CHAPTER 6 DESIGN OF BUILDING AND UTILITIES

CHAPTER 6 DESIGN OF BUILDING AND UTILITES

6.1 Buildings

6.1.1 Design Conditions

(1) Design Concepts

In order to achieve an optimum port building plan for the La Unión Port, the following design concepts are established for the design on the basis of the results of several site surveys, studies and through in-depth discussion with CEPA and port engineers. After being reviewed, the following concepts were retained.

- Functional and Easy Usability
- Pleasant and Friendly to Users
- Compliance with Natural Conditions and Structurally Sound
- Easy Maintenance and Durability
- Harmonious Design with the Environment and Scenery

(2) Laws, Codes and Regulations for Design

The design of buildings and building utilities of the Project is carried out basically in compliance with the following local laws and codes. However, in the case where no relevant laws, codes and regulations exist in El Salvador but they are deemed indispensable for the design, then applicable international laws, codes and regulations were adopted for the Project as listed below:

1) Building Laws
- National Building and Urban Development Law.
- Regulation related to the Development and Land Use Planning Law of the Metropolitan Area of San Salvador (AMSS) and Bordering Municipalities (OPAMSS, July 1996, El Salvador).

2) Structural Codes
- Technical Standards for Seismic Design for Wind Design and Comments (ASIA, 1997, El Salvador).
- Regulation for the Structural Security on the Construction.
- Special Standards for Housing and Building Design; Special Standards for Quality Control of Structure Materials and its Comments; Special Standard for the design of Foundations and Walls (slope) Stability (ASIA, 1997, El Salvador).

3) Environmental Law

Environmental Regulations (Edición Jurídica Salvadoreña, 2000).

4) International Standard
- ASTM : American Society for Testing & Materials

- AIA Graphic : The American Institute of Architects, Architectural Standard–2000.
- AIA Handbook, : The American Institute of Architects, The Architects Professional Practice – 2000.
- Uniform Building Code 1997 (U.S.A.).
- NFPA (National Fire Protection Association, U.S.A.).
- ACI: American Concrete Institute 1999 (U.S.A.).
- AISC: American Institute of Steel Construction 1997 (U.S.A.).

(3) **Design Criteria**

1) Building Floor Area

The building floor area is determined to accommodate the number of persons, equipment and a volume of incoming and outgoing commodities in the port.

The required number of persons for major buildings is established through in-depth discussion with CEPA as summarized below:

Table 6.1.1 Number of Persons to be Accommodated

Building Name	Approximate Number of Persons to be Accommodated
Port Administration Building	92
Container Freight Station (CFS)	15
Maintenance and Repair Shop	20

The floor area calculation for the Port Administration Building, Container Freight Station (CFS), Maintenance and Repair Shop and Terminal Gates has been discussed in Chapter 3.

The calculated floor areas for major buildings including mezzanime floors are listed below:

Table 6.1.2 Floor Area Required for Major Buildings

Building Name	Floor Area Required (m^2) Approximately
Port Administration Building	2,540
Container Freight Station (CFS)	2,420
Maintenance and Repair Shop	1,440

2) Building Construction Materials

Building construction materials are selected in consideration of availability of local products so as to achieve easy and low maintenance cost of the building facilities. However, in cases where materials intended to be used are not available locally with regard to the quality, imported materials which shall be qualified officially are adopted instead in the design. In any case, materials are selected comparing their quality against specifically salt corrosion, maintenance and economical aspect.

3) Soil Conditions

From the data of borehole No. BS-14 and Geological Section (1), the foundation of most buildings is determined to be pile foundation supported by gravel sand strata with an average N- value of 30.

4) Design Load

There are several kinds of loads and forces to be considered for the structural analysis as listed below.

Dead Load and Live Load:

"Module 1 Regulations for Structural Safety of Constructions" is applied for determining the dead and live loads. The crane load for designing the Maintenance and Repair Shop is considered as follows:

Table 6.1.3 Factor of Crane Impact

Direction of Load	Factor
Vertical	1.1
Lateral to crane rail	0.2
Parallel to crane rail	0.1

Seismic Load:

Special structural consideration is made since the proposed construction site is located in an earthquake prone area. According to "Module 1 Regulations for Structural Safety of Constructions" and "Technical Standards for Seismic Design, for Wind Design and Comments", the site is located in the seismic zone I, of which the seismic zoning factor is given at 0.4. Based on this factor, the seismic coefficient to be used for calculation of seismic loads of each building is determined by calculating through the formula established in the said Regulations and Standard at 0.2 G.

Wind Load:

The wind load for building structures varies in accordance with the building shape, height and surface condition of the construction site. According to "Technical Standards for Seismic Design, for Wind Design and Comments", the basic wind pressure in the area is 30 kg/m^2 which corresponds to zone C.

Load Combinations:

There are several cases of design load combinations to be set with load factors of the design method (Ultimate Strength method) presented in the " Module 1 Regulations for Structural Safety of Constructions". The design is carried out by using the greatest element stress of nine (9) load combination cases. The load combination factors are tabulated below.

Table 6.1.4 Load Combination and Load Factory

Load Combination	B	Load Factors						
		DL	*LL	SL	WL	E	T	LP
1	1.00	1.40	1.70	0.00	0.00	0.00	0.00	1.40
2	0.75	1.40	1.70	1.87	0.00	0.00	0.00	1.40
3	1.00	0.90	0.00	1.43	0.00	0.00	0.00	0.00
4	0.75	1.40	1.70	0.00	1.70	0.00	0.00	1.40
5	1.00	0.90	0.00	0.00	1.30	0.00	0.00	0.00
6	1.00	1.40	1.70	0.00	0.00	1.70	0.00	1.40
7	1.00	0.90	0.00	0.00	0.00	1.70	0.00	0.00
8	0.75	1.40	1.70	0.00	0.00	0.00	1.40	1.40
9	1.00	1.40	0.00	0.00	0.00	0.00	1.40	0.00

Symbols;

B: Load Combination Factor
DL: Dead Load
LL: Live Load
SL: Seismic Load
WL: Wind Load
E: Earth Pressure
T: Temperature
LP: Weight or Liquid Pressure

Notes;

- Example for Load Combination 1: 1.00 (1.40DL+1.70LL+1.40LP)
- Impact load to be included in live load.

5) Structural Calculation

Computer analysis is applied for structural calculation design. The STAAD-III Ver. 21.1w is used as structure analysis program for superstructures. The design is carried out in accordance with the allowable stress method based on stiffness matrix. Concrete members and sections are designed based on the ultimate strength method.

6) Structural Conditions

The values for live load, wind factor and seismic importance factor used in the design are shown below.

Table 6.1.5 Structural Conditions

Live Load	Roof (slope < 5%)	100 kg/m^2
	(slope > 5%)	20 kg/m^2
	Office	250 kg/m^2
	Maintenance Shop floor	2000 kg/m^2
Wind Factor of Location K		1.6
Seismic Importance Factor I	Administration building	1.2
	Others	1.0

7) Structural Materials

The strength of basic materials for building structures are listed below:

Table 6.1.6 Structural Materials

Concrete strength	210, 280 kg/m²
Steel strength for reinforcement	GRADE 40, ∠1 GRADE 60 ∠1
Steel strength	A – 36 ∠1

∠1 ASTM Standard

6.1.2 Port Administration Building

The Port Administration Building will play a vital role in the port area since it shall effectively and efficiently support the management, operation and maintenance of the port activities. The building contains three major offices: one is port administration office of CEPA which acts as a comprehensive port management and control office; the second group consists of various offices such as custom, immigration, quarantine and other incidental offices and facilities to handle import and export port activities; the third group is the office of the concessionaire of the container terminal, which will manage day to day port operations.

The building is designed as a 3-storied reinforced concrete framing structure for the general portion, provided with an additional 3-storied port control tower onto the roof of the main structure which includes port control office, meeting room and other incidental rooms, from which the entire port activities will be monitored.

The design parameters for the Port Administration Building are as follows:

Table 6.1.7 Design Parameters for Port Administration Building

Column spacing	8.00 meters
Bay spacing	6.00 meters
Number of stories	3+3
Maximum height	Approx. 26.0 meters
Story height	Approx. 3.8 meters
Floors, columns and beams	Reinforced concrete
Walls	Concrete hollow bocks
Roof	Reinforced concrete
Foundation beams	Reinforced concrete

6.1.3 Container Freight Station (CFS)

The Container Freight Station will have the functions to facilitate the stuffing and un-stuffing of LCL containers. To this end, the CFS will be located behind the Container Yard and provided with platforms for receiving LCL containers and for easy access of cargo trucks. The CFS will also be provided with several small storages at one side of the building for custody of valuable cargoes, offices and incidental rooms, and also space for future expansion. Special design consideration is exercised to provide large overhang eaves for enabling cargo handling operation even in the rainy days, large openings for ventilation on the roof together with rooftop skylights for taking the natural light into the room.

The design parameters for the CFS are as follows:

Table 6.1.8 Design Parameteers for CFS

Maximum column spacing	30.0 meters
Bay spacing	7.5 meters
Number of stories	1 + Mezzanine
Maximum height	14.2 meters
Roof slope	31%
Roof framing structure and columns	Steel
Slab, foundation beam	Reinforced concrete

6.1.4 Maintenance and Repair Shop

The Maintenance and Repair Shop will have the functions to facilitate the checking and repair of the port cargo handling machines and equipment and their maintenance to keep them in good operational conditions. The building will be provided with large openings on the roof to assure ventilation and natural lighting. The maintenance space for big machine "RTG" will be provided outdoors beside the building since it is too large to be accommodated inside. The shop will have an overhead traveling crane with a maximum hoisting capacity of 5 tons for handling heavy parts such as engine, compressor, etc. The floor inspection pits will be provided below the first floor to allow the inspection of the underside of the equipment. The shop is designed to be completely watertight against rainwater, so as to allow work during the rainy days. The building will also be provided with washing and cleaning areas, offices, a storage and a training room for workers.

The design parameters for the Maintenance and Repair Shop are as follows:

Table 6.1.9 Design Parameters for Maintenance and Repair Shop

Maximum column spacing	24.0 meters
Bay spacing	6.0 meters
Number of stories	1 + Mezzanine
Maximum height	14.900 meters
Roof slope	34%
Roof framing structures and columns	Steel
Floor slab, foundation beams	Reinforced concrete

6.1.5 Gates

Two gates will be provided around the entrance of the Container Yard and Multi-purpose Yard area. The Cargo Gate will be located at the entrance of the Multi-purpose yard to check the documents and cargo weight to control custom regulation and bonds. The Container Gate will be located at the entrance of the container yard where the documents and cargo weight should be checked.

The Container Gate will be provided with six (6) lanes and islands on which control offices are provided to handle their tasks. The number of lanes shall be expanded to 10 lanes by the 2015 target year. The Cargo Gate will be provided with three (3) lanes with the same functions as container gates. The Container Gate will be connected to the custom office in the Port Administration Building through the telephone and computer line to be provided in the future. The Cargo Gate will be likewise connected to the Port Administration Building. All gates will be built with steel framing structures covered with formed steel roof sheeting.

The design parameters for the Gates are as follows:

Table 6.1.10 Design Parameters for Gates

Item	Cargo	Container
Maximum column spacing	5.2 meters	6.4 meters
Bay spacing	6.0 meters	6.0 meters
Number of stories	2 (partially)	2 (partially)
Maximum height	10.6 meters	10.6 meters
Roof slope	83 %, 66%	83%, 66 %
Roof structure	Steel	Steel
Columns	Reinforced concrete	Reinforced concrete
Floor slabs, foundation beams	Reinforced concrete	Reinforced concrete

6.1.6 Other Buildings and Facilities

(1) Power Supply Station

A 46 kV power supply line from the existing Sub-Station located in San Miguel is available near the site. The Power Supply Station will be the main electric power receiving station having functions of stepping down the voltage and supplying electric power to the general buildings and the port area. The building will also involve the emergency generator room in order to back up the power shortage in case of power failure in the commercial line. The building was designed as a reinforced concrete structure on concrete foundation.

(2) Parking Shed

Parking sheds will be provided to protect a certain number of cars of management staff from sunshine and salty rain. The sheds are designed to have steel columns and canopy covered by corrugated cement fiberboard. The sheds will be located in the courtyard of the Port Administration Building.

(3) Security Fence

A security fence will be provided for securing safety at the main entrance and around the electric and air-conditioning outdoor equipment area including gate doors. The fence is designed with galvanized steel pipe framings covered by steel wire net in conjunction with overhang barbed wire strands.

(4) Landscaping

Based on the green zone allocated in the port master plan, landscaping is designed with a view of providing a best working circumference to the working people as well as creating an attractive scenery in the port area. Some monument symbolizing the area will be provided in a selected place in the future. Various plants will be arranged utilizing local varieties with due consideration of environmental condition specified by MARN.

6.1.7 Building Utilities

(1) Scope of Works

Mechanical and electrical utilities are designed for the proposed buildings as shown in Table 6.1.1 together with buildings features, taking into consideration the design conditions, regulations and standards.

Table 6.1.11 Proposed Building Features

No.	1	2	3	4	5	6
Building Name / Building Features	Port Administ-ration Building	Container Freight Station	Mainte-nance and Repair Shop	Container Gate	Cargo Gate	Power Supply Station
BUILDINGS						
Total Flooor Area (m3) 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)	6.0	7.5	6.0	6.0	6.0	7.0/6.0
Foundation/Foundation Beams/Floors	RC	RC	RC	RC	RC	RC
Columns/Beams	S	S	S	S	S	S
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	√	√	√	√	√	√

No.	1	2	3	4	5	6
Building Name / Building Features	Port Administration Building	Container Freight Station	Maintenance and Repair Shop	Container Gate	Cargo Gate	Power Supply Station
Lighting System	√	√	√	√	√	√
Telephone System	√	√	√	√	√	√
Fire Alarm System	√	√	√	√	√	√
Lightning Protection System	√	√	√	√	√	√

(2) General

1) The following standards and regulations are applied for building utilities design:
- NFPA: National Fire Protection Association (U.S.A)
- ASTM: American Society for Testing and Materials (U.S.A)
- AWWA: American Water Works Association (U.S.A)
- ASME: American Society of Mechanical Engineers (U.S.A)
- ASHRAE: American Society of Heating, Refrigeration and Air-Conditioning Engineers (U.S.A.)
- NPC: National Plumbing Codes (U.S.A)
- NEC: National Electrical Code (U.S.A)
- IEEE: The Institute of Electrical and Electronic Engineers Standard (U.S.A)
- ANSI: American National Standard Institute (U.S.A)
- NEMA: National Electrical Manufactures Association (U.S.A)
- UL: Underwriter's Laboratories, Inc. (U.S.A)

2) The design conditions are as follows:
- Outside Temperature:
  Dry Bulb[DB (°C)] 37.2
- Room Temperature
  Dry Bulb [DB (°C)] 25
  Relative Humidity [RH (%)] 50 to 60

(3) VAC (Ventilation and Air-Conditioning) System

1) Central VAC System

The centralized VAC system is designed for the Port Administration Building. It consists of the following major equipment:

Two (2) air cooled chillers with screwed compressors having a cooling capacity of 62 kW with R-22 of refrigeration and delivery at leaving temperature of 5.5 °C. Chillers will be located outside building.

Two (2) chilled water circulation pumps installed outside the building to supply required flow.

For supply of cooled fresh air to the 1st, 2nd, 3rd and 4th to 6th floors, four (4) air handling units will be installed on each floor up to the 4th floor.

Ceiling mounted type fan coil units will be provided in each room in order to control the room temperature.

Emergency power will be supplied to a half of chillers and circulation pumps and all air handling units in case of power failure.

2) Individual VAC System
The office areas in the CFS, Maintenance and Repair Shop, Container Gate and Cargo Gate, and Power Supply Station were designed to have individual air-conditioning system.

3) Ventilation System
Kitchens, toilets, mechanical and electrical rooms are designed to be equipped each with a mechanical or natural ventilation system in accordance with each room's condition.

(4) Plumbing System

Kitchens, toilets, mechanical and electrical rooms are designed to be equipped each with a mechanical or natural ventilation system in accordance with each room's condition.

1) Water Supply System
A water supply system is designed to meet all the water demands for washrooms, kitchen and other water demand points. This system will be connected with the outside water main from the water supply systems.

2) Sewage, Drainage and Vent System
Proper sewage, drainage and vent systems are designed in accordance with National Plumbing Code (U.S.A) for toilets and kitchen in each building.

3) Firefighting System
The firefighting systems are designed to be provided in each building, in accordance with requirements of NFPA. The Port Administration Building will be equipped with an indoor firefighting system with firehydrant boxes on each floor connected to main firefighting pipes. A booster fire pump will be installed underneath the staircase to assure extra pressurization. NFPA-categorized fire extinguishers will be provided in all buildings.

(5) Internal Electrical System

1) Port Administration Building
The lighting level in each area will be in accordance with requirements of the Illuminating Engineering Society of North America (IESNA) Standard.

Fixtures of fluorescent high efficiency parabolic troffers type will be used, adapted to computer screen use. In the entrance area, lightings will be located along the access roads. All the lighting fixtures will be connected to priority groups of the generators. Emergency lights with battery will be provided on escape routes.

The distribution panel will include separate groups for lighting, outlets and air-conditioner units. In each room, duplex grounded power outlets will be installed as shown on drawings.

A fire alarm and CCTV system and a voice/data network system will be installed. A telephone exchanger will be located in the telephone room and a fire alarm panel will be located in the guard room. The lightning protection system will consist of one active type arrestor provided on the roof of each building.

2) Cargo Gate and Container Gate

The gates will have a lighting level of 100 lux. The fixtures will be watertight of Metal Halide industrial pendant type. The gate offices are designed to have a lighting level of 500 lux. Some outlets and telephone/data connections will be installed.

The weighbridges to be furnished under another contract will have their own electric feeder circuits and telephone/data connections. Therefore, some conduit piping will be provided to connect with related offices.

3) Power Supply Station

The lighting level in the Power Supply Stations is designed to be 200 lux. Some outlets and telephone/data connections will be installed for service purposes. Fire alarm and lightning protection are designed to be complete systems.

4) Container Freight Station (CFS)

The lighting levels will be similar to those in the Port Administration Building. The general luminous level of 50 lux on the ground floor will be ensured by the installation of Metal Halide industrial pendant type fixtures. Translucent roof sheet will be used in day time. Several outlets will be provided near the entrance doors for service purposes.

Relevant rooms will be equipped with the same electrical systems as the Port Administration Building. Fire alarm, telephone/data wiring and lightning protection will be part of the systems to be installed. Some special electric outlets for charging forklift battery will be installed in the Maintenance and Repair Shop.

Similar rooms will have the same lighting levels and systems as the Port

Administration Building, except for the working areas where illumination level is designed to be 200 lux, supplied with Metal Halide industrial pendant type fixtures. Fire alarm, telephone/data and lightning systems are designed to meet the local requirements according to the functions of the buildings.

6.2 Electrical Systems

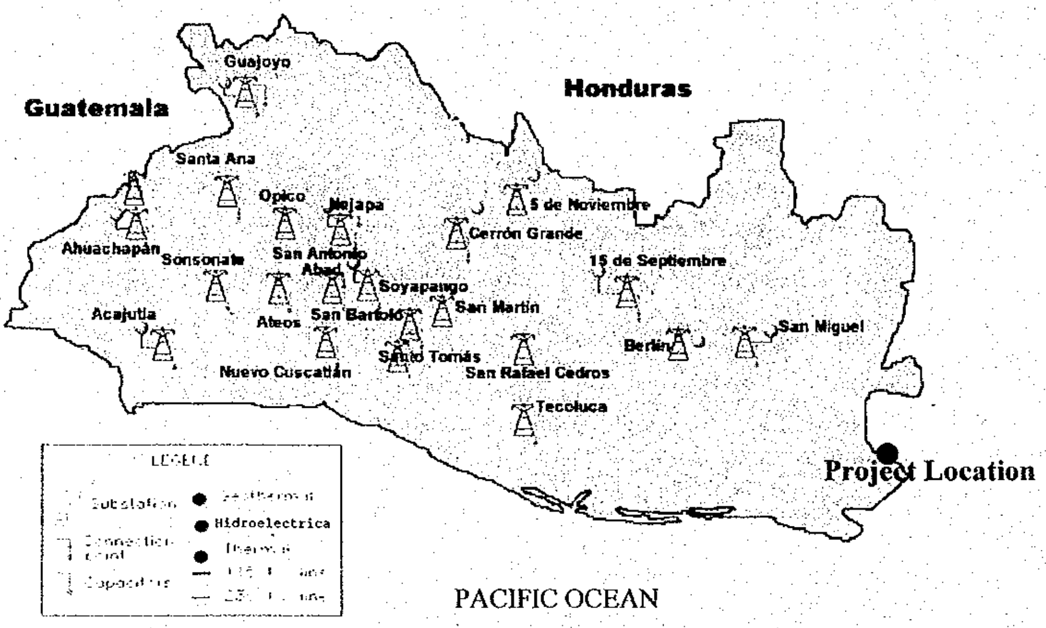
6.2.1 Power Generation and Distribution

(1) Regulatory Framework

In El Salvador Electrical Power Generation and Distribution is regulated by the General Superintendence of Electricity and Telecommunications (SIGET). Their role is to supervise the market activity and approve tariffs. There is also a transaction unit "Unidad de Transacciones" which regulates the wholesales to the different energy distributors.

(2) Generation

As of 2001, electricity is generated by 10 generation plants of which four (4) are hydroelectric dams, four (4) are thermal plants, and two (2) are geothermal plants. Their locations are shown in Figure 6.2.1.



[Source: www.cel.gob.sv website – original in Spanish]

Figure 6.2.1 Electrical Generation Network

In 1996, a decree is approved by the Salvadorean Congress allowing the formation of new private power generating companies. The hydroelectric dams and geothermal plants are owned by the government under the administration of a state corporation named Executive Commission of the Lempa River "Comisión Ejecutiva Hidroeléctrica del Río Lempa" (CEL), and the thermal plants are privately owned by major generating companies: the Nejapa Plant by Nejapa Power, the Acajutla Plant, San Miguel Plant and Soyapango Plant by Duke Energy, CEL shares 46.9% of the national electricity production and the private companies 36%. Table 6.2.1 shows the installed capacity.

A new thermal generation plant is being built in the Cortés Port in Honduras. This plant will have a generation capacity of 700 MVA and it is expected that it will start operation in 2003. It is planned that a transmission line will directly connect this generation facility and the Nejapa Plant in San Salvador. The plant owner and developer are AES Corporation.

Table 6.2.1 Main Power Generating Plants in El Salvador

Main Generator	Installed Capacity	Operation Started in
Hydroelectric-Guajoyo (CEL)	15 MW, 1 unit	1964
Hydroelectric-Cerrón Grande (CEL)	135 MW, 2 units	1977
Hydroelectric-5 de Noviembre (CEL)	81.4 MW, 5 units	1954
Hydroelectric-15 de Septiembre (CEL)	156.6 MW, 2 units	1983
Geothermal-Ahuachapán (CEL)	95 MW, 3 units	1975
Geothermal-Berlín (CEL)	60 MW, 2 units	1992
Thermal-Soyapango (DUKE ENERGY)	53.9 MW, 3 units	1994
Thermal-San Miguel (DUKE ENERGY)	31.9 MW, 1 unit and motorgenerator	1985
Thermal-Acajutla (CEL), recently acquired by DUKE ENERGY	21.99 MW, 5 units	1966
Thermal-Nejapa Power	151.2 MW	1994
Thermal-Duke Energy	367.4 MW	2001

(3) Distribution

Electrical distribution is fully privatized and the country is divided into four (4) regions that are served by four companies named CLESA in the Western Region, CAESS in the Northern Central Region, EEO in the Eastern Region, and DELSUR in the South Central Region.

CLESA, CAESS and EEO are owned mostly by AES Corporation and DELSUR by PPL. The project area is served by EEO (Empresa Eléctrica de Oriente) which also serves four provinces: Usulután, San Miguel, Morazán, and La Unión.

(4) Current Conditions at the Site

a) Transmission Line

Electricity supply to La Unión City is assured by EEO from the San Miguel Substation through two transmission lines of 29 MW and 19.5 MW laid out on either side of the right-of-way of the National Route CA 1 and Route 1233 from San Miguel to La Unión. Only the 29 MW line is used currently, and by law transmission lines are allowed to be used only up to 80% of their maximum capacity. Therefore only 23.2 MW of power are available from this line (see Table 6.2.2).

Table 6.2.2 Power available in La Unión City

	Line 1	Line 2
Physical Capacity	29 MW	19.5 MW
Regulated Transmission Capacity (80%)	23.2 MW	15.6 MW
Emergency Transmission Capacity (95%)	27.6 MW	18.5 MW

EEO could use the 19.5 MW line, if needed, with a regulated transmission capacity of 15.6 MW. This 2nd line could be further upgraded up to a maximum of 29 MW without the need for upgrading the line itself. It would only require to upgrade the safety switches at the San Miguel Substation and to get approved of the government regulatory agency who will evaluate the need for such upgrade. After approval the upgrade will take place within a week. These two lines can transmit 27.6 MW, 95% of physical capacity, in an emergency situation.

Currently there is no real generation redundancy on the network as both the 19.5 MW and 29 MW lines originate from the San Miguel Substation. EEO only has transmission redundancy due to the division of the transmission lines into three different sections which interconnect at different points to provide alternative supply routes in case of problems on the lines.

EEO is carrying out a feasibility study on additional power supply to La Unión City from a different source (other than the San Miguel Substation). Two alternatives under study are the construction of a new 40 MW transmission line and the construction of a power generation plant near La Unión.

Through interviews with EEO, it was known that under current operating conditions and the current capabilities EEO would be able to feed 8 MW to the port without any problem. Provision of 10 MW will be more difficult and 12 MW is out of their current capabilities. However their expansion plans for the new 40 MW line is scheduled to be completed in or before 2005.

b) Submarine Cables

Electricity supply to the biggest islands (Zacatillo, Conchaguita, and Meanguera) in the Fonseca Gulf is now done through sub-marine cables that connect the mainland to the islands of Zacatillo and Conchaguita as well as to Meanguera (see Figure 6.2.2). Two cables are laid from the mainland (Playa Santana) to Zacatillo Island (Punta La Estufa) and from Zacatillo Island (Punta Los Negritos) to Conchaguita Island (Punta El Caguano) and from Conchaguita Island (Punta El Flor) to Meanguera Island (Punta El Peladero). The cables were installed in February 2002.

6.2.2 Power Demand

Power demand of the port is estimated to be not over 4 MVA at the port's full development. The calculation makes according to the following requirements:

(1) Connection to Gantry Cranes

The gantry cranes have a power demand of approximate by 750 kW each. With a demand factor of 0.70 and a power factor of 0.75, this results in a maximum power consumption of 700 KVA. In the power supply station, two switchgears will be installed. These switchgear will be couplied with the 4.16 kV power supply cables to the electric cable junction connection pits of the gantry cranes. Each crane will be equipped with a switchgear on the incoming line and a transformer in order to provide the needed supply voltages for the crane installation.

(2) Connection to Movable Pneumatic Unloader or Movable Loader for Sugar

The movable pneumatic unloaders have a total power demand of approximate by 800 kW for two sets. With a demand factor of 0.6 and a power factor of 0.75, this results in a maximum power consumption of 640 KVA. The movable loaders have a total power demand of approximate by 300 kW for three sets. With a demand factor of 0.6 and a power factor of 0.75, this results in a maximum power consumption of 240 KVA. In the power supply station, one switchgear space will be provided. The switchgear in the future will be coupled with the 4.16 kV power supply cable to the electric cable junction connection pit in the Multi-purpose Berth of movable pneumatic unloaders or movable loaders which will be equipped with a switchgear on the incoming line and a transformer in order to provide the needed supply voltage.

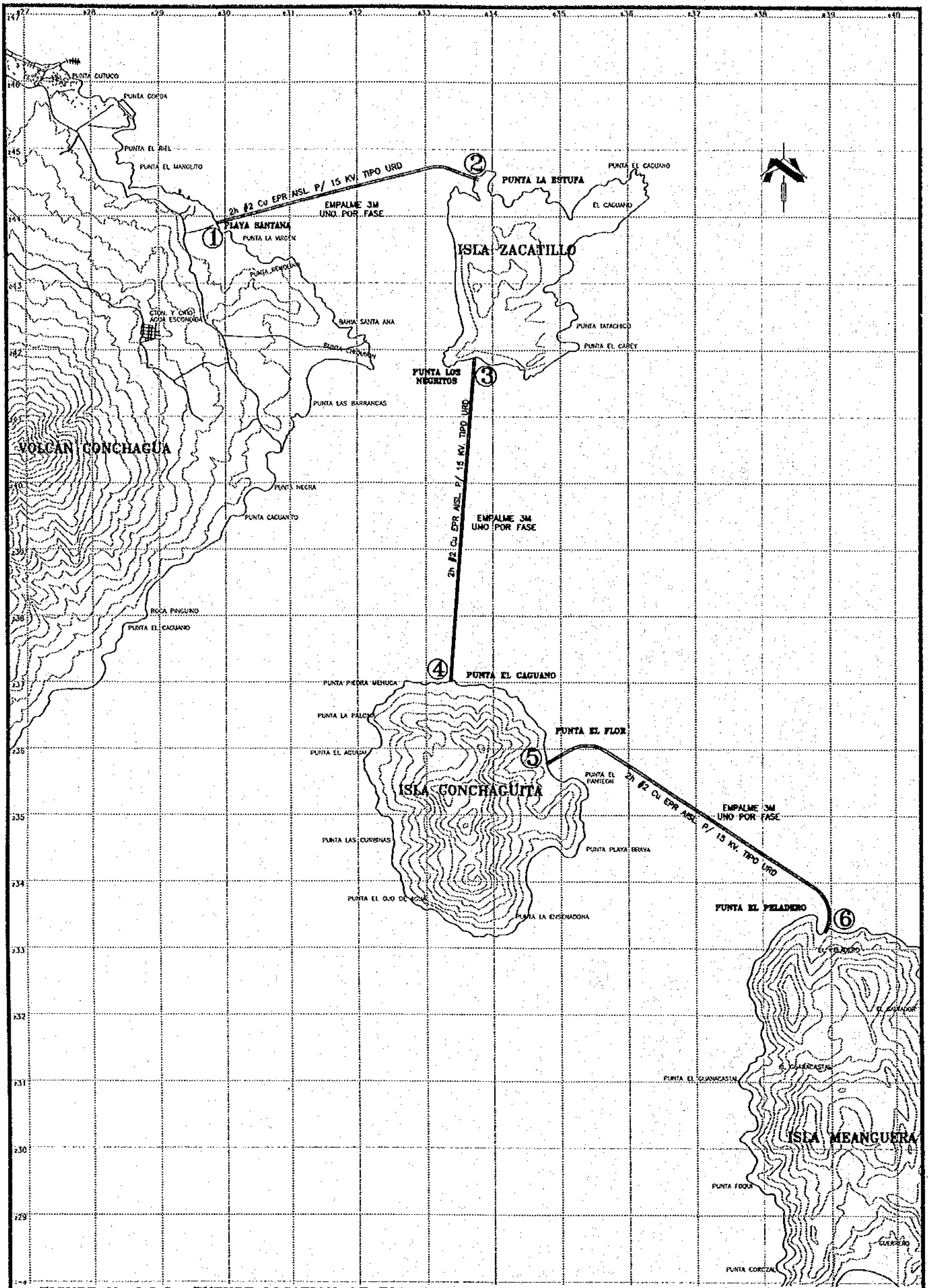


FIGURE No.6.2.2 FUTURE LOCATION OF ELECTRICAL SUPPLY CABLES TO ISLANDS IN THE FONSECA GULF AREA

(3) Connection to Movable Belt Conveyors

The movable belt conveyors have a power demand of approximate by 500 kW. With a demand factor of 0.6 and a power factor of 0.75, this results in a maximum power consumption of 400 KVA. In the power supply station one switchgear space will be provided for future installation. The switchgear will be coupled with the 4.16 kV power supply cable to the electric cable junction pit mentioned in (2) above. The conveyor will be provided with a switchgear on the incoming line and a transformer in order to provide the needed supply voltage for the conveyor installation in future.

(4) Connection to Reefers

Eight (8) special weatherproof outlet boards will be installed in the reefer container area in order to supply electric power to up to 64 containers. They will be provided with two (2) voltage levels: 240 V 3ø and 480 V 3ø. The power demand will be approximate by 350 kW and with a demand factor of 0.6 and a power factor of 0.85, this results in a maximum power consumption of 250 KVA.

(5) Connection to Area Lighting

The area lighting will be supplied from the 480 V switchgears in the power supply station. The power demand was estimated as follows:

- - Container yard lighting 80 KVA
- - Open yard lighting 27 KVA
- - Street and maintenance area lighting 16 KVA

(6) Connections to Mechanical Systems

The mechanical systems consist of water purification facility, water pumping station, water treatment facility and firefighting system pump.

Power supply to the purification facility and water pumping station will be made directly from the EEO 13.2 kV electric network in the area.

The water treatment facility and first fighting equipment will be connected to the Panel-board installed in the near building. The power demand is included in item (7) below

(7) Connections to Buildings

Feeder cables will connect the various buildings in the port from the 480 V or 208-120 V switchgears in the Power Supply Station. The buildings will have a power demand as listed in following table:

Table 6.2.3 Power Demand of Buildings

Port Administration Building	240 KVA
Container Freight Station	110 KVA
Maintenance and Repair Shop	110 KVA
Container Gate	55 KVA
Cargo Gate	35 KVA
Power Supply Station	40 KVA

(8) Connection to Outlets

Besides particular outlets and connection points for gantry cranes, reefers, etc., service outlets will be placed in the electric service pit of each berth for gantry crane maintenance equipment and supply for shops. A total of seven outlets will be provided for each berth with following specifications.

- Three outlets for gantry cranes: 3-phase, 480 V AC, 60 Hz, 50 A.
- Four outlets for ships: 3-phase, 440 V AC, 60 Hz, 50 A with single phase 120 V AC, 60 Hz, 16 A.

120 V power will be supplied to three (3) light beacons located in the port area.

(9) Total load

The total load was estimated as follows:

- Gantry cranes	1,400 KVA
- Movable pneumatics	640 KVA
(Including Movable loaders)	(240 KVA)
- Belt conveyors	400 KVA
- Reefers	250 KVA
- Area lighting	123 KVA
- Buildings	590 KVA
- Service outlets	165 KVA
- Total	3,568 KVA
	(3,168 KVA)

6.2.3 Power Supply Plan

The main supply source will be the 46 kV network of EEO. Electric power for the port can be fed from the supply Line 1 located along the road, which carries power from the San Miguel Substation to the CORSAIN Substation.

The following equipment will be provided under the Port Reactivation Project in La Unión Province and accommodated in the Power Supply Station.

-Transmission line and Substation (46 kV transmission line. 46 kV outdoor switchgear. 46/4.16 kV 4 MVA transformer)

- Power distributing equipment (4.16 kV, 480 V and 208-120 V switchgear cubicles.

- Distribution transformers (Two 4.16 kV/ 480 V 1 MVA and one 480 V/208 – 120V 0.5 MVA)
- Emergency power generating units (Two 4.16 kV 1 MVA engine generator)

(1) Transmission Line and Substation

Electric power for the port will be fed to the 46 kV outdoor switchgear in the transformer yard of the Power Supply Station through a 46 kV overhead transmission line (650 m) and pole mounted section switches, and afterwards connected to the 46/4.16kV transformer.

The maximum simultaneous power consumption of the La Unión Port is estimated at less than 4 MVA under the port's full operating conditions.

The 46 kV outdoor switchgears will consist of:

- One for SF6 circuit breaker
- One for disconnecting switch
- Three for current transformers
- Three for potential transformers
- Three for lightning arresters

The transformer is features are as follows:

- Location : Outdoor transformer yard of the Power Supply Station
- Type : 3-phase, 60 Hz, ONAN type
- Voltage : 46 / 4.16 KV
- Capacity : 4 MVA
- Number : 1 set

(2) Power Distribution Equipment

The power distribution equipment in the switchgear cubicle room of the Power Supply Station will consist of three switchgear cubicle groups: one 4.16 kV switchgear cubicle and two 480 V and 208-120 V switchgear cubicle groups.

The 4.16 kV switchgear cubicle groups will consist of:

- One for incoming line from 46/4.16 kV transformer
- Two for gantry crane feeders
- One for cargo handling equipment feeder (only space)
- One for cargo handling belt conveyor (only space)
- Two for distribution transformer 4.16/0.48 kV primary lines
- One for distribution transformer 4.16/0. 208-012 kV primary lines
- One for change-over switch for normal/emergency condition
- Two for diesel engine generator line

The 480 V Switchgear cubicle groups will consist of:

- Two for distribution transformers 4.16/0.48 kV secondary line
- One for tie circuit between No. 1 group and No. 2 group
- Five feeders for service outlet

- Four feeders for flood lighting
- Two feeders for reefer outlet
- Two feeders for street lighting
- One feeder for port administration building
- One feeder for Container Freight Station
- Two spare for feeder

The 208-120V Switchgear cubicle groups will consist of:

- One for distribution transformer 4.16/0.208-0.12 kV secondary line
- One feeder for maintenance and repair shop
- One feeder for container gate
- One feeder for cargo gate
- Two spare for feeder

(3) Distribution Transformers

Two 4.16/0.48 kV transformers and one 4.16/0.208-0.12 kV transformers will be provided and accommodated in the transformer room of the Power Supply Station.

The 4.16/0.48 kV transformer will have the following features:

- Location : Transformer room of the Power Supply Station
- Type : 3-phase, 60 Hz, ONAN type
- Voltage : 4.16/0.48 kV
- Capacity : 1 MVA
- Number : 2 sets

The 4.16/0.208-0.12 kV transformer will have the following features:

- Location : Transformer room of the Power Supply Station
- Type : 3-phase, 60 Hz, ONAN type (4 wire for secondary)
- Voltage : 4.16/0.208-0.12 kV
- Number : 1 set

(4) Emergency Power Generating Units

Most of the electrical loads in the container yard and a part of some building loads will be equipped with an emergency power supply. These consist of the loads for gantry cranes, container yard lighting, reefers, main functions of the Port Administration Building, Maintenance and Repair Shop, Container Gate, Cargo Gate, Power Supply Station, etc.

Emergency power will be provided by two diesel generator units, by transferring from the normal power system by means of a transfer swith in case of emergency. The emergency power system will take over the 480 V and 208-120V essential loads and gantry crane loads by means of a programable controller activated by a transfer switch. The system will be complete with an automatic control unit including the start procedure for engine, the fuel and cooling system, voltage and frequency regulation and paralleling controller.

The generator will have the following features:

- Location : Generator room of the Power Supply Station
- Diesel engine : Exposed indoor type, radiator cooling type
- Rating type : Stand-by
- AC generator : 3-phase, 4.16 kV, 60 Hz, brushless type
- Control panel : Self-standing cubicle type
- Daily fuel tank : 2-indoor 1.5 m^3 (6 hours at 100% load)
- Fuel tank : 8 m3 underground type (15 hours at 100% load)

(5) Underground Cables

Power cables are basically designed to be placed in PVC conduits one meter below the ground level. Cable pits will be constructed where bends or major joints of cables occur. The Pits will be constructed by brickworks with reinforced concrete slab covers. Manholes with appropriate spacing will be placed along the line for easy maintenance access.

Underground cables will be of XLPE/PVC copper type for 5 KV and 600V lines, ranging in size from 14 mm^2 (No. 6AWG) to 500 mm^2 (1000 MCM).

From the transformer to the ultimate loads, the voltage drop shall not be over 4.0% under full load conditions. The voltage drop for equipment such as gantry cranes, loaders, conveyors, reefers, etc. shall be kept at maximum 2.0% at the outlet (connection point) of the load.

(6) Power Supply for Water Purification Facility

Because the water purification facility will be located outside the port site, near the water tank, it was planned to use an electric power supply system different to that of the Power Supply Station. This service will consist on a primary 3-phase, 13.2 Kv line, mounted on concrete poles, with a substation with 3 sets of 1-phase 15 Kva, 13.2/0.48 Kv transformers, to feed a 25 HP pump.

(7) Power Supply for Deep Well

Because the deep well will be installed outside the port facilities, and its location will depend on the corresponding survey of deep well it is planned to use an electric power supply system different to that of the Power Supply Station. This service will consist on a primary 3-phase, 13.2 Kv line, mounted on concrete poles, with a substation with 3 sets of 1-phase 25 Kva, 13.2/0.48 Kv transformers, to feed a 40 HP pump. This service, as well as that of the water purification facilities will be connected to the EEO 13.2 Kv electric network in the area.

6.2.4 Area Lighting

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 parkings 10 – 15 lux

(1) Container Terminal and Multipurpose Areas

Lighting with above levels will be provided by light masts. A lighting mast will have a height of 25 m (multipurpose and reefer yard) and 36 m (Container Yard) and will be placed as intervals of approximately by 60 – 100 meters. On each mast a corona with high pressure sodium floodlights (6 x 1000 W) will be installed to give an equal lighting level in the individual parts within the areas. Lighting level uniformity shall be reached on the basis of the following calculation:

E(min) over E(av)> 0.4

The quayside area will be illuminated with light fixtures mounted on the cranes to present a local level of 100 lux within the operational area of the cranes. In the non productive hours, the illumination of the quayside area will be reduced to 10 – 15 lux.

(2) Maintenance Areas

The maintenance area beside the Maintenance and Repair Shop will be illuminated with Metal Halide lamps (400 W) on light poles of 12 meters high.

(3) Access Roads

The access roads and parking areas around the Port Administration Building will be illuminated with high pressure sodium lamps (250 W) on light poles of 12 meters high. The entrance gates will have an illumination level of 25 – 40 lux.

(4) Other Lighting

Around the Container Freight Station and Maintenance and Repair Shop, lighting will be provided by high pressure sodium fixtures mounted on the wall or on the roof.

6.2.5 Various Systems

(1) Fire Alarm System

Fire alarm systems will be installed with control panels, fire detectors, break-glass push buttons, slow whoops and cabling systems in various buildings. A main control panel will be installed in the Port Administration Building. Alarm functions will also be separately collected in the fire brigade area. In office buildings the installations will be of the "built in" type and in sheds the installations shall be of the "built up" type. Near the light mast, call points on the site will be located if needed. Fire detectors will not cover more than 1000 m^2 per group with a maximum of 30 individual fire detectors. Break glass bush buttons will not cover more than 10 points in one group. The groups shall cover only one floor, except staircases in the buildings.

(2) Grounding

The grounding system will consist of ground electrodes, connectors and copper conductors. For neutral grounding of transformers, at least two electrodes will be used for each unit. Protective grounding of high and low voltage systems with copper conductors and locally to drive in electrodes in ground or soil will be part of the system.

The generator units shall be connected to ground at the star point. The transformers (triangle star type) shall be connected to ground via a secondary star point.

(3) Lightning Protection

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

6.2.6 Telephone/Data Network

Communication systems on land will connect the port with the national telecom network for adequate operation of the Port. The telephone company will extent the systems in the La Unión port region by the completion year to meet the requirements of the Port.

(1) Telephone and Data System

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

The computer network belonging to the container operation system will be linked with active components to the network. These requirements will be incorporated in the design of the data system including active components.

The telephone exchange will include facilities for security and back-up. Cabling will follow underground routes in conduits.

(2) Mobile Phones

For the port's operating activities, 20 mobile phones shall be integrated in the telephone system for daily use by operators. In further development, the number of mobile phones will be extended.

(3) VHF-System

A VHF-system connecting by aerial transmission the Port with the shops shall give radio link to the vessels. Empty conduits will be installed between the antenna and the navigation control room.

6.3 Water Supply System

6.3.1 Existing Water Supply System

(1) Water Production and Distribution

Water supply in El Salvador is controlled and operated by the "Administración Nacional de Acueductos y Alcantarillados (ANDA)", which is a government entity.

Countrywide ANDA produced 267.27 million m^3 of water of which 10.7% or the equivalent of 28.5 million m^3 were produced to serve the population and industry in the Eastern Region of the country.

Particularly in La Unión Province, the current water supply system is split into two; ANDA water supply and supply from private wells by private companies for self consumption. ANDA has 3 water generation systems in La Union City with a total pump capacity of 26 gal/s (98 lit/s) and a water storage capacity of 1050 m^3. This capacity has allowed ANDA to cover the required peak hour demand which in the last five years (1996-2000) has remained constant at about 42 gal/s (159 lit/s) with the average demand remaining also constant at about 18 gal/s (68 lit/s).

ANDA distributes water to the city through a pipe network laid under municipal roads. The biggest water main in the system is an 8" (20.32 cm) cast iron pipe and most of network is made up of 2 1/2" pipes (6.35 cm).

ANDA had planned to start construction of additional deep well with tank with a storage capacity of 2000 m^3, however, this plan was halted due to lack of funds for the project.

(2) Present Condition at Acajutla Port

Regarding water supply for Acajutla Port, there are 2 wells in the Acajutla Port with a capacity of 13.3 gal/s (3 m^3/min) each. The deepest well is 120 m for the Well No. 1 and 100 m for the Well No. 2. Water is being pumped from the well, chlorinated and then stored in two metal tanks with a capacity of 190 m^3 each located near the wells. Then, water is distributed to the port area for the use of buildings/vessels and for firefighting. The water main pipes in the port area are made of cast iron with a diameter of 6" and 8" (15.24 cm and 20.32 cm) and secondary pipes are made of PVC or cast iron with a diameter of 1" to 4" (2.54 cm to 10.16 cm). The Well No. 1, however, will be demolished due to its superannuated condition.

CEPA has a plan to construct a new well with a capacity of 13.3 gal/s (3 m^3/min). The construction cost is approximately US$160,000 (excluding TAX), including excavation work, screening work, water pump, water pipe, etc.

(3) Present Condition at La Unión Port Site

There are two wells in the Cutuco area which are administrated by CEPA, one at the area administrated by CORSAIN, and three wells in La Gaviota. The location of wells are shown in Table 6.3.1.

Table 6.3.1 Coordinates of Existing Wells in La Unión Port Area

Well I.D	Latitude	Longitude
Cutuco 1	13° 29'2"	87° 49'48"
Cutuco 2	13° 20'1"	87° 49'45"
CORSAIN	13° 19'22"	87° 49'25"
Gaviota 1	13°18'53"	87° 51'57"
Gaviota 2	13° 24'02"	87° 53'45"
Gaviota 3	13° 14'58"	87° 51'07"

The Cutuco 2, Well is of drilled type and is being used for water distribution to the Cutuco Port. The water surface of the well is at around 12 meters below the ground level. Its water supply capacity was estimated at 15 to 20 gal (38.1 to 50.8 liters) per minute, according to interviews with the port personnel.

The Cutuco 1 Well was used to supply water to a shrimp processing plant located on the east side of the Cutuco Port. However, the plant was closed in 1997. It is reported that this is a shallow well and the capacity is not known.

The CORSAIN Well is a drilled type deep well and is currently used for self consumption. It is equipped with a pump system, which can fill 2 tanks with a total storage capacity of about 2,000 m^3 in 24 to 36 hours. Therefore the well capacity was estimated at between 1.2 and 1.6 m^3/s.

A limited survey was carried out of wells around CEPA grounds in the La Unión Port area to verify the water depth. A well was found in the yard of a private house near the Navy. Local habitants said that the well was closed because the water service from ANDA was introduced around August 2001. The water surface of the well was found at around 17 meters below the ground level. Another well was visited at a location about 100 meters east of this one but the depth could not be checked since it was abandoned and objects have been thrown in the well, preventing measurement.

6.3.2 Design Standard and Code

Planning and design of the water supply facilities were carried out based on the following standards and codes.

- Agua Potable, Agua Envasada, Aguas Residuales Descargadas a Un Cuerpo

Receptor in El Salvador (1997).

6.3.3 Water Demand

The total water demand is studied based on the demand for each building, vessels (Container Vessel and Bulk Vessels) and firefighting. The maximum water demand is 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 as discussed below.

(1) Water Demand for Buildings

The average and maximum water demand per day for each building is calculated as shown in Table 6.3.2.

Table 6.3.2 Water Demand for Buildings

	Area (m^2)	Number of Persons	Water Demand		
			Unit	Average (1)	Maximum (1) x 1.1
			Lit/P	m^3/day	M^3/day
Administration Building	2,500	100 *1 (100)*2	120 (120)	12.0 (12.0)	13.20 (13.20) 26.40
Container Freight Station	2,200	15 (25)*3	120 (120)	1.8 (3.0)	1.98 (3.30) 5.28
Maintenance and Repair Shop	1,200	20	120	2.4	2.64
Power Supply Station	320	3	120	0.36	0.40
Total Demand for Buildings				30.3	34.72

Remarks: *1 This figure was rounded from 92 to 100 persons.
*2 This figure is the average number of visitors to the Administration Building.
*3 This figure is the average number of visitors to the Container Freight Station.

(2) Water Demand for Vessels

The maximum water demand for vessels is estimated on the assumption that a container vessel and a bulk vessel will be moored at the port in the same day. The average water demand of container and bulk vessels is 300 m^3, which is composed of 100 m^3 for drinking water and 200 m^3 for boiler. The maximum water demand should be computed with an additional 10 % to the average water demand according to Design Guideline for Water Supply Facilities in Japan (2000). Therefore, the maximum water demand is calculated at 660 m^3 (2 vessels x 300 m^3 x 1.10) per day.

(3) Water Demand for Firefighting

The water demand for firefighting is estimated considering the water capacity by building, container yard, and vessel. The water demand for indoor and outdoor firefighting system of buildings is calculated at 57.6 m^3 as shown in Table 6.3.3

Table 6.3.3 Water Demand of Buildings for Firefighting

	Drain-pipe Pressure (kg/cm²)	Discharge Volume (lit./min)	Number of Fire Hydrants	Water Volume (m³)	Total Water Volume (m³)
(Indoor)					
Administration Building	1.7	130	6	2.6	15.6
(Outdoor)					
Administration Building	2.5	350	2	7	14
Container Freight Station	2.5	350	2	7	14
Maintenance and Repair Shop	.5	350	1	7	7
Power Supply Station	2.5	350	1	7	7
				Total	57.6

According to NFPA 307 Standards for the Construction and Fire Protection of Marine Terminals, Piers, and Wharves (2000 edition) published by the National Fire Protection Association, the number and location of hydrants and hose connections for wharf and marine terminal yard should not be spaced further than 90 m from each other, nor more than 45 m from the dead-end area. Therefore, it is necessary to supply 28 hydrants in the wharf and container, multi-purpose passenger yard and open storage. The necessary water demand for the area is calculated at 196 m³ as shown in Table 6.3.4.

Table 6.3.4 Firefighting Water Demand Calculation for Wharf Area

	Drain-pipe Pressure (kg/cm²)	Discharge Volume (lit./min)	Number of Fire Hydrants	Water Volume (m³)	Total Water Volume (m³)
Container and Multi-purpose Yards, Passenger Berth, etc	2.5	350	28	7	196

As a result, the total water demand for firefighting is calculated at 253.6 m³.

6.3.4 Sources of Water

Possible sources of water should be evaluated based on field surveys and laboratory tests. Therefore, in order to grasp the exact location and capacity of wells, it is necessary to carry out an exploratory survey.

In El Salvador, the potable water quality is regulated by the Salvadorean Proposed Standard NSO 13.07.01 published in 1997 by the National Council of Science and Technology (Consejo Nacional de Ciencia y Tecnología: CONACYT), which is an adaptation of the Potable Water Guidelines published by the World Health Organization.

According to the information obtained from CEPA, 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. Consequently, the construction of a deep well is excluded from the scope of the La Unión Port Project.

6.3.5 Water Storage and Distribution System

(1) Plan for Water Storage and Distribution System

There are 2 alternative cases for the water storage and distribution system as shown in Figure 6.3.1

The water distribution route to the port area in Case-1 is by way of purification system and water storage tank from well.

The water distribution route to the port area in Case-2 is by way of purification system, water storage tank, pump station and water tower from well.

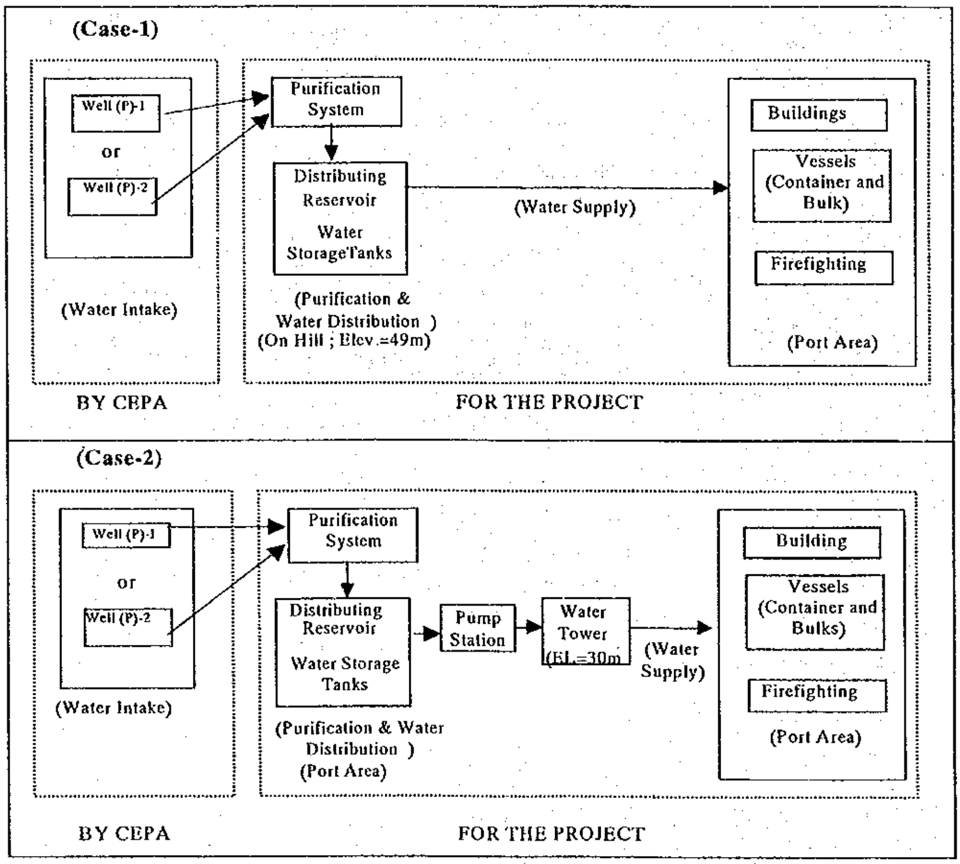


Figure 6.3.1 Alternative Systems for Water Distribution and Storage

The advantage and disadvantage of the two alternative cases for water distribution systems are shown in Table 6.3.5. As a result, Case-1 is selected in consideration of the advantage-disadvantage analysis results of Case-1 over Case-2.

Table 6.3.5 Comparison of Alternative Cases for Water Distribution and Storage

	Advantage	Disadvantage
Case-1	It is possible to secure enough water pressure and head since water tank will be installed at a high place between 47 and 49 m. Therefore the number of water pumps can be minimized. Stable water supply to port is possible because of natural flowing instead of artificial flowing by using pumps. It is not necessary to install water tower. Operation cost is cheaper than Case-2. Maintenance is more easy than Case-2. Sanitary water can be provided.	The length of pipeline out of port area is longer than Case-2. In case of suspension of water supply at main water pipe between reservoir and entrance of port along the general road, it is impossible to ensure stable water supply to the port.
Case-2	It is possible to ensure stable water supply to the port. It is possible to minimize water pipeline.	The structure of water tower is not stable against earthquake. The required number of water pumps and capacity are larger than in Case-1. Construction of a water tower is required for water supply for such purposes as washing, water quality test, etc. The construction cost is higher than Case-1 since water tower will be constructed.

Therefore, two alternative storage capacities and structural types are considered for the storage tanks:

1) Alternatives for storage:
   - Two tanks with the capacity of 500 m^3 each
   - One tank with the full capacity of 1,000 m^3

   The two tanks alternative is chosen since it allows supplying water to the Port with one tank meanwhile the other is under maintenance.

2) Alternatives for structural type of storage tank:
   - Concrete Tank
   - Metal Tank

   The metal tank type is selected since its construction period and their construction cost are less than the concrete one.

(2) Required Water Pressure for Each Facility

The required water pressure for buildings, firefighting and water supply for vessels is calculated as shown in Table 6.3.6. The maximum design water pressure is 3.57 kgf/cm^2 which corresponds to the Port Administration Building since the head lost at the six-story building is highest among the port buildings.

Table 6.3.6 Required Water Pressure

	Water Supply		Number of Floor or Head Lost	Required Water Pressure	
	unit	Total Demand			
	Lit/P	m^3/day		(Mpa)	kgf/cm^2
Water Supply for Buildings					
Administration Bldg	120	24.0	6 Floor	0.35	3.57
Container Fright Station	120	1.8	1 Floor	0.15	1.53
Maintenance and Repair Shop	120	2.4	1 Floor	0.15	1.53
Power Supply Station	120	0.7	1 Floor	0.15	1.53
Fuel Station	120	0.7	1 Floor	0.15	1.53
Water Supply for Firefighting (Each Hydrant)					
Administration Bldg (Indoor)	-	2.6	6 Floor	0.17	1.73
Administration Bldg (Outdoor)	-	7.0	-	0.25	2.55
Container Freight Station (Outdoor)	-	7.0	-	0.25	2.55
Maintenance and Repair Shop (Outdoor)	-	7.0	-	0.25	2.55
Power Supply Station (Outdoor)	-	7.0	-	0.25	2.55
Container Yard (Outdoor)		7.0	-	0.25	2.55
Water Supply for Vessel					
Container Vessel	-	330	10 m	0.25	2.55
Bulk Vessel	-	330	10 m	0.25	2.55

6.3.6 Design Condition

(1) Case of Water Supply

Two alternative cases of water supply are applied as follows. The diameter and layout of pipeline is calculated according to the result of discharge and effective head.

Case-1: Normal Condition

Water Delivery: Hourly maximum consumption

Water Supply: Daily maximum consumption

Case-2: Abnormal Condition (in case of fire)

Water Delivery: Daily maximum consumption + water for firefighting

Water Supply: Daily maximum consumption

(2) Water Level of Reservoir (Water Storage Tank)

L.W.L. is applied as the reservoir water level.

(3) Ground Level

The ground level is assumed to be the developed ground level at panel points of the water pipeline.

(4) Velocity Within Pipe

The maximum velocity within pipe is assumed to be 3 m/s.

(5) Effective Head

The effective head is assumed to be between 15 m and 75 m.

(6) Piezometric Head

The piezometric head is assumed to be less than 80‰.

(7) Calculation Model

The calculation model is prepared using the Hazen Williams formula. The formula is defined as follows.

$$H=10.666 \times C^{-1.85} \times D^{-4.87} \times Q^{1.85} \times L$$

Where;

- H: Loss head (m)
- C: Velocity coefficient: 110
- D: Diameter of pipeline (m)
- Q: Discharge (m^3/s)
- L: Length of pipe between panel points (m)

6.3.7 Result of Calculation

(1) Diameter of Pipeline

The diameter of the main pipeline inside and outside the port area is calculated to be 150 mm and 300 mm respectively according to the calculation of pipeline network. The main pipe outside the port means the section from the reservoir to a diverging point in the port. The diameters of the pipes are summarized in Table 6.3.7.

Table 6.3.7 Diameters of Pipes

Water Supply for Building	Necessary Diameter (mm)
Administration Building.	75
Container Freght Station	38
Maintenance and Repair Shop	38
Power Supply Station	38
Fuel Station	38
Water Supply for Firefighting	
Administration Bldg. (Indoor)	150
Administration Bldg. (Outdoor)	150
Container Freight Station (Outdoor)	150
Maintenance and Repair Shop (Outdoor)	150
Power Supply Station (Outdoor)	150
Container Yard (Outdoor)	150
Water Supply for Vessels	
Container Vessel	150
Bulk Vessel	150
Main Water Pipeline in Port Area	150
Main Water Pipeline out of Port Area	300

(2) Location and Depth for Laying Water Pipelines Underground

1) In order to prevent damage to and by various pipelines under the ground such as telephone line and electric line, the water pipeline should be installed at minimum intervals of 0.3 m from other pipelines.
2) In order to prevent possible lifting movement by pressure and damage of pipeline by traffic, a minimum overburden should be secured as shown in Table 6.3.8.

Table 6.3.8 Minimum Overburden for Water Pipes

Location of Pipe	Minimum Overburden	Remarks
Public Road (Roadway)	More than 1.2 m	-
Public Road (Sidewalk)	More than 0.9 m	-
Private Road	More than 0.75 m	At places with heavy traffic, a minimum overburden of more than 1.2 m shall be secured
Land for Building	More than 0.3 m	Generally 0.45 m is applied

(3) Installation of Sluice Valves

Sluice valves will be installed at intervals of 500 m to 1000 m for the main pipeline and 250 m to 500 m for the secondary pipeline. Moreover, they will also be installed at the diverging points of the water pipeline network in order to stop flowing water and to adjust discharge in the pipe.

(4) Installation of Air Valve and Blowoff Valve

Air valves and blowoff valves will be installed at places of undulation such as the water main pipe section between the Water Storage Tanks and the entrance of the port along the main road.

(5) Water Meter

Water meters will be installed on the water pipe lines for buildings and vessels in order to know the exact water volume supplied. In the case of the Acajutla port, CEPA sold water to private companies and vessels at US$ 0.30 and US$ 1.55 per m^3 respectively in 2000.

6.4 Firefighting System

6.4.1 Present System

(1) Present Firefighting System at the Site

The El Salvador Fire Department does not have its own standard and code of practice. The accepted practice is to use the code from the United States of America or any other internationally recognized Fire Code.

The port area will be equipped with firefighting capabilities that will allow immediate response to a fire incident in the port. The equipment should be capable of initiating firefighting before the arrival of the La Unión Fire Brigade. The response time from the La Unión Fire Department to the Port Entrance is about 5 minutes.

The Fire Department of La Unión, through the Ministry of Interior, acquired one new pump truck with a tank capacity of 100 gallons (378.5 liters) in January 2001 and is expecting to receive an additional tank truck with a tank capacity of 8000 gallons (30.28 m^3) in the near future. It is assumed that the equipment reliability is high since the pump truck is new. The truck is not designed to use saline water, however it could be used in extreme emergencies as long as the distance from the pump centroid to the inlet is not more than 10 meters. T he fire hydrants in the City are under normal gravity pressure from the storage tanks since they are located at high places.

The Fire Department of San Miguel City has also acquired a new pump truck similar to La Unión's and its response time to La Unión City is about 45 minutes. The fire brigade consists of 6 person teams that work in three hours shifts.

Regarding the firefighting system for the port, the distribution system for drinking water will also be used for firefighting. The diameter of 150 mm is enough to transport 63 m^3/h for simultaneous use of 3 hydrants (3 x 21 m^3/h).

(2) Firefighting System of Acajutla Port

There are 28 hydrants and 49 valves for firefighting system in the Acajutla Port. The capacity of each hydrant is 40 PSI (2.81kgf/cm^2). The hydrants and valves are connected to the general water supply pipe system in the Acajutla Port. CEPA owns a firefighting truck with tank in the Acajutla Port for use in case of emergency. The hydrants on the pier were installed at intervals of about 45 meters.

The existing fire extinguishers and hydrants are shown in Figures 6.4.1 and 6.4.2.

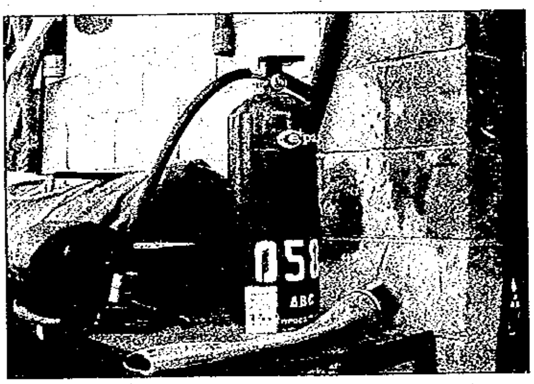


Figure 6.4.1 Fire Extinguisher

Figure 6.4.2 Underground Type Hydrant

6.4.2 Code for Firefighting Facility

Planning and design for the firefighting facilities sare carried out based on the following standard and code.

- NFPA 10 Standards for Portable Fire Extinguishers, (1998 Edition): National Fire Protection Association (USA).

- NFPA 20 Standards for Installation of Stationary Pumps for Fire Protection (1999 Edition); National Fire Protection Association (USA).
- NFPA 22 Standards for Water Tanks for Private Fire Protection (1998 Edition); National Fire Protection Association (USA).
- NFPA 307 Standards for Construction and Fire Protection of Marine Terminals, Piers, and Wharves (2000 Edition); National Fire Protection Association (USA).

6.4.3 Fire Hydrants and Stand-by Hose for Terminal Area

The distribution system with a diameter of 150 mm has a regular pattern of outlets for fire hydrants of 64 mm (2 1/2") according to NFPA307. The entire terminal will be covered with this grid of 80 m – 90 m. The fire hydrants for outdoor structures such as wharf, yard and around building will be installed at 34 points.

Concretely, hydrants will be installed as follows:

- 28 outdoor hydrants for wharf, container/bulk yard and open storage.
- 6 outdoor hydrants for around buildings such as 2 hydrants for the Port Administration Building, 1 hydrant for the Container Freight Station, 1 hydrant for Fuel Station, 1 hydrant for the Maintenance/Repair Shop and 1 hydrant for the Power Supply Station.
- 6 indoor hydrants for the Port Administration Building, one for each floor.

The types of hydrants to be installed will be as follows:

- 28 outdoor hydrants: underground type in order to avoid collision by trailers and loading/unloading equipment (single plug).
- 6 outdoor hydrants: stand type (twin plug).
- 6 indoor hydrants: Box type by manual system (single plug).

6.4.4 Fire Hoses in Buildings

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

6.4.5 Extinguishers and other Firefighting Equipment

Portable extinguishers will be placed inside the buildings, according to the NFPA 10 Standards. In order to support the action of fire hydrants, seven (7) weather-proof, wheeled 125 pounds ABC type extinguishers will be installed in the outdoor structures in the port area: two for the Container Yard, one for the Passenger Terminal, one for the Bulk Yard, one for the Fuel Station, one for the Power Station and the Maintenance and Repair Shop area, and the last one for the Container Freight Station area.

Seven fire station cabinets will be installed strategically in the outdoor structures: two for the Bulk Yard, two for the Container Yard, one for the Passenger Terminal, one for the Power Station area and the last one for the Administration Building area. These cabinets will contain the basic required equipment to operate the hydrants in case of a fire, in accordance with NFPA standards.

For immediate response in case of a large fire in the Port area, a mobile Fire Pump will be provided instead of a fire truck for the Project.

6.5 Wastewater Treatment System

6.5.1 Present Condition of Wastewater Treatment System at Acajutla Port

Regarding the sewerage system in the Acajutla Port, there are 11 septic tanks made of concrete and 1 septic tank made of metal around the building. A concrete pipeline of 6" (15.24 cm) connects the building and the septic tanks. Wastewater is discharged into the sea directly from the septic tanks. There is an oil separator in the maintenance and repair shop, and that facility is connected to the sewerage pipeline.

6.5.2 Design Standard and Code

Planning and design for the wastewater facilities are carried out based on the following standard and code.

- Agua Potable, Agua Envasada, Aguas Residuales Descargadas a un cuerpo Receptor in El Salvador (1997).

6.5.3 Design of Wastewater Treatment System

(1) Wastewater Treatment System for the Project

The wastewater system for buildings will consist of two separated pipelines as follows:

Sanitary Drainage: to dispose of effluents containing bodily waste from water closets and urinals.

Waste Drainage: to dispose of clear wastewater effluents from sinks, showers, floor drains and wash basins.

These two or three drainage pipelines are planned to converge in connecting manholes. Joint wastewater is planned to be collected into a ϕ150 mm main pipe, and then conveyed to wastewater treatment plants.

(2) Design Concept

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.

The discharge volume of wastewater was determined as shown in Table 6.5.1

Table 6.5.1 Wastewater Discharge Volume

	m^3/day	m^3//hr	m^3/min	m^3/s
Daily Average Volume	44.25	1.8437	0.0307	0.000512
Daily Maximum Volume	61.95	2.5812	0.0430	0.000716
Hourly Maximum Volume	106.20	4.425	0.0737	0.001229

The water quality after treatment is determined according to the Salvadoran Environmental Protection Requirement in NSO. 13. 07. 03.01 standards as shown in Table 6.5.2

Table 6.5.2 Planned Water Quality

	Inflow Water Quality (mg/lit.)	Discharged Water Quality (mg/lit.)	Removal Ratio (%)
BOD	200	30*	85

The discharge volume of wastewater from each building is assumed as shown in Tables 6.5.3 and 6.5.4. The Container Freight Station is separated from the main wastewater pipeline since it is necessary to secure a steep slope for pipes due to a quite little discharge volume and longer distance from the CFS to the main pipe.

Two treatment facilities for wastewater will be required: one for the Container Freight Station (Treatment Facility N° 2) and one for the other buildings such as Administration Building, Maintenance and Repair Shop and Power Supply Station (Treatment Facility N° 1). The locations of pipeline and treatment facilities for wastewater are shown in Figure 6.5.1

Table 6.5.3 Planned Discharge Volume of Wastewater for Treatment Facility No. 1

	Area (m^2)	Number of Persons	Wastewater Volume(Daily Average Volume)		Wastewater Volume (Daily Maximum Volume) x 1.4		Max. Wastewater Volume (Hourly Maximum Volume) x 3.0			
			Lit/P	m^3/day	Lit/P	m^3/day	Lit/P	Lit	m3/day	m3/s
1. Administration Bldg.	2,500	112*[1] (100)*[2] 212	150	16.8 (15.0) 31.8	210	23.52 (21.0) 44.52	630.0	70,560 (63,000) 133,560	70.56 (63.0) 133.56	0.00155
2. Maintenance and Repair Shop	1,200	20	150	3.00	210	4.20	630.0	12,600	12.60	0.00015
3. Power Supply Station	320	3	150	0.45	210	0.63	630.0	1,890	1.89	0.00002
Total Demand		235		35.25		49.35			148.05	0.00172

Remarks: *[1]: This figure consists of 100 workers for Administration Building, 6 workers for Container Gate, and 6 workers for Cargo Gate.
*[2]: This figure is the average number of visitors to the Administration Building.

Table 6.5.4 Planned Discharge Volume of Wastewater for Treatment Facility No. 2

	Area (m^2)	Number of Persons	Sewage Volume(Daily Average Volume)		Sewage Volume (Daily Maximum Volume) x 1.4		Max. Sewage Volume (Hourly Maximum Volume) x 3.0			
			unit	Demand	unit	Demand				
			Lit/P	m^3/day	Lit/P	m^3/day	Lit/P	Lit	m3/day	m3/s
1. Container Freight Station	2,200	15 (25)*1	150	2.25 (3.75)	210	3.15 (5.25)	630.0	9,450 (15,750)	9.45 15.75	
Total Demand		40		6.00		8.40		25,200	25.2	0.00029

Remarks: *1: This figure is the average number of visitors to the Container Freight Station.

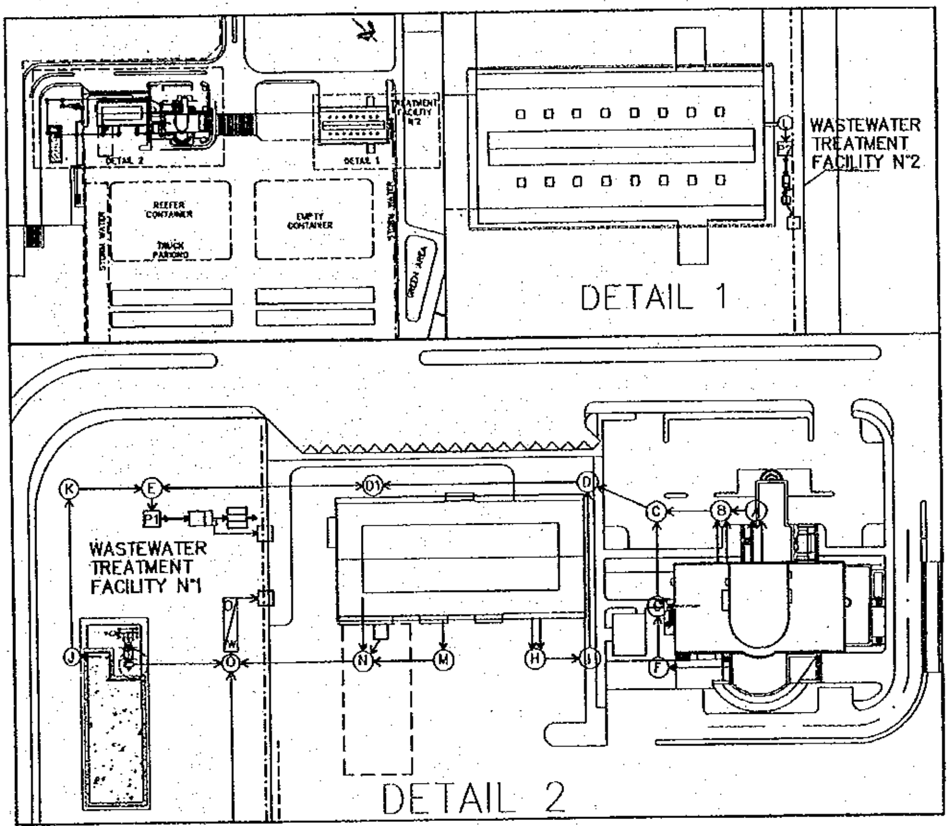


Figure 6.5.1 Location of Wastewater Treatment Facilities

6.5.4 Design Condition

(1) Velocity Within Pipes

The applied maximum and minimum velocities within pipes are 3 m/s and 0.6 m/s respectively.

(2) Diameter of Pipes

The minimum diameter of pipe should be more than 150 mm for the main pipe and feeder pipes for buildings in order to avoid clogging of pipes.

(3) Roughness Coefficient

Concrete Pipe: 0.013, PVC: 0.010

(4) Minimum Overburden

The minimum overburden of 100 cm below surface or thickness of pavement with 30 cm as clearance is applied.

(5) Maximum Interval of Manhole

The interval between manholes should not be more than 50 m.

(6) Calculation Model

The calculation model os applied using the Manning formula as follows:

V= $1/n \times R^{2/3} \times I^{1/2}$
Q= A x V
V= Velocity (m/s)
$^0/_{00}$= Slope
R= A/P
A= Section area for flowing (m^2)
P= Wetted perimeter (m)
Q= Discharge (m^3/s)
N= Roughness coefficient

6.5.5 Result of Calculation

The diameter of main pipes and feeder pipes is calculated as 150 mm. The material of pipe is determined to be PVC (VU) in consideration of the velocity within pipes.

The results of calculation are summarized in Table 6.5.5

Table 6.5.5 Wastewater System Summary
(Administration Building, Maintenance and Repair Shop, Power Station)

	Ground Level	Grade (%)	Distance (m)	Material	Roughness Coefficient	Diameter of Pipe (mm)	Velocity (m/s)	Name and Depth of Manhole	
A								A	+1.200
From A to B	+5.537	1.0	7.50	VU	0.01	150	1.120	B	+1.325
From B to C	+5.537	1.0	14.10	VU	0.01	150	1.120	C	+1.572
F								F	+1.200
From F to G	+5.602	1.0	13.16	VU	0.01	150	1.120	G	+1.382
From G to C	+5.592	1.0	20.47	VU	0.01	150	1.120		
From C to D	+5.537	1.0	16.10	VU	0.01	150	1.120	D	1.783
H								H	+1.200
From H to I	+5.602	1.0	12.00	VU	0.01	150	1.120	I	+1.370
From I to D	+5.602	1.0	38.00	VU	0.01	150	1.120		
From D to D-1	+5.637	1.0	47.14	VU	0.01	150	1.120	D-1	+2.404
From D-1 to E	+5.637	1.0	47.14	VU	0.01	150	1.120	E	+2.925
J								J	+1.200
From J to K	+5.857	1.0	36.30	VU	0.01	150	1.120	K	+1.613
From K to E	+5.857	1.0	18.13	VU	0.01	150	1.120		
From E to Pump		1.0							

**Table 6.5.6 Wastewater System Summary
(Container Freight Station)**

	Ground level (m)	Grade (%)	Distance (m)	Material	Roughness Coefficient	Diameter of Pipe (mm)	Velocity (m/s)	Name and Depth of Manhole	
L								L	+1.200
From L to Pump	+5.332	1.0	5.00	VU	0.01	150	1.120		

6.5.6 Wastewater Treatment Facilities

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

This System consists of the following processes:

Preliminary Treatment: raw wastewater from buildings runs through a filtering screen contained in a tank in order to retain coarse materials.

Biological Treatment (Activated Sludge): consists in two processes: aeration process and settlement process.

Aeration Process: the wastewater coming from the preliminary treatment is conducted into the Aeration Tank. In this tank the wastewater is injected with air through fine bubble diffusers in order to create the suitable environment for bacteria to degrade the organic pollutant matter.

Settlement Process: After the aeration process the treated sludge-water mixture is conducted to a Settlement or Clarification Tank. In this tank the water and the activated sludge are separated. This separation is achieved by sludge settlement by gravity to the bottom of the tank. In order to maintain an adequate balance of sludge in the system, a portion of the sludge must be recycled into the aeration tank. The surplus sludge, which does not reenter into the system, must be withdrawn periodically to avoid an excessive accumulation. The surplus sludge is conducted into a digester tank where its stabilization is reassumed to reduce its volume and to facilitate its later disposal.

Disinfection: the clarified and treated water coming from a decanter is conducted into a Chlorination Tank. In this tank pathological bacteria are destroyed.

Sludge Digestion: The surplus sludge from the aeration tank is conducted into a sludge digestion tank or Sludge Digester. In this tank the sludge is injected with air by coarse bubble diffusers. Through this aeration process the sludge becomes thicker and continues to degrade. At every certain period the degraded or stabilized sludge must be removed from the digester based on a sludge dwelling time calculus. The stabilized sludge is odorless and is suitable for disposing into sun drying beds.

6.5.7 Oil/Water Separator

In order to avoid disposing oil waste into the ocean directly, an oil/water Separator should be installed at the Port, in accordance with Salvadoran Environmental Standards.

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

The cleaned water will be disposed into the storm water drainage.

The following criteria are considered in designing the Oil/water Separator:

Storm water will be avoided as much as possible to be derived into the oil/water separator in order to minimize its size.

BMPs (Best Management Practices) are assumed to be applied for the maintenance and repair tasks.

Models proposed by the United States Environmental Protection agency (USEPA) and by the American Petroleum Institute (API) are applied.

A 750 mg/l concentration of the influent is assumed.

The effluent concentration obtained shall be less than 20 mg/l according to Salvadoran Environmental Regulations.