOTAL	14.635	3.681	906	138	53	22	19.435	
%	75 %	19	5	1	0	0		100
CALM							6.139	(24%)
							25,574	

NOTE: /1 AEROPUERTO "BARRIOS"
/2 1968 - 1973

Strong winds over 15 m/sec appear only in the directions of W and WSW.

b) The most common wind direction is north (35%) followed by west (17%). Winds also occur from NE (8%) and E (7%). Fortunately NE, E and W winds blow into Santo Tomas port from the land side, so they have little chance to cause waves.

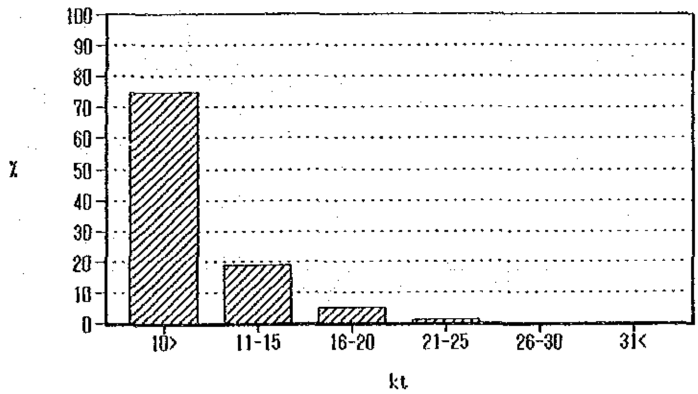


Fig. 2.1.2 Frequency of Wind Velocity

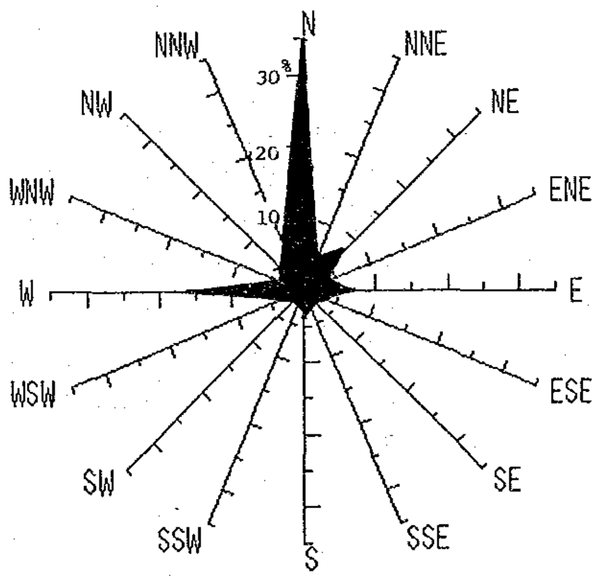


Fig. 2.1.3 Wind Rose

c) Generally, strong winds occur from 13:00 to 20:00. Especially, from 17:00 in the rainy season, strong winds frequently appear together with heavy squalls. From 01:00 to 08:00, there seems to be no seasonal change. The data are shown in Fig. 2.1.4.

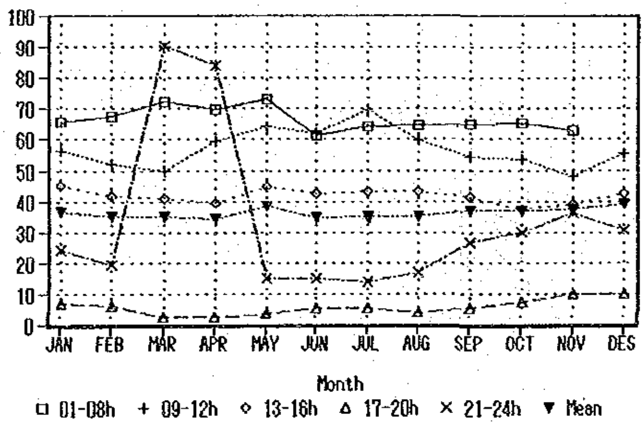


Fig. 2.1.4 Frequency of Calm Winds

(2) Tropical Storms

There are very few hurricanes and tropical storms that move toward the west in the Caribbean sea. Only twenty-three such storms have been recorded since 1880. The record of these tropical storms is shown in Table 2.1.2. Hurricanes and tropical storms which pass through the Pacific Ocean and have little influence on Santo Tomas Port are eliminated. The records of two (2) tropical storms and four (4) hurricanes which occured since 1954 are used to determine the design wave with a twenty-year ocurrence period for the port design. Their courses are shown in Fig. 2.1.5.

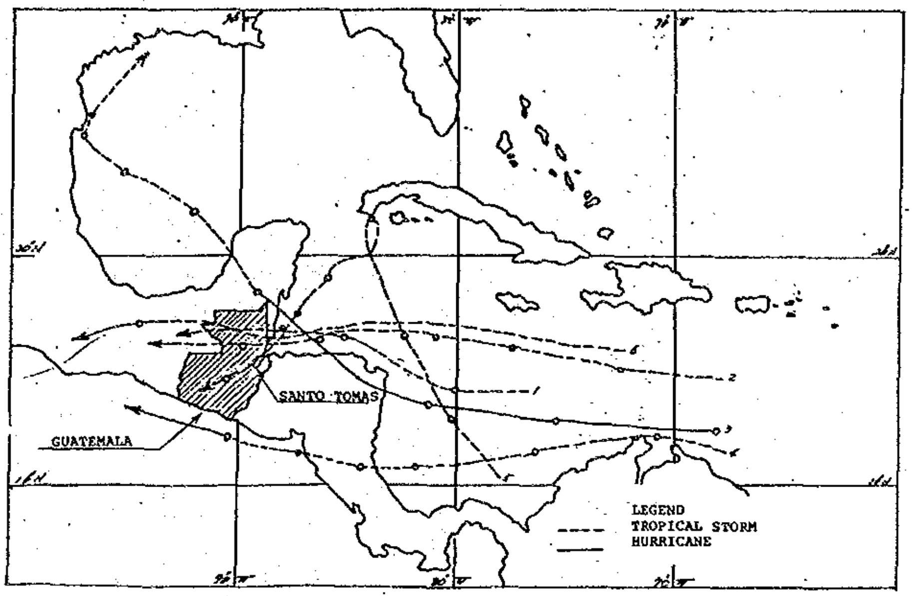


Fig. 2.1.5 Tracks of the Tropical Cyclones from the North Atlantic .

Table 2.1.2 Tropical Cyclones from the North Atlantic

No.	TYPE	YEAR	PERIOD	NAME
1	H	1,880	4 - 14 Ago.	
2	T	1,890	12 - 22 Sep.	
3	H	1,916	12 - 19 Ago.	
4	H	1,916	27 Ago. - 2 Sep.	
5	H	1,923	12 - 17 Oct.	
6	T	1,924	18 - 21 Jul.	
7	T	1,931	11 - 17 Jul.	
8	H	1,931	5 - 12 Sep.	
9	T	1,932	7 - 18 Oct.	
10	H	1,933	10 - 19 Sep.	
11	H	1,933	16 - 24 Sep.	
12	H	1,934	4 - 21 Jun.	
13	T	1,936	9 - 11 Oct.	
14	H	1,941	23 - 30 Sep.	
15	H	1,942	4 - 11 Nov.	
16	H	1,945	2 - 5 Oct.	
17	H	1,949	27 Sep. - 6 Oct.	
18	T	1,954	24 - 27 Sep.	GILDA
19	H	1,969	19 Ago. - 4 Sep.	FRANCELIA
20	H	1,971	5 - 17 Sep.	EDITH
21	H	1,971	11 - 24 Sep.	OLVIA-IRENE
22	T	1,971	12 - 22 Nov.	LAURA
23	H	1,974	15 - 21 Sep.	FIFI

LEGEND
T ...... TROPICAL STORM   H ——— HURRICANE

2.1.2 Precipitation

a) Annual precipitation

Fig. 2.1.6 shows annual precipitation.

Annual precipitation varies from 2,621 mm to 3,673 mm, a variation of 1,052 mm. The average value is 3,200 mm over several years. On average, there are 210 rainy days each year.

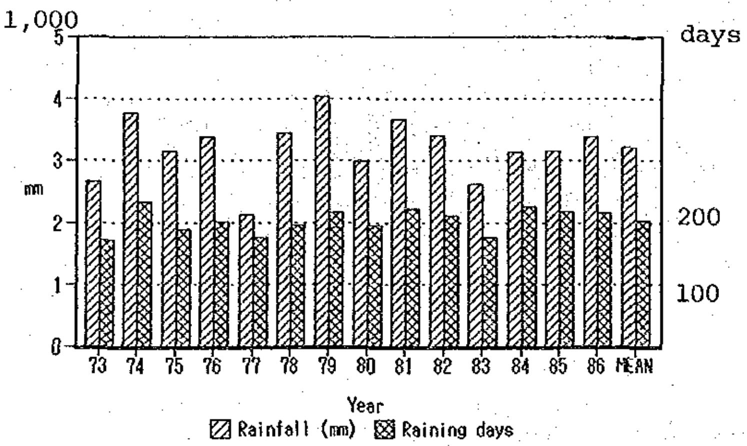


Fig. 2.1.6 Annual Rainfall

b) Monthly precipitation

Fig. 2.1.7 shows monthly precipitation.

Precipitation is heavy in the rainy season of July, August, September and October and reaches 3,000 mm a year.

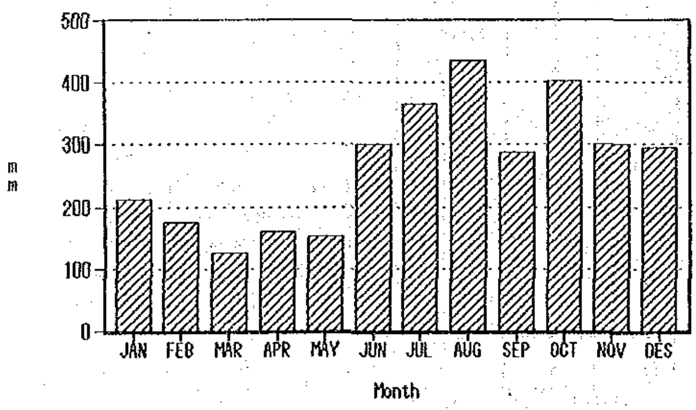


Fig. 2.1.7 Monthly Rainfall

The August precipitation reaches 430 mm and rain usually falls on twenty-five days in August. From March to May in the dry season, monthly rainfall is 130 mm to 190mm, and it rains about twelve days per month.

2.1.3 Temperature

Fig. 2.1.8 shows monthly average maximum temperatures and minimum temperatures. During summer (April - September) high temperatures of more than 30° are observed and in winter (November - March) relatively low temperatures of 26° - 30° are observed.

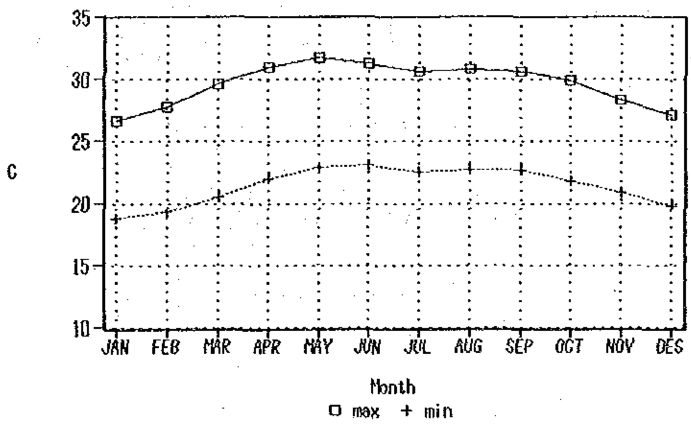


Fig. 2.1.8 Monthly Temperature

2.2 Sea Conditions

2.2.1 Tidal level

In Guatemala there are two tidal standard levels, the Atlantic tidal and the Pacific tidal.
At Santo Tomas de Castilla, the Atlantic tidal standard level is utilized.
Fig.2.2.1 shows the Atlantic tidal standard level.
M.L.W is adopted as datum zero on the chart and bathymetrical map, and M.W.L is adopted on the topographical map.

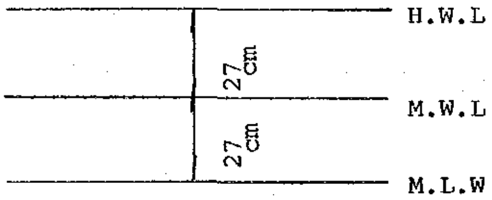


Fig 2.2.1 Tidal level

(1) Tidal observation

Tidal range observation is continuing at the station mentioned below, but the tide gauge is not so sensitive, so the data are not accurate. Thus, additional observation data were collected by means of a transit theodolite and rod during the sounding survey.

1) Tide Station:

a) Location of the station
Latitude 15-41'-37" N
Longitude 88-37'-16" W

b) Date of installation:
Installed in 1963 by Institute Geografico National

c) Type of tidal gauge:
Fuese type tide gauge

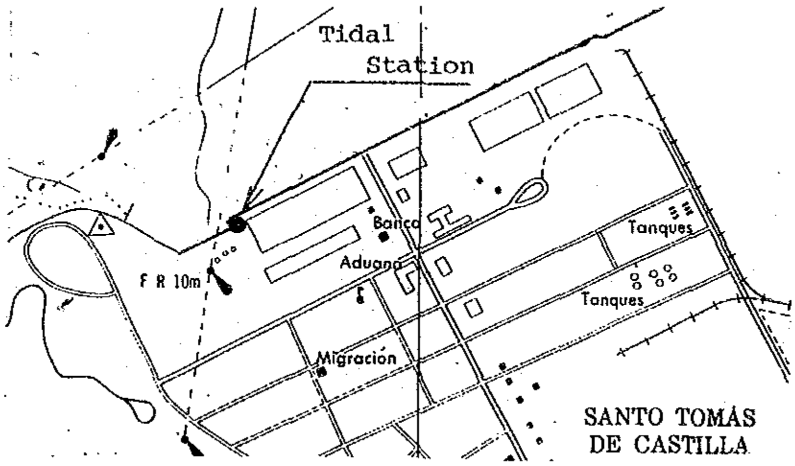


Fig. 2.2.1 Tidal Station

2) Observation data in Santo Tomas Port

The data from the year 1964 to 1985 after the installation of the equipment were collected and put in order. Fig. 2.2.2 shows typical tidal levels schematically.

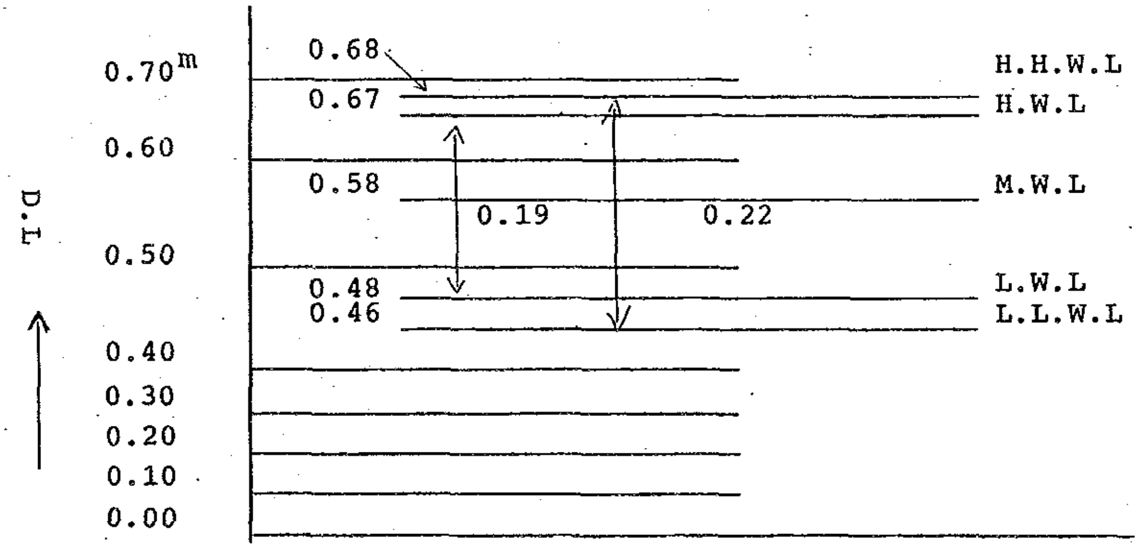


Fig. 2.2.2 Observed Tidal Level

(2) Tide Table

The calculated value of the tidal level in Santo Tomas de Castilla, Puerto Barrios and Livingston are published by INSIVUMEH.
But these value are calculated with the standard tidal data from Key West, Florida in the U.S.A (which is located at Lat. 24-33, Long. 81-48) instead of using data from Santo Tomas Port.

There is a big difference between the calculated tidal level and the tidal level actually measured at Santo Tomas Port; the former is large and the latter is small.

2.2.2 Tidal Current

No tidal current observation data are available in Santo Tomas Bay, so the outline of the current in the bay is made based on interviews with persons working in the port for many years. A brief current survey using buoys was also executed and the results are shown in Fig. 2.2.3.

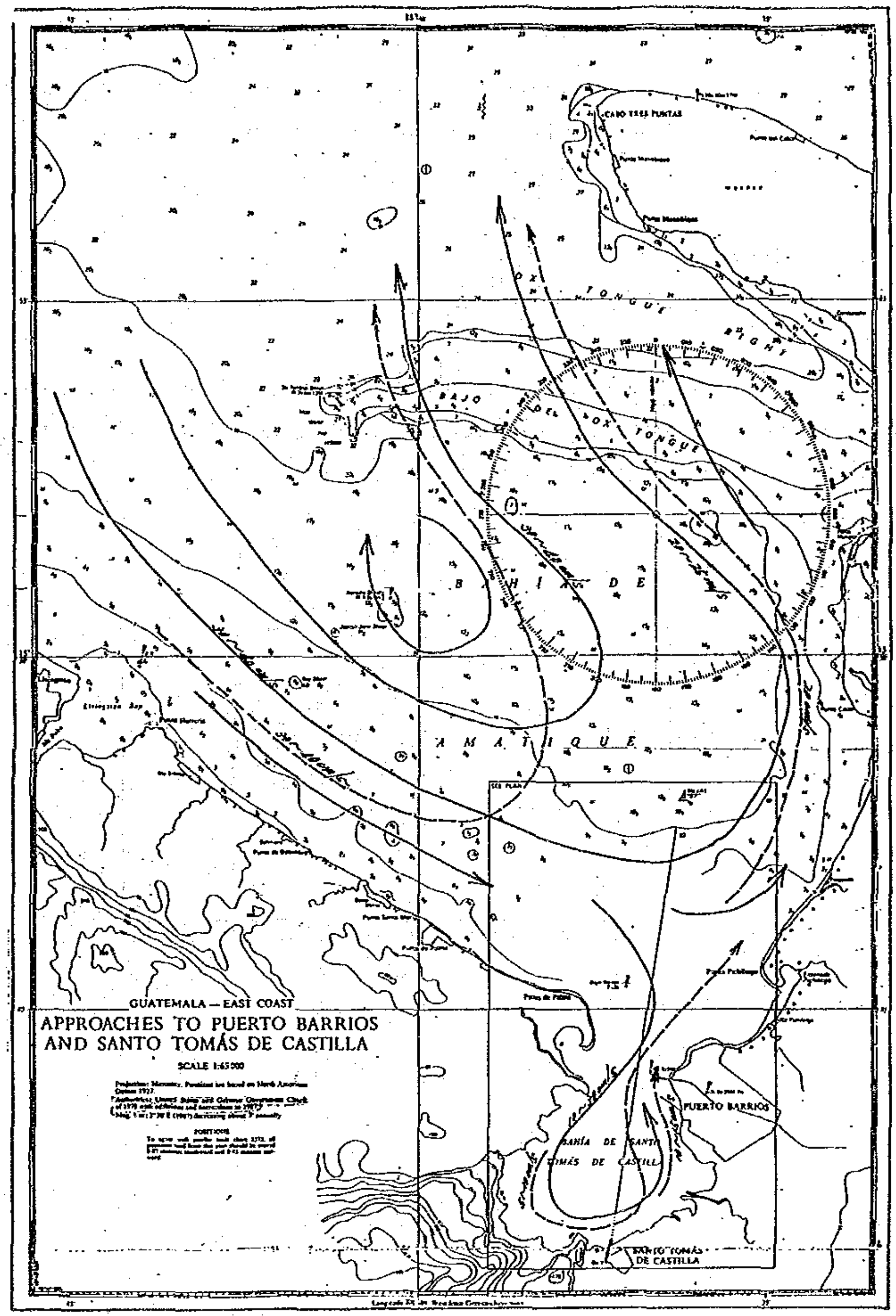


Fig. 2.2.3 Tidal Current

2.2.3 Sea Water

The high precipitation and water flowing down from rivers makes the salt density low. The data on temperature and specific gravity of the sea water were collected and put in order.

(1) Sea Water Temperature

There is no special seasonal change, and the mean temperature in each month is 27 °C-31°C.

The average high temperature in each month is consistent throughout the year but the average monthly low temperature comes down to 20°C in January and February. These data are shown in Fig. 2.2.4

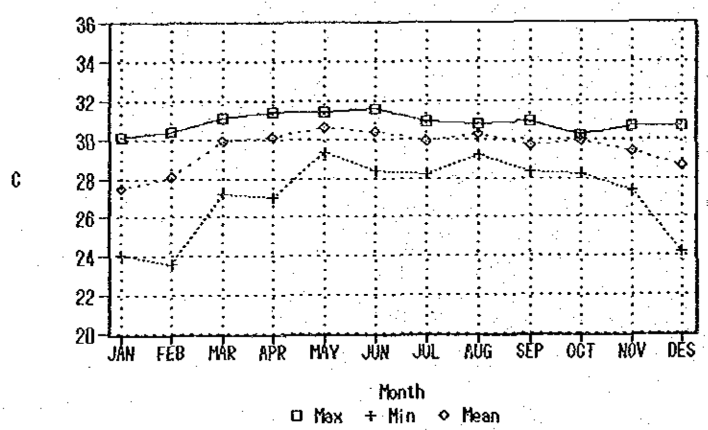


Fig. 2.2.4 Sea Water Temperature

(2) Specific Gravity

The salt density in the sea water is very low as mentioned above, so the specific gravity of the sea water, naturally, is also low. The average specific gravity is 1.017 grams per cubic centimeter, which is a very low value compared with the 1.025 gr/cm^3 of normal sea water as shown in Fig. 2.2.5.

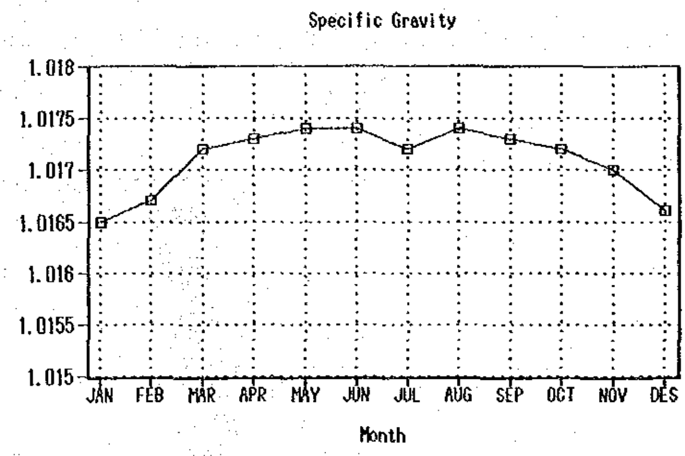


Fig. 2.2.5 Specific Gravity

(3) Salt Density

The average annual salt density is 2.35 percent and it is lowest in January, February and December as shown in Fig. 2.2.6

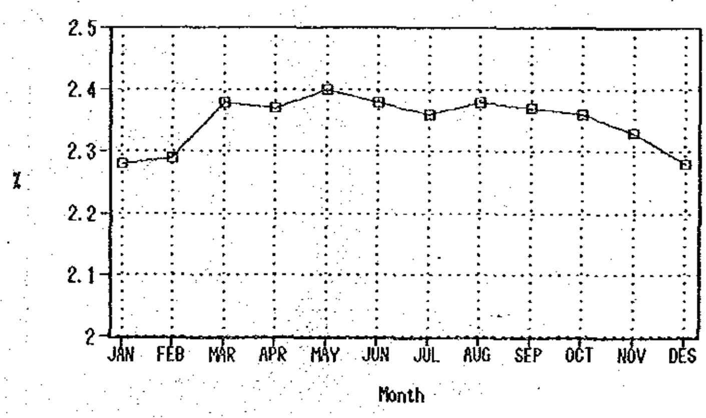


Fig. 2.2.6 Salt Density

2.2.4 Sounding Survey

To obtain the bathymetrical map necessary for the planning of the navigational channel, a sounding survey was executed at the area shown in Fig 2.2.7. The sounding was conducted using an echo sounder installed under the survey boat, and the survey boat was directed utilizing two control points on land using the integrated angle method.

The sounding was executed at intervals of 50 m in the turning basin and 100 m in the navigational channel. Fig. 2.2.8 shows a bathymetrical map of a portion of the turning basin.

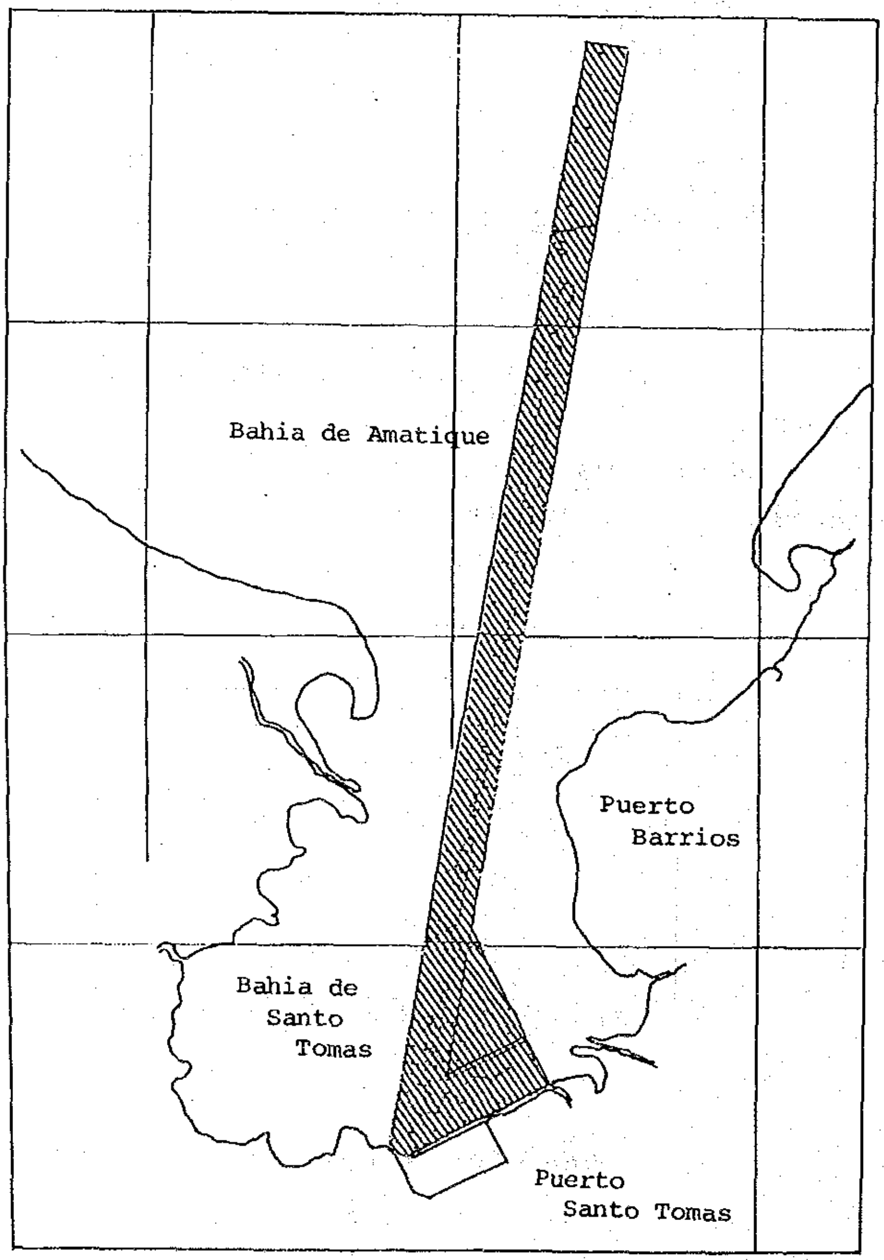


Fig. 2.2.7 Location of the Sounding Survey

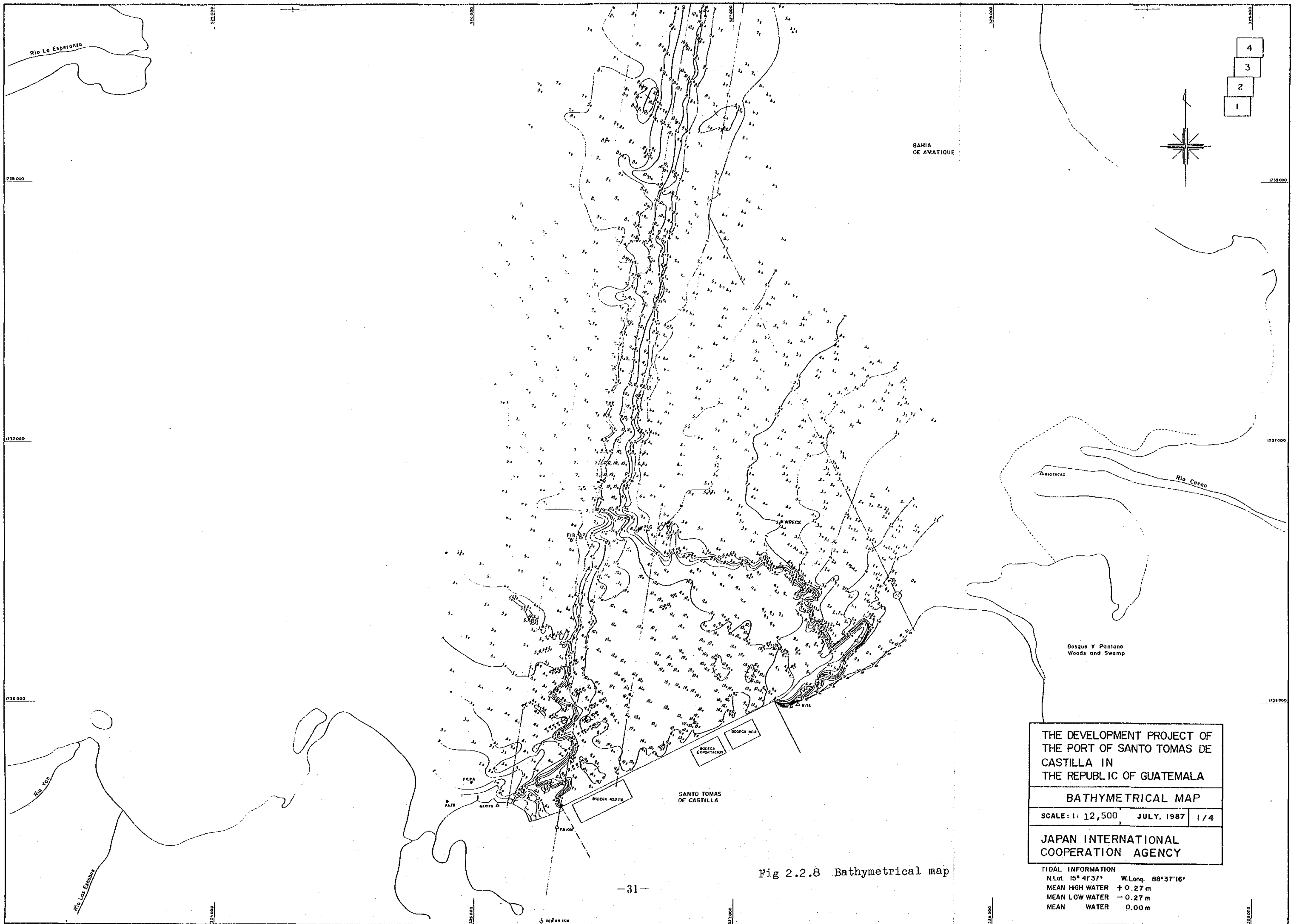


Fig 2.2.8 Bathymetrical map

2.2.5 Seabed Condition

The seabed of Santo Tomas Bay is relatively flat and shallow. The water depth of the existing navigational channel varies from -9.4 to -10.5 m from datum level.

Fig 2.2.10 shows the soil profile obtained by Swedish sounding and soil sampling.

The seabed material of the turning basin and of the navigational channel consists of very soft marine clay to a depth of at least -15 m from datum level except at point SB-3. At location SB-3 hard soil assumed to be diluvial clay appears at a depth of -12 m from datum level.

Fig 2.2.9 shows the depth distribution of soil properties at bore hole No. A. The liquid limit ranges from 80 - 90%, the plastic limit ranges from 40 - 45 %, and the plasticity index (IP) ranges from 20 - 40. Consequently, the soil may be classified as high plasticity clay.

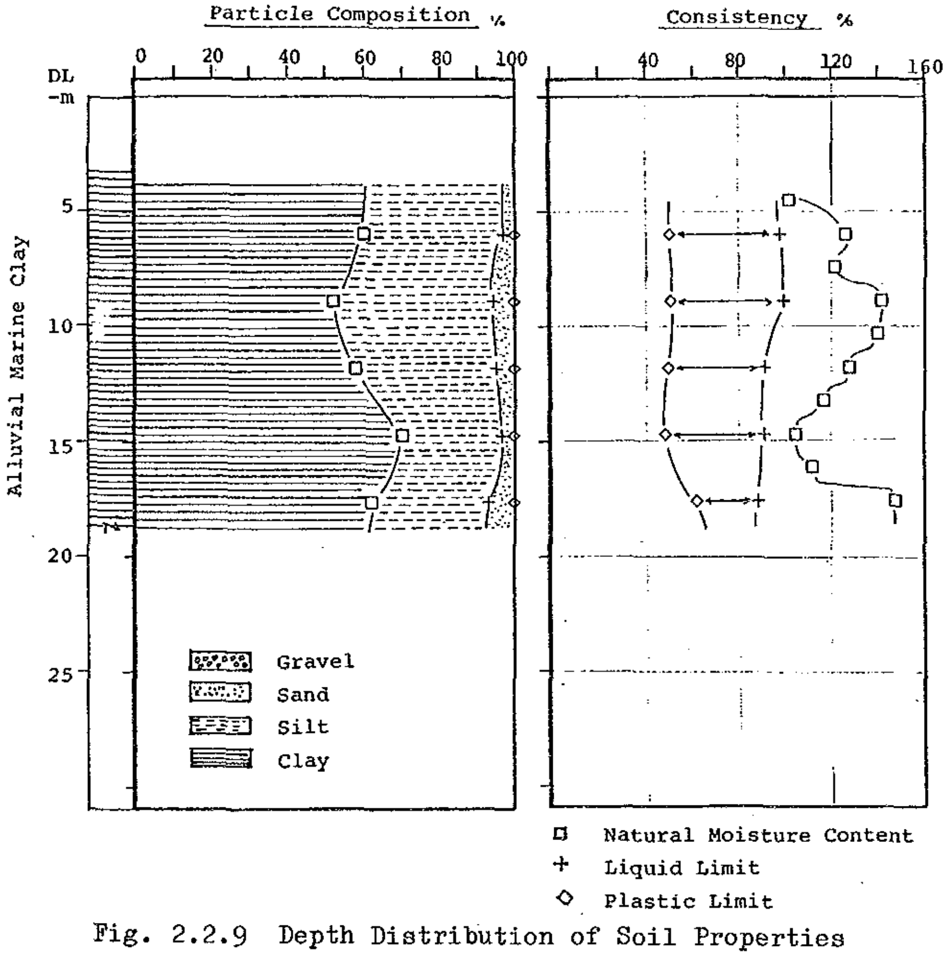
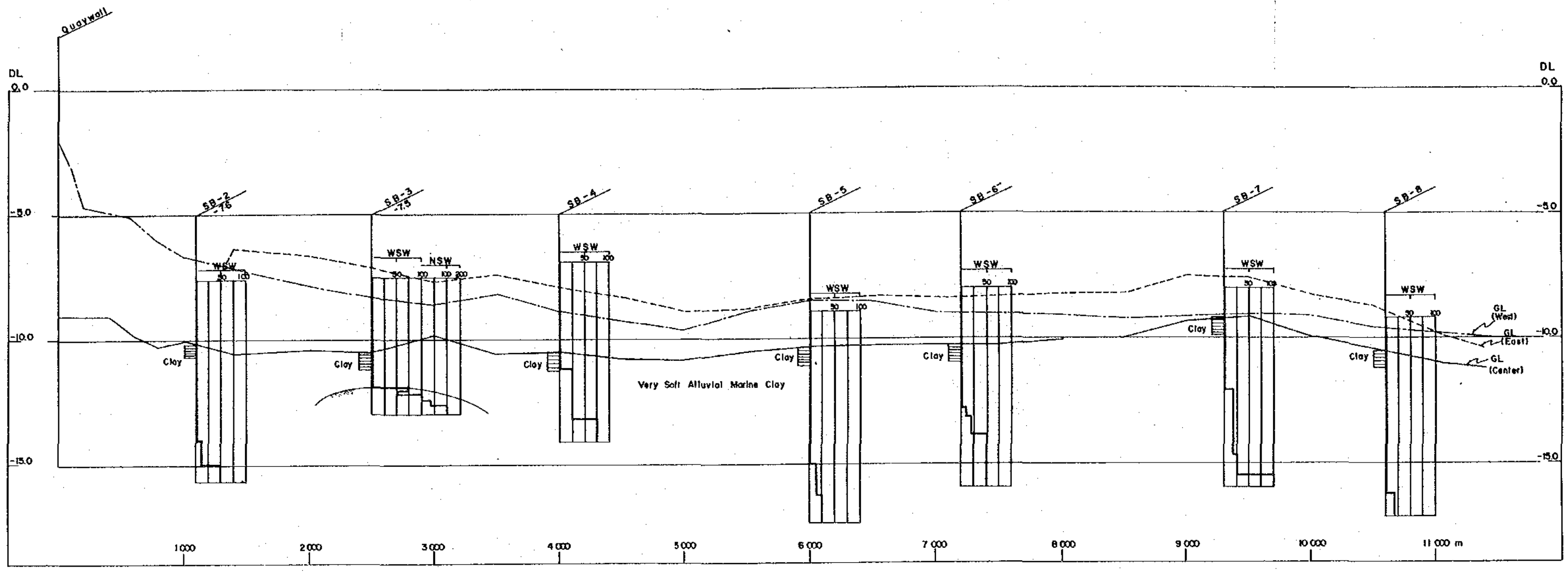
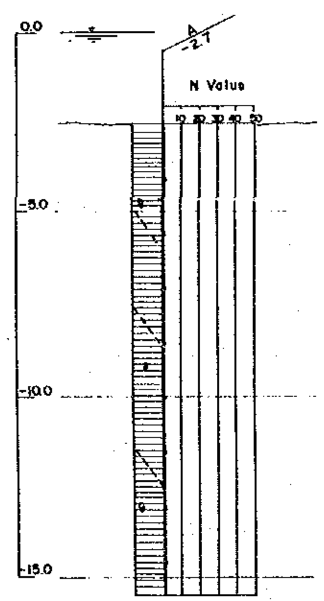
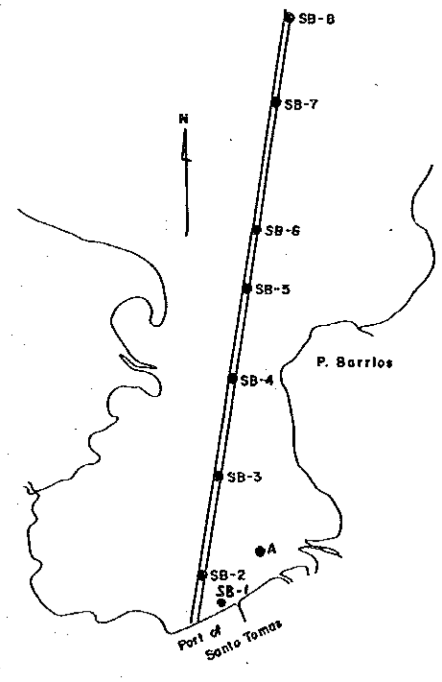


Fig. 2.2.9 Depth Distribution of Soil Properties







Note
N value : Penetration Resistance
of Standard Penetration Test
W.S.W : Settling Load
N.S.W : Number of Half Revolutions
for 1 m

Fig. 2.2.10 Soil Profile (Navigationnal Channel)

As the natural water content of the soil is greater than the liquid limit it can be said that the soil is unstable.

Fig. 2.2.11 shows the plasticity chart. The liquid limit and the plasticity index are distributed along line A and the samples show a liquid limit of greater than 50 %. Accordingly, the soil is classified as CH or MH (high plasticity clay or silt) on the basis of Unified Soil Classification.

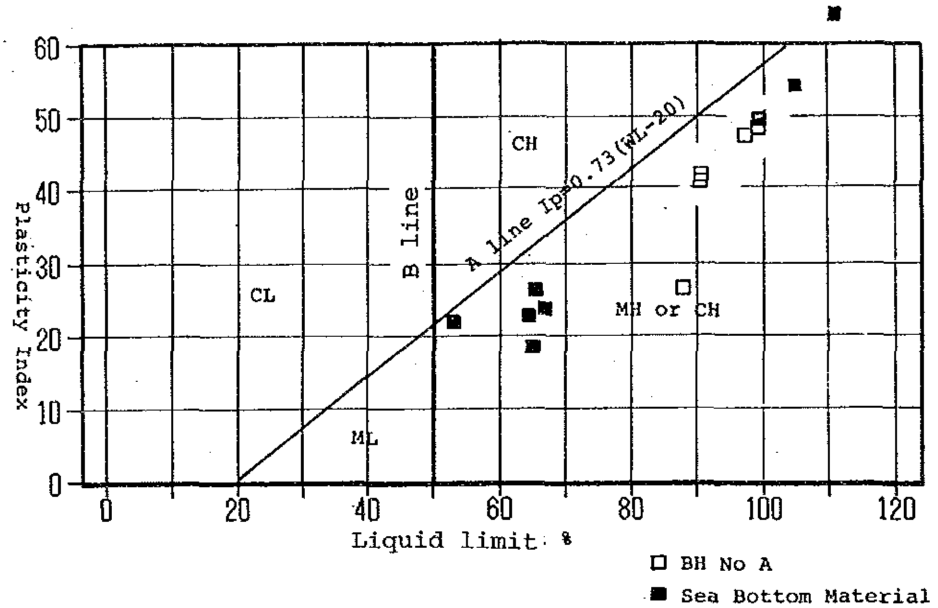
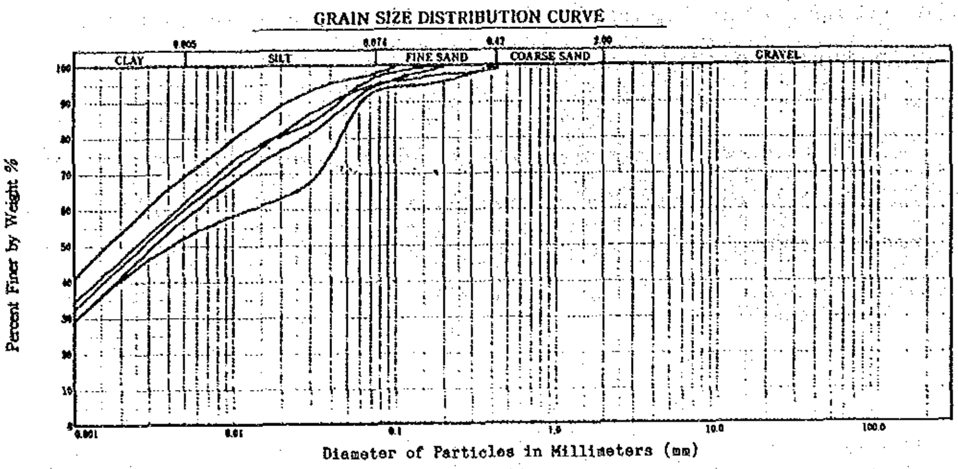


Fig. 2.2.11 Plasticity Chart

Fig. 2.2.12 shows a comparative diagram of grain size distribution curves and Fig. 2.2.13 shows a distribution map of the intermediate diameter D50 of the soil. Because the soil mainly consists of very small soil particles, the intermediate diameter of the soil D_{50} ranges from 0.001 mm to 0.015 mm.



Sea bottom

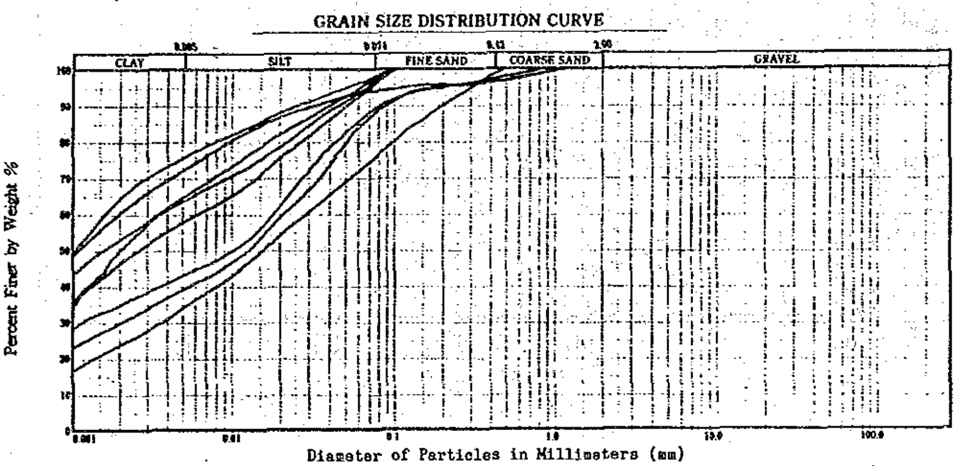


Fig. 2.2.12 Grain Size Distribution Curve

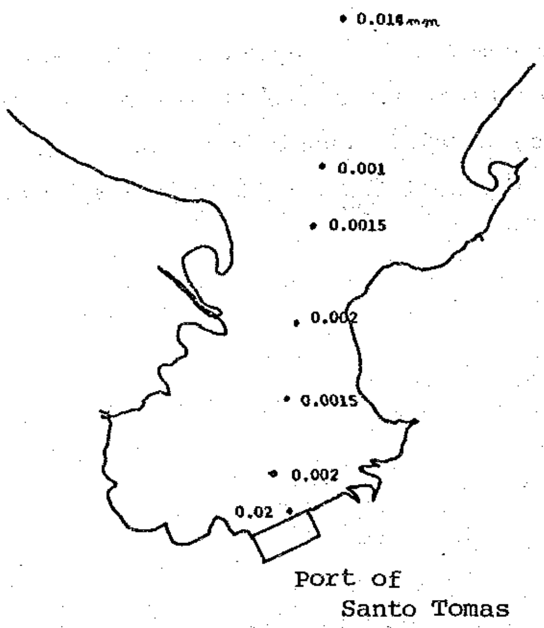


Fig. 2.2.13 Distribution map of D_{50}

2.3 Geographical Conditions

2.3.1 Topographical Conditions

The topography around Santo Tomas Bay is divided into a highland area consisting of third era rock and its highly weathered deposits (residual soil), and part of an alluvial plain which has been formed by rivers flowing into the bay. Fig 2.3.1 shows the geographical map of the area surrounding the port of Santo Tomas de Castilla.

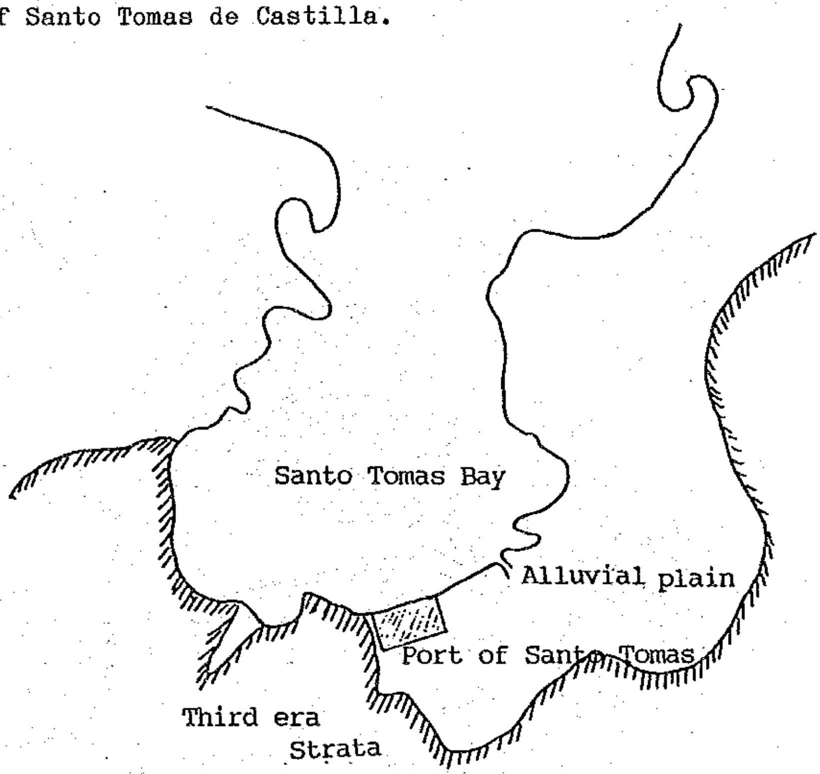


Fig 2.3.1 Geological Map

The port of Santo Tomas de Castilla is located on the transition area between the highland and the alluvial plain. But the expansion area is located on the swampy area of the plain.

2.3.2 Topographical survey

A topographical survey was executed to obtain the necessary map for the facility planning of the port expansion at the location shown in Fig. 2.3.2. Azimuth and altitude were determined using the control points of BITTA II and the existing quaywall line.

The interval of the survey lines was 20 m and a leveling survey was executed along each survey line. The survey results are summarized on a map with a scale of 1/2,500. Fig. 2.3.3 shows the topographical map.

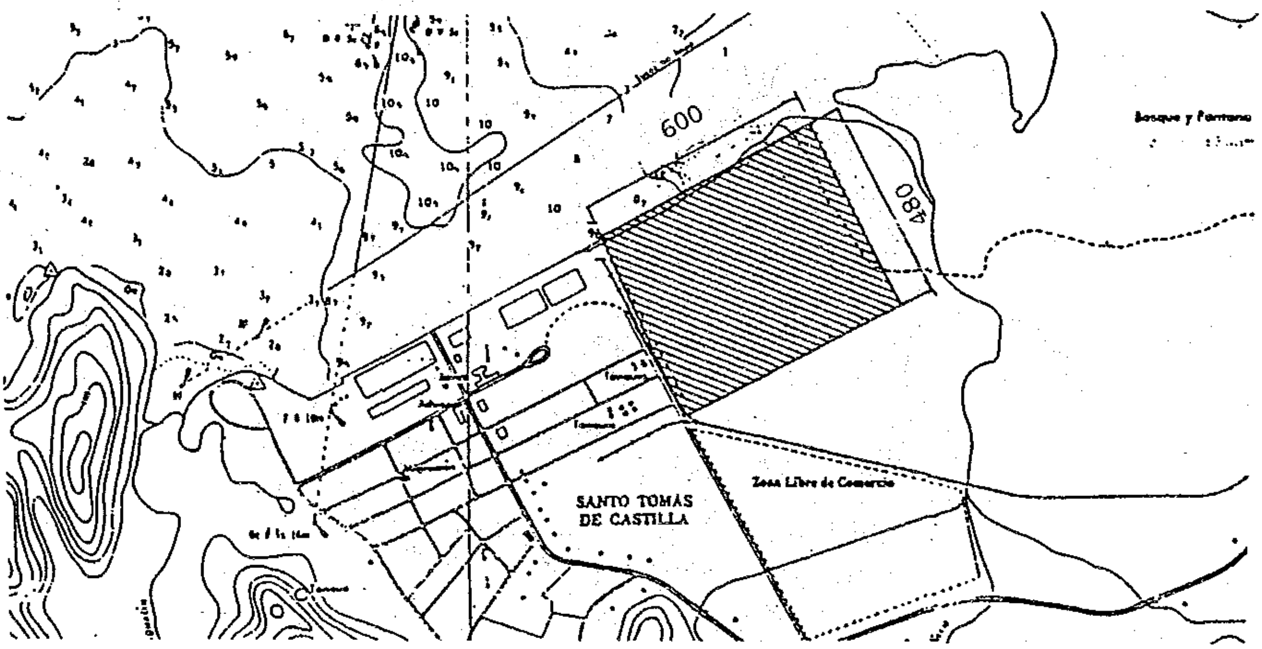


Fig 2.3.2 Location of the Topographical Survey

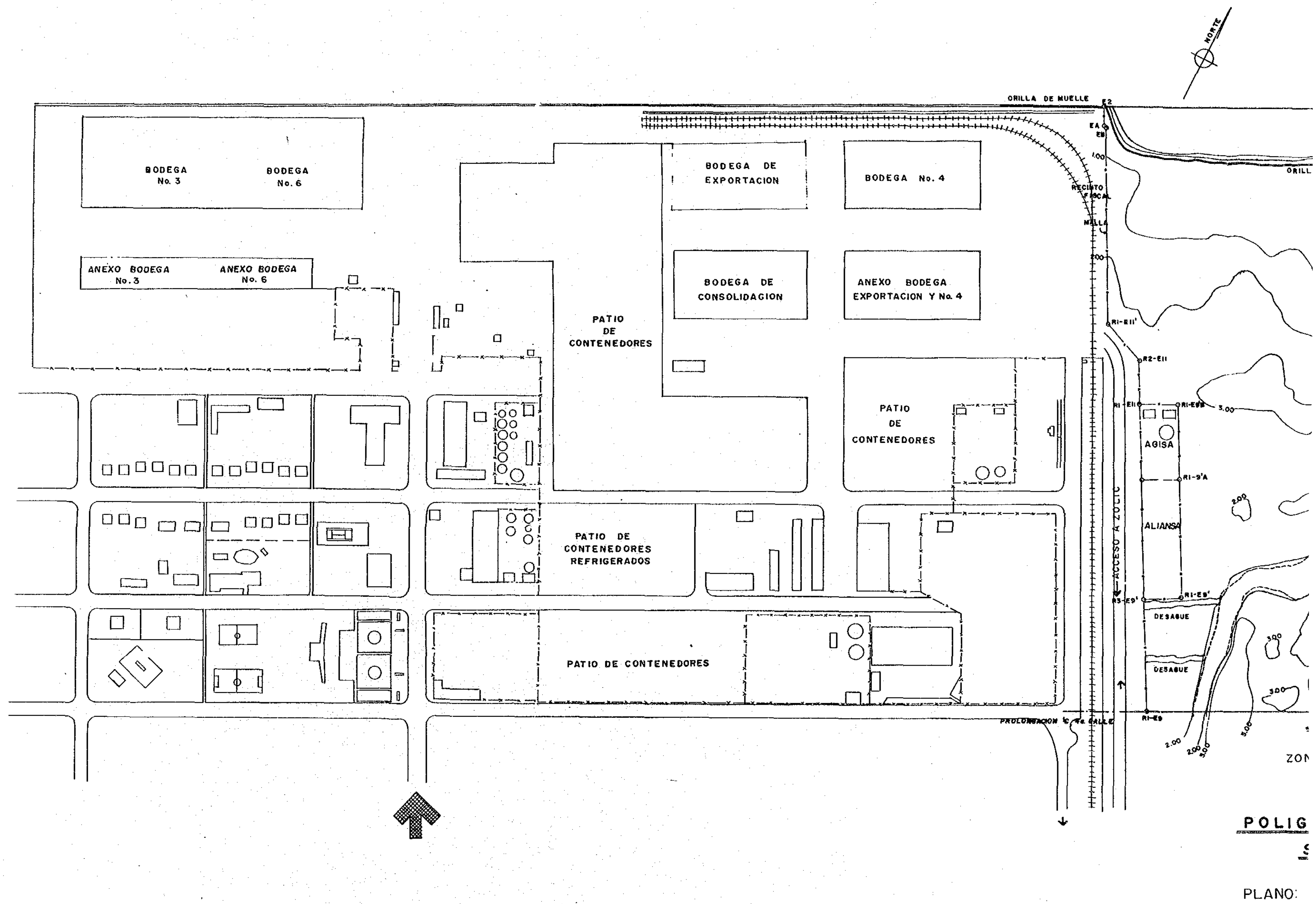


Fig. 2.3.3. Topographical Map

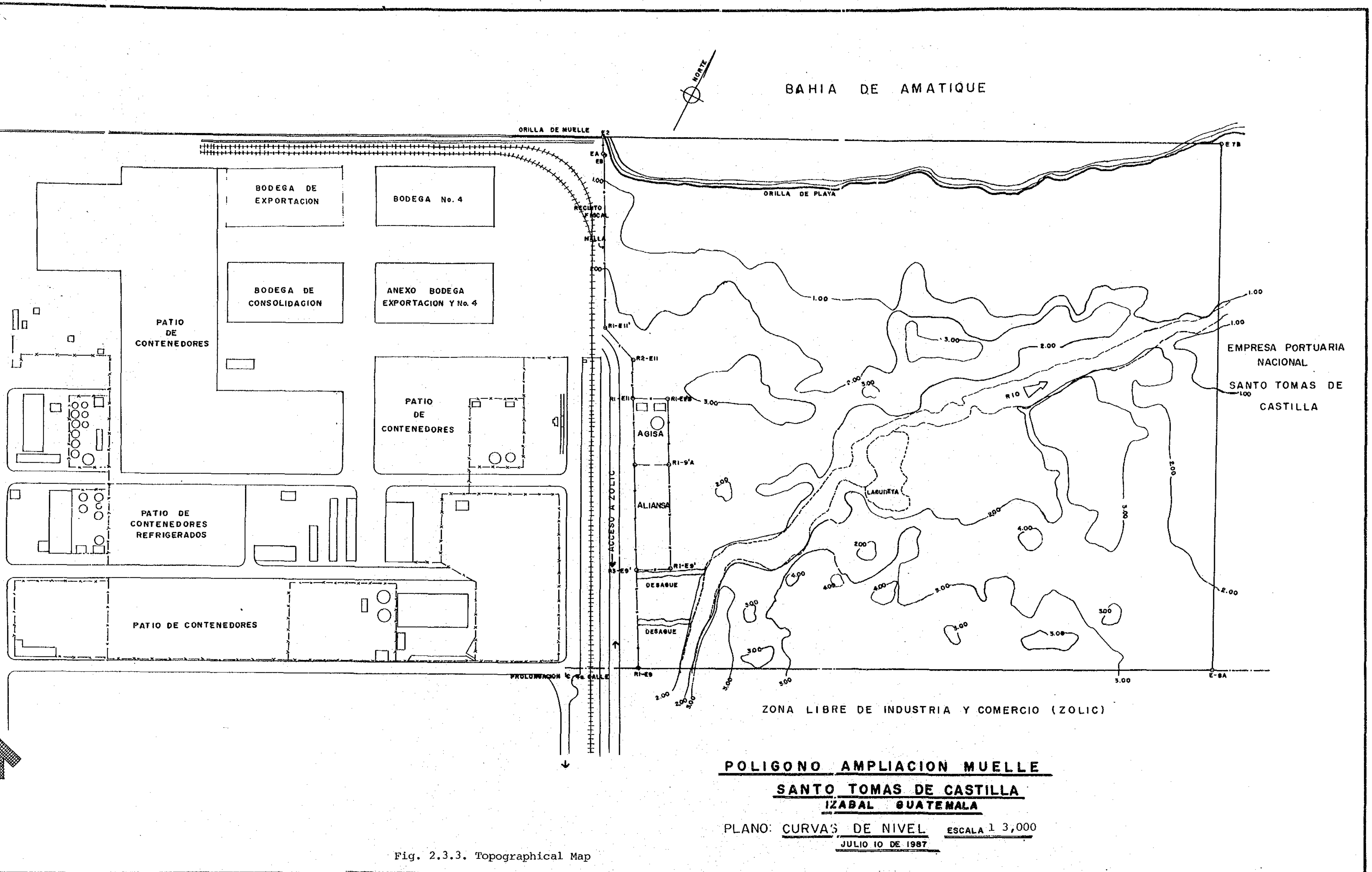


Fig. 2.3.3. Topographical Map

2.3.3 Soil Investigation

To explore the subsoil conditions and to obtain the characteristics of the soil which will be necessary for further study of the facility planning and design of structures, a soil investigation was executed at the locations shown in Fig. 2.3.4.

The soil investigation included borings, Swedish soundings and laboratory soil tests. Table 2.3.1 shows the items and quantities of the works of the soil investigation.

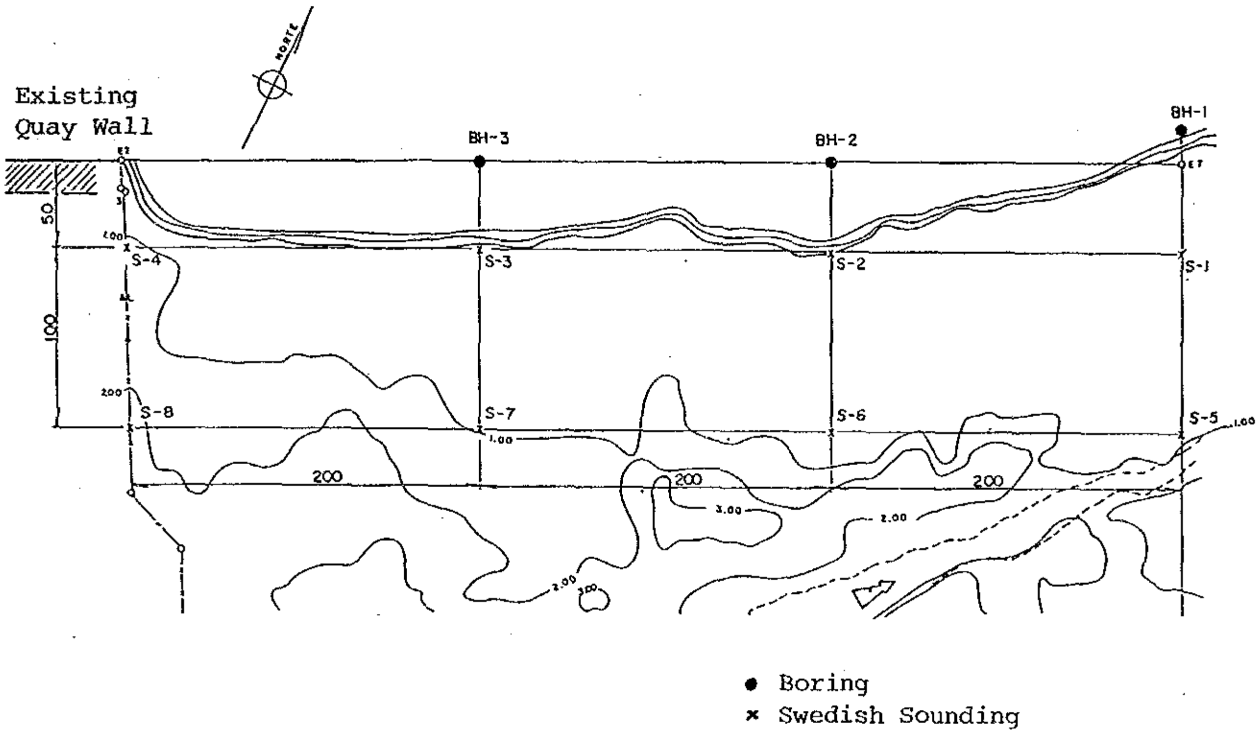


Fig 2.3.4 Location of the Soil Investigation

Table 2.3.1 Items and Quantities of Soil Investigation

Bore hole No	Boring land	shore	S.P.T.	U.D.	U.C.	Conso.	Wn	Gs	Sieve	Hydro	LL,PL	Bulk
BH-1	25.9		10	6	6	6	10	5		7	10	6
BH-2	24.9		10	8	7		13	8	4	8	10	7
BH-3		24.0	15				7	6		6	6	
A		14.8	10				10	5		5	5	
Sea Bottom							9	9		9	9	
Total	50.8	38.8	45	14	13	6	40	24	4	26	31	13

Swedish Sounding

Offshore 7 places

On land 8 places

Abbreviations

S.P.T.	Standard Penetration Test
U.D.	Undisturbed Sampling
U.C	Unconfined Compression Test
Conso.	Consolidation Test
Wn	Natural Water Content
Gs	Specific Gravity
Sieve	Mechanical Analysis (sieve)
Hydro	Mechanical Analysis (Hydraulic)
LL,PL	Liquid Limit and Plastic Limit
Bulk	Bulk Density

2.3.4 Soil Conditions

Fig 2.3.5 shows a sketch of the geological structure of the surroundings of the project area.

It can be assumed that the geological structure of the project area is composed of four strata, namely bedrock, diluvial marine clay, residual soil and alluvial marine clay.

Existing port facilities are located on the residual soil stratum, and the port expansion area and navigation channel are located on the alluvial marine clay stratum.

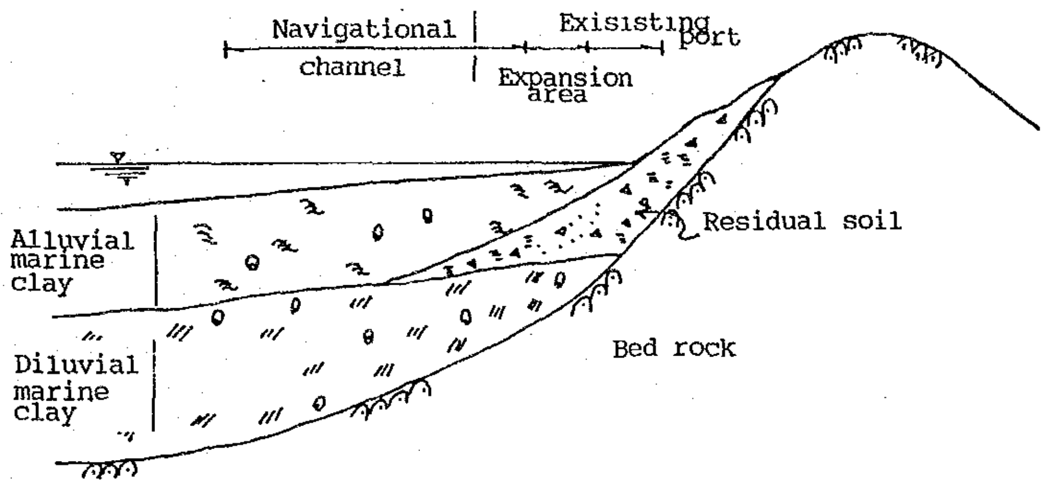
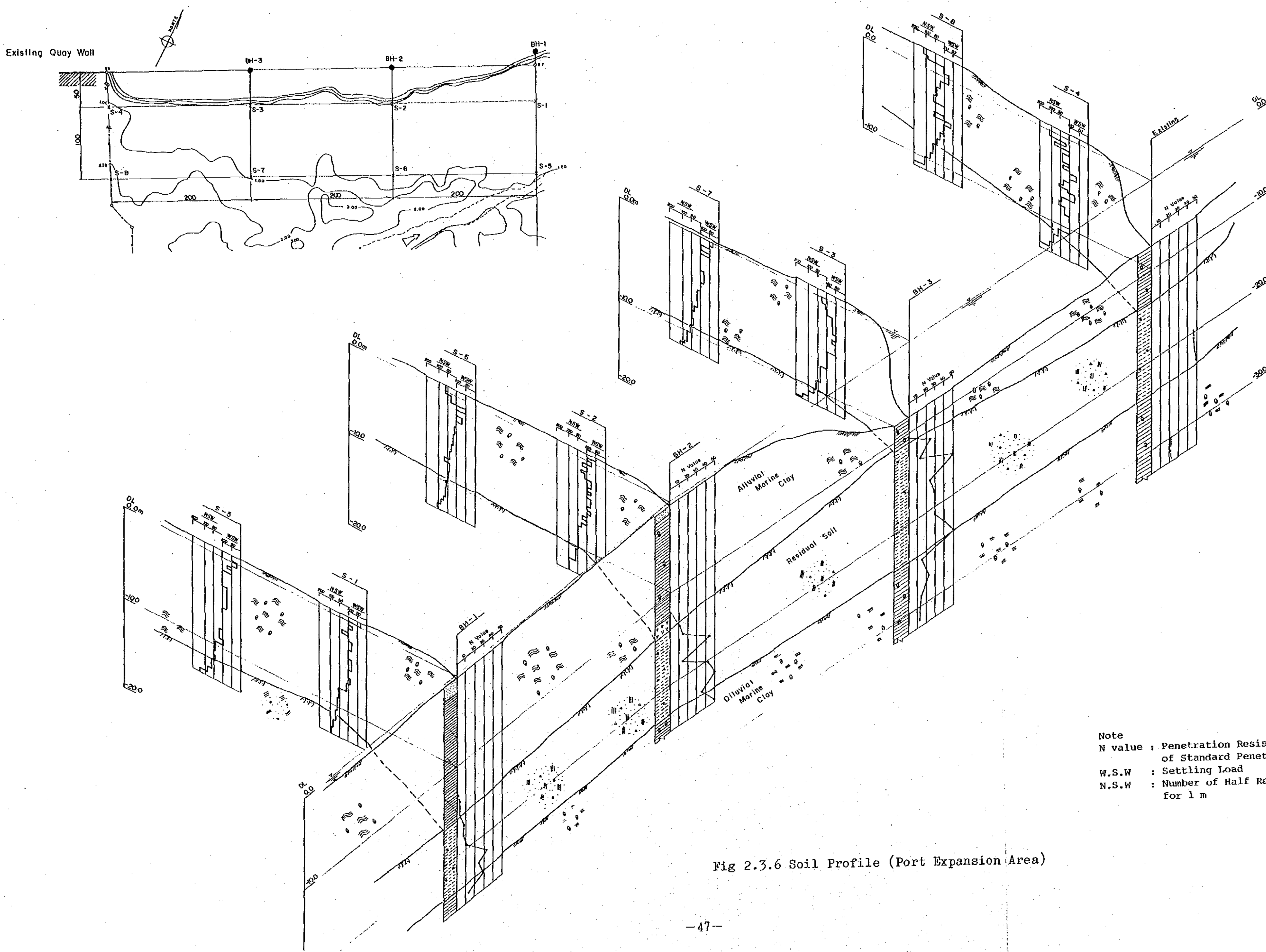


Fig. 2.3.5 Geological Structure

Fig. 2.3.6 shows the soil profile obtained by the soil investigation. In this soil investigation, three layers of soil strata are confirmed. The characteristics of each of the strata are as follows.



Note
N value : Penetration Resistance of Standard Penetration Test
W.S.W : Settling Load
N.S.W : Number of Half Revolution for 1 m

Fig 2.3.6 Soil Profile (Port Expansion Area)

(1) Alluvial Marine Clay

This layer consists of very cohesive clayey soil colored greenish gray or dark gray including large amounts of shell fragments. The stratum is relatively homogeneous but contains partial sand seams.
The soil is so soft that the N values (penetration resistance by standard penetration test) are measured as zero (sunk by hammer weight).

(2) Residual soil

Underneath the alluvial marine clay, a secondary deposition of residual soil has been accumulated. The stratum mainly consists of clayey soil colored brown or yellowish brown irregularly including fine to medium sand and gravels. The stratum has a consistency of stiff to hard, but as the stratum is not homogeneous, the N values vary from 20 to more than 50.

(3) Diluvial Marine Clay

This stratum consists of greenish gray clay including large amounts of fine to medium sand, and small shell fragments are observed. The stratum has a medium stiff consistency, and as the stratum becomes deeper the soil tends to be more soft. The N values vary from 10 to 20.

2.3.5 Soil Properties

(1) Alluvial marine clay

Fig. 2.3.7 shows the soil properties.

a) Consistency

The liquid limit ranges from 60 - 90 %, the plastic limit ranges from 30 - 40 % and the plasticity index ranges from 30 - 40. Consequently, the soil is classified as high plasticity clay. As the natural water content ranges along the liquid limit, the soil is unstable and sensitive.

On the plasticity chart, the liquid limit and plasticity index are distributed along A Line and the liquid limit is greater than 50%. Accordingly, the soil is classified as CH or MH (high plasticity clay or silt) on the basis of Unified Soil Classification.

b) Particle size distribution

The soil consists 30 - 60 % of clay particles, 40 - 60 % of silt and 5 - 20 % of sand. Intermediate particle size ranges from 0.002 mm to 0.015 mm.

c) Unconfined compression strength

Fig. 2.3.7 shows the depth distribution of compression strength (qu) based on the results of the unconfined compression test. Compression strength (qu) increases linearly as depth increases, according to the formula of qu=0.034+0.0356xDL (DL: depth in meter qu: kg/cm^2).

d) Properties of consolidation

Fig. 2.3.8 show the properties of consolidation.
The coefficient of consolidation (Cc) determined as the gradient of a straight line on the e - log P curve which indicates compressibility of the soil ranges from 0.05 - 0.1. The coefficient of consolidation (Cv) corresponding to "Py" ranges from 0.4 - 0.1 cm2/sec. These coefficients show standard values for alluvial marine clay.

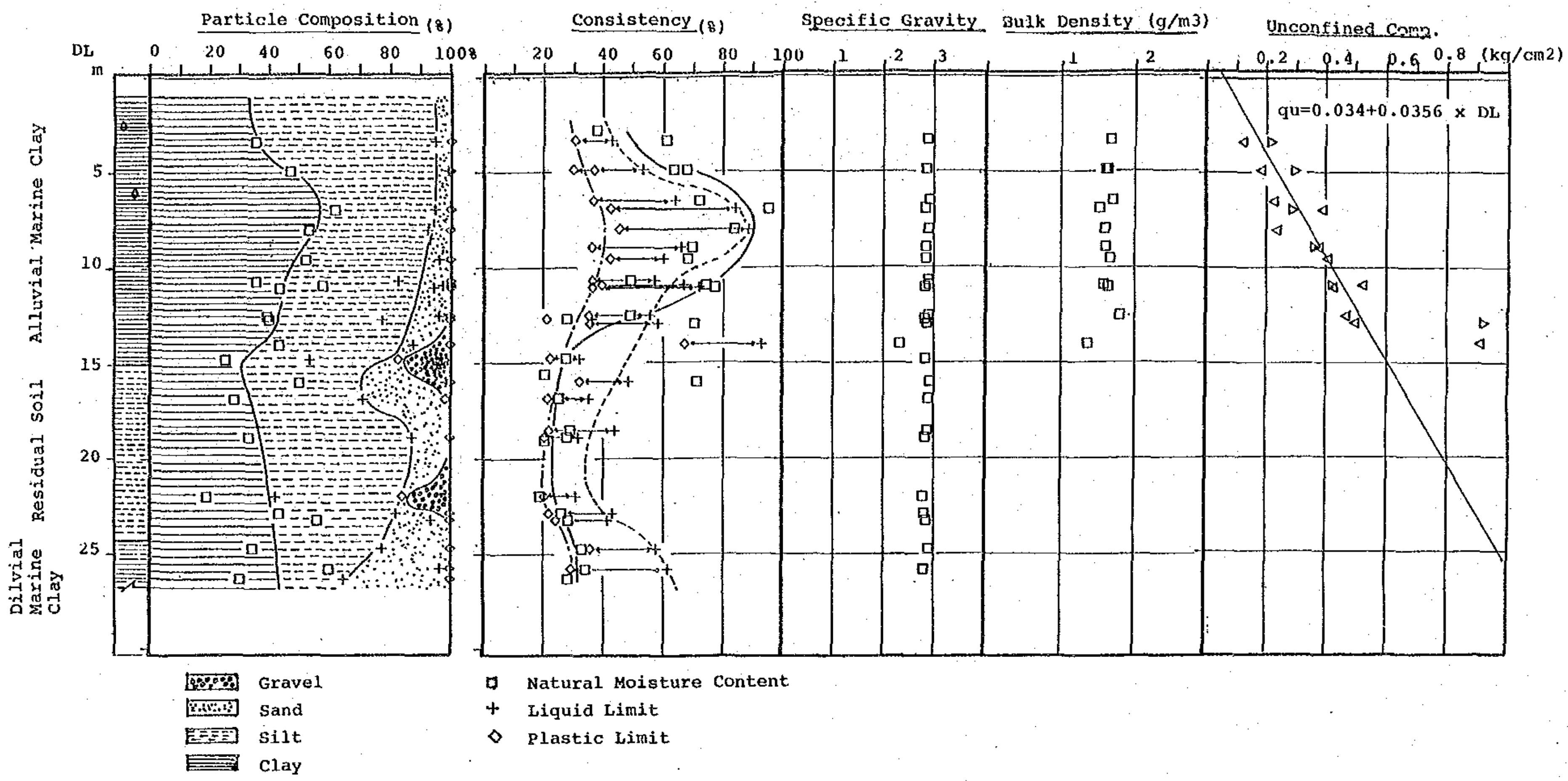
(2) Residual soil

The liquid limit ranges from 30 - 50 %, the plastic limit ranges from 20 - 25% and the soil is classified as CL or ML (low plasticity clay or silt).

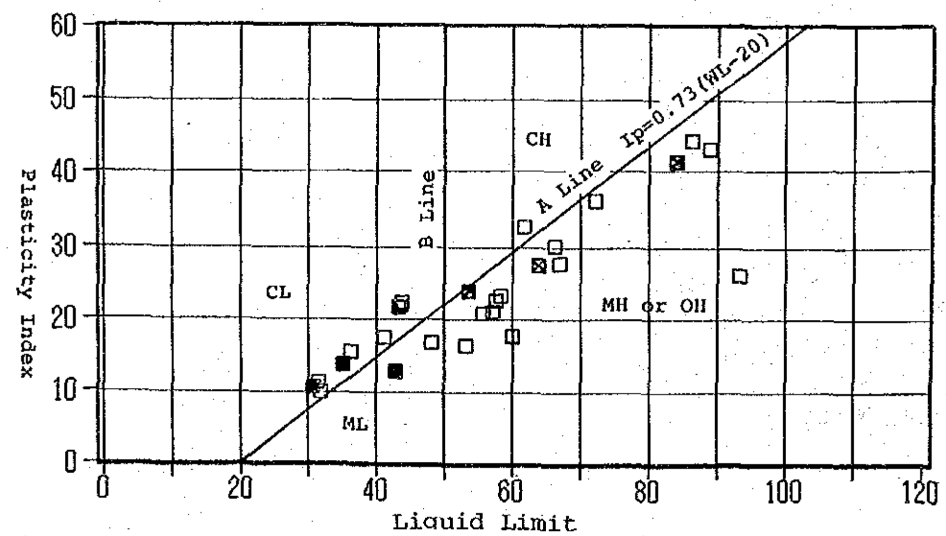
(3) Diluvial marine clay

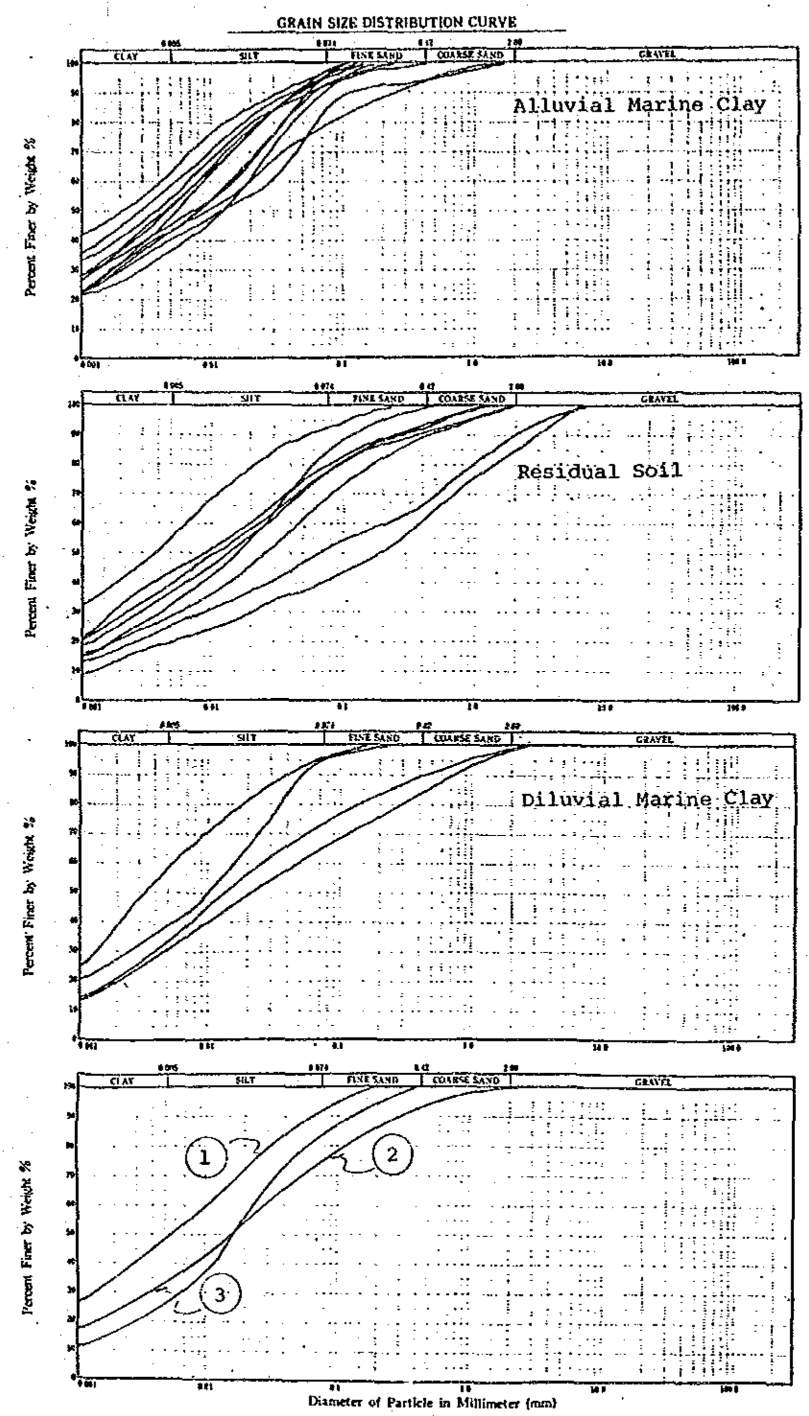
The liquid limit ranges from 60 - 80 %, the plastic limit ranges from 20 - 30% and the soil is classified as CH or MH. However, the soil is stable because the natural water content ranges near the plastic limit and is very low.

Depth Distribution of the Soil Properties



Plsticity Chart





	Gravel %	Coarse Sand %	Fine Sand %	Silt %	Clay %	Colloid %	Dmax mm	[illegible] mm	[illegible] mm	Coeff of Uniformity Uc	2.0mm Under %	0.42mm Under %	0.074mm Under %
1	-	-	7	40	53	(35)	0.42	0.01	-	-	100	100	93
2	-	7	19	49	25	(16)	2.00	0.03	-	-	100	94	74
3	-	-	18	49	33	(23)	0.42	0.02	-	-	100	100	82

Fig. 2.3.7 Soil Properties

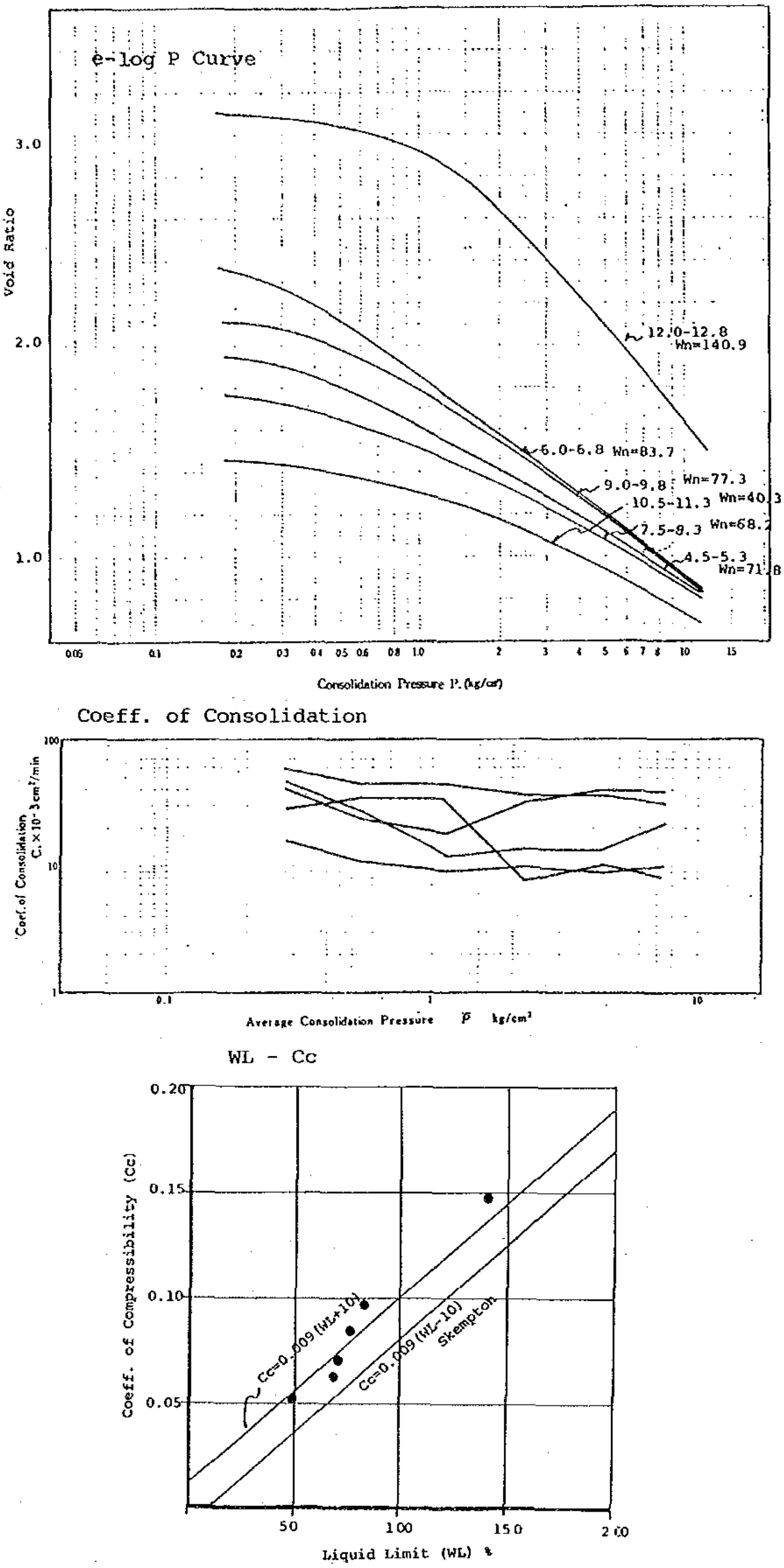


Fig. 2.3.8 Properties for the Consolidation

2.4 Hydrology

2.4.1 Main Rivers in Izabal District

There are many big rivers and a large lake in Izabal district as shown in Fig. 2.4.1 For example, the river Motagua has its origin far away in the township of Chichicastenango in Quiche district, and passes through Alta Verapaz, El Progress, Zacapa and Izabal and finally discharges into the Bay of Omoa. The river is 400 kilometers long and for 200 kilometers from the river mouth it is navigable. Its drainage area is 25,100 square kilometers.

The river Polochic starts in the mountainous region called Xucaneb. Gathering a lot of branches, the river flows down to the outlet in the Izabal lake. The river has a length of approximately 260 kilometers.

The river Sarstun, whose name is derived from the Mayan language and means white rock, is located at the boundary of Izabal and Belize and is navigable by launches. It has an average depth of 5 meters and is about 40 meters wide. The total length of the river reaches 140 kilometers. This river is important for commercial relations with Peten, Alta Verapaz, Livingston and Puerto Barrios.

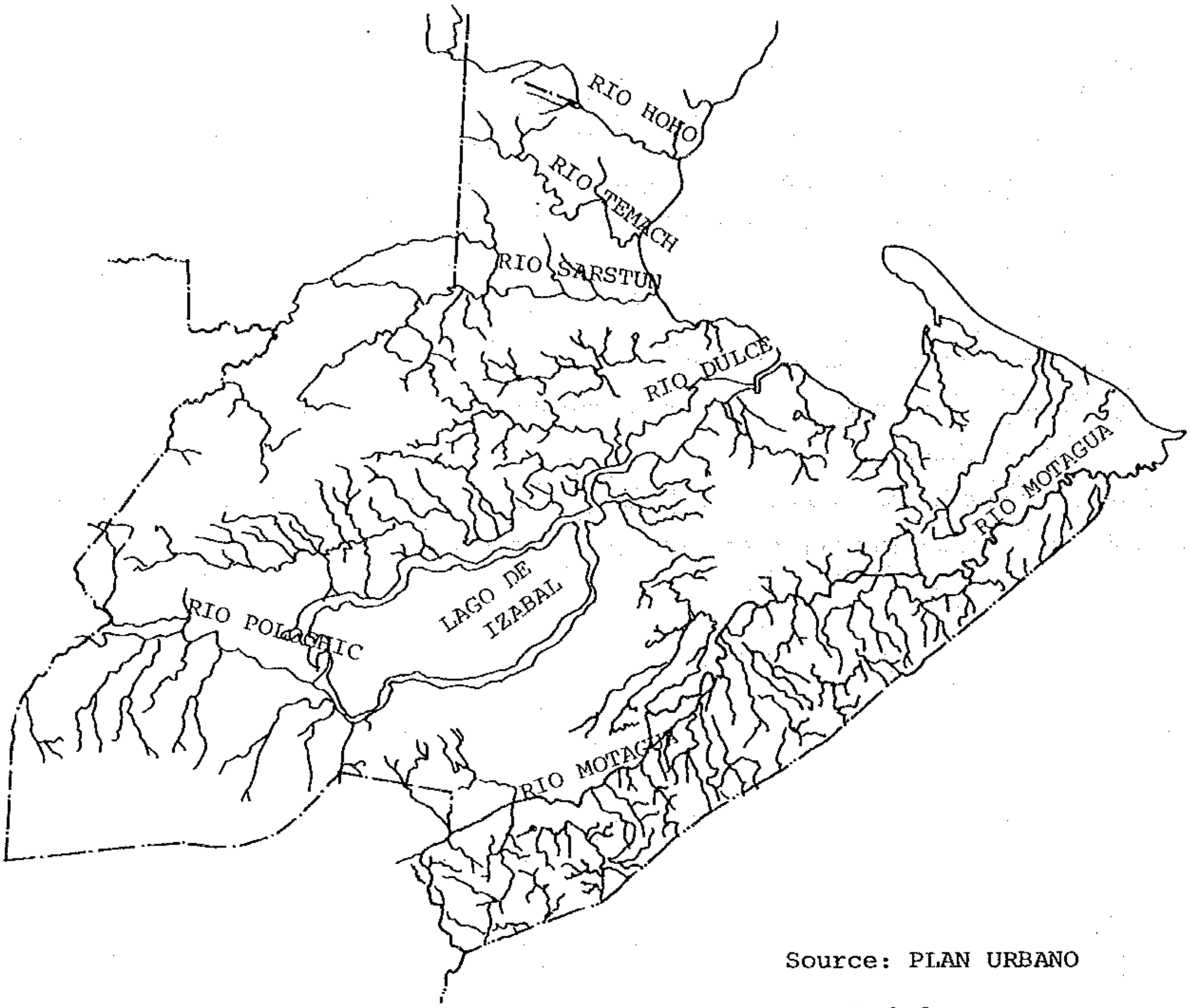
Lake Izabal is an important hydrological resources in the district. It has an area of 590 square kilometers, and it is used for coastal traffic for trade and tourism among El Estor, San Felip de Lara, Mariscos, El Golfete, Rio Dulce, Livingston and Amatique Bay.

The lake receives a lot of river water and water falls from the mountainous area around it, mainly the water of the Polochic river and its tributary, and runs down the river Dulce and flows into Amatic Bay.

In general, as shown in Fig. 2.4.2, rainfall in the district reaches from 2,000 mm to more than 3,000 mm per year. All of the heavy rainfall in the district is distributed into three big rivers, i.e. the Motagua, the Dulce (incl. Lago Izabal and the Polochic) and the Sarstun, and flows into Amatic Bay.

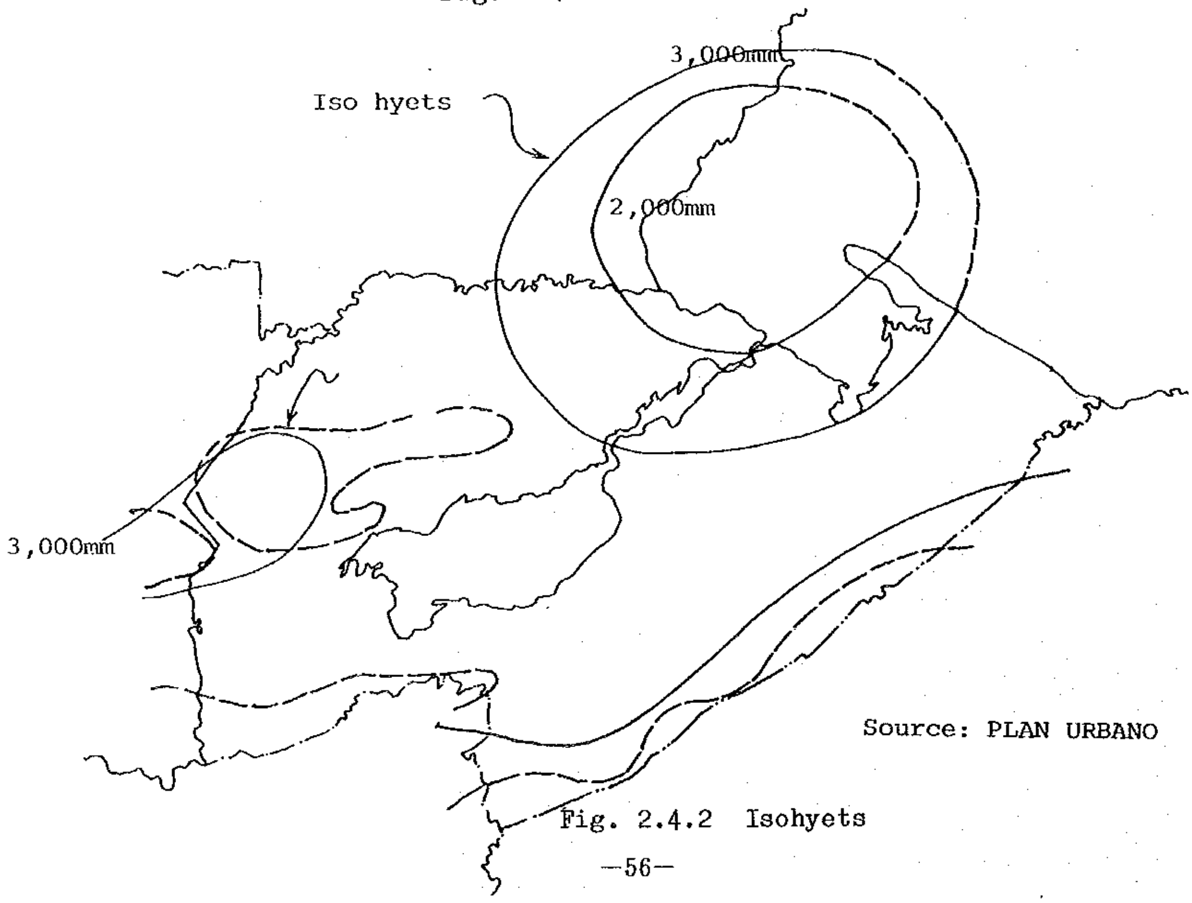
If the mouths of the big rivers were near Santo Tomas Bay, the sediment brought down by the rivers would be tremendous and maintenance dredging would be a serious problem.

But fortunately the mouths of these big rivers are remote from Santo Tomas Bay and have little influence on the local sedimentation.



Source: PLAN URBANO

Fig. 2.4.1 Main Rivers in Izabal



Source: PLAN URBANO

Fig. 2.4.2 Isohyets

2.4.2 Rivers Flowing into Santo Tomas Bay

There are twelve rivers flowing down into Santo Tomas Bay as listed below, and their locations are shown in Fig. 2.4.3

1. SAN CARLOS
2. LA ESPERANZA
3. LA ROMANA
4. QUEBARADO
5. ROMANEITO
6. YAN
7. LAS ESCOBAS
8. SAN AGUSTIN
9. QUEBRADA SECA
10. CÁCAO
11. SALADO
12. ESCONDIDO

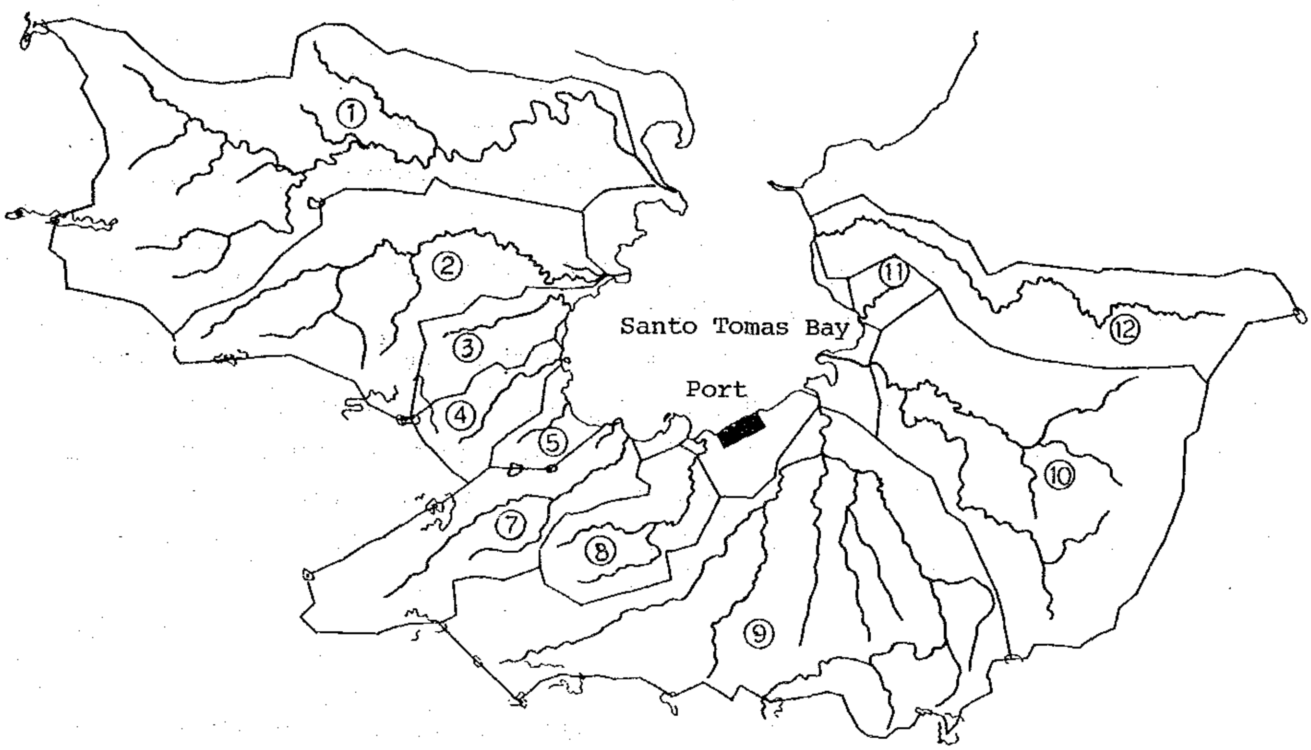


Fig. 2.4.3 Location of the Rivers in the Bay

(1) San Carlos

The river is located at the entrance of Santo Tomas Bay just opposite Puerto Barrios pier. A boat with a portable engine can navigate the river to about 4 kilometers upstream. The depth of the river at its center is nearly 3.0 meters, and the width is around 25 - 30 meters near the river mouth. There are mangroves one or two kilometers up the river, followed by pasture. Generally the river is very calm and looks as if the stream is not flowing. The width becomes gradually narrow and at the end of the navigable stream where there is a wooden bridge, it is only about 10 - 15 meter wides.

(2) La Esperanza

The river is very small. Its width is about 3 meters and it is very shallow at the river mouth.

(3) La Romana

The river is navigable until 400 meters upstream from the river mouth, and it is surrounded by thick mangroves. It is about 10 meters wide and 3 meters deep near the mouth of the river.
At 300 meters upstream, there is a place where hot water is coming out and it is used for bathing by the local inhabitants.

At a distance about 100 meters upstream from the hot spring, further navigation becomes impossible. There is a small wooden jetty about 40 meters long. The jetty is used as a loading and unloading wharf for cargos transported from inland and from Santo Tomas and Puerto Barrios. The access road to the jetty is 5 meters wide and paved with gravel, and seems to be maintained well.

(4) Quebrado

The river originates in a 500 meter high mountain, comes down between steep mountains and flows into the sea just behind Diablo island.
But the hinter area of the river is small, so it seems to present no trouble for the port planning.

(5) Romaneito

The source of the river is located in mountains more than 400 meters high.
But it has only a two square kilometer drainage area, so it seems to present no hindrance for port planning.

(6) Yan (omitted)

(7) Las Escobas

The source of the river is in a 900 meter high mountain, and the river comes down through mountainous areas and flows into the sea. The river has clean and abundant water all year round, and the water is supplied as a potable water to Puerto Barrios by a company. The company has a water intake basin with chlorination equipment at a height of 150 meters.
The width of the river at its mouth is 5 meters. Around the river mouth, it looks very shallow and a sandbank with course aggregate is seen at low tide.

(8) San Agustin

The source of the river is 300 meters high and the river flows down into the sea on the west side of Santo Tomas wharf.
The right hand side of the river mouth is famous for bathing. The sea is shallow for a good distance from the shore because of the sand discharged by the river.

(9) Quebrada Seca

The river consists of several branches, such as, "Seca", "Culebreo", "Piedras Negras", "Derumbe", etc., and flows down into Santo Tomas Bay as "Rio Quebrada Seca". *The Seca and Culebreo were different prior to the second extension* works of Santo Tomas port. The drainage area of the river is 32.8 square kilometers, and its cross sections have been measured as shown in the following pages.

(10) Cacao

The river flows through a prairie area and is very gentle. The drainage area of the river is 24.2 square kilometers. Cross sections of this river have also been measured.

2.4.3 Characteristics of the Rivers

The characteristics of the rivers, such as drainage area, maximum elevation, discharge volume of rainfall and mean gradient are calculated and shown in Table 2.4.1.

The most influential rivers for the new port planning are the Quebrada Seca and the Cacao rivers.
The cross sections of the two rivers, S-1, S-2, S-3 and C-1, C-2, C-3, are measured with a rod as shown in Fig. 2.4.4. The depths around the river mouths are also sounded as lines P-1, B-1 and B-2.

Table 2.4.1 Characteristics of the Rivers

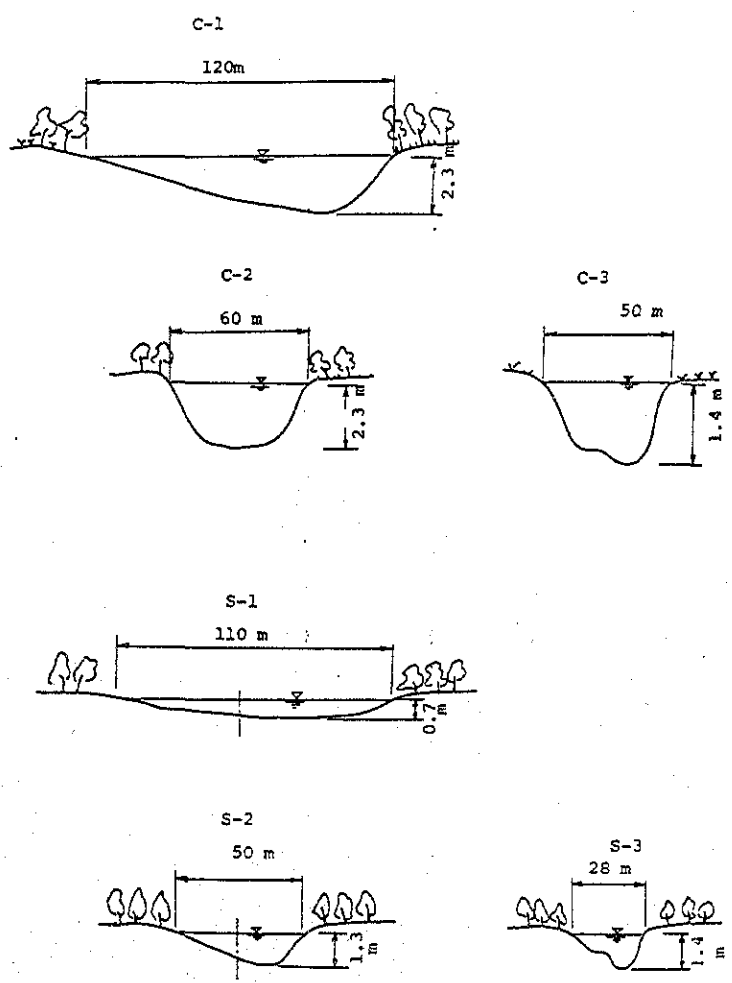
No.	Name	Drainage Area	Maximum Elevation	Length	Mean Grad.	Discharge
		(km.sq)	(m)	(km)	(%)	(m^3/sec.)
1.	SAN CARLOS	33.3	300	15.0	2.0	110.0
2.	LA ESPERANZA	17.1	300	9.0	3.0	60.0
3.	LA ROMANA	3.6	500	3.5	14.3	12.0
4.	QUEBRADO	3.3	500	3.0	16.7	10.0
5.	ROMANEITO	1.9	300	2.0	15.0	6.0
6.	YAN	-	-	-	-	-
7.	LAS ESCOBAS	10.2	1,000	7.0	14.3	35.0
8.	SAN AGUSTIN	5.4	500	4.5	12.0	18.0
9.	QUEBRADA SECA	32.8	300	10.0	3.0	110.0
10.	CACAO	24.2	100	8.0	1.2	80.0
11.	SALADO	-	-	-	-	-
12.	ESCONDIDO	12.5	80	9.0	0.9	40.0

2.4.4 Sedimentation from the Rivers

In general, littoral drift and siltation problems are weighty and should be seriously considered in port planning.

To estimate the sedimentation volume from the rivers in Santo Tomas Bay, a sounding map from February 1984 and the sounding map which was drawn up for the current study are compared.
From these two maps, it seems that the effect of littoral drift and sedimentation from the rivers is rather small as shown in Fig. 2.4.5.

From the viewpoint of drainage area, the drainage area of the Seca for example is only 32.8 square kilometers, so the sediment from the river is not so large. Thus, littoral drift and sedimentation in Santo Tomas Bay are not considered to be serious problems.



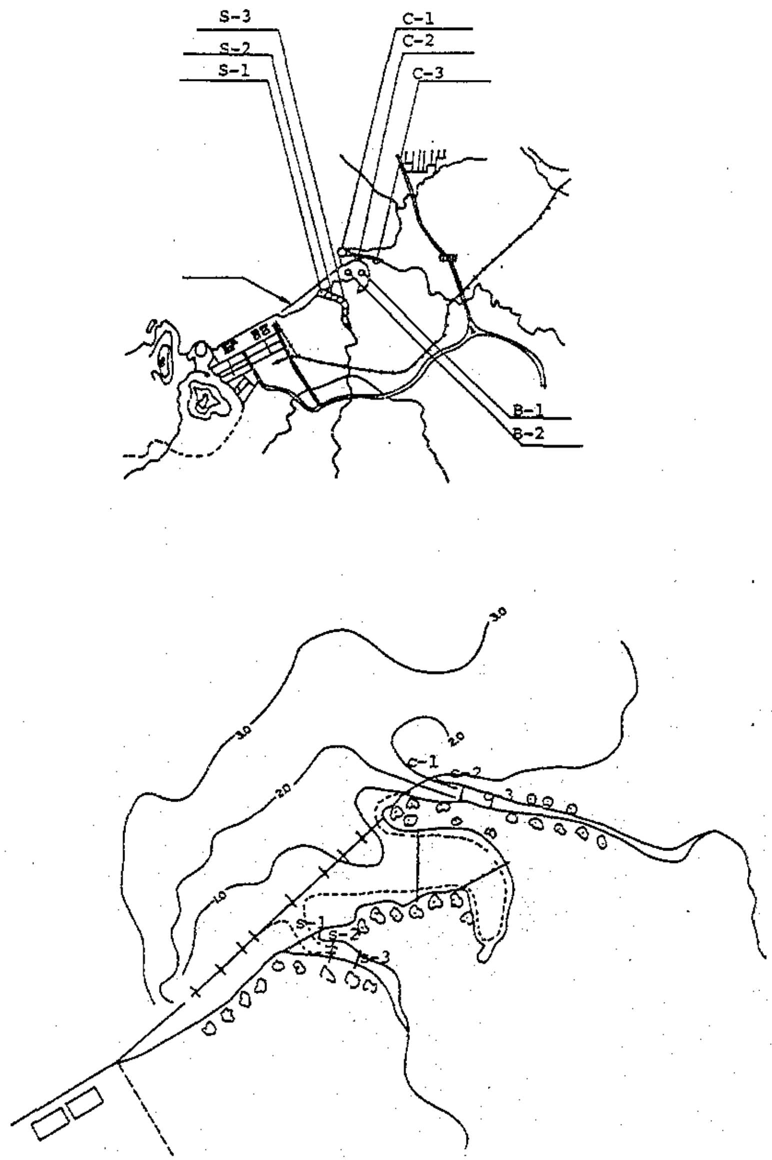


Fig. 2.4.4 Cross Sections of the Rivers

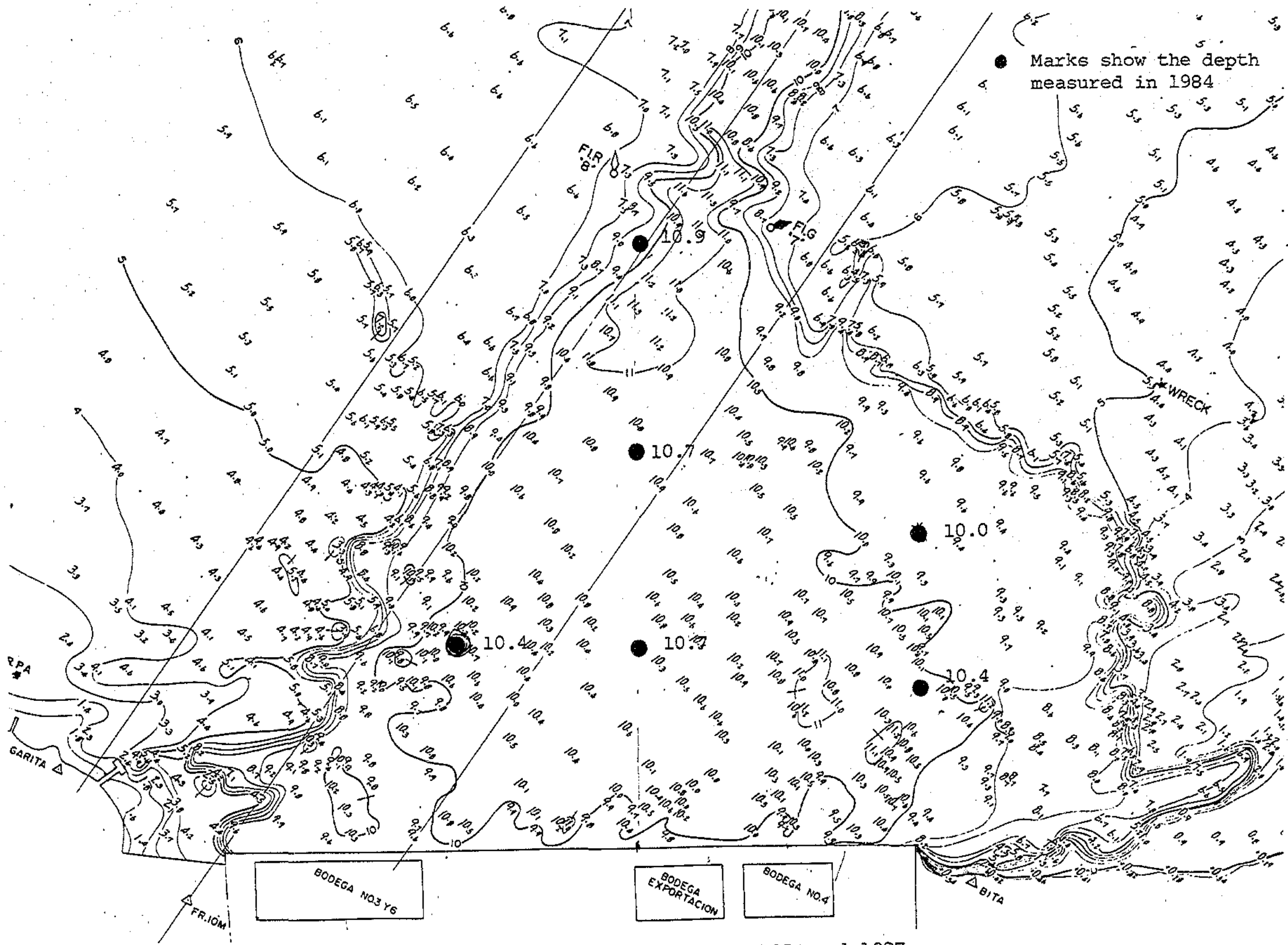


Fig. 2.4.5 Depth Compariosn in 1984 and 1987

2.5 Seismo-Geological Location of Santo Tomas Port

2.5.1 General

Topographical and geological features in Guatemala are classified in five morphotectonic regions as indicated below.

- The Pacific coastal plain
- The Pacific volcano belt or range
- The volcanic plateau and mountain range
- The central mountain range
- The lowlands of Pefén

Santo Tomas Port is located within the central mountain region, which is formed by a series of sub-parallel and arched mountain ranges convexed towards the south, extending through the central part of Guatemala to Chiapas, Mexico, and up to the Carribean sea. The port is also located between the Polochic and Motagua faults in the southern zone as shown in Fig. 2.5.1 and 2.

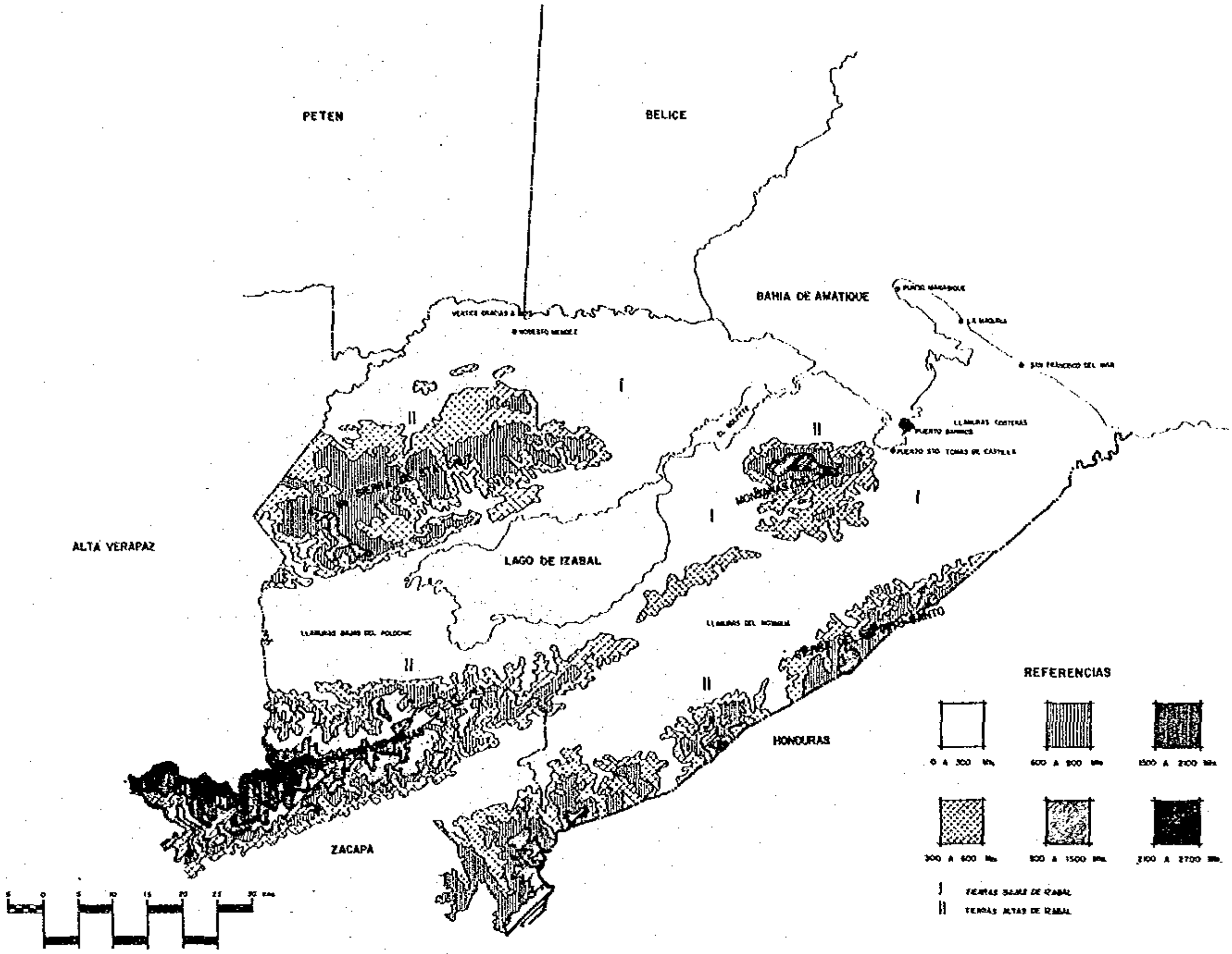


Fig. 2.5.1 Hypsometric Map

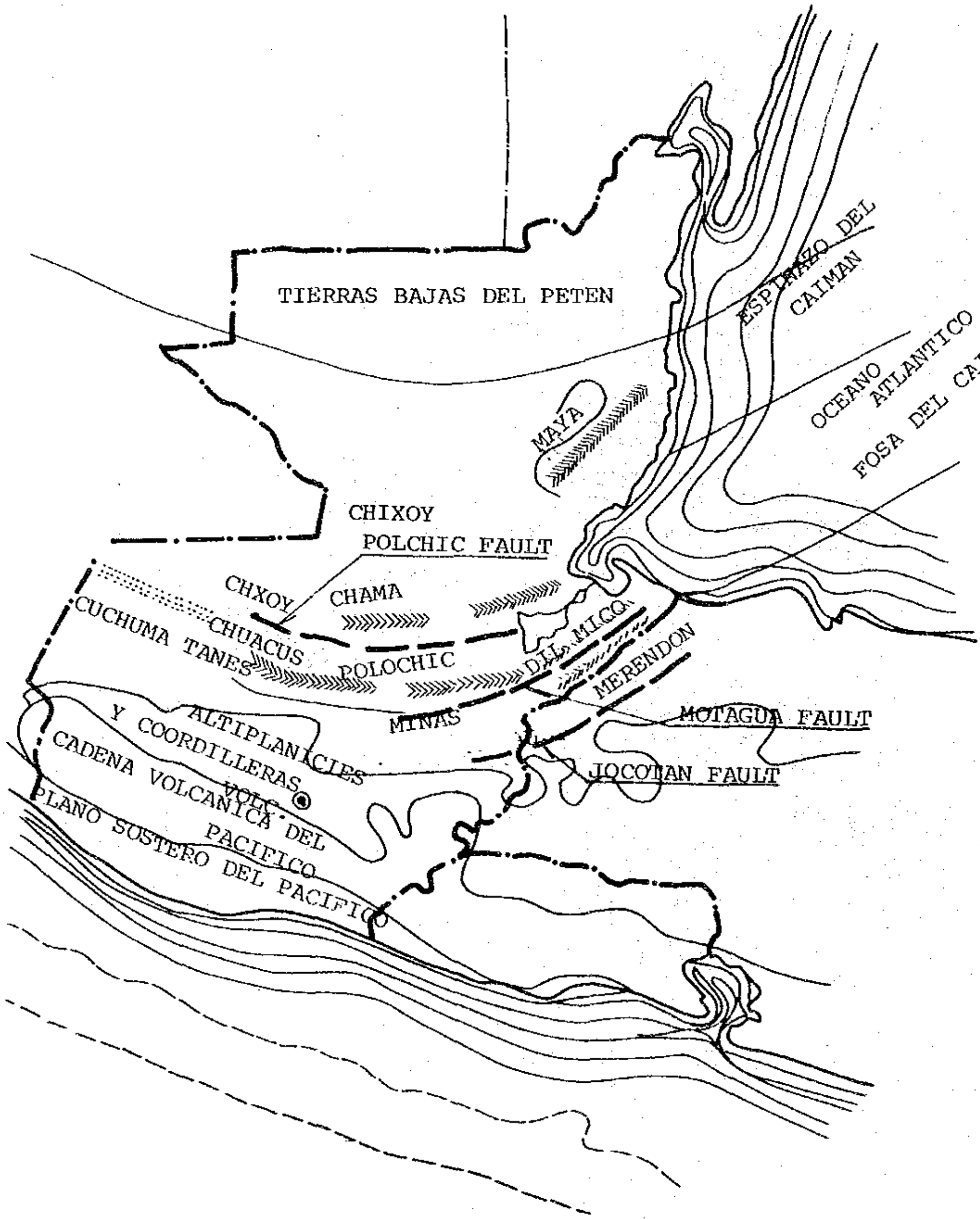


Fig. 2.5.2 Physiographical Map

The Polochic fault runs from the Caribbean Sea towards the western boundary of Guatemala and Mexico with a total length of about 400 kilometers, while the Motagua fault starts near the Caribbean Sea, running for about 300 kilometers towards the east.

Considering the past seismic record in Guatemala, Stanford University recommended a method to calculate seismic resistant design for the nation with the cooperation of the Guatemalan government.

According to the recommendation, Guatemala is divided into three seismic zones as shown in Fig. 2.5.2. Santo Tomas port is in zone III where seismic acceleration values are the highest. Therefore the values to be used in detailed design should be considered seriously.

2.5.2 Seismic Forces for Structures

The total lateral force on shear (V) is given by the formula below,

$$V = A \times D \times B \times Q \times W$$

where, A is decided by zone acceleration values
D is taken from mean dynamic amplification factor
B is taken from structural behavior factor
Q is decided by penalty values
W is the total dead load and the floor line load

The value V is tentatively calculated by the above formula

$$V = 0.45 \times 2.0 \times 1/5 \times 1.0 \times W = \text{approx. } 0.2\ W$$

where, A = 0.45
D = 2.0
B = 1/5
Q = 1.0

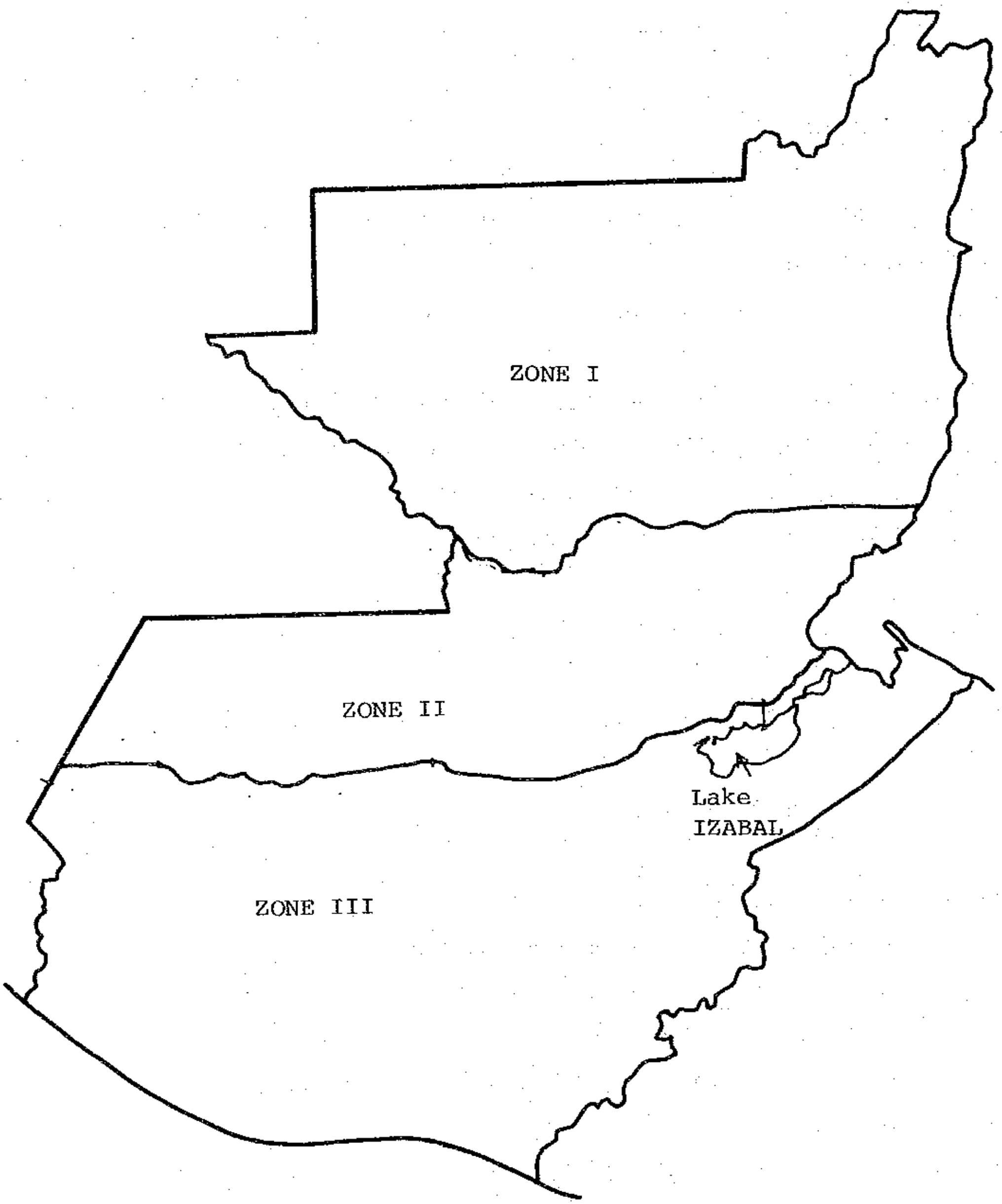


Fig. 2.5.3 Seismic Zones

2.6 Hindcasting of Waves

2.6.1 Calmness analysis at Santo Tomas Port

The wave heights, wave directions and frequency are calculated to verify the degree of calmness at Santo Tomas Port.

First, actual fetches in some directions at the mouth of Santo Tomas Bay are determined from the 1/500.000 scale map as shown in Fig 2.6.1 and then converted to effective fetches by using Savillis Formula.

Second, wave heights and period at the mouth of the port are calculated by the S.M.B method using wind data which were observed 25,568 times at Puerto Barrios airport from 1968 through 1973, and converted to effective fetches.

Third, these wave heights and period at the mouth of Santo Tomas bay are converted to the heights and period at the front of Santo Tomas Port by using wave diffraction analysis. The frequency of the wave occurance is also calculated in connection with the frequency of the winds. The results are shown in Table 2.6.1.

Table 2.6.1 Frequency of the Wave Occurence

	0.0 ~ 0.3	0.3 ~ 0.5	0.5 ~ 1.0	1.0 ~ 1.5	1.5 ~ 2.0	2.0 > m	TOTAL
N	6,041 23.6	769 8	70 0.3				6,880 time 26.9 %
NNE	761 3.0	120 0.5	7 0				888 3.5
NE	1,527 6.0	17 0.1					1,544 6.1
ENE	582 2.3						582 2.3
E	1,327 5.2						1,327 5.2
ESE	343 1.3						343 1.3
SE	52 0.2						52 0.2
SSE	196 0.8						196 0.8
S	506 2						509 2
SSW	128 0.5						128 0.5
SN	177 0.7						177 0.7
WSN	260 1.0						260 1.0
W	3,333 13.0						3,333 13.0
WNW	520 2.0						520 2.0
NW	952 3.7	2 0.0					954 3.7
NNW	1,603 6.3	132 0.5	4 0				1,739 6.8
Calm	6,139 24.0						6,139 24.0
TOTAL	24,447 95.6	1,040 4.1	81 0.3				25,568 100

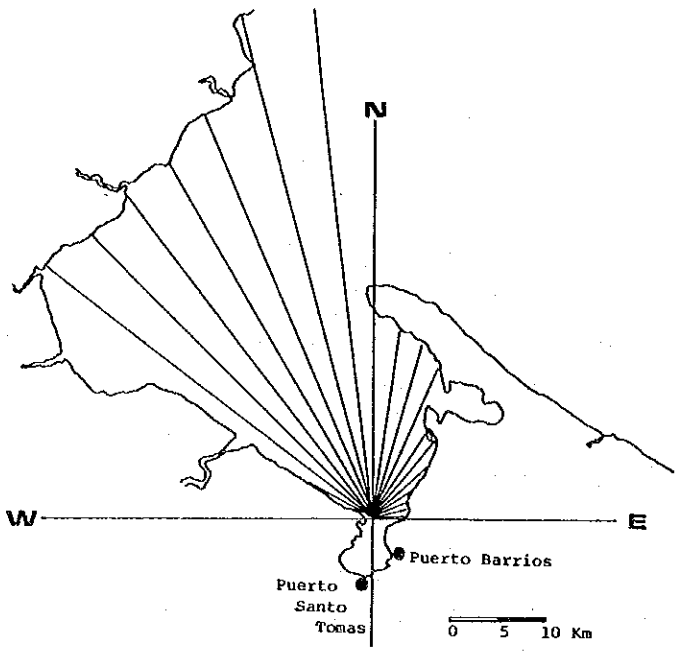


Fig. 2.6.1 Fetches

2.6.2 Wave height for design

To decide the wave height for the design of port facilities, the following three critical wind cases are applied from cyclone and tropical storm data for 20 years and calculated using the same method described above.

Case 1	wind velocity	10.3 m/s	(N)	Fetch	30,330 m
Case 2	"	9.3 m/s,	(NNW)	"	33,670 m
Case 3	"	33.9 m/s,	(W)	"	6,820 m

Table 2.6.2 Predicted Wave Height and Period

	At the mouth of the bay		At the front of the port	
	height	period	height	period
Case 1	1.04 m	3.74 s	0.54 m	3.74 s
Case 2	0.95 m	3.64 s	0.42 m	3.64 s
Case 3	2.05 m	4.21 s	0.19 m	4.21 s

Then the wave conditions for facility design should be as follows.

Wave direction: North
Wave period : 4.0 seconds
Wave height : 0.6 meters

CHAPTER 3 PRESENT CONDITIONS OF THE PORT FACILITIES

3.1 Background of Santo Tomas Port

The Atlantic coast of Guatemala offers appropriate natural locations for deep sea ports. Especially, Santo Tomas Bay is an excellent natural bay extending back from Amatique Bay.
Puerto Barrios Port is located at the entrance of Santo Tomas Bay and was the only port able to accommodate vessels with deep drafts.

Nevertheless, the facilities of Puerto Barrios were limited to only one pier owned by the International Railways of Central American (IRCA). This pier used to be able to accommodate four (4) vessels of the Victory type and two small vessels simultaneously. Cargo transportation to the pier was carried out only by railroad and there were some transit sheds on the pier.

Unfortunately, the pier was damaged by earthquake in 1976, and thereafter only the remaining the part of the pier (approximate 200 m) was operational.
Early in the 1950's, there were no roads between the coastal regions and the rest of the country, and the railroad from Puerto Barrios to Guatemala City and to Puerto San Jose, on the Pacific coast, was the only vital communication and transportation link for internal commerce.

The railroad from Puerto Barrios goes up the Rio Motagua valley toward Guatemala City which is located 1,480 meters above sea level.

An extensive road construction and improvement program to connect Guatemala City with the coasts was initiated by the government in 1951. The completion of these roads was indispensable to the cargo transportation by trucks.

Under these circumstances and due to the economic growth in Guatemala, the construction of the first port dealing with truck cargo was inevitable.

The bay of Santo Tomas where the first such port was built is 6 kilometers long and 4 kilometers wide. The Three Points Cape peninsula and a long reef of coral origin called Ox Tongue serve as double protection against high waves. The maximum tide oscillation is very small, less than 50 centimeters, and there are no special currents entering into the bay.

With these favorable geographic conditions, swell, tidal currents and siltation present no serious problems in Santo Tomas Bay.

The location proposed for the construction of the port was the site of the existing Santo Tomas village. At this location, there was a considerable area which was almost flat with little declivity from the hills in the south up the coast. There were only about 50 inhabitants prior to the construction of the port.

The climate at Santo Tomas Bay, as described in Chapter 2, is typical of the Atlantic tropical coast of Central America, with high and more or less even temperature, high precipitation and high humidity.

There are two seasons with January to June considered as the dry season and the rest of the year as the rainy season. But there is regular rainfall during the dry season as along the Pacific Coast.

Fig. 3.1.1 shows the location of Santo Tomas Bay and its surroundings.

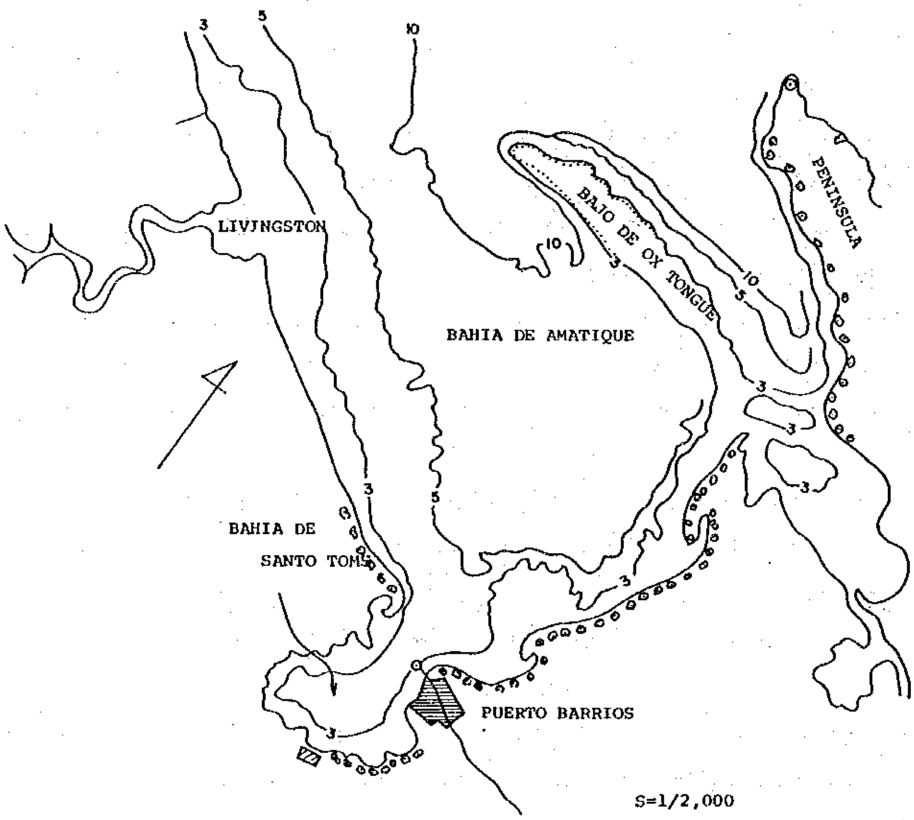


Fig. 3.1.1 Location of Santo Tomas Bay