# CHAPTER 5 DESIGN OF ACCESS CHANNEL

## 5.1 Design Criteria for Access Channel

The design of the access channel was carried out in consideration of the expected ship sizes, natural conditions, and the expected ship passage pattern. The channel will be navigable only for one way traffic. The Vessel Traffic Service System to be installed in the Port will be control the navigation in the channel and determine the time for alternate passage of incoming and outgoing ships in the channel.

## 5.2 Design of Navigation Channel and Basin

For the purpose of defining the various channel dimensions, the Guidance for Design "Publication PTC II-30 by PIANC, June 1997" was referred to.

**Table 5.1 Determination of Channel Configuration**

| Channel Configuration | | Depending on | Requirements Estimated by | Verified by |
|---|---|---|---|---|
| Alignment | | - Bathymetry, topography<br>- Capital and maintenance dredging volumes<br>- Ease of navigation | - Volume calculation<br>- Sediment | Fast-time ship manoeuvring simulation |
| Width | Straight | - Vessel size<br>Ship length, beam | PIANC Code | Fast-time ship manoeuvring simulation |
| | Bend | - Vessel size: length, beam and change in heading | Geometry | Fast-time ship manoeuvring simulation |
| Underkeel Clearance | Squat | - Vessel size: length, beam, draught and forward speed | Underkeel Clearance Model | |
| | Pitch/roll | - Vessel size: length, beam, draught and wave height | Underkeel Clearance Model | |
| Channel depth | | - Underkeel clearance<br>- Maintenance dredging | | |
| Side slopes | | Bed material and exposure to waves and currents | Empirical formula | |

The approach channel has a bend at Zacatillo Island which is the physical boundary between the inner channel and the outer channel. The view from the port or from offshore to Zacatillo Island is unobstructed, hence a lighthouse will be erected at Peninsula Los Negritos in Zacatillo Island to aid the navigation.

The bend is located in the strait at Cape Chiquirin and ships have to turn by about 80 degrees there. The bend area has naturally deep waters with a width of more than 400 m.

The radius of the turning basing was determined to be 2 times the overall length of the largest ship expected to use the port, thus the radius was fixed at 600 meters.

The total underkeel clearance for the outer channel was calculated, in consideration of wave induced vertical motion from 1.5 m waves, computed squat and allowance for the disastrous net underkeel clearance at 1.4 m for container ships and 2.2 m for bulkers. The required depth of water (dredged level) applied for the outer channel in consideration of the total underkeel clearance and the draught at a speed of 9 knots is 14.5 meters.

The side slopes were determined based on the soil types found in the channel areas which were sandy and gravelly silt. Based on the above and the guidelines from the empiric British Standard 6349: Part 5, the recommended design slopes are as follows:

Berth and turning area: 1 in 3 ~ 5

Inner channel: 1 in 3 ~ 5

Outer channel: 1 in 5

Considering the strong currents in the channel it was determined to carry out a special ship maneuvering simulation to consider conditions not accounted for in the PIANC standard.

The simulation conditions were based on the design ship size, depths of water, model tugboat to be applied, eight wind directions and two wind velocities (12 and 15 m/s), Low Water Level elevation, current velocities (1, 2 and 3 knots). A total of 192 cases were evaluated for the unberthing and 384 cases for the channel navigation.

The following table shows the comparative results of the layout of the navigational channel based on the fast time ship simulation vs. the PIANC standard.

**Table 5.2 Width of Navigation Channel**

| Ship Type | Container | | Bulker | |
|---|---|---|---|---|
| Channel | Outer | Inner | Outer | Inner |
| PIANC Standard | 142 m | 132 m | 148 m | 151 m |
| Fast-Time Simulation | 130 m | 140 m | 137 m | 151 m |

The bottom width of the outer and inner channel was determined at 137 m and 140 m respectively. Since the navigation draft of bulkers is smaller than that of container ships, these channel widths can accommodate the bulkers, as illustrated below.

The channel section on straight segments is shown in Figure 5.1

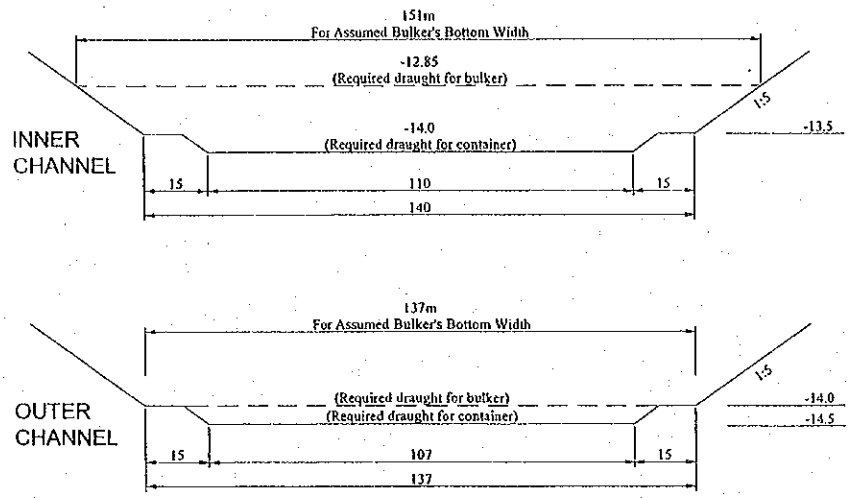



**Figure 5.1 Channel Section on Straight Segment**

The following table shows the operational criteria.

**Table 5.3 Operational Criteria**

| Natural condition | Outer channel | Inner channel |
|---|---|---|
| Wind velocity (average) | 12 m/sec | 12 m/sec |
| Current velocity (follow) | 2 knots | 2 knots |
| Wave height (H1/3) | 1.5 m | 1.0 m |
| Visibility | 3 miles | 3 miles |

## 5.3 Sedimentation Analysis

A hydrodynamic model was assembled with the physical elements of the channel to assess the potential of sedimentation in the deepened areas of the channel and turning basin.

Current measurements undertaken by the JICA Study Team were used to calibrate the flow model. Thereafter, spring and neap tidal currents were simulated in the model, for existing conditions and for the channel deepened by dredging.

Tidal currents were simulated for the dry season conditions assuming negligible fluvial discharge down the rivers that feed into the Gulf, and also for the wet season conditions using data obtained for the rivers.

Wave activity also gives rise to the potential of infill, particularly in the more exposed outer channel. The annual wave climates take into account stormy or anormal conditions. Swell waves do not penetrate into the inner channel area and therefore were not simulated in the model.

Sediment data on the site indicate that the region in characterized mainly by muddy

sediments with high levels of suspended sediment concentrations, particularly in the turning basin and inner channel where wave action is significant.

Sedimentation in the channel occurs due to three main mechanisms:

1) Degradation of the channel side slopes. This is a geotechnical issue of side slope stability, though wave and tidal conditions are a controlling influence.

2) Infill due to direct sedimentation as a consequence of reduced bed shear stress in the deepened channel, and cross currents that transport sediment-laden water into it.

3) Potential fluidization of the bed due to wave effects, the transport of fluid mud into the channel under gravity. This process is only likely to occur in the outer channel where wave action is relatively strong.

Simulations were carried out separately for mud infill and sand infill under the conditions of mean tide and spring tide. Depositions of mud and sand per tide were summed up based on the annual tide movement.

The following table shows the predicted infill volume of the channel according to the results of sedimentation analysis.

**Table 5.4 Predicted Infill Volume of Channel**

| | Turning Basin | Inner Channel | Outer Channel | Total |
|---|---|---|---|---|
| Sand Infill | 248.9 | 89.6 | 64.9 | 403.4 |
| Mud Infill | 229.2 | 363.6 | 247.2 | 840.0 |
| Total Infill | 478.1 | 453.2 | 312.1 | 1,243.4 |

Of the 1,243,000 $m^3$ of yearly infill, 403,000 $m^3$ comprise mud and 840,000 $m^3$ comprise sand.

## 5.4 Navigation Aids and Vessel Traffic Services

It is essential to clearly identify the limits of the navigation channel during day and night for the safe navigation, a lighthouse and light buoys are therefore necessary for support to the pilot and captain of the ships.

The following table and figure describe and show the location of each required element of navigational aid.

**Table 5.5 Recommended Navigation Aids System**

| Description | Specification | Unit | Number |
|---|---|---|---|
| Lighthouse | 10 m high aluminum ally made | set | 1 |
| Channel Entrance Mark | Lighted buoy at the entrance of channel | sets | 2 |
| Channel Marker | Lighted buoy for inner and outer channels | sets | 11 |
| Basin Marker | Lighted buoy for turning basin | sets | 3 |
| Light Beacon | Jetty marker at the corners of berths | sets | 3 |

The traffic control center to be located in the Administration Building will be equipped with

a VHF radio communication system to receive timely the estimated time of arrival (ETA) and estimated time of departure (ETD) from ships. Information about clearance for entering/leaving the channel and any other information concerning pilot and tug assistance will also be transmitted via the VHF radio. The system will incorporate an Automatic Identification System (AIS) in which the location of the ship at open sea and channel with ETA, ETD and other information will be shown in display.

# CHAPTER 6 DESIGN OF BUILDINGS AND UTILITIES

## 6.1 Buildings

### 6.1.1 Design Conditions

#### (1) Design Concepts

The following design concepts were established in order to achieve optimum port buildings.

- Functional and Easy Usability
- Compliance with Natural Conditions and Structurally Secured
- Easy Maintenance and Durability
- Harmonious Design with the Environments and Scenery

#### (2) Laws, Codes and Regulations for Design

Designs of buildings were carried out based on El Salvador, Japan, U.S.A. and other international applicable standards:

- OPAMSS : Planning Office of the Metropolitan Area San Salvador
- ASIA : Association of Architects and Engineers
- UBC : Uniform Building Code 1997 (USA).
- NFPA : National Fire Protection Association (USA).
- NEC : National Electrical Code (USA)
- ANSI : American National Standard Institute (USA)
- JIS : Japan Industrial Standard (Japan)
- Others : International Applicable Standards

#### (3) Design Criteria

1) Building Floor Areas

The building floor areas were determined to accommodate the number of persons, equipment and volume of port commodities.

2) Building Construction Materials

Major building construction materials were selected in consideration of availability of local products in order to achieve easy and low maintenance cost. In any case, the materials were selected by comparing quality, salt corrosion resistance, maintenance and economical aspect.

3) Structural Aspect

Structural design was carried out on the basis of geological data, climatic conditions of proposed site in consideration of building values, materials and stress/load combinations in order to accomplish safe and economical structures.

4) Building Finishes

All buildings will be finished with local made products in order to achieve easy and low maintenance cost of the building facilities.

5) Aesthetic Design

Building design was considered to give an attractive appearance and to match the surroundings. The Port Administration Building was designed to give a symbolic impression and partially finished with a local made slate stone masonry. The Container Gates as the main entrance into the port area were designed with a motif of sea waves on the exterior appearance so as to be harmonized with the sea and mountain ranges.

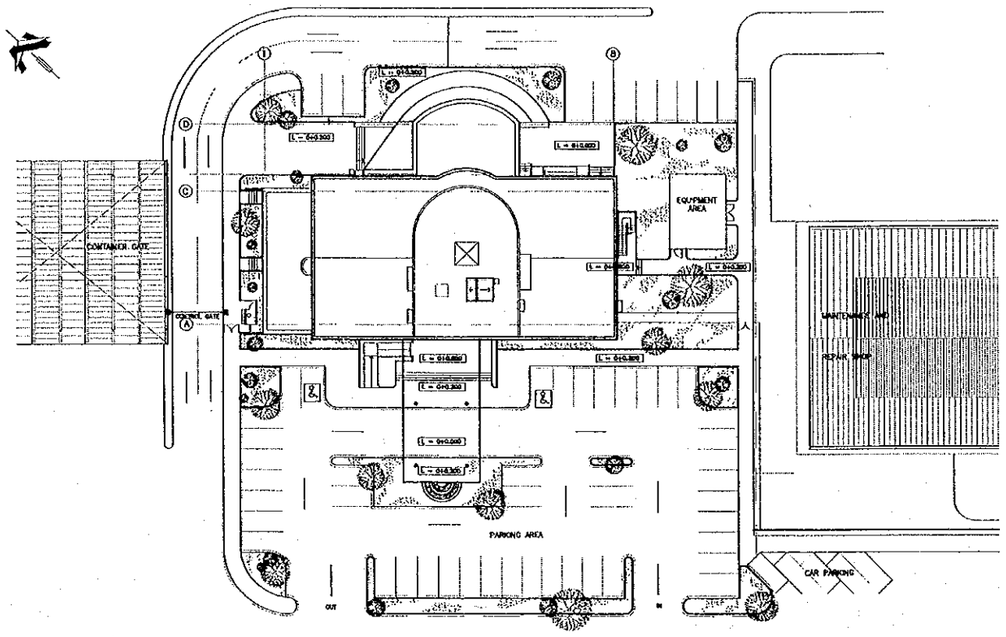
### 6.1.2 Buildings Features

The following six (6) major buildings were designed with utilities.

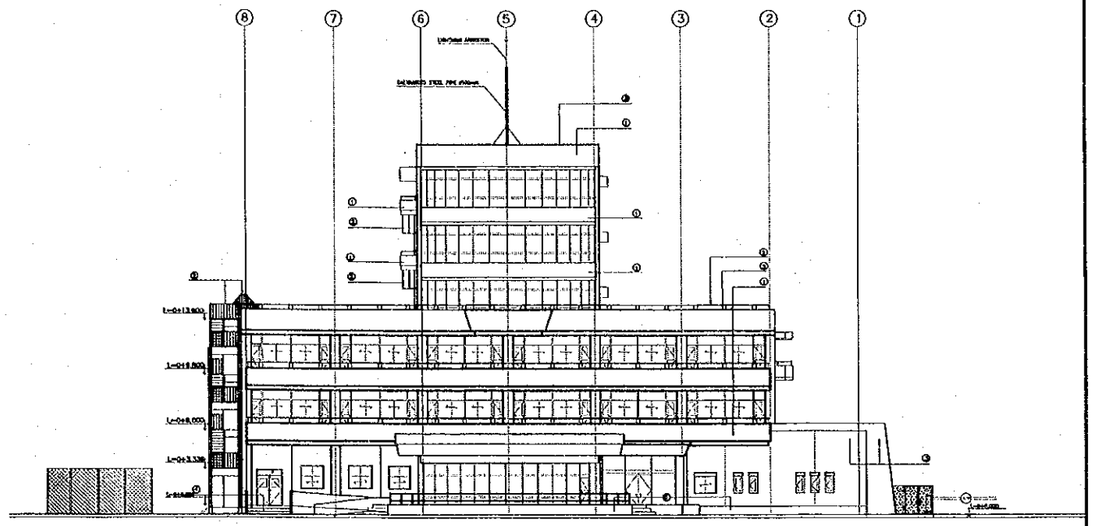
## Table 6.1 Proposed Building Features

| Building Name / Building Features | Port Administration Building | Container Freight Station | Maintenance and Repair Shop | Container Gate | Cargo Gate | Power Supply Station |
|---|---|---|---|---|---|---|
| BUILDINGS | | | | | | |
| Total Floor Area ($m^2$) On lane | 2,540 | 2,420 | 1,440 | 6 lanes | 3 lanes | 326 |
| Number of Stories | 6 | 2 | 2 | 2 | 2 | 1 |
| Maximum Height (m) | 26.0 | 14.2 | 15.2 | 10.6 | 10.6 | 5.2 |
| Max Column Spacing (m) | 8.0 | 30.0 | 24.0 | 6.7 | 6.7 | 7.0 |
| Bay Spacing (m) | 6.00 | 7.50 | 6.00 | 6.0 | 6.0 | 7.0 / 6.0 |
| Foundation/ Foundation Beams / Floors | RC | RC | RC | RC | RC | RC |
| Columns / Beams | RC | S | S | S | S | RC |
| Walls | CHB | CHB | CHB | CHB | CHB | CHB |
| Roof and Framing | RC | S | S | S | S | RC |
| UTILITIES | | | | | | |
| Central Air-Conditioning System | ✔ | | | | | |
| Individual Air-Conditioning System | | ✔ | ✔ | ✔ | ✔ | ✔ |
| Central Ventilation System | ✔ | | | | | |
| Individual Ventilation System | | ✔ | ✔ | ✔ | ✔ | ✔ |
| Water Supply System | ✔ | ✔ | ✔ | | | ✔ |
| Sanitary Fixtures | ✔ | ✔ | ✔ | | | ✔ |
| Drainage System | ✔ | ✔ | ✔ | | | ✔ |
| Fire Fighting System & Extinguishers | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Sub Main Power Supply System | ✔ | | | | | |
| Power Distribution System | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Power Outlet System | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Lighting System | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Telephone System | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Fire Alarm System | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Lightning Protection System | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |

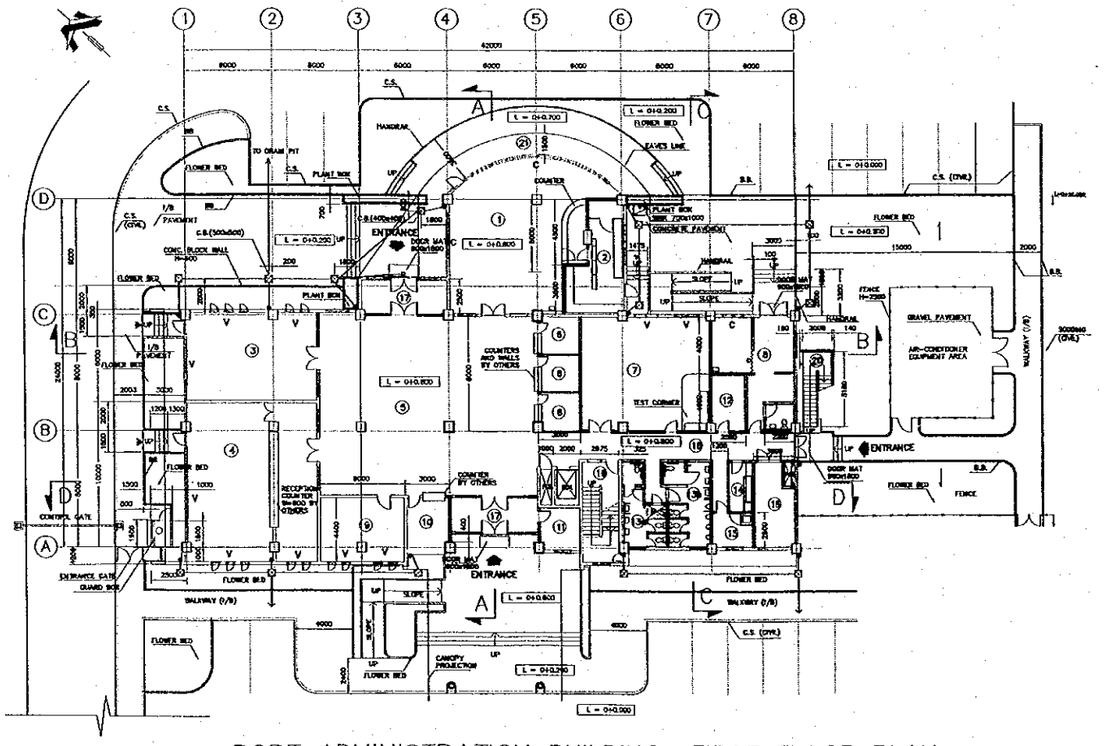
LEGEND: CHB: Concrete Hollow Block, RC: Reinforced Concrete, S: Steel Construction.



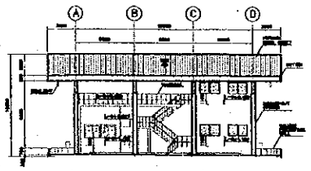

PORT ADMINISTRATION BUILDING: LANDSCAPING

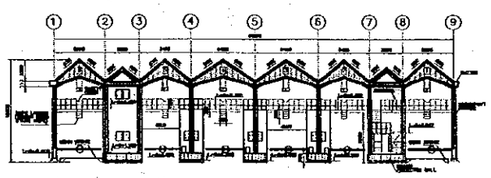


PORT ADMINISTRATION BUILDING: ELEVATION

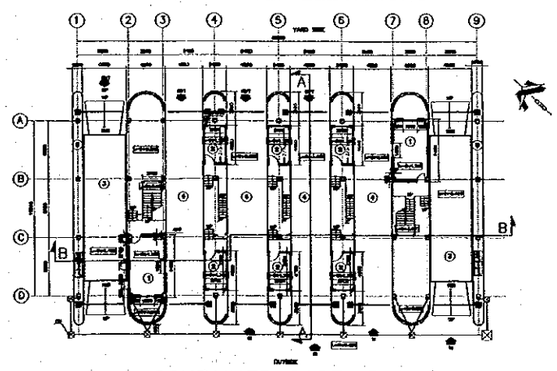



PORT ADMINISTRATION BUILDING: FIRST FLOOR PLAN

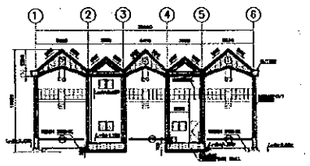


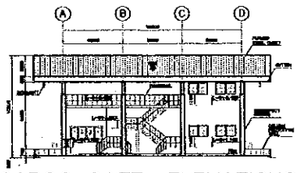


CONTAINER GATE: ELEVATIONS

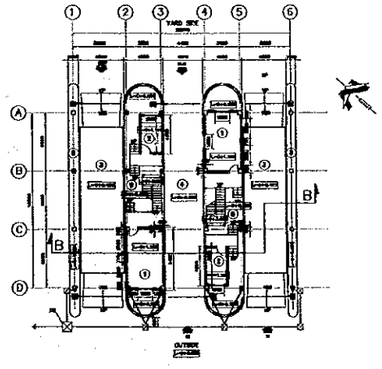


CONTAINER GATE: PLAN



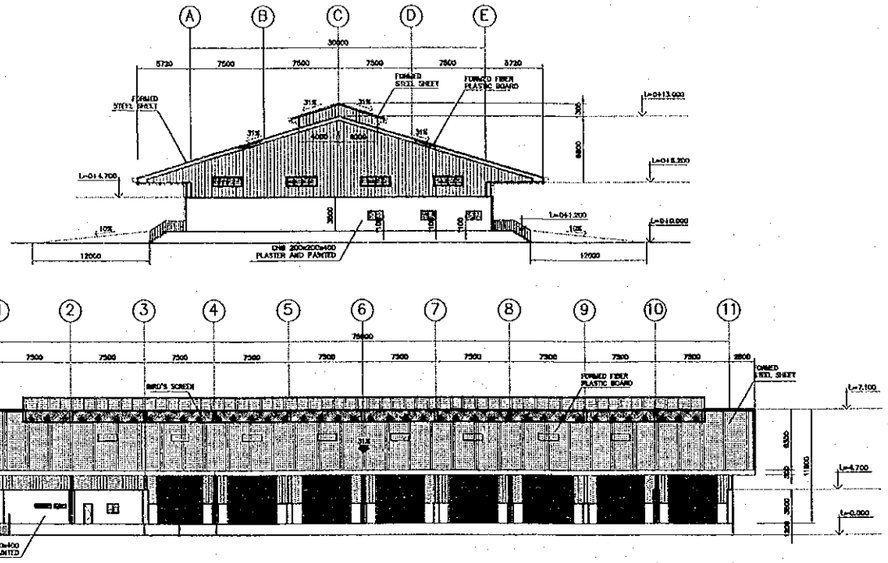


CARGO GATE: ELEVATIONS

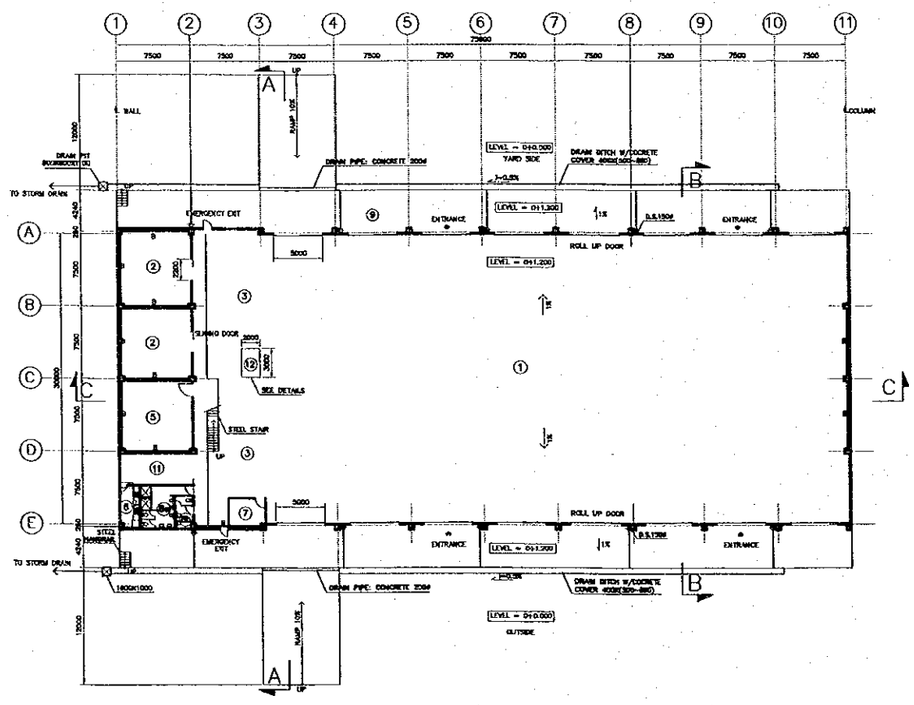


CARGO GATE: PLAN

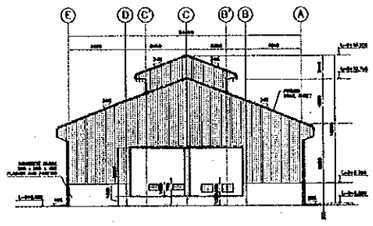
FIGURE 6.1 PLAN AND ELEVATION OF MAJOR BUILDINGS (1/2)

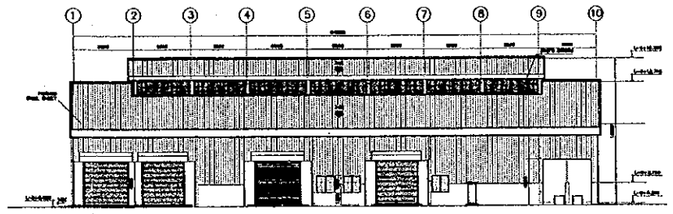


CONTAINER FREIGHT STATION: ELEVATIONS

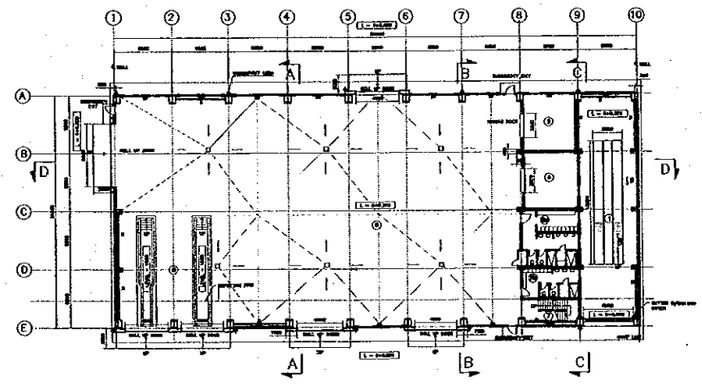


CONTAINER FREIGHT STATION: FIRST FLOOR PLAN





MAITENANCE AND REPAIR SHOP: ELEVATIONS



MAINTENANCE AND REPAIR SHOP: FIRST FLOOR PLAN

FIGURE 6.2 PLAN AND ELEVATION OF MAJOR BUILDINGS (2/2)

## 6.2 Electrical System

Electrical power for the La Unión Port was planned to be supplied through a 46 kV transmission line from the San Miguel substation situated about 46 kV north-west of the center of the port.

Power demand of the Port was estimated to amount not over 4 MVA at full development. The power demands for each load are summarized below:

**Table 6.2 Power Demand**

| Electrical Load | Power Demand (kVA) |
|---|---|
| Gantry cranes | 1,400 |
| Movable loaders ( future ) | 640 |
| Belt conveyers ( future ) | 400 |
| Reefers | 250 |
| Area lighting | 125 |
| Buildings | 590 |
| Service outlets | 165 |
| Spare | 430 |
| Total | 4,000 kVA |

Therefore, the following electrical power facilities will be provided under the Project and accommodated in the Power Supply Station.

- 46 kV transmission line (about 650 m, along the port access road )
- 46/4.16 kV substation (46 kV outdoor switchgear and one 46/4.16 kV 60 Hz 4,000 kVA transformer) in the transformer yard.
- Power distribution equipment (4.16 kV, 480 V and 208-120 V switchgear cubicle) in the switchgear room.
- Distribution transformers (Two 4.16/0.48 kV 1,000 kVA transformer and One 4.16/0.208-0.12 kV 500 kVA transformer) in the transformer room.
- Main control board and auxiliary panel in the control room.

In addition to the equipment above, two units of diesel engine generator will be provided in the generator room for emergency power supply to the load below:

**Table 6.3 Emergency Power Supply**

| Emergency Load | Supply Demand (kVA) |
|---|---|
| Gantry cranes | 1,400 |
| Reefers | 250 |
| Area lighting | 35 |
| Building and others | 315 |
| Total | 2,000 |

The emergency power generating unit will have the following specifications:

- Diesel engine : Exposed indoor, radiator cooling type.
- AC generator : 3 –phase, 4.16 kV, 60 Hz ,1,000 kVA, brushless type.

- Fuel tank : 8 $m^3$ underground type (15 hours at 100% load).

The main underground power cables will be XLPE/PVC copper cables for 5 kV and 600 V, ranging in size from 14 $mm^2$ to 500 $mm^2$. The power cables were basically designed to be placed in PVC conduits one meter below the ground level. Cable pits will be constructed at bends or major joints of cable.

The following categories of area lighting will be applied:

| | |
|---|---|
| - Flood lighting of container terminal | 25 – 40 lux |
| - Flood lighting of multipurpose areas | 25 – 40 lux |
| - Lighting of maintenance areas | 100 lux |
| - Lighting of access roads and parking | 10 – 15 lux |

The lighting levels in the Containers Terminal and Multi-purpose Terminal will be ensured by light masts. A lighting mast will have a height of 25 m (Multi-purpose and reefer areas) and 36 m (Container Terminal) and will be placed in a grid of approximately by 60 m – 100 m. On each mast a corona with high pressure sodium floodlights (6 x 1,000 W) will be installed.

In various buildings, a fire alarm system will be installed with control panels, fire detector, break-glass push buttons, slow whoops, and cabling systems.

Lightning protection systems will be provided in a grid on the buildings with copper wires, arrestors and electrodes. Lightning masts will be have arrestors and electrodes. All equipment will have its own lightning connection to ground.

Communication systems on land will connect the harbor with the national telecom network and serve operation purposes for adequate operation of the Port.

For internal and external communication in the Port area, a telephone exchange will be installed in the Port Administration Building with 30 external lines and 150 – 180 internal lines. All buildings will have a connection either with copper or glass fiber cable, depending on the distance of the building to the exchange. In the buildings, branch boxes will feed UTP-network for data and voice communication.

The computer network for container operation will be linked with active components to the network.

For port operating activities 20 mobile phones will be integrated in the telephone system for daily use by operators.

A VHF-system connecting, by aerial transmission, the Port with the ships will give radio link to the vessels.

## 6.3 Water Supply System

### (1) Water Demand

The total water demand was based on water demand for the buildings, vessels (Container Vessel and Bulk Vessel) and firefighting. The maximum water demand was calculated at 948.3 $m^3$ per day, which includes 34.7 $m^3$ for buildings 660.0 $m^3$ for vessels (Container and Bulk), and 253.6 $m^3$ for firefighting.

### (2) Source of Water

A deep well for the La Unión Port will be furnished by CEPA before starting the construction of the Project. Moreover, CEPA will provide the pipeline from the deep well to the water purification facility before or during the port construction.

### (3) Water Storage and Distribution System

The storage capacity and structural type of water storage tank were determined in consideration of construction cost, maintenance, construction period and so on as follows

- Two tanks with a capacity of 500 $m^3$ each

- Metal tank

### (4) Required Water Pressure for Each Facility

The maximum design water pressure is 3.57 $kgf/cm^2$ which corresponds to need of the Port Administration Building since this head lost at this six story building is the highest among the port buildings.

### (5) Required Diameter of Pipes

The diameter of pipeline was calculated as follows:

**Table 6.4 Dimension Required Water Pipes**

| Water Supply | Required Diameter (mm) |
|---|---|
| Water supply for Building | |
| - Administration Bldg. | 80 |
| -Other Buildings | 40 |
| Water Supply for Firefighting | 150 |
| Water Supply for Vessels | 150 |
| Main Water Pipeline in Port Area | 150 |
| Main Water Pipeline out of Port Area | 300 |

## 6.4 Firefighting System

### (1) Planed Firefighting System

The distribution system for drinking water will also be used for firefighting. A pipe diameter of 150 mm is enough to transport 63 $m^3/hr$ of water for simultaneous use of 3 hydrants (3 x 21 $m^3/hr$).

**(2) Fire Hydrants and Stand-by Hose for Terminal Area**

Outdoor and indoor fire hydrants for were planned to be installed at 34 and 6 points respectively.

**(3) Fire Hoses and fire extinguishers in Buildings**

In the buildings and sheds, fire hoses were planned to be directly connected to pipes of 62 mm (2 1/2").

Seven (7) weather proofed, wheeled 125 pounds ABC type Extinguishers were planed to be installed outdoors of the port area.

## 6.5 Wastewater Treatment System

**(1) Planned Wasterwater Treatment System**

Wastewater Discharge Source: Administration Building, Maintenance and Repair Shop, Power Supply Station, and Container Freight Station (CFS).

Method of Discharge: Separate Method, which consists in separating wastewater from storm water in order to minimize the size of the wastewater treatment facilities.

**(2) Pipeline for Wastewater System**

The diameter of the main pipe and feeder pipe was calculated to be 150 mm. The recommended pipe material is PVC (VU) in consideration of the low roughness coefficient within pipes.

**(3) Sewerage Treatment Facility**

The type of Wastewater Treatment System was determined based on the Environmental Standards of El Salvador. According to the standards for the discharges, BOD for domestic water should not be over 30 mg/l. In order to guarantee the fulfillment of this standard and considering the existing system in El Salvador, the "Activated Sludge" System, in the modality of "Expanded Aeration" was selected.

**(4) Oil/Water Separator**

Oil/water Separators were planned to collect not only the wash water from the Maintenance and Repair Shop, the RTG repair Yard, the Fuel Station and the Power Station's tank trench and external transformer trench, but also the storm water from container yard and Multi-purpose yard.

# CHAPTER 7 DESIGN OF EQUIPMENT

## 7.1 Design of Quayside Gantry Crane

In the Container Terminal, quayside gantry cranes with an efficient capacity will be installed to load/unload containers expected in the Port. In order to handle containers up to the target year 2015, two units of quayside gantry crane for Panamax type container vessels are required to achieve efficient port operation.

The quayside gantry cranes to be installed in the Port shall load and unload not only containers but also hatch covers, lashing gear and non-containerized heavy cargo.

The quayside gantry crane was designed to be of rail-mounted type, having a hinged boom on the seaside and fixed girder on the landside. The traversing trolley of the rope-operated type will be provided on the girders. The main hoist and trolley drives shall be simultaneously fully operational.

In designing principal performance specification of cranes, the average mechanical handling capacity of the cranes was set at 35 boxes per hour.

The principal functions and dimensions of the cranes were determined as follows and Figure 7.1 shows the general arrangement and features of the cranes:

The cranes for the Multi-purpose Berth is supplied by the port users. So the installation of rail only is considered for the detailed design, which has 10 m span in standard dimension.

1) Type:

Rope trolley type, rail mounted, single lifting gantry, traveling

Inverter control system

Telescopic type (20′, 40′, 45′) spreader

2) Basic Dimensions:

| | |
|---|---|
| Hoist capacity (including spreader) | min 50 t |
| (under spreader) | min 40.6 t |
| (under heavy lift hook beam) | min 45 t |
| Outreach | min 37.5 m |
| Span | 25 m |
| Lift (total) | 46 m |
| Lift (above seaside rail surface) | 32.8 m |
| Traveling distance | 430 m |
| Power supply system | Cable real system |

3) Operating Speed

| | |
|---|---|
| Main hoist | |
| With empty spreader | not less than 150 m/min |
| With full load (under spreader 40.6 t) | not less than 65 m/min |

4) Wheel load and rail conditions of gantry rail

Allowable wheel load

| | | |
|---|---|---|
| At service conditions (max) | Seaside 38.5 t/wheel | Landside 31 t/wheel |
| At seismic conditions (max) | Seaside 50 t/wheel | Landside 58 t/wheel |

5) Power source of crane

| | |
|---|---|
| Voltage | 4,160 volt |
| Phase | 3 |
| Frequency | 60 Hz |

## 7.2 Design of Tugboats

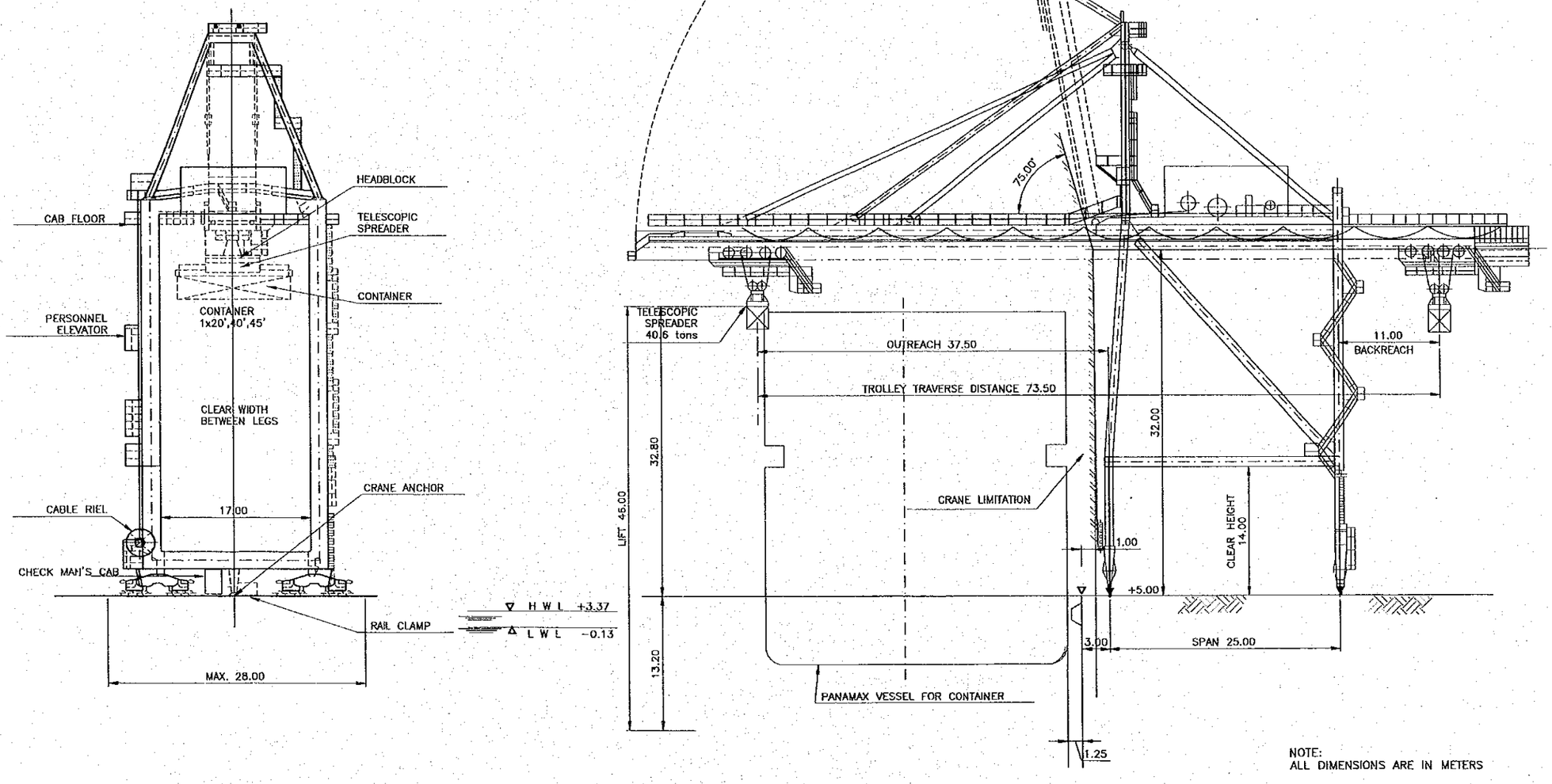
The 22 km long approach channel was designed on the basis of one lane traffic. The oceanographic conditions such as current speed and waves are considerably severe for maneuvering the ships entering and leaving the channel of the Port, and therefore assistance of tugboats is required. In the design of the channel, a simulation study was conducted and it was concluded that two units of 3,600 PS class tugboats are required to assist in berthing and de-berthing operations.

The tugboat was designed as a steel hulled twin screw type tugboat, equipped with twin diesel propulsive engines with a total output of 2,646 kW (3,600 PS) and two 360 degrees steerable propeller units to engage in mooring.

The general arrangement of the Tugboats is show in Figure 7.2.

The vessel shall have the following principal dimensions:

| | |
|---|---|
| Length, overall: | 33.50 m |
| Breadth, moulded: | 9.40 m |
| Depth, moulded: | 4.00 m |
| Designed draft, moulded: | 3.10 m |
| Gross Tonnage, International: | Approx. 280 Tons |
| Deadweight | Approx. 135 MT |
| Main Engine: | 2 sets of diesel engine, non reversible type<br>Total power 2,646 kW (3,600 PS) in the range of 720 –1,000 rpm |
| Propeller: | 2 sets of 360 degrees steerable Z-drive type propellers, |
| Service speed: | 12.5 knots on fully loaded draft at 85% rated output of main engines with 15% sea margin. |
| Bollard pull: | 441 kN (45 tonf) on sea trial condition at 100% rated output of main engines. |




NOTE:
ALL DIMENSIONS ARE IN METERS

| REV. NO. | DATE | COORDINATE | BY | APPROVED | DATE |
|---|---|---|---|---|---|
| | | | | | |

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

COMISION EJECUTIVA PORTUARIA AUTONOMA (CEPA)

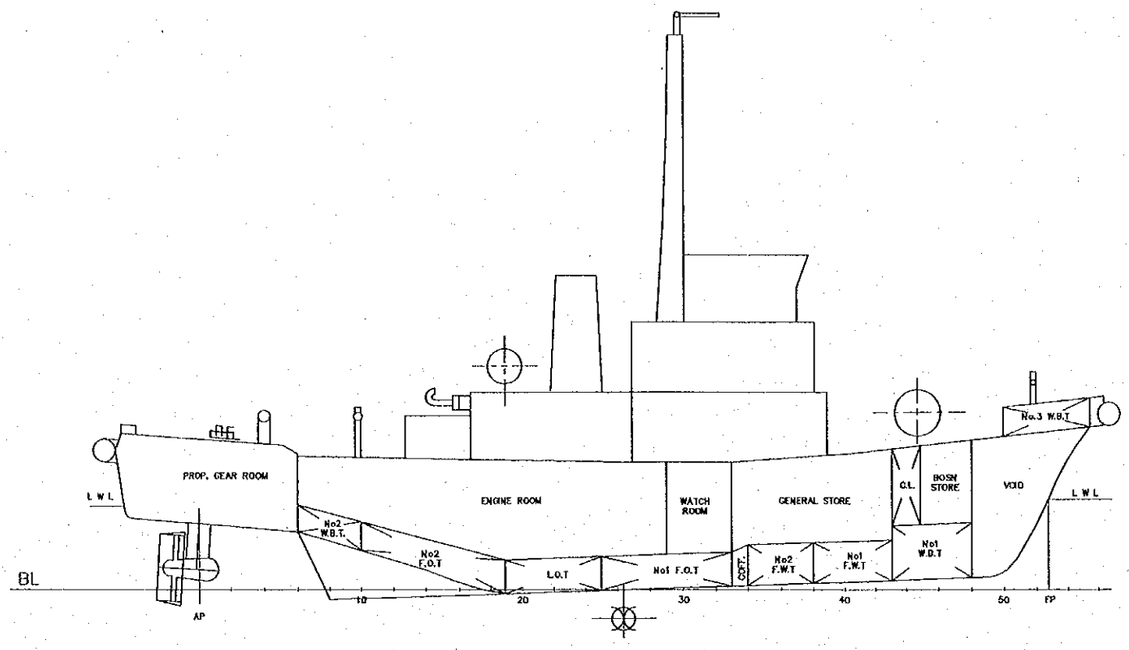
THE DETAILED DESIGN ON PORT REACTIVATION PROJECT IN LA UNION PROVINCE OF THE REPUBLIC OF EL SALVADOR

NIPPON KOEI CO., LTD.

DESIGNED BY :
CHECKED BY :
APPROVED BY :

**Figure 7.1 General Feature of Quayside Gantry Crane**

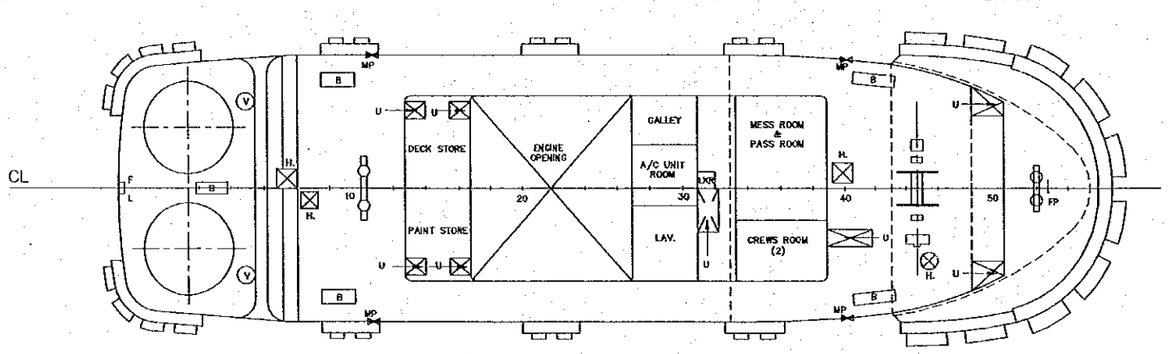
DATE : AUGUST/2002
SCALE : NOT TO SCALE
DRAWING NO: —



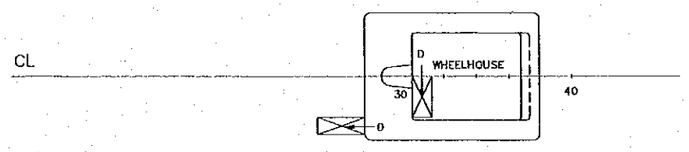

## PRINCIPAL PARTICULARS

| | |
|---|---|
| LENGTH (O.A.) | 33.50 m |
| LENGTH (P.P.) | 29.00 m |
| BREADTH (MLD) | 9.40 m |
| DEPTH (MLD) | 4.00 m |
| DRAFT (MLD) | 3.10 m |
| GROSS TON | 280 ton |
| MAIN ENGINE | 2 X 1,323 kW (2 X 1,800 = 3,600 PS) |
| SERVICE AREA | COASTING SERVICE |

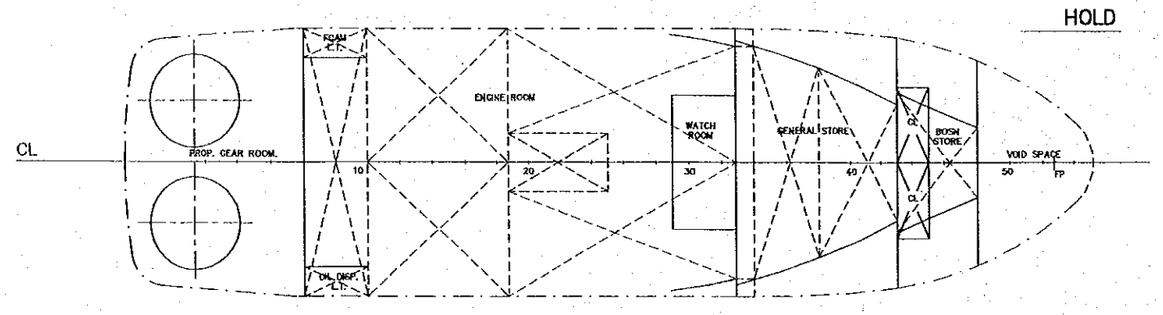
## UPPER DECK



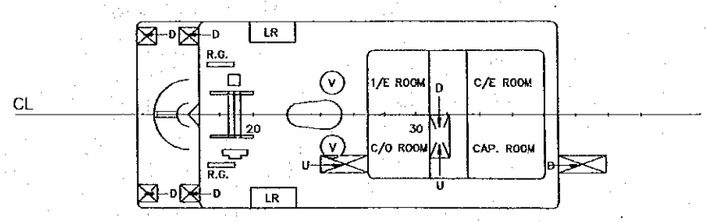

## NAV. BRIDGE DK.




## HOLD




## ENGINE CASING TOP & BRIDGE DECK

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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

COMISION EJECUTIVA PORTUARIA AUTONOMA (CEPA)

THE DETAILED DESIGN ON PORT REACTIVATION PROJECT IN LA UNION PROVINCE OF THE REPUBLIC OF EL SALVADOR

NIPPON KOEI CO., LTD.

DESIGNED BY :

CHECKED BY :

APPROVED BY :

**Figure 7.2 General Arrangement of tugboat**

DATE : OCTOBER/2002

SCALE : 1:200

DRAWING NO: —

# CHAPTER 8 CONSTRUCTION AND IMPLEMENTATION SCHEDULE

## 8.1 General Scope of Construction

The Project will be implemented under the following three (3) packages.

Package A: Civil and Building Works

Package B: Procurement of Cargo Handling Equipment

Package C: Procurement of Floating Equipment

## 8.2 Construction Method

### 8.2.1 Workable Days

The number of workable days for civil and building works was estimated assuming that Sunday, National Holiday and the days of bad weather due to wave, rain, and wind are non-workable days. The workable days of major works items were estimated as follows:

| | | |
|---|---|---|
| Channel Dredging | : | 77.4% |
| Construction of Structures in Harbor Area | : | 80.2% |
| Earthworks | : | 75.8% |

### 8.2.2 Countermeasures for Environmental Protection

Eighteen permit conditions and 14 mitigation measures were instructed by Ministry of Environment and Natural Resources (MARN) to be implemented for environmental protection during the execution of this Project. Especially regarding the mitigation measures during dredging works, action shall be taken to monitor turbidity at 12 stations every 24 hours throughout the dredging period.

### 8.2.3 Dredging Works

A volume of 2,860,000 $m^3$ will be dredged in the turning basin, 4,469,000 $m^3$ the inner channel, and 4,160,000 $m^3$ in the outer channel. Dumping areas will be created both offshore at a distance of 25 km from the port and onshore on both sides of the terminal.

Suitable dredged material will be used for reclamation and unsuitable material will be disposed of at spoil areas. Dredged sand material, which is classified as suitable material of at for reclamation, will be filled into the reclamation area. The remaining volume will be disposed of in the offshore dumping area.

### 8.2.4 Berths

A grab dredger fleet will be employed for the excavation of soft material of foundation. Excavation will be carried out to expose the layer having N-value of not less than 30 in order to obtain the design bearing capacity of caisson foundation. The core of rubble stone caisson mound, a sound stone material size ranging from 10 kg/piece to 250 kg/piece, will be placed after removal of soft material. Rubble stone will be placed by Gutt Barge and compacted by vibration or a similar method.

Seventeen concrete caissons for the Container Berth and 12 for the Multi-purpose Berth will be produced. Two caissons will be produced at a same cycle. A 6,000-ton loading class floating dock will be employed for caisson producing.

Upon completion of rubble mound construction, caissons will be placed to the final position and filled by sand. After filling of sand into caissons, backfilling behind caissons with stone material will be carried out.

### 8.2.5 Revetment

The West Revetment and East Revetment will be of stone mound type with armor stone and Temporary Revetments including A-North, A-West and B will be of sand mound type with armor stone.

Grab dredger will be employed for excavation of soft material. Immediately after completion of excavation of soft soil, replacement material will be filled into dredged trenches by gutt barge. In order to prevent liquefaction of the replaced layer, well graded material of with sand gravel will be used.

The core of revetment will be composed of stone material with a size ranging from 10 kg/piece to 250 kg/piece. Stone material will be dumped directly by dump trucks, and rolled by bulldozers. Backhoe will be employed for leveling of slopes. Gutt barge will be employed for stone placing work in the offshore portion.

### 8.2.6 Reclamation

Where soft material exists in the reclamation area, it will be replaced by borrow material. Grab dredger will be employed for excavation of soft material. Reclamation material will be obtained from both sources, i.e. cutting of a hill on the side of the project area and dredged sand material suitable for reclamation. Immediately after finishing removal of soft soil for the reclamation area, reclamation work will be commenced.

Cut material from a hill at the borrow will be hauled to and rolled directly in the reclamation area. Dredged sand material classified as suitable material for reclamation will be filled by means of hydraulic fill from suction dredger through discharge pipes to the reclamation area.

## 8.3 Implementation Plan

Financing of the project costs is expected to be made by JBIC and BCIE with the following financing percentage at maximum:

| | JBIC | BCIE |
|---|---|---|
| Civil and Building Works (Package A) | 75% | 25% |
| Procurement of Cargo Handling Equipment (Package B) | 100% | - |
| Procurement of Floating Equipment (Package C) | 100% | - |
| Consultancy Services | 100% | - |

The procurement of services and goods will be proceeded basically based on the JBIC guidelines

CEPA will procure a consulting firm for the construction supervision through the shortlisting method. The services to be provided include assistance in bidding process, construction supervision of Package A works, supervision of procurement of equipment for Packages B and C, and assistance during the defects liability period. The total contract period is expected to be about 70 months including the service during the defects liability period.

A contractor will be selected based on the JBIC guidelines through an international competitive bidding (ICB). The bidding process for Package A works will start with the prequalification of prospective bidders followed by bidding by the prequalified bidders. The construction period of this package is expected to be 36 months plus a 12-month defects liability period.

Same as Package A, manufacturers will be selected through international competitive bidding (ICB). Bidding for Packages B and C will be proceeded separately as these contracts will be concluded individually. The bidding process is same as Package A, i.e. through prequalification of prospective bidders and bidding by the prequalified bidders. The contract period of Package B is 20 months and that of Package C is 16 months. The defects liability period of both packages is 24 months.

# CHAPTER 9 COST ESTIMATE

## 9.1 Basis of Cost Estimate

The unit rates and prices for labor, materials, plant and equipment were estimated based on the current price of July 2002.

The exchange rate used in the estimates was set

At 1 US$ = JY 120.00 and 1 US$ = ¢ 8.75

Price escalation between the time of preparation of the cost estimate and the project implementation period was estimated at 2% based on the monthly index of direct construction costs issued by the Central Bank of El Salvador. This percentage was applied for the local currency portion, while no price escalation was applied for the foreign currency portion considering economic indices of international market.

## 9.2 Cost Components

The value added tax (IVA) of 13% is imposed by laws and regulations of the Government of the Republic of El Salvador. According to mutual agreement between the two governments Japanese firms are exempted from payment of all taxes to be imposed in the country. CEPA is arranging with the authorities concerned to exempt all local taxes for all nationals engaged in the Project. Thus taxes and duties were not considered in the cost estimate of this Study.

In general, large scale machinery, plant and equipment are not available in the country especially the marine floating equipment. Hence, such large scale machinery, plant and equipment were considered to be imported from abroad and their mobilization/ demobilization costs were duly considered.

A physical contingency estimated at 7 % of the base cost of the Civil and Building Works Package and provisional sums estimated at 350,000 US$ were included in the cost estimated.

## 9.3 Project Cost

The cost for the Package A: Civil and Building Works was estimated at 90.8 million US$, which is composed a foreign currency portion of 38.2 million US$ and a local currency portion of 52.6 million US$.

The cost for procurement of two quayside gantry cranes was estimated at 12.8 million US$, and that of two tugboats at 7.0 million US$.

# CHAPTER 10 PORT OPERATION AND MANAGEMENT

## 10.1 Port Configuration

In the first phase, the La Unión Port will have three types of marine terminals: one Container Terminal, one Multi-purpose Terminal, and one Passenger and Ro-Ro Terminal. Each terminal will have one berth and a back yard just behind the berth. Thus, they are terminals of the so-called marginal type which are completely different from the old-fashioned jetty type configuration of the Acajutla Port.

## 10.2 Port Operation

Under the strong privatization policy undertaken by GOES, it is unexceptionally expected that the La Unión Port will operate as a Landlord port where port services will be solely provided by private operators based on a concession agreement with the public entity (Port Authority), namely CEPA.

It is recommended that the concession of the Container Terminal and Multi-purpose Terminal be granted to two different entities. In the initial stage the concession of the Multi-purpose Terminal shall be granted to a single operator until more berths are added in the next phase, the terminal shall then be split into two divisions or more in terms of concession for cargoes if sufficient cargo in one commodity becomes large enough to make it feasible to be managed by a single entity. Under this same privatization scheme it is also recommended that the tugboats procured by CEPA be handed over to a private operator to provide stevedoring services on a license agreement.

The following diagram illustrates the interrelationship of the entities concerned with the operation and management of the port activities. It clearly defines the responsibilities and competence of each stake holder.

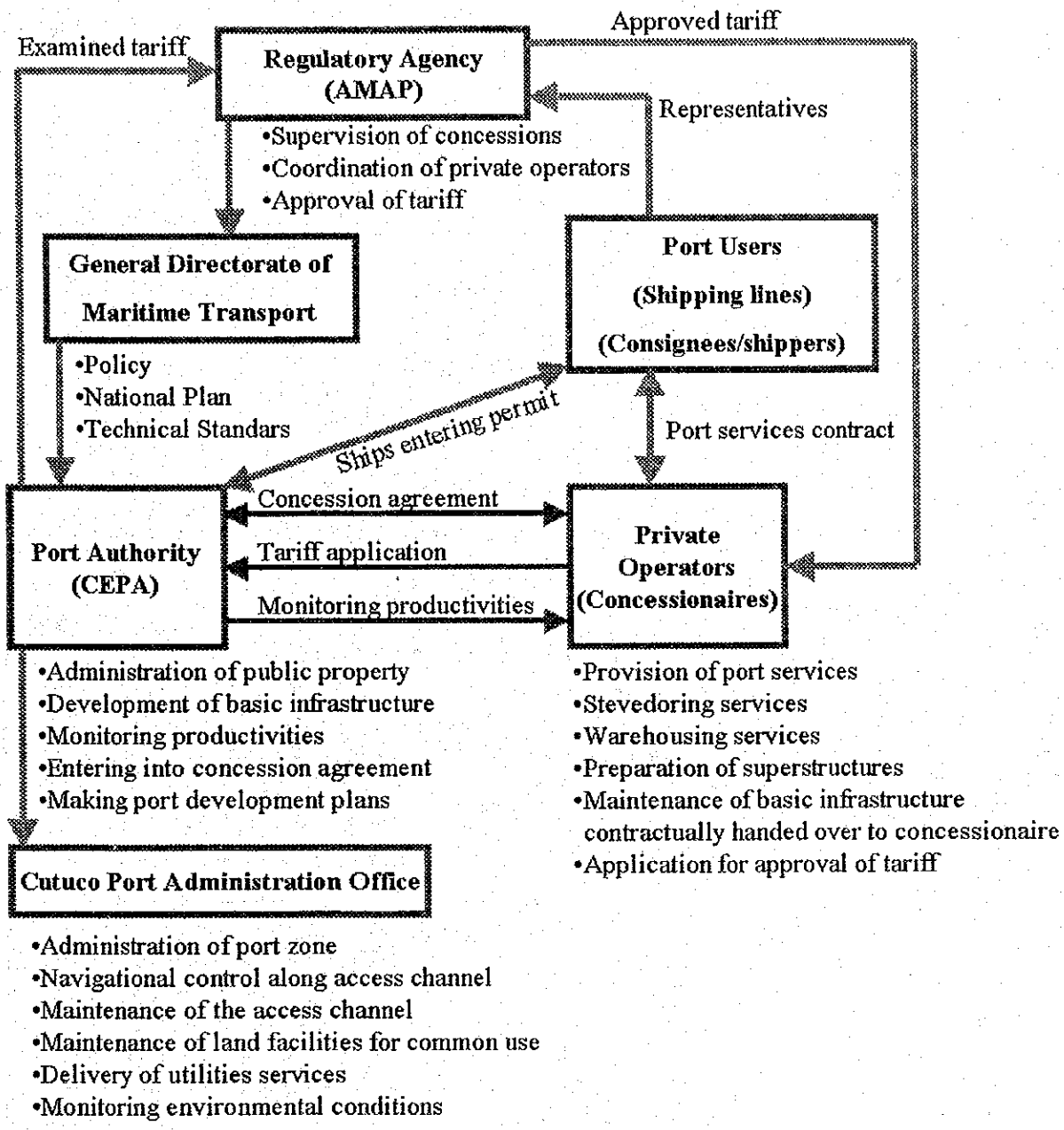


**Figure 10.1 Institutional Framework of La Union Port**

# CHAPTER 11 ECONOMIC AND FINANCIAL EVALUATION

## 11.1 Economic Evaluation

The economic feasibility of the Project was examined based on the costs and the benefits to the national economy. The Economic Internal Rate of Return (EIRR) and the Benefit/Cost ratio (B/C ratio) were applied in order to appraise the feasibility.

Two cases of "With Project" and "Without Project" were compared to obtain economic benefits. In both cases the existence of the Acajutla Port was considered in order to evaluate the two alternatives under real conditions.

### (1) Assumptions in Economic Analysis

The economic evaluation for the Project was made under the following assumptions:

Base year: 2001 (benefit and cost base year)

Project life: 30 years

Exchange rate: US$1.00 = J¥120.00 = ¢8.75

### (2) Results of Economic Evaluation

The economic evaluation expressed in EIRR was computed at 16.4% for the base case.

A sensitivity analysis was carried out for the following cases:

Case A: The total costs increase by 5% and the benefits decrease by 10%

Case B: The total costs increase by 10% and the benefits decrease by 10%

Case C: The total costs increase by 10% and the benefits decrease by15%.

The resulting EIRRs in Case A, B and C were 14.2 %, 13.5% and 12.7%, respectively.

Assuming social discount rates of 8%, 10% and 12%, the Benefits-Costs ratios (B/C ratio) of the Project were computed at 1.88, 1.60 and 1.37, respectively. On the other hand, the resulting Net Present Values in the above three cases are 145 million US$ (8%), 90 million US$ (10%) and 51 million US$ (12%).

Considering the fact that the current interest rate in El Salvador as of December in 2001 was 9.1% and the consumer price index in 2001 was up 1.4% against the preceding year, an EIRR of 10% is considered as a reasonable criterion on the safe side evaluation. The resulting base case EIRR of the Project, 16.4%, exceeds the above-mentioned criterion. In addition, even in sensitivity analysis the EIRR in all of the cases exceeds, the criterion. Thus, the La Unión Port Project is judged economically justifiable.

## 11.2 Financial Evaluation

The financial viability of the Project was examined from the viewpoint of capital investment to confirm whether it could yield sufficient returns. In this study, to measure the financial viability quantitatively, the Financial Internal Rate of Return (FIRR) on gross capital base

was calculated and compared with the assumed average interest rate of the funds to be raised for the Project to confirm whether FIRR could exceed the interest rate.

**(1) Assumptions in Financial Analysis**

| | | | |
|---|---|---|---|
| Base year | : | 2001 (benefit and cost base year) | |
| Project life | : | 30 years | |
| Interest rate | : | JBIC Loans | 2.2% (Civil Works and Equipment) |
| | | | 0.75% (Engineering Services) |
| | | BCIE Loans | 7.6% (Civil Works and Equipment) |
| | | Local Bank Loans | 9.1% (over one year) as of Dec. 2001 |
| | | | 7.83% (one year or less) as of Dec. 2001 |

The weighed average of interest rates in the initial investment was estimated to be 4.11%.

**(2) Results of Financial Evaluation**

The resulting FIRR of the Project is 13.4% in the base case. A sensitivity analysis was carried out for the following cases.

Case A: The total expenses increase by 5% and the incomes decrease by 10%

Case B: The total expenses increase by 10% and the incomes decrease by 10%

Case C: The total expenses increase by 10% and the incomes decrease by 15%

The resulting FIRRs in Cases A, B and C are 11.2%, 10.6% and 9.8%, respectively.

The resulting base case FIRR of the Project, 13.4%, exceeds the weighed average interest rate of the funds (4.11%). In addition, even in sensitivity analysis the FIRR in all of the cases exceeds that interest rate. Thus, the La Unión Port Project is judged financially viable.

# CHAPTER 12 ENVIRONMENTAL STUDY

## 12.1 Environmental Study

The environmental assessment for the Project was completed and approved by MARN on 15 December 2000 (Resolution MARN-N 400-2000) with following conditions.

- Implementation of 14 Mitigation Measures
- Posting of Security Guarantee by CEPA
- Implementation of 18 Environmental Conditions

An additional environmental study was carried out during the design. The following environmental surveys were conducted to collect additional information required for the study and predictions of sediment dispersion behavior were performed by numerical modeling to assess the environmental impacts of changes in the approach to the borrow, reclamation, dredging and disposal operations.

1) Ecological survey in the reclamation area (benthos, marine biology)
2) Ecological survey in the borrow area (terrestrial plant and animal)
3) Offshore ecological survey in the dredging area (tidal current, water quality, seabed material, benthos)
4) Offshore ecological survey in the dumping area (water quality, seabed material, benthos)
5) Fishery activity survey
6) Present condition survey (water quality, seabed material, benthos)
7) Air quality observation
8) Water quality for future monitoring purpose (water quality)

Based on the above environmental surveys and the updated information of the designs, additional assessment of environmental impacts was performed taken into consideration the dredging and dumping operation, borrow operation, and reclamation work.

### (1) Impact of Dredging and Disposal Operation by Dredging in Outer Channel

It was concluded that the turbidity dispersion by dredging in the outer channel is not significant while the dredging in the inner channel needs to be performed with utmost care. For controlling turbidity in the vicinity of the dredging area, a total of 12 stations will be established and the turbidity will be monitored during the dredging work. When turbidity increases above the trigger levels, countermeasures including suspension of the dredging operation shall be applied.

### (2) Impact of Discharge from Onshore Dumping and Reclamation Areas

The turbidity dispersion due to discharge from onshore dumping and reclamation areas will not be significant. However, turbidity shall be monitored during the dumping operation. If turbidity exceeds the trigger level, countermeasures shall be applied.

### (3) Impact of Borrow Operation

Prior to site clearance in the borrow area, temporary bunds or permanent revetments will be constructed to enclose the area and to create a sediment settlement pond.

Same as onshore dumping and reclamation activities, turbidity shall be monitored during construction. Compared to the original plan, the borrow area will become smaller, thus the impact of borrow operation will be reduced.

## 12.2 Amendment of Original Permit

Based on additional environmental study results, amendment of certain Mitigation Measures and Permit Conditions was proposed and it was accepted by MARN. The proposed amendments include the following major items:

- Amend Mitigation Measure 1 to re-vegetate 24 ha of land with 15,000 trees (including 6 ha of mangroves), and rescue wildlife and relocate it in the adjacent undamaged area. This is because the area of vegetation was reduced from 20 ha (Original Permit) to 12 ha measured based on the completed detailed design. The re-vegetation density of 625 trees/ha is common to apply and reasonable;
- Omit from Mitigation Measure 6 the incinerator to treat solid waste from the operating port. Waste from ships is not significant as it is treated by the ship itself and the waste produced by the port activities will be a relatively small quantity, which can easily be dealt with by the municipal waste collection service;
- Omit from Mitigation Measure 8 the use of silt curtains around the dredger and disposal site as these are normally used only in highly sensitive environments with rich growths of coral, which is not the case in La Unión Bay due to its natural turbidity. Monitor turbidity instead and set Trigger Levels to protect any sensitive areas, with dredging being required to cease if Trigger Levels are reached.
- Supplement Mitigation Measure 8 by establishing turbidity monitoring stations and setting Trigger Levels of increases in SS as follows.

  Station 1-2: 60 mg/ltr above ambient (to protect the filter-feeding mollusks)

  Station 3-5: 100 mg/ltr above ambient (to protect the fish nursery)

  Station 6-12: 200 mg/ltr above ambient

  These values were proposed on the basis of the levels predicted by the modeling for the dredging methods most likely to be used, and levels which animals living in a naturally turbid environment should be able to withstand.
- Amend Mitigation Measure 8. MARN suggested the original offshore dumpsite south of Latitude 13°N, at a depth of 43 m. However with MARN approval the alternative offshore dumping site was considered, to reduce the cost of disposal (as it is closer to

the dredging areas), and to protect the environment at the original offshore dumping dumpsite about which MARN was concerned. The results of the surveys showed that the benthos at both sites was neither rare nor in particular needed protection, and that there would not be significant impacts from the disposal. MARN therefore approved disposal at the alternative offshore dumping site.

- Add Mitigation Measure 16 relating to dumping of dredged spoil, which limits reclamation to 27 ha for the port, and 11 and 24 ha for the onshore dumping areas on the north-western and south-eastern sides.
- Amend Permit Condition 13 to allow port construction to commence before La Unión bypass has been completed, as the road project has been delayed, which could hinder completion of the port. Instead, an alternative route of the access road shall be provided for the port traffic before the road is finished, to keep heavy traffic out of La Unión City.

## 12.3 Environmental Management and Monitoring Plan

The Environmental Management and Monitoring Plan was prepared and accepted by MARN, this being the document that defines in detail how the environment is to be protected, managed and monitored throughout the Project.

# CHAPTER 13 CONCLUSION AND RECOMMENDATION

It was confirmed that the Project is quite viable and feasible from the technical, economic and financial aspects. The early implementation of the Project is prerequisite and CEPA must extend strong port sales for potential port users to assure and expand the port cargo.

To allow the port development to play an important role in the country and in Central America and to contribute economic and financial benefits, CEPA shall coordinate with relevant authorities and government concerned in the implementation and promotion of the Project.

Periodical monitoring of the depth of the channel and turning basin shall be performed by CEPA during the construction and operation stages. Since the estimated soil deposit volume is significant and the approach channel is a vital facility of the port, CEPA shall prepare a future maintenance scheme based on the monitoring results.

CEPA shall proceed with a privatization scheme as early as possible so that necessary change in the yard layout plan of the Terminals can be accommodated before the Project startsstarts in relation with the cargo handling system to be introduced by the concessionaire:

Buildings

- Port administration building
- CFS
- Maintenance and repair shop

Yard layout

- Container stacking area
- Pavement.