## 1-3 Transportation

### 1-3-1 Roads

In this section, port roads and access roads are considered.

(1) Port roads

Most of the port roads lead right up to the wharves. These roads, laid out within the port area, have been built for the purpose of transporting cargo to and from the wharves. In general, port roads are those roads that link wharves with other wharves and wharves with truck roads outside the port.

Port roads are used not only for transporting port related cargo, but are also used by port workers commuting to their jobs.

(2) Access roads

Access roads that pass near the Manzanillo Metropolitan Zone include national road 200. National road 200 presently runs along Cuyutlan Lagoon from El Colomo to Manzanillo, but in recent years large-sized cars related to the port and industry, and cars passing through the area use the by-pass which connects El Colomo with Tapeixtles. Further, a four-lane highway (Manzanillo ~ Colima ~ Guadalajara) is under construction and will be completed in a few years. After the road is completed, transportation of cargo will be expedited and volume is expected to increase. As most of the cargo except oil handled at the port of Manzanillo is transported to and from inland areas, this highway will become the lifeline of the port of Manzanillo.

Thus, currently the only major access road for the coastal area around Manzanillo and Santiago Bays is national road 200. Considering the plan to develop the port for commercial and touristic purposes, a new by-pass (Tapeixtles ~ Miramar) will be constructed as the future access road. The existing national road will be fully equipped as an inter-regional highway. The route of the new by-pass will be selected considering topography and the increased built-up area of the expanded Manzanillo Metropolitan Zone.

(3) Estimated traffiv volume

1) Forecast method

In order to estimate peak hourly traffic volumes, both business traffic (trucks and related vehicles) and commuter traffic are forecast.

It is assumed that peak hours for business traffic will not coincide with peak hours for commuter traffic, with commuter traffic being concentrated in the morning and evening for durations of one hour. Business traffic in this case is defined as all traffic except commuter traffic.

2) Forecast of business traffic volumes

Table VII-2 indicates the planned annual cargo handling tonnage in the year 2000 for the port and industrial complex and also indicates cargo shares handled by road and rail transport. Estimates for cargo share by mode of transport are:

| Cargo | Transport mode | Share (%) |
|---|---|---|
| Inward | Road | 45 |
| | Railway | 55 |
| Outward | Road | 80 |
| | Railway | 20 |

**Table VII-2 Forecast Traffic Volume by Transport Modes for Land Transport Cargoes in 2000**

(Unit: '000 t)

| Inward | | | Outward | | | Total | | |
|---|---|---|---|---|---|---|---|---|
| Road | Railway | Total | Road | Railway | Total | Road | Railway | Total |
| 354 | 432 | 786 | 1,816 | 480 | 2,296 | 2,170 | 912 | 3,082 |

Planned traffic volume has been estimated using the following equation. This equation is an empirical formula that is used in drawing up master plans for Japanese port projects.

This formula permits a simple forecast of the traffic volumes generated by a port and industrial complex from a macroscopic viewpoint, so it is especially useful for long-term port plans.

$$\text{Planned traffic volume (vehicles/hr)} = z \times \frac{1}{w} \times \frac{\alpha}{12} \times \frac{\beta}{30} \times \frac{1+\delta}{\epsilon} \times \gamma \quad \cdots\cdots\cdots \text{(VII-1)}$$

where, $z$ : Annual cargo volume (ton)

$w$ : Average tonnage/truck

$\alpha$ : Monthly variation (peak month/ordinary month)

$\beta$ : Daily variation (peak day/ordinary day)

$\delta$ : Rate of related vehicles (Related vehicles/all trucks)

$\epsilon$ : Loading rate (loaded trucks/all trucks)

$\gamma$ : Hourly variation (generated traffic volume of peak hour/generated traffic volume of peak day)

It is assumed that by the year 2000, values for $w$, $\alpha$, $\beta$, $\delta$, $\epsilon$, $\gamma$, will be close to values found in Japan, therefore the following values have been employed.

$w = 8$ $\alpha = 1.0$ $\beta = 1.5$

$\delta = 0.5$ $\epsilon = 0.5$ $\gamma = 0.2$

Equivalent passenger car units are assumed as follows:

| | | |
|---|---|---|
| Passenger car | : 1.0 | 50 (%) |
| Bus | : 3.0 | 5 (%) |
| 2-Axle truck class | : 2.0 | 35 (%) |
| Trailer | : 3.0 | 5 (%) |
| 5-Axle (and above), Combination | : 4.0 | 5 (%) |

Traffic volumes that will pass along roads in the port and industrial complex have been ferecast as follows:

| | Transported Cargo Volume ('000 t) | Total Transported Mixed Traffic (vehicles/hr) | Volume per Peak Hour Passenger Car Units (vehicles/hr) |
|---|---|---|---|
| Port Roads | 2,170 | 678 | 1,153 |

3) Forecast of commuter traffic volume

The commuter population in the port area can be broken down as follows:

| | | |
|---|---|---|
| Fishery | : | 1,600 employees |
| Port | : | 4,600 employees |
| Industry | : | 3,500 employees |
| Total | : | 9,700 employees |

Commuter transport modes are assumed as follows:

| Percentage per mode | | Occupancy Rate | Passenger Car Unit |
|---|---|---|---|
| Private Car | 35% | 2.0 person/vehicle | 1.0 |
| Motorcycle | 5% | 1.0 | 0.5 |
| Bus | 60% | 45.0 | 3.0 |

It is assumed that commuter traffic will be concentrated in one hour in the morning and in the evening.

Calculation results are as shown below.

| Commuter Traffic Mixed Traffic (vehicles/hr) | Peak Hour Volume Passenger Car Units (vehicles/hr) |
|---|---|
| 1,156 | 1,164 |

4) Design traffic volume for truck roads

A comparison of results from the traffic volume forecast reveals that commuter traffic volume is a little greater than business traffic volume. Therefore, the peak-hour, one-way commuter traffic volume has been used in setting design traffic volume for access roads, and the business traffic volume has been used in setting design traffic volume for port roads.

(4) Number of lanes

According to design traffic volumes, the number of lanes per side is as follows:

| | |
|---|---|
| Port road | 2 |
| Access road | 2 |

If the four-lane road that is under construction is completed, the demand for the access road will be satisfied in the year 2000. A four-lane port raod will be planned for the year 2000; the central two lanes will be constructed first, and then the other lanes will be constructed after checking traffic conditions. The inter-regional highway connected with the port road will need more capacity than the port road because of the addition of regional traffic other than the traffic from the port road. Alternatively, the construction of a by-pass will be considered so that the inter-regional, non-port traffic will not have to pass by the port.

(5) Typical cross sections

Fig. VII-2 Shows the typical cross section of the main roads.

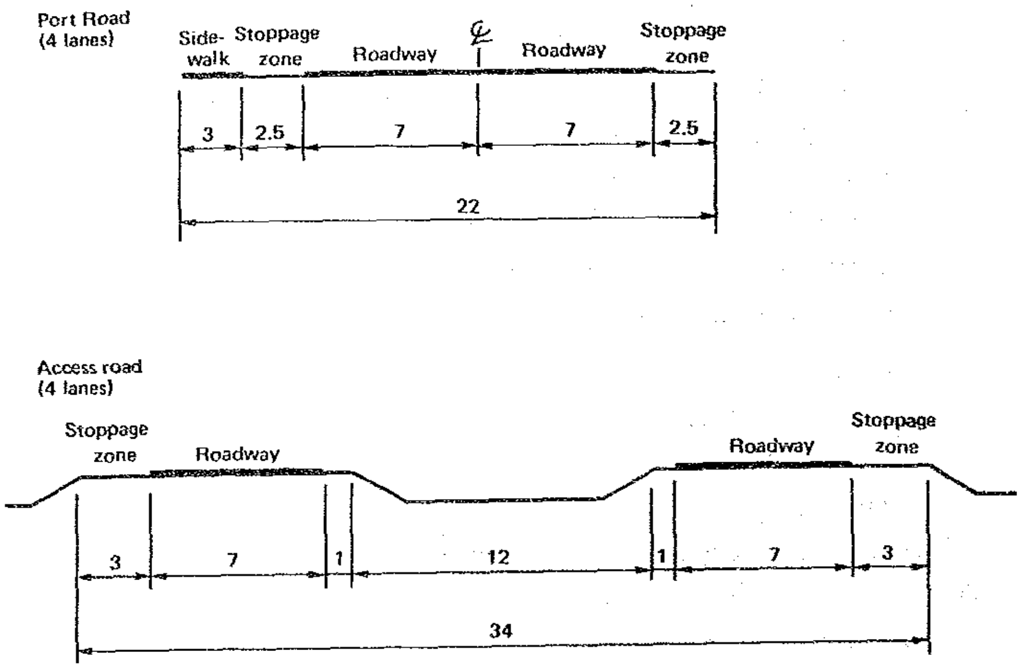



Fig. VII-2 Typical Cross Section of the Main Roads

## 1-3-2 Railways

The capacity of existing railway transportation is about 3,000,000 tons per year and the primary cargo is iron pellets. At present when the iron pellet production increases, the transportation of other cargoes decreases. But in order to increase available railway transportation for port cargo which will increase in conjunction with developing the inner port of Manzanillo, railways need rehabilitating. Track and freight cars for general and container cargo must be improved. In order to avoid transportation confusion in Manzanillo City, the railway within the central zone will be removed and a new route through Cuyutlan ~ El Colomo ~ Tapeixtles to "Peña Colorada" and the inner port and marshalling yard will be established. Further research is needed to decide the new route and marshalling yard scale.

(1) Layout of port railway

The port railway has been planned to run beside the port road in order to provide easy access to the industrial zone located around "Peña Colorada" and at the commercial port and so as not to disrupt the city's living environment. The port railway has been planned to exclusively handle cargoes relating to "Peña Colorada" and the commercial port, and a marshalling yard which will function as the freight station for the port of Manzanillo.

(2) Planned traffic volume for the port railway

Cargoes from "Peña Colorada" and the commercial port are shown below. These volumes can be converted into numbers of trains per day, assuming the following:

① A locomotive can pull 2,000 tons.

② If a loaded wagon weighs a total of 50 tons, its freight will weigh 25 tons.

③ One train is composed of 40 wagons.

The results in terms of the number of trains per day are as follows: 12 trains per day depart from the Manzanillo Port Area, therefore, in both directions, 24 trains operate per day.

| | Cargo Volume ('000 t) | Central Railway Traffic (No. of Trains) |
|---|---|---|
| Peña Colorada | 3,600 | 10 |
| Commercial Port | 480 | 1.3 |
| Total | 4,080 | 11.3 |

### 1-3-3 Fuel Oil Distribution Facility

Presently, the transportation of fuel oil from PEMEX inland is almost all carried out by tank lorries traveling through the city. Tank lorry operation within the city is generally undesirable and should be minimized. It is potentially dangerous as it includes the possiblity of traffic accidents and fires.

The existing commercial port functions in the outer port other than the PEMEX oil facility will be abolished by the year 1990, and the outer port is planned to become a tourist port. Considering that the handling volume of PEMEX will increase in the future, the negative effects on the tourist port and on the city will continue to grow.

It seems that the oil distribution system, that is carrying the oil by tank lorry through the city, has to be reconsidered. Constructing an oil distribution facility at the outskirts of the city might be the best way to resolve this problem.

## 2. Scale of Port Facilities

### 2-1 Planning Concepts

This section describes the general planning concepts in accordance with the overall development policy described in Chapter IV.

(1) Port development to cope with modernization of sea transportation.

1) Development of container terminal

Throughout worldwide sea transportation, the trend is towards increasing containerization of general cargo. As mentioned in Chapter VI, containerization at Manzanillo Port is expected to continually grow in the future. Accordingly, a container terminal which can easily accommodate large full-container vessels and make possible efficient handling of container cargo should be developed.

2) Development of large scale mooring facilities

There is no doubt that sea transport vessels will continue to become bigger and more specialized. This trend is most noticeable in vessels which transport bulk cargoes such as grains, ore, etc. Accordingly, large scale mooring facilities which can accommodate these large, specialized ships should be developed.

(2) Port development to improve traffic flow

Various measures should be taken to improve traffic flow. Increased cargo handling efficiency at the wharf would effect quicker dispatch of vessels. Rationalization of transportation within the port and between the port and the areas behind it is also desirable.

Specialization of wharves would also improve handling efficiency and traffic flow.

(3) Port safety

Hazardous materials are handled at the PEMEX facilities in the outer port. All possible precautions must be taken to prevent accidents in and around the PEMEX facilities.

The inner port is constructed utilizing the San Pedrito Lagoon and consequently portions of the inner port are somewhat narrow. Precautions must be taken to ensure safe passage of vessels and safe cargo handling within the inner port. Accordingly, the harbour facilities are laid out in a manner which will permit safe operation in the inner port.

(4) Port development reserving space for future development

The Master Plan must leave room for further development in the long term. Manzanillo Port is to be the center of regional development. As further expansion of port facilities may be necessary after the year 2000, space should be set aside for future development.

Accordingly, the innermost zone of the inner port is reserved for future growth. In further expansion of the port becomes necessary, this area could be used. Alternatively, the area could also be used for urban growth or for industrial use.

(5) Port development in harmony with the adjacent urban area

As described in Chapter IV, commercial port functions (other than PEMEX) in the outer port will be abolished, and all commercial port functions will be transferred to the inner port. The area adjacent to the outer port will become a nuclear zone of the city of Manzanillo, and the plan to move commercial port functions should prevent any detrimental influence from interfering with urban plans. Thus the outer port should be in harmony with the adjacent urban area.

However, the commercial and fishery port activities in the inner port will have to be controlled so that they do not interfere with the urban areas near the inner port.

## 2-2 Commercial port

### 2-2-1 Premises of the Investigation

(1) Ship size and average handling volume

In planning to build port facilities such as wharves, it is indispensable to accurately determine the size and number of berths required. Since the size of the berths depends on the size of the ships which will call at port, the first thing is to determine the size of ships which will utilize the port in the future.

The future size of ships is usually predicted by considering present ship size, future cargo predictions, and the trend that ships are getting bigger and bigger. Herein, a detailed analysis is made for planning each individual wharf.

The average discharging/loading volume for different types of cargo handled at Manzanillo Port in the last five years, very important data for predictions future ship size, is given in Table VII-3.

(2) Cargo handling capacity in 2000

The future cargo handling capacity of the port of Manzanillo is estimated by analyzing the present situation and the possibility of future improvements such as the introduction of high capacity cargo handling equipment and operation systems for general cargoes, agricultural bulk, mineral bulk and container cargoes.

The actual values and the estimates of cargo handling capacity in the year 2000 are shown in Table VII-4.

## Table VII-3 Average Discharging/Loading Volume at Manzanillo Port

(Unit: t)

| Type of Cargo | 1979 | | | 1980 | | | 1981 | | | 1982 | | | 1983 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number of Ships | Total Dis-charging /Loading Volume | Average Dis-charging /Loading Volume | Number of Ships | Total Dis-charging /Loading Volume | Average Dis-charging /Loading Volume | Number of Ships | Total Dis-charging /Loading Volume | Averag Dis-charging /Loading Volume | Number of Ships | Total Dis-charging /Loading Volume | Average Dis-charging /Loading Volume | Number of Ships | Total Dis-charging /Loading Volumve | Average Dis-charging /Loading Volume |
| (Foreign Trade) | | | | | | | | | | | | | | | |
| General Cargo | 205 | 301,258 | 1,470 | 212 | 503,857 | 2,377 | 189 | 479,948 | 2,539 | 146 | 308,649 | 2,114 | 144 | 255,044 | 1,771 |
| Agricultural Bulk | 27 | 508,259 | 18,824 | 38 | 731,437 | 19,248 | 37 | 730,574 | 19,745 | 10 | 189,861 | 18,986 | 27 | 553,303 | 20,492 |
| Mineral Bulk | 12 | 201,173 | 16,764 | 7 | 104,064 | 14,866 | 9 | 122,917 | 13,657 | 5 | 105,632 | 21,126 | 2 | 42,149 | 21,075 |
| (Domestic Trade) | | | | | | | | | | | | | | | |
| General Cargo | 23 | 49,419 | 2,149 | 48 | 65,967 | 1,374 | 35 | 56,113 | 1,603 | 22 | 43,354 | 1,971 | 16 | 44,239 | 2,765 |
| Mineral Bulk | – | – | – | 9 | 72,701 | 8,078 | 2 | 22,446 | 11,223 | 6 | 81,131 | 13,521 | 11 | 192,268 | 17,479 |
| (Total) | | | | | | | | | | | | | | | |
| General Cargo | 228 | 350,677 | 1,538 | 260 | 569,824 | 2,192 | 224 | 536,061 | 2,393 | 168 | 352,003 | 2,095 | 160 | 299,283 | 1,871 |
| Agricultural Bulk | 27 | 508,259 | 18,824 | 38 | 731,437 | 19,248 | 37 | 730,574 | 19,745 | 10 | 189,861 | 18,986 | 27 | 553,303 | 20,492 |
| Mineral Bulk | 12 | 201,173 | 16,764 | 16 | 176,765 | 11,048 | 11 | 145,363 | 13,215 | 11 | 186,763 | 16,978 | 13 | 234,417 | 18,032 |

Source: DGODP, "Estadísticas del Movimiento Portuario Nacional de Carga y Buques"

**Table VII-4 Cargo Handling Capacity of the Port of Manzanillo**

| Type of Cargo | Item | Actual | 2000 |
|---|---|---|---|
| General Cargo | Average handling performance<br>Working efficiency<br>Working conditions | 77 t/hour·ship<br>0.5<br>2 gangs/ship<br>ship gear | 80 t/hour·ship<br>0.8<br>2 gangs/ship<br>ship gear |
| Container | Average handling performance<br>Working efficiency<br>Working conditions | 12 TEU/hour·ship<br>0.6<br>2 gangs/ship<br>70t truck crane | 50 TEU/hour·ship<br>0.7<br><br>2 container gantry cranes |
| Agricultural Bulk | Average handling performance<br>Working efficiency<br>Working conditions | 150 t/hour·ship<br>0.5<br>ship gear with glove bucket | 320 t/hour·ship<br>0.8<br>2 pneumatic unloaders |
| Mineral Bulk | Average handling performance<br><br>Working efficiency<br>Working conditions | 150 t/hour·ship<br><br>0.4<br>ship gear with glove bucket | 350 t/hour·ship (cement)<br>160 t/hour·ship (others)<br>0.8<br>loading belt conveyor (cement)<br>ship gear with glove bucket (others) |

Note: (1) Actual figures show the 1983 data calculated from "Sistema Estidístico Operacional Indicadores de Rendimiento 1983" (DGODP)

(2) Working efficiency shows the ratio of real operating time to total working time including the waste of time caused by weather conditions, lack of equipment, accidents, etc.

### 2-2-2 Present Port Capacity of Manzanillo Port

In order to determine the required scale of the facilities for future cargo traffic, it is necessary to determine the present port capacity of the Port.

Since port capacity varies according to the type of cargo, size of the lots, size of the berth, method of loading and unloading, and other factors, it is often represented simply as the volume of cargo handled at the port. The present capacity of Manzanillo Port is estimated using the total cargo volume converted into general cargo.

The converted cargo volume is calculated based on the premise that general cargo is 1 and bulk cargo is 0.5.

Some of the data related to the handling of general cargoes is shown below.

① Average discharging/loading capacity per ship .... 77 tons/hour
(Average number of gangs per ship ............. 2 gangs)

② Working efficiency ......................... 0.5

③ Average actual hours worked per day ........... 18 hours

④ Working days per year ....................... 330 days

The 330 days figure is forecast assuming that windy days with a wind velocity of 15m/sec or more account for 5% of the days each year (based on actual statistics), and that rainy or other bad weather days account for another 5%. As cargo cannot be handled under these conditions, the number of days available for using berths is:

365 days x 0.9 = 330 days

⑤ Number of berths at Manzanillo Port ........... 8.67 berths

The 8.67 berths figure comes from the following thinking. As shown in Table III-15, cargoes excluding petroleum and its derivatives are handled at 10 berths. However, three ships can not be moored at the same time at "Muelle Fiscal". Moreover, as "Muelle de Cabotaje", with a water depth of 5.0m ~ 7.0m, can not be approved as a large mooring facility, this berth is counted as 2/3.

Using this data, the annual port capacity for handling general cargo is estimated as follows:

$$77 \times 0.5 \times 18 \times 330 \times 8.67 \fallingdotseq 1{,}983{,}000 \text{ tons}$$

Assuming that the berth occupancy ratio is 100%, the port capacity of Manzanillo Port is estimated as 1,983 thousand tons.

On the other hand, the converted cargo volume in 1983, 1990 and 2000 is estimated as follows:

1983 ............ 692,000 tons
1990 ............ 1,659,000 tons
2000 ............ 2,282,000 tons

This means that the berth occupancy ratio will be:

1983 ............ 34.9%
1990 ............ 83.7%
2000 ............ 115.1%

This shows that the cargo handling volume forecast for 1990 will almost reach the limit of the present facilities capacity of Manzanillo Port.

### 2-2-3 Methods to Determine the Number of Berths

For planning purposes, various methods are used to determine the required number of berths. In this study, the following two methods are used to determine the number of berths for Manzanillo Port:

① Method considering the frequency of ship entry and cargo handling capacity

② Method of simulation by queuing theory

These methods are explained below.

(1) Method using frequency of ship entry and handling capacity

$$\text{Number of berths} = \frac{\text{Total number of mooring days}}{\text{Annual number of workable day} \times \text{Berth occupancy ratio}} \quad \cdots \text{(VII-2)}$$

where, Total number of mooring days:

(Number of calling ships) x (Per ship average days of mooring)

Number of calling ships:

$$\frac{\text{Annual cargo volume handled}}{\text{Average handled cargo volume per ship}}$$

Per-ship average days of mooring:

$$\frac{\text{Average handled cargo volume per ship}}{\text{Average cargo handling capacity per day}} + \begin{array}{l}\text{Number of days necessary for}\\ \text{purposes other than cargo handling}\end{array}$$

Berth occupancy ratio: 0.4 ~ 0.7

(According to the UNCTAD report, the berth occupancy ratio for conventional general cargo operations should be set so as not to exceed the figures given in Table VII-5, which are based on a ratio of ship cost to berth cost of 4 to 1:

**Table VII-5 Berth Occupancy Ratio**

| Number of Berths in the Group | Recommended Maximum Berth Occupancy (%) |
|---|---|
| 1 | 40 |
| 2 | 50 |
| 3 | 55 |
| 4 | 60 |
| 5 | 65 |
| 6 ~ 10 | 70 |

)

(2) Method of simulation by queuing theory

1) Application of queuing theory to port planning

Ships calling at a port expect to be moored at a designated berth immediately, in the order of arrival, and carry out cargo handling. If a ship is already berthed at the quay and there is no room, the latter ship has to wait until after the first ship completes its cargo handling and leaves. (The ship expects to be berthed as soon as it enters a port. However, the port management body wants to minimize the number of quays in order to increase efficiency, that is to minimize investment. How to balance these conflicting desires, namely, what service level should be set, is important in port planning.)

This phenomenon of ships arriving and leaving a port can be analyzed by queuing theory, as in the analysis of the situation at a bank, where variables include the number of windows and the time each customer takes at the windows. For a port, the variables include the arrival of ships, the number of berths and the berthing time. Great efforts are being exerted to clarify the pattern of ship entries and the berthing time at ports. As to the pattern of ship entries, normally it is a random: Poisson arrivals, namely, entry time intervals are of exponential distribution.

In the pattern of the berthing time by ships as expressed by a histogram, normally there is one peak that is rather on the left side and it often conforms to the Erlung distribution in Phase 2 or Phase 3 (See Fig. VII-3).

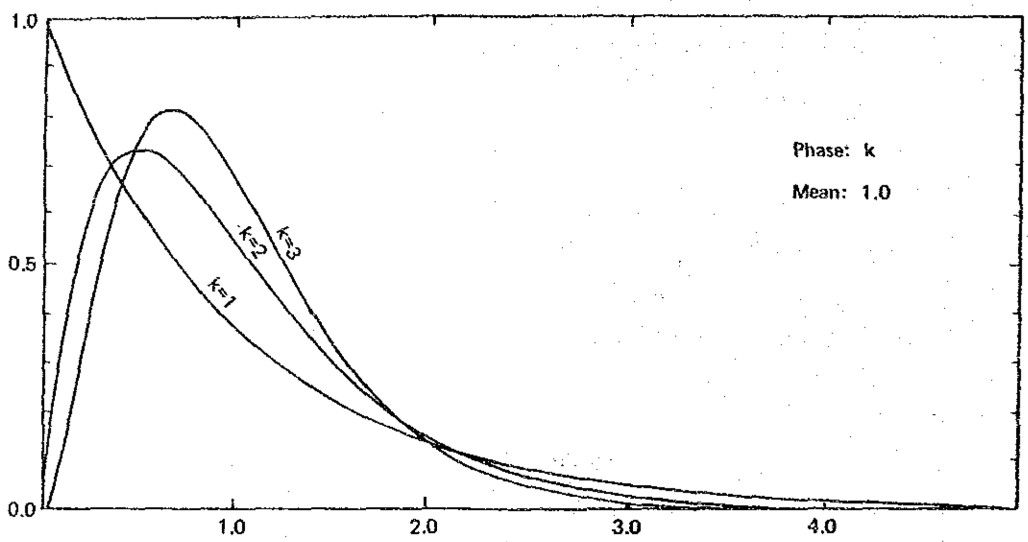



**Fig. VII-3 Erlung Distribution**

As is known already, the following four factors are indispensable to the determination of the queuing phenomenon:

① Distribution of arrivals of ships to be berthed

② Distribution of berthing time

③ Number of berths

④ Methods of service

Factor ④ concerns such matters as service in the order of arrival or preferential service. Normally, service in the order of arrival predominates but, in the case of a container port, preferential service is sometimes given to full-container ships.

2) Methodology of simulation test

Queuing theory has been used to make a projection concerning the situation of ships calling at or leaving a port. However, theoretical analysis alone cannot cope with the complicated reality of port activities. For this reason, a computer is used to follow the movement of ships, i.e. entering/berthing, loading/unloading and leaving.

The flow of the simulation model used in this study is shown in Fig. VII-4.

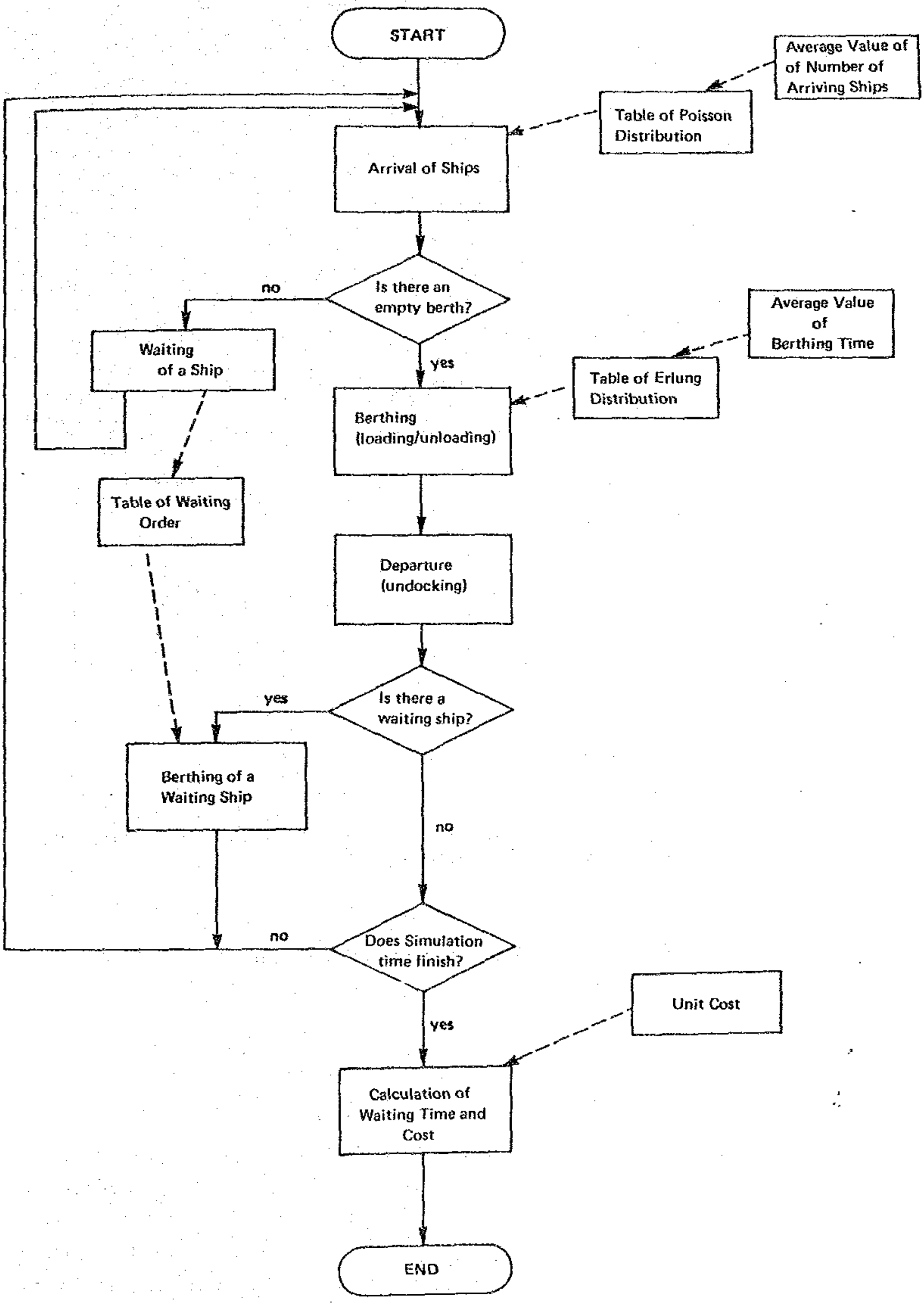
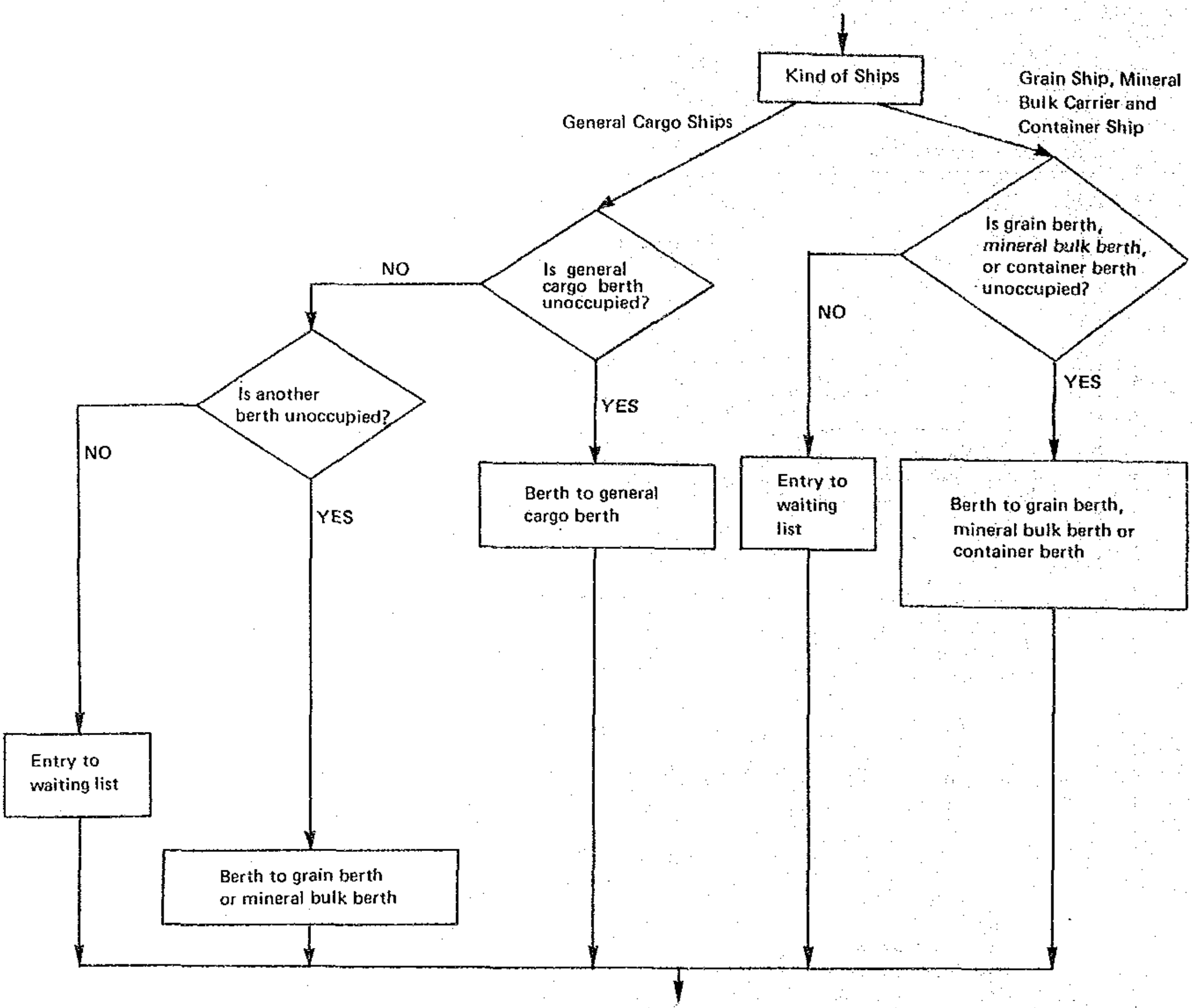



Fig. VII-4 (a) Flow Chart of the Simulation Model




Note: Container vessels, grain carriers, and mineral bulk carriers can only be berthed at the berth allocated for each type of cargo. General cargo carriers can berth at any berth.

**Fig. VII-4 (b) Flow Chart of Ship's Arrival**

In general, input data are comprised of ship types, number of berths, frequency distribution of calling ships, and frequency distribution of mooring time. Output data are comprised of the number of waiting ships, their waiting time and berth occupancy.

3) Basic conditions of simulation tests

Basic conditions of simulation tests are shown bellow.

① Per-ship cargo volume and the number of ships are assumed from actual results.

② As indicated in Fig. VII-5, a Phase 2 Erlung distribution applies well to the berthing time of general cargo ships. This distribution is used for other ship types, too.

③ From the present situation of ship entry, 10% of the total number of vessels can enter the port at nighttime.

④ Simulation tests are performed for both the Master Plan and the Short-term Development Plan.

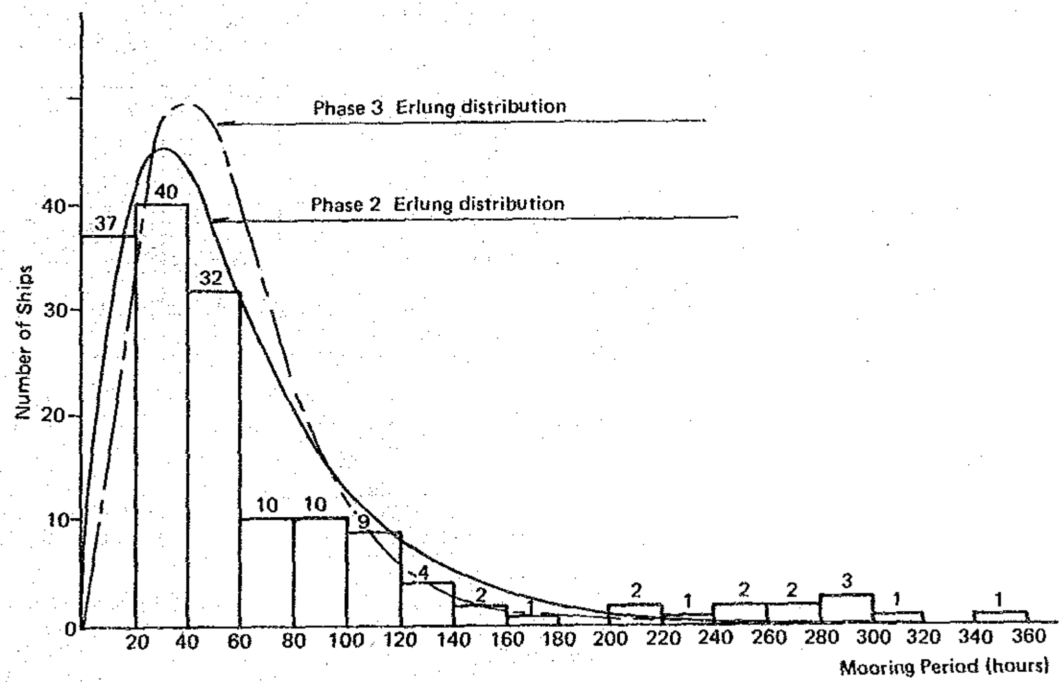



**Fig. VII-5 Relation between Mooring Period and Number of Ships (General Cargo Carriers, 1983)**

(3) Procedure for determining the number of berths

Fig. VII-6 shows the procedure for determining the number of berths using the two methods employed in this study.

First, the number of berths required for the target year is estimated by type of cargo by the method using the frequency of ship entry and handling capacity.

Next, the simulation test is conducted for the overall plan.

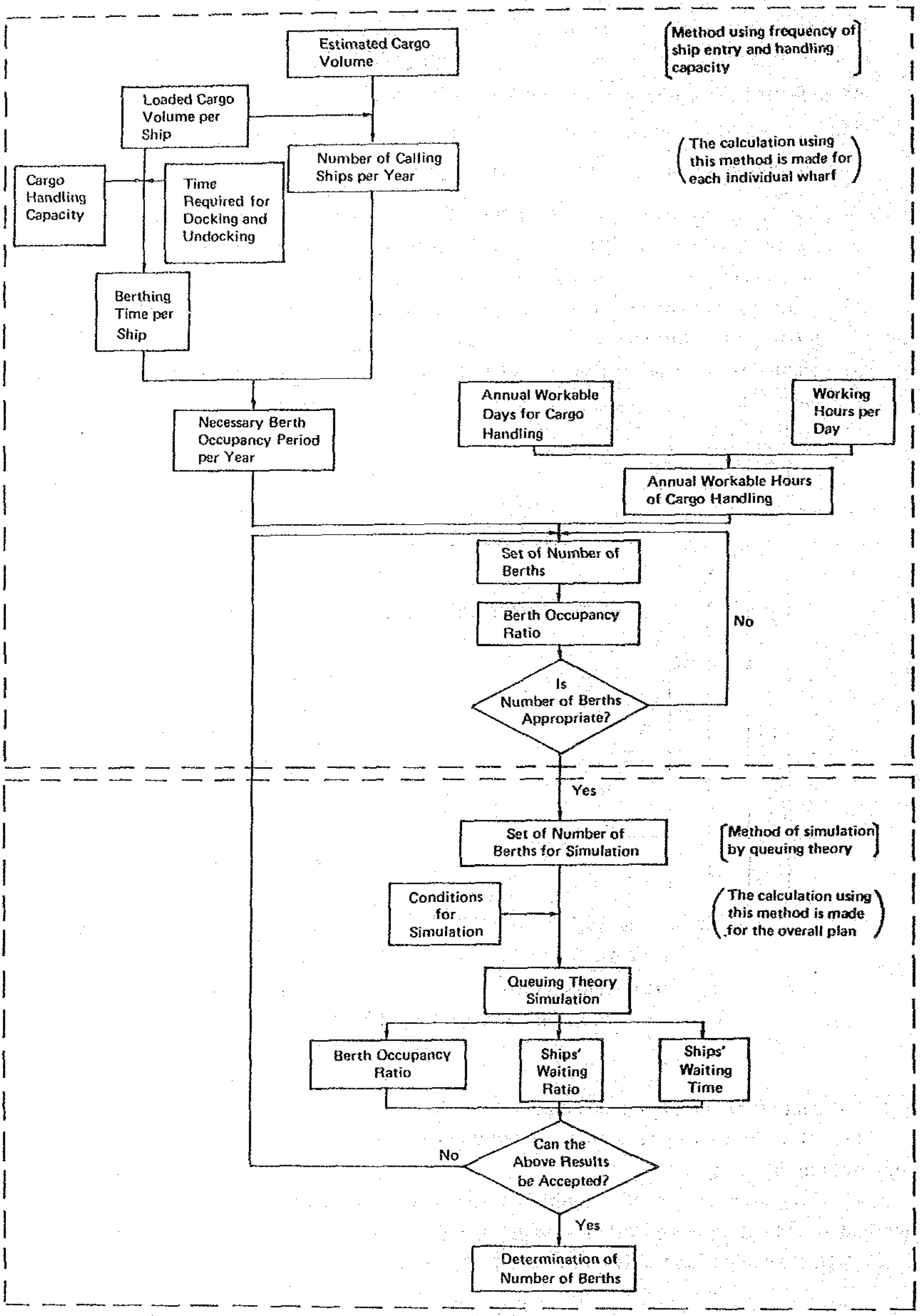



**Fig. VII-6 Flow Chart for Determining Number of Berths**

### 2-2-4 General Cargo Wharf (Foreign Trade)

(1) Determination of ship and berth size

1) Present ship size

According to the data of DGODP, among the general cargo ships calling at Manzanillo Port from January to August, 1984, the maximum ship size was about 25,000 DWT, as shown in Table VII-6.

**Table VII-6 Size of General Cargo Ships**

| Item | Gross Tonnage (G/T) | Dead Weight Tonnage (DWT) |
|---|---|---|
| No. 1 | 16,664.57 | 24,442 |
| No. 2 | 16,149.9 | 23,720 |
| No. 3 | 16,087.25 | 22,241 |

Note: Data are from January to August, 1984.
Source: DGODP

On the other hand, the size of liner ships transporting general cargo which call at Manzanillo Port is shown in Table VII-7.

So, the maximum ship size of liner ships calling at Manzanillo Port is 16,000 ~ 17,000 DWT.

**Table VII-7 Liner Ships Calling at Manzanillo Port**

| Company | Frequency | Ship Size | |
|---|---|---|---|
| | | DWT | Ship Length (m) |
| Kawasaki Kisen Kaisha | Once a month | 16,000 | 156 |
| Navicana, S.A. | Once a month | 12,000 | 160 |
| Nippon Yusen Kaisha | Once a month | 14,000 | 157 |
| Nedlloyd Line | Once a month | 12,000 | 160 |
| Japan Line | Once in 4 months | 16,000 | 165 |
| Mitsui OSK Line | Once a month | 14,000 | 150 |
| Float Mercante Gran Colombiana | Once a month | 12,000 | 160 |
| TMM | 7 times/month | 17,000 | 178 |

Source: DGODP

2) Determination of ship and berth size for the Plan

The majority of ships transporting general cargo in the world are of the 15,000 to 20,000 DWT class. The nature of transport cargo being what it is, rapid emergence of inordinately large ships is unthinkable. Under these circumstances, 20,000 DWT class conventional ships, mainly regular liners, and 30,000 DWT class special carriers like multipurpose ships, will be the ships which the general cargo wharf at Manzanillo Port will accommodate.

The dimensions of the proposed general cargo berths are shown in Table VII-8.

**Table VII-8 Dimensions of Proposed General Cargo Berths**

| Kind of Berth | Ship Size (DWT) | Size of Berths | |
|---|---|---|---|
| | | Length (m) | Water Depth (m) |
| General cargo berths | | | |
| For conventional ships | 20,000 | 200 | 11.0 |
| For special carriers | 30,000 | 250 | 12.0 |

(2) Required number of berths

For calculating by the method considering the frequency of ship entry and handling capacity, the following conditions are assumed:

① The volume of foreign trade general cargoes handled in 2000 excluding containerized cargoes is 926 thousand tons.

② The average cargo handling capacity per ship is 80 tons/hour·ship. A working efficiency of 0.8 is presumed considering unaboidable waste of time.
The 80 tons/hour·ship figure is assumed based on the actual handling volume of 77 tons/hour·ship in 1983.

③ For general cargo, the average per ship discharging/loading volume is 2,500 tons.
The 2,500 tons per ship discharging/loading volume is forecast based on the actual data from the last five years, as shown in Table VII-3.

④ The number of days available for using berths is 330 days per year. The number of hours that cargo is handled per day is assumed to remain 18 hours per day as at present.

⑤ Days necessary for purposes other than cargo handling are presumed to be 0.5 days per ship.

Based on the above assumptions, the necessary number of general cargo berths (for foreign trade) in 2000 is determined as follows:

$$\text{Number of calling ships} = \frac{926{,}000}{2{,}500} \fallingdotseq 370 \text{ ships}$$

$$\text{Per ship average days of mooring} = \frac{2{,}500}{18 \times 80 \times 0.8} + 0.5 \fallingdotseq 2.7 \text{ days}$$

Total number of mooring days = 370 ships x 2.7 days = 999 ship· days

The berth occupancy ratio is calculated by substituting suitable numbers as the number of berths. Table VII-9 shows the results.

Table VII-9 Berth Occupancy Ratio by Number of Berths

| Number of Berths | Berth Occupancy Ratio | Estimate |
|---|---|---|
| 4 | 0.76 | Δ |
| 5 | 0.61 | O |
| 6 | 0.50 | X |

Thus by the method considering frequency of ship entry and handling capacity, the number of berths required as general cargo berths is four or five.

(3) Cargo handling and storage facilities

The size of cargo handling and storage facilities including the storeyard, transit shed, and warehouse must be determined according to the types, volume, and handling conditions of cargoes.

1) Flow of cargo at Manzanillo Port

Table VII-10 shows the movement of general cargo at Manzanillo Port in 1981 and 1982.

Table VII-10 Movement of General Cargo at Manzanillo Port

(Unit: %)

| Type of Cargo | Item | Direct Cargo | | | Indirect Cargo | | |
|---|---|---|---|---|---|---|---|
| | | Railway | Truck | Sub-total | Storeyard | Storage Facilities | Sub-total |
| Broken General Cargo | Export | 5.4 | 8.2 | 13.6 | 22.4 | 64.0 | 86.4 |
| | Import | 8.0 | 12.2 | 20.2 | 8.6 | 71.2 | 79.8 |
| | Total | 7.5 | 11.3 | 18.8 | 11.6 | 69.6 | 81.2 |
| Unitized General Cargo | Export | 0.7 | -- | 0.7 | 1.5 | 97.8 | 99.3 |
| | Import | 42.5 | 41.2 | 83.7 | 1.5 | 14.8 | 16.3 |
| | Total | 40.4 | 38.9 | 79.3 | 1.5 | 19.2 | 20.7 |
| Total | Export | 4.4 | 7.5 | 11.9 | 19.8 | 68.3 | 88.1 |
| | Import | 22.5 | 24.4 | 46.9 | 5.7 | 47.4 | 53.1 |
| | Total | 19.8 | 21.7 | 41.5 | 7.8 | 50.7 | 58.5 |

Source: DGODP

As shown in this table, about 80% of the broken general cargo goes through the storeyard and storage facilities. On the other hand, about 80% of unitized general cargo is directly transported by railway or by truck.

In planning storage facilities at Manzanillo Port for the year 2000, the present situation of cargo flow and cargo handling efficiency must be takn into consideration.

The movement of general cargoes at the Port in the year 2000 is forecast as shown in Table VII-11. The vast majority of scrap iron is handled in the storeyard.

**Table VII-11 Cargo Handling Share at Manzanillo Port in 2000**

(Unit: %)

| Type of Cargo | Item | Direct Cargo | | | Indirect Cargo | | |
|---|---|---|---|---|---|---|---|
| | | Railway | Truck | Sub-total | Storeyard | Storage Facilities | Sub-total |
| General Cargo excluding Scrap Iron | Export | 4 | 6 | 10 | 20 | 70 | 90 |
| | Import | 20 | 20 | 40 | 10 | 50 | 60 |
| Scrap Iron | Import | 10 | – | 10 | 90 | – | 90 |

By using the ratios from Table VII-11, the volumes of cargo passing through the storage facilities and storeyard are estimated as shown in Table VII-12.

**Table VII-12 Volume of Cargoes Passing through Storage Facilities and Storeyard in 2000**

(Unit: '000 t)

| Type of Cargo | Item | Volume of Cargo | Indirect Cargo | | |
|---|---|---|---|---|---|
| | | | Storeyard | Storage Facilities | Sub-total |
| General Cargo excluding Scrap Iron | Export | 146 | 29 | 102 | 131 |
| | Import | 652 | 65 | 326 | 391 |
| | Sub-total | 798 | 94 | 428 | 522 |
| Scrap Iron | Import | 128 | 115 | – | 115 |
| Total | | 926 | 209 | 428 | 637 |

2) Size of the storage facilities

The storage facilities consist of a transit shed and a warehouse. The necessary area of transit sheds is generally determined by the following formula:

$$A = \frac{N}{R\alpha W} \quad \cdots\cdots (VII\text{-}3)$$

where, A : Necessary area of transit shed ($m^2$)

N : Annual volume of cargoes handled

R : Turnover of transit shed: 20 times a year

$\alpha$ : Utilization rate: 0.5

W : Volume of cargoes per unit area: 1.5 tons/$m^2$

For convenience in calculation, we have used the available data for the volume of cargo passing through both the storage facilities as "N" in the above formula. Thus the resultin areas "A" approximates the appropriate area for both the storage facilities.

In the cargo volume of 428,000 tons to be stored, heavy weight cargo like iron and steel is included. This type of cargo will be handled on the heavy weight cargo wharf. So, when planning the size of the storage facilities, this type of cargo has to be separated from the other general cargo.

Assuming that 50% of the cargo volume for iron and steel is handled on the heavy weight cargo wharf and 54% of that volume is stored at the storage facilities on that wharf, the area of the storage facilities for each type of cargo is calculated as follows:

(General cargo excluding heavy weight cargo)

$$A = \frac{343,220}{20 \times 0.5 \times 1.5} \fallingdotseq 22,900 \text{ m}^2$$

As the net area of existing facilities is about 7,500 $m^2$, the net area of storage facilities for general cargo excluding heavy items that has to be newly constructed by the year 2000 is 15,400 $m^2$.

So, the required total area of new storage facilities is estimated as follows:

Required total area = 15,400/0.75 = 20,540 $m^2$

The 0.75 is the rate based on the relation between the net area and total areas of storage facilities. Though the actual rate for this is about 0.6, the 0.75 figure is forecast assuming that more efficient storage facilities will be constructed by the year 2000.

(Heavy weight cargo)

$$A = \frac{157,000 \times 0.54}{20 \times 0.5 \times 1.5} = 5,652 \text{ m}^2$$

Required total area = 5,652/0.75 ≒ 7,540 $m^2$

3) Size of the storeyard

The necessary area of open storage yards is determined by the following formula:

$$A = \frac{N}{R\alpha W} \quad \cdots\cdots \quad \text{(VII-4)}$$

where, A : Necessary area of open storage yards ($m^2$)

N : Annual volume of cargoes handled

R : Turnover of open storage yards: 10 times a year

$\alpha$ : Utilization rate: 0.7

W : Volume of cargoes stacked per unit area: 2.0 tons/$m^2$

For Manzanillo Port, $A = \frac{94,000}{10 \times 0.7 \times 2.0} \fallingdotseq 6,720 \text{ m}^2$

4) Cargo handling equipment

As for the berths for handling general cargo, two systems should be considered: one for handling scrapped iron and one for handling other general cargo. The main commodities of general cargo in 2000 are forecast as follows:

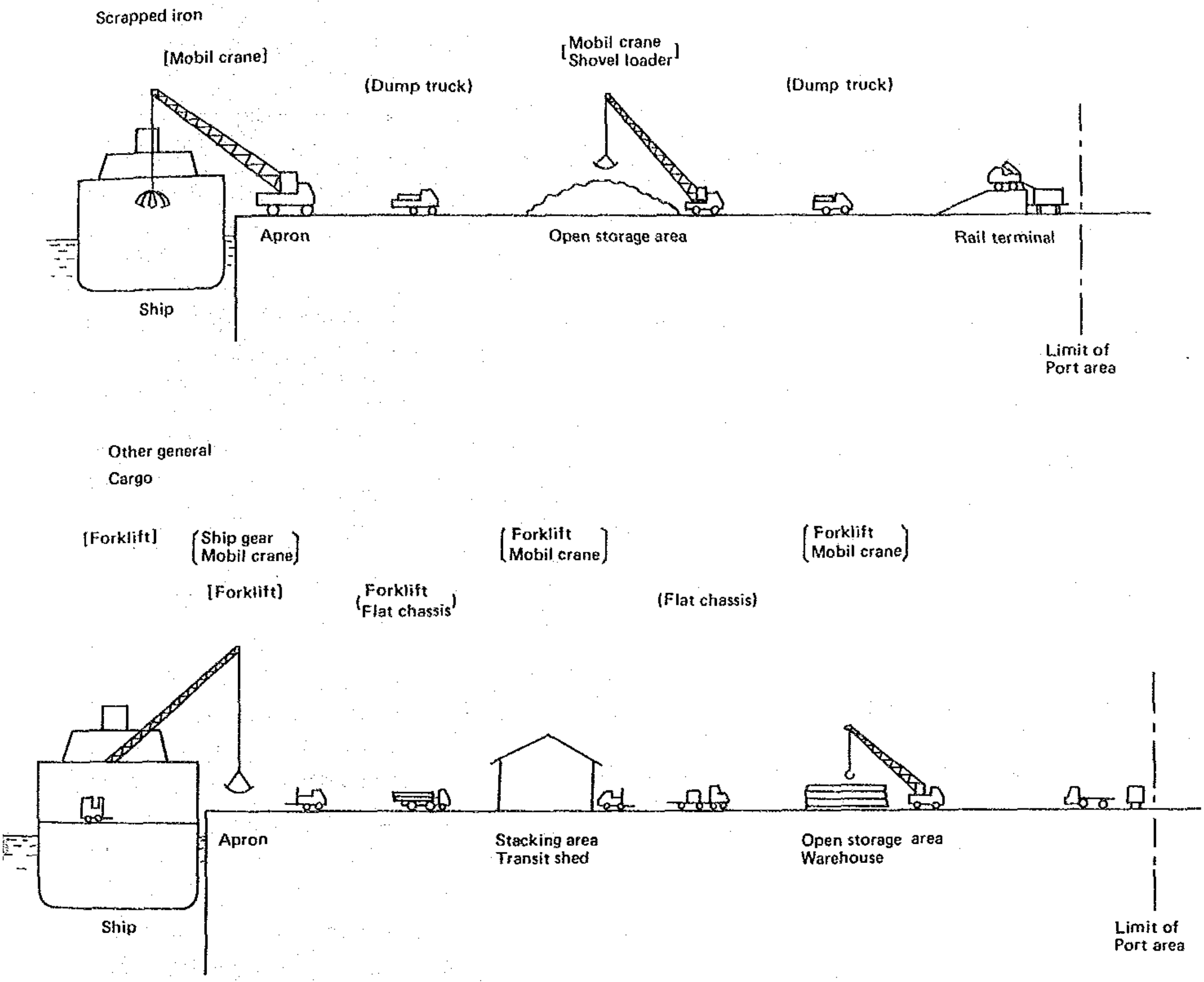
Iron and steel, Sugar, Machinery, Scrapped iron, Steel bars.

Considering the above, large quantities of heavy cargoes will be handled at Manzanillo Port. Cargo handling equipment should be chosen with this in mind.

The throughput of indirect cargo and the handling equipment suitable for each activity are shown in Fig. VII-7. And the following machines in Table VII-13 are required to handle general cargo.

**Table VII-13 Cargo Handling Equipment for General Cargo**

| Equipment | Capaicty | Number of Machines | Remarks |
|---|---|---|---|
| Mobile Crane | 70 t | 2 | For handling heavy cargo |
| 〃 | 15 t | 3 | For handling scrapped iron |
| 〃 | 9 t | 3 | For handling heavy cargo |
| Forklift | 7 t | 20 | |
| 〃 | 3.6 t | 8 | |
| 〃 | 2.7 t | 12 | |
| Tractor | | 6 | |
| Flat Chassis | | 12 | Calculated with a standard capacity of 10 t |
| Dump Truck | 15 t | 5 | For scrapped iron transfer |
| Shovel Loader | 3.5 $m^3$ | 1 | Stacking for scrapped iron |




Mobil crane handles heavy cargo.

Note: [ ] shows charging/discharging and stacking equipment.
( ) shows transfering equipment.

**Fig. VII-7 Throughput of Indirect Cargo and Handling Equipment**

2-2-5 Container Wharf

(1) Determination of ship and berth size

Major vessels capable of loading containers in Mexico are a full-container ship (2,700 G/T, 378 TEU) of Tecomar, S.A., a multi-purpose ship (16,000 G/T, 816 TEU) of TMM and two semicontainer ships (12,600 G/T, 420 TEU), all of which are operating on the American East Coast and European/Mexican routes, as shown in Table VII-14.

**Table VII-14 Present Situation of Holding Ships for Foreign Trade in Mexico**

| Kind of Ships | Number of Ships | Gross Tonnage ('000 G/T) | Dead Weight Tonnage ('000 DWT) | TEU |
|---|---|---|---|---|
| Oil Goods Tanker | 19 | 243 | 394 | – |
| Oil Tanker | 7 | 187 | 310 | – |
| LPG Tanker | 8 | 182 | 226 | – |
| Bulk Carrier | 5 | 128 | 206 | – |
| Multi-Purpose Carrier | 3 | 79 | 143 | 816 |
| General Cargo Carrier | 8 | 56 | 74 | 48 |
| Chemical Goods Tanker | 3 | 41 | 70 | – |
| Conventional Ship | 2 | 25 | 33 | 840 |
| Container Ship | 1 | 3 | 5 | 378 |
| Total | 56 | 944 | 1,461 | 2,082 |

Source: Seatrade Publication, "The Seatrade 1982"

With development of container transport, the worldwide trend is towards larger and faster container vessels. Container vessels of the 50,000 DWT and 3,000 TEU class are beginning service one after another.

The servicing condition of container vessels in Japan is shown in Table VII-15.

Table VII-15 Characteristics of Full-container Ships in Japan

| Name of Ships | Gross Tonnage (G/T) | Dead Weight Tonnage (DWT) | Length of Ship (m) | Maximum Draft of Ship (m) | TEU | Constructed Year |
|---|---|---|---|---|---|---|
| Hakusan Maru | 23,602 | 22,935 | 209 | 10.52 | 1,198 | 1973 |
| Hiei Maru | 23,766 | 24,075 | 212.5 | 10.53 | 1,183 | 1972 |
| Haruna Maru | 16,214 | 19,620 | 187 | 10.52 | 851 | 1968 |
| Hira Maru | 24,794 | 24,344 | 214.6 | 10.52 | 1,072 | 1978 |
| America Maru | 31,854 | 32,207 | 222.5 | 11.61 | 1,676 | 1982 |
| Shin Kashu Maru | 31,012 | 28,615 | 222.5 | 11.00 | 1,450 | 1981 |
| Beishu Maru | 23,668 | 24,191 | 212.5 | 10.52 | 1,183 | 1970 |
| Hikawa Maru | 24,770 | 23,514 | 214.6 | 10.52 | 1,277 | 1974 |
| Hotaka Maru | 21,057 | 20,400 | 196 | 10.52 | 977 | 1970 |
| Kiso Maru | 38,540 | 31,771 | 261.2 | 11.73 | 1,836 | 1972 |
| Yashima Maru | 35,480 | 31,310 | 245.9 | 11.03 | 1,730 | 1976 |
| Australia Maru | 24,044 | 23,304 | 213 | 10.52 | 1,166 | 1969 |

From the global point of view, containerization in Mexico is by no means sufficient, a fact which necessitates the drastic advance of Mexican containerization. Container transport in Manzanillo Port in the year 2000 must be advanced enough to keep pace with maritime transportation throughout the world.

Considering the worldwide trends, we assume a design standard of 40,000 DWT class ships for the container berth. The dimensions of a berth capable of accommodating such vessels are given in Table VII-16.

Table VII-16 Dimensions of Proposed Container Berth

| Kind of Berth | Ship Size (DWT) | Size of Berth | |
|---|---|---|---|
| | | Length (m) | Water Depth (m) |
| Container Berth | 40,000 | 300 | 13.0 |

(2) Required number of berths

For calculating by the method considering the frequency of ship entry and handling capacity, the following conditions are assumed:

① The volume of container cargoes handled in 2000 is 516 thousand tons.

② The per-container cargo volume is 14 tons.

The figure of 14 tons per container is based on actual data at Manzanillo Port in 1983. In that year, 1,650 TEU of container cargo was handled at Manzanillo Port with a total volume of 22,887 tons.

$$\frac{22{,}887\ \text{t}}{1{,}650\ \text{TEU}} \fallingdotseq 14 \text{ tons per standard container}$$

③ Based on the actual results at Lázaro Cárdenas Port, the handling capacity of a container crane is 25 TEU/hour.
The working efficiency is assumed to be 0.7 considering possible time waste in using the container crane and cargo handling by outside vessels.

④ The number of container cranes per berth is 2 cranes.

⑤ It is assumed that the per-ship number of loaded containers that are loaded or unloaded is 300 TEU. The 300 TEU per ship figure is forecast based on the current handling patterns of loaded containers at the port. It is said that an average of 200 to 250 TEU per ship is presently handled at Manzanillo Port. Since the import/export ratio for container cargo in 2000 is 73% for import and 27% for export, the ratio of empty containers to loaded containers is 46%. So, the per-ship number of containers to be handled is forecast as 440 TEU.

⑥ The number of days available for using berths is 330 days per year. The cargo handling hours per day are assumed to be 18 hours.

⑦ Days necessary for purposes other than cargo handling are presumed to be 0.5 days per ship.

Based on the above assumptions, the necessary number of container berths in 2000 is calculated as follows:

$$\text{Total number of containers in 2000} = \frac{516{,}000}{14} \times 1.46 \fallingdotseq 53{,}800 \text{ TEU}$$

$$\text{Number of calling ships} = \frac{53{,}800}{440} \fallingdotseq 123 \text{ ships}$$

$$\text{Per-ship average days of mooring} = \frac{440}{18 \times 25 \times 2 \times 0.7} + 0.5 \fallingdotseq 1.2 \text{ days}$$

$$\text{Total number of mooring days} = 123 \text{ ships} \times 1.2 \text{ days} \fallingdotseq 148 \text{ ship·days}$$

If one berth is used as a container berth, the berth occupancy ratio is 0.45. So, the necessary number of container berths is one.

(3) Size of the container terminal

The container terminal consists of the following facilities other than the quay wall.

① Container yard
② Container freight station
③ Maintenance shop
④ Administration office
⑤ Cargo handling equipment

The size of these facilities varies according to the cargo handling system. There are three major cargo handling systems, that is to say, the chasis system, the straddle carrier system and the transfer crane system. In addition to these systems, some container cargoes are handled by forklifts.

Each system has its own pros and cons. In deciding on one system or the other, it is necessary to make a full study of the land requirements and handling volume at the port.

Considering the size of the yard, ease of maintenance, and efficient operation, the straddle carrier system seems to be the most suitable for Manzanillo Port. Usually the size of the container yard is determined based on the forecast of cargo volume. However, in the case of Manzanillo Port if we base the size of the yard solely on the forecast volume, the yard would be unusually small. Various difficulties could occur from such a small yard, and it might be difficult to expand such a yard in the future. Thus, instead of determining the yard size solely on the basis of forecast cargo volume, we have adopted a standard yard size for the plan. Fig VII-8 shows the layout of the container terminal.

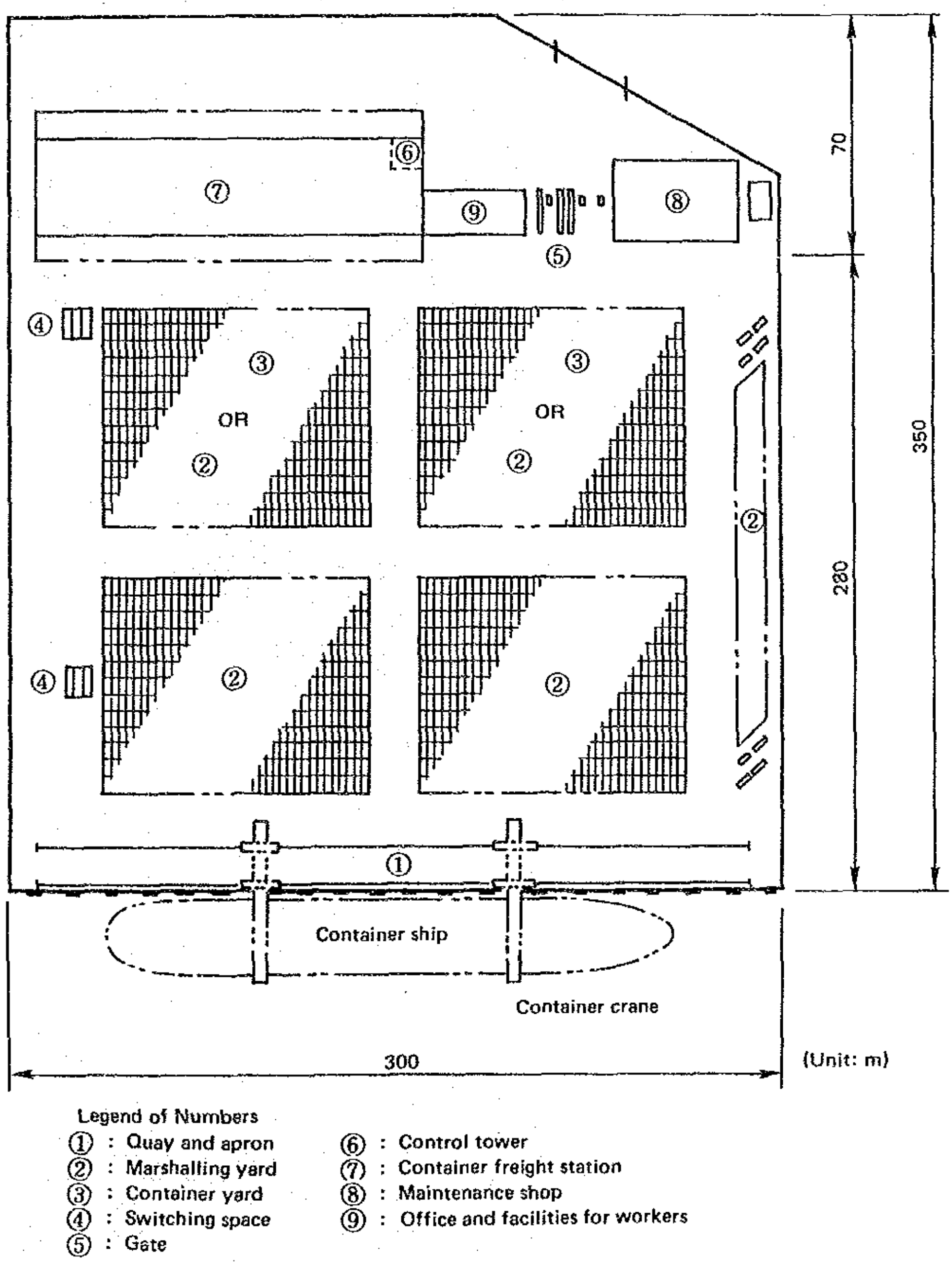



**Fig. VII-8 Layout of Container Terminal**

(4) Cargo handling equipment

The equipment required for handling container cargo is planned based on the experience at Japanese container terminals.

Two gantry cranes will be used, considering the future growth of container volume through the year 2000. Although two cranes may seem to be unnecessary considering the forecast container cargo volume, we believe that two cranes should be used. The timing of the introduction of the second gantry crane will have to be decided after careful analysis of the movement of container cargo in the future.

Table VII-17 and Fig. VII-9 (a), (b) show the required equipment for handling container cargoes.

**Table VII-17 Cargo Handling Equipment for Container Cargo**

| Equipment | Capacity | Number of Machines | Remarks |
|---|---|---|---|
| Gantry Crane | 30.5 t | 2 | Fig. VI-9(a) |
| Straddle Carrier | 30.5 t | 6 | Fig. VI-9(b), 3 units for each gantry crane |
| Forklift | 33 t | 2 | For stacking work |
| 〃 | 7 t | 2 | For handling empty container |
| 〃 | 3.6 t | 2 | 〃 |
| 〃 | 2.7 t | 2 | For vanning/devanning work |
| Chassis | 20' | 3 | |
| 〃 | 40' | 2 | |
| Trailer Head | | 2 | |
| Truck Scale | 50 t | 2 | |

| Specification | |
|---|---|
| Hoisting Load | Hoisting Load 16t<br>Rated Load 30.5t |
| Hoisting Speed | 40/90 m/min |
| Trolley Travel Speed | 125 m/min |
| Gantry Travel Speed | 45 m/min |
| Boom Hoist Speed | 8 min/one way |

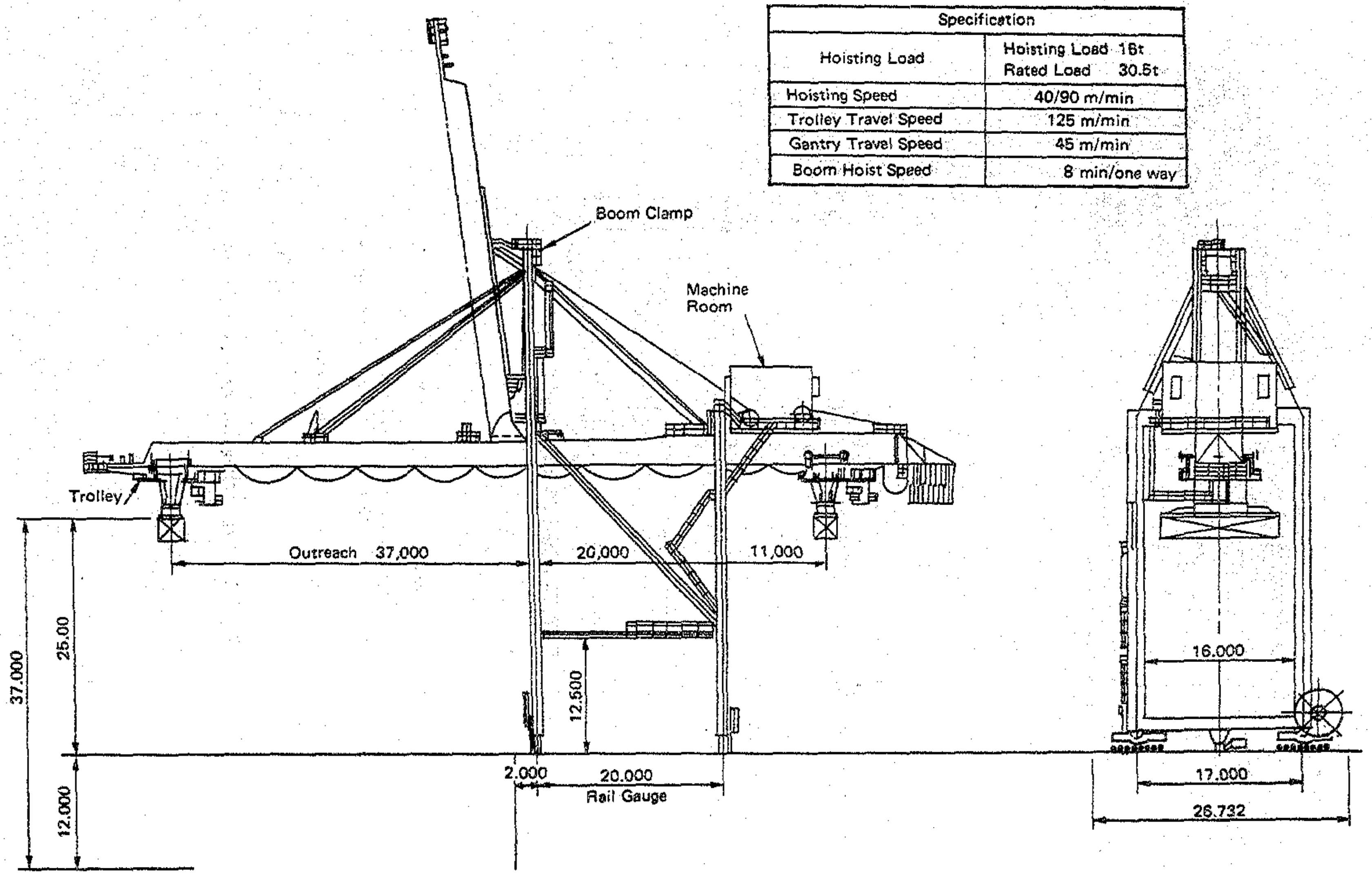



Fig. VII-9(a) Container Gantry Crane

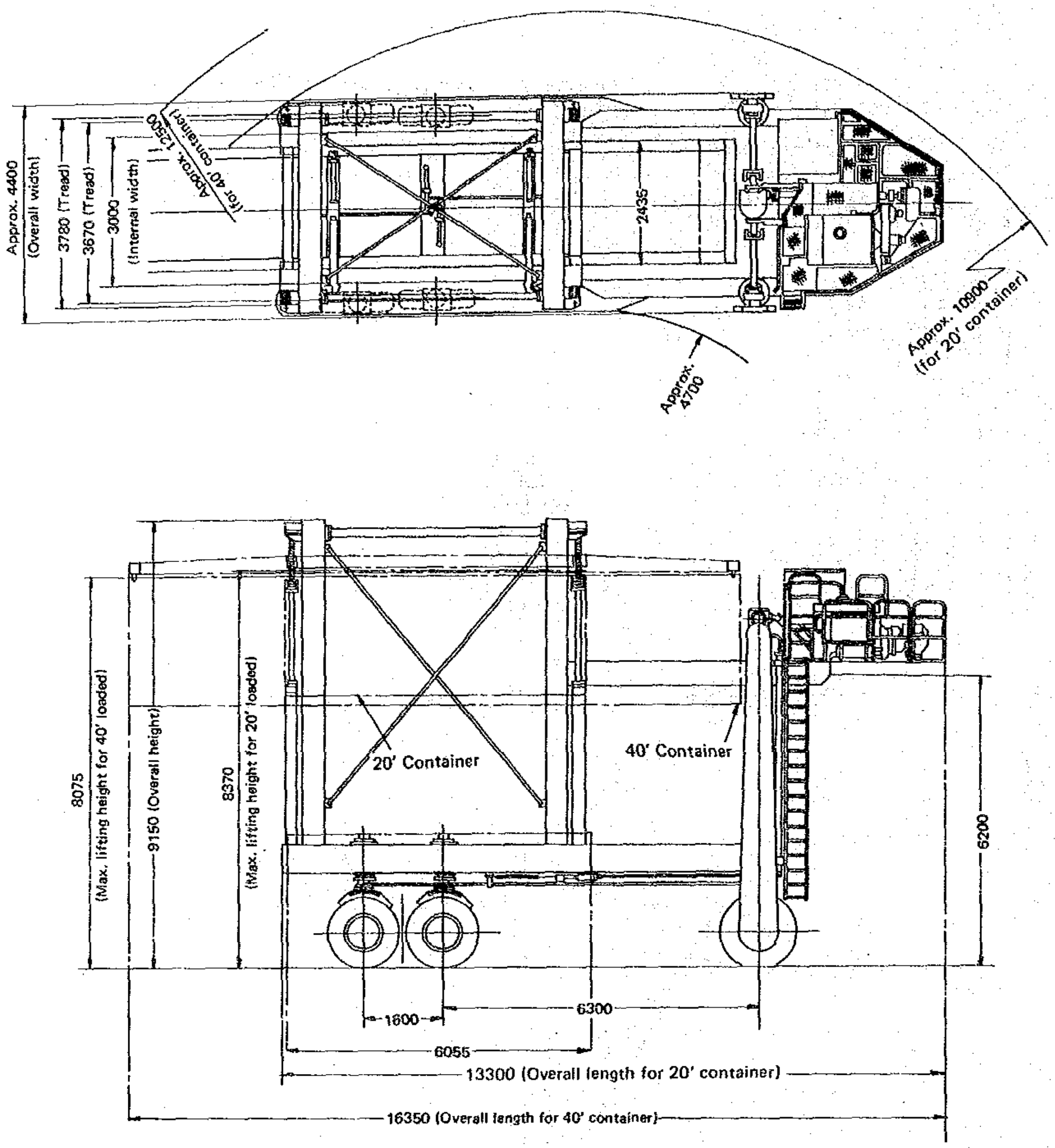



Fig. VII-9(b) Straddle Carrier

## 2-2-6 Grain Wharf

(1) Determination of ship and berth size

As shown in Table VII-3, for ships calling at Manzanillo, the average loading and unloading volume of agricultural bulk cargo is about 20,000 tons per ship.

As the dead weight tonnage of bulk carriers is generally equal to the loading/unloading cargo volume, the size of agricultural bulk carriers is estimated as 20,000 to 25,000 DWT.

As for bulk carriers, the largest ships which entered Manzanillo Port from January to August, 1984, are listed in Table VII-18.

**Table VII-18 Size of Agricultural Bulk Carriers**

| Item | Gross Tonnage (G/T) | Dead Weight Tonnage (DWT) |
|---|---|---|
| No. 1 | 20,276 | 34,607 |
| No. 2 | 17,113 | 33,217 |
| No. 3 | 20,627 | 32,234 |

Source: DGODP

Thus we assume that the majority of grain vessels calling at Manzanillo Port are of the 25,000 to 30,000 DWT class.

So far as general bulk cargo is concerned, it is necessary to increase cargo handling efficiency. As imports increase hereafter, we expect larger and larger vessels to be utilized. Table VII-19 shows the size of grain carriers in the world from 1970 to 1980. Though vessels less than 40,000 DWT still account for more than 50% of all vessels, the share of these smaller vessels is gradually decreasing, a situation which shows that the trend is going toward larger and larger ships as part of the rationalization of transport.

**Table VII-19 World Grain Carriers**

(Unit: %)

| DWT ('000 t) | 1970 | 1975 | 1980 |
|---|---|---|---|
| Less than 40 | 89 | 69 | 52 |
| 40 ~ 60 | 10 | 15 | 20 |
| 60 ~ 80 | 1 | 7 | 17 |
| 80 ~ 100 | – | 2 | 2 |
| More than 100 | – | 7 | 9 |

Source: Cargo Systems Research, Consultancy Division

On the other hand, the specifications of the CONASPO grain wharf which was recently completed at Lázaro Cárdenas Port are as shown in Table VII-20.

Table VII-20 Specifications of CONASPO Grain Wharf at Lázaro Cárdenas Port

| Item | Size of Berths | |
|---|---|---|
| | Length (m) | Water Depth (m) |
| For Foreign Trade | 324 | 14.0 |
| For Domestic Trade | – | 11 ~ 12 |

Although the grain handling facilities at Manzanillo Port need not be as comprehensive as the new major facilities at Lázaro Cárdenas, the facilities at Manzanillo must be able to accommodate the 40,000 DWT vessels which continue to handle much of the world grain traffic.

(2) Required number of berths

For calculating by the method considering the frequency of ship entry and handling capacity, the following conditions are assumed:

① The volume of grain cargoes in 2000 is 705 thousand tons.

② As for grain cargo handling, high efficiency is the most important goal. Present per ship grain cargo handling efficiency is quite low, about 150 tons/hour·ship. If the more efficient equipment were to be used, cargo handling efficiency would increase. Assuming simultaneous use of two pneumatic unloaders per ship, the grain cargo handling capacity in the year 2000 is forecast as 320 tons/hour·ship.

③ The average per ship loading/unloading volume is 21,000 tons. The 21,000 tons per ship figure is based on the trend in the last five years shown in Table VII-3.

④ The berths are available for use 330 days per year. The cargo handling hours per day are assumed to be 18 hours.

⑤ Days necessary for purposes other than cargo handling are presumed to be 1.0 day per ship.

Based on the above assumptions, the necessary number of grain berths in 2000 is calculated as follows:

$$\text{Number of calling ships} = \frac{705{,}000}{21{,}000} \fallingdotseq 34 \text{ ships}$$

$$\text{Per-ship average days of mooring} = \frac{21{,}000}{18 \times 320 \times 0.8} + 1.0 \fallingdotseq 5.6 \text{ days}$$

$$\text{Total number of mooring days} = 34 \text{ ships} \times 5.6 \text{ days} \fallingdotseq 191 \text{ ship days}$$

The berth occupancy ratio by the number of berths is as shown in Table VII-21.

**Table VII-21 Berth Occupancy Ratio by Number of Berths**

| Number of Berths | Berth Occupancy Ratio | Estimate |
|---|---|---|
| 1 | 0.58 | O |
| 2 | 0.29 | X |

According to this method, the number of berths required as grain berths is one.

However, considering that the berth occupancy ratio for one berth is a high value, 0.58, as compared with the standard value of 0.4, for simulation tests, two cases, the case of one berth and the case of two berths, are examined.

(3) Cargo handling and storage facilities

1) Flow of cargo at Manzanillo Port

The destination of 90% of agricultural bulk cargo imported at the port of Manzanillo is within the state of Jalisco, and 95% of this cargo is transported directly from the shoreside by trucks.

However, the arrangement of trucks is not satisfactory, so the discharging efficiency at Manzanillo has been low as compared with other ports. Therefore, storage silos will be included in the Master Plan in order to raise the discharging efficiency.

Considering the nature of the commodities, their handling volume, the distance to the destinations and the interval of calling vessels, half of the total handling volume will be stored in the silo. Almost all of the stored grain will be transported by railway. Thus, the share of inland transport of grain by railway will increase to about 40%.

The movement of grain cargoes at the Port in the year 2000 is forecast as shown in Table VII-22.

**Table VII-22 Movement of Grain in 2000**

(Unit: '000 t)

| Type of Cargo | Total Cargo Volume | Direct Cargo | | | Indirect Cargo | | |
|---|---|---|---|---|---|---|---|
| | | Railway | Truck | Sub-total | Storeyard | Storage Facilities | Sub-total |
| Grain | 705 | – | 355 | 355 | – | 350 | 350 |

2) Size of the grain silos

Assuming that the turnover rate of silos is 10 times per year, the silo capacity required in 2000 is calculated to be 35,000 tons. Assuming 1,700 m$^3$ (diameter 8.0 m, height 40.0 m) as the size of a silo, its storage capacity is 1,250 tons (apparent specific gravity of grain: 0.75 tons/m³). If a system of silos is composed of 28 silos (4 rows x 7 silos), as illustrated in Fig. VII-10, it is possible to secure a total capacity of 35,000 tons (1,250 tons x 28).

Hence, constructing silos of this scale by the year 2000 is proposed. Considering the estimated import volume (705,000 tons) and average discharging volume per ship, it does not seen necessary to introduce a big capacity unloader.

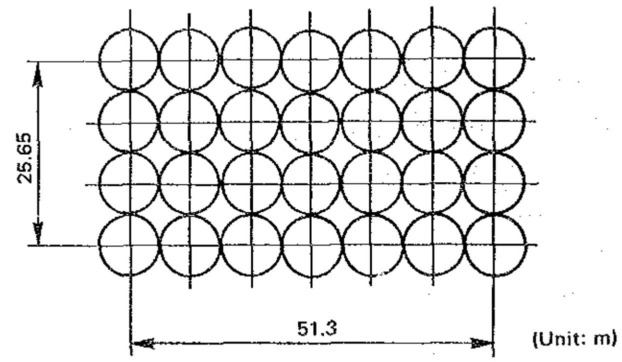



Fig. VII-10 Layout of Silos

Fig. VII-11 shows the flow of grain cargoes in the port area, and Table VII-23 shows the list of handling equipment concerned with the grain cargo handling. Moreover, the flow chart of the grain silo system is shown in Fig. VII-12.

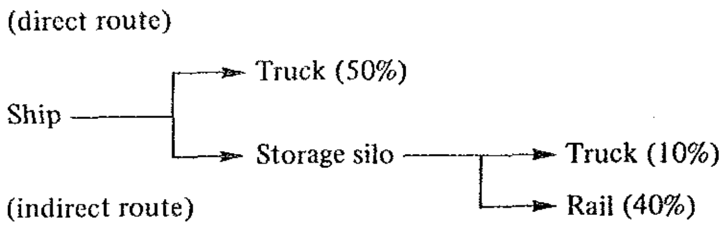
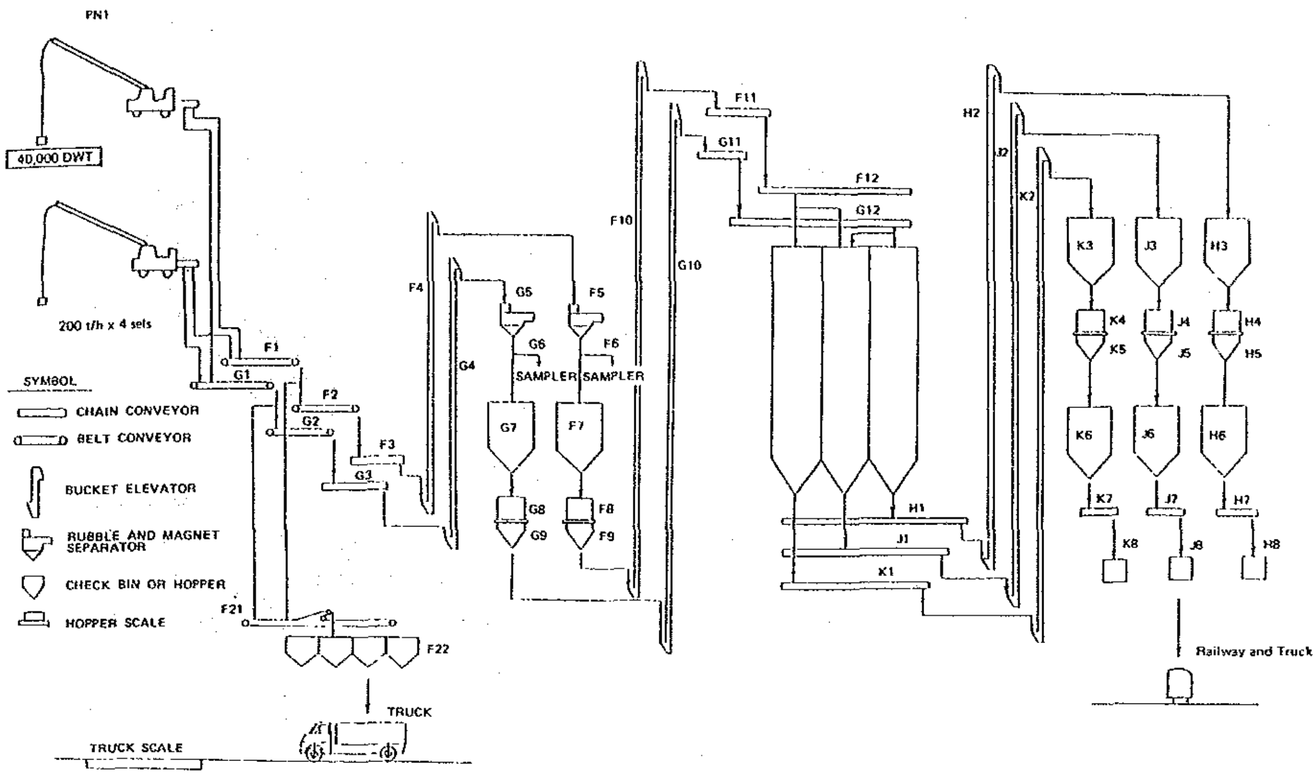



Fig. VII-11 Cargo Flow in the Port Area

**Table VII-23 Handling Equipment for Agricultural Bulk**

| Equipment | Capacity | Number of Machine | Remarks |
|---|---|---|---|
| Pneumatic Unloader | 200 t/hour | 4 | Tire mounted type |
| Belt Conveyor | 440 t/hour | 650m x 2 lines | |
| Chain Conveyor | 440 t/hour | 50m x 2 lines | |
| Hopper | 200 m³ | 3 | For direct loading to trucks |
| Truck Scale | 50 t | 1 | |
| Silo | 35,000 t | 1 set | |
| Tractor | | 2 | For moving pneumatic unloader |
| Mobile Crane | 9 t | 1 | For setting up discharging pipe |
| Payloader | 3.5 m³ | 2 | For use on ships |




Flow Diagram (Machine List)

1) Unloading Flow Diagram

| | | | |
|---|---|---|---|
| Vessel | | Max 40,000 DWT | |
| ↓ | | | |
| Pneumatic Unloader | (PN1, PN2) | 200 t/h x 4 | Travelling type with two nozzles |
| ↓ | | | |
| Belt Conveyor | (F1, G1) | 440 t/h x 2 | |
| ↓ | | | |
| Belt Conveyor | (F2, G2) | 440 t/h x 2 | |
| ↓ | | | |
| Chain Conveyor | (F3, G3) | 440 t/h x 2 | |
| ↓ | | | |
| Bucket Elevator | (F4, G4) | 440 t/h x 2 | bucket elevator tower receiving equipment |
| ↓ | | | |
| Rubble & Magnet Separator | (F5, G5) | | |
| ↓ | | | |
| Sempler | (F6, G6) | | |
| ↓ | | | |
| Check Bin | (F7, G7) | | |
| ↓ | | | |
| Hopper Scale | (F8, G8) | 5 t/batch X 2 | |
| ↓ | | | |
| Hopper | (F9, G9) | | |
| ↓ | | | |
| Bucket Elevator | (F10, G10) | 440 t/h x 2 | |
| ↓ | | | |
| Chain Conveyor | (F11, G11) | 440 t/h x 2 | |
| ↓ | | | |
| Chain Conveyor | (F12, G12) | 440 t/h x 2 | |
| ↓ | | | |
| Chute | | | |
| ↓ | | | |
| Silo | 35,000 t | | |

2) Loading Flow Diagram

| | | | |
|---|---|---|---|
| Silo | | | |
| ↓ | | | |
| Chain Conveyor | $(H_1, J_1, K_1)$ | 150 t/h X 3 | Bucket elevator tower discharge equipment |
| ↓ | | | |
| Bucket elevator | $(H_2, J_2, K_2)$ | 150 t/h X 3 | |
| ↓ | | | |
| Check Bin | $(H_3, J_3, K_3)$ | | |
| ↓ | | | |
| Hopper Scale | $(H_4, J_4, K_4)$ | 1.5 t/batch X 3 | |
| ↓ | | | |
| Hopper | $(H_5, J_5, K_5)$ | | |
| ↓ | | | |
| Chain Conveyor | $(H_6, J_6, K_6)$ | 150 t/h X 3 | |
| ↓ | | | |
| Loader | $(H_7, J_7, K_7)$ | 150 t/h X 3 | |
| ↓ | | | |
| Railway and Truck | | | |

Notes

1. The pneumatic unloader is not provided with truck loading equipment.
2. When loading a truck without being routed through a silo, a truck loading hopper is used for truck loading rather than the $F_1$ or $G_1$ belt conveyor.

| | | |
|---|---|---|
| Belt Conveyor | (F1, G1) | 440 t/h x 2 |
| ↓ | | |
| Belt Conveyor | (F21) | 440 t/h x 2 (with Tripper) |
| ↓ | | |
| Truck Loading Hopper | (F22) | 200 m³ x 3 |
| ↓ | | |
| Truck | | |
| ↓ | | |
| Truck Scale | | |

**Fig. VII-12 Flow Chart of Grain Silo System**

### 2-2-7 Mineral Bulk Wharf

(1) Determination of ship and berth size

As shown in Table VII-3, the average loading and unloading volume of mineral bulk cargo in the last five years 17,500 tons per ship. So, the average mineral bulk carrier is generally in the 20,000 DWT class. As for mineral bulk cargo, as in the case of agricultural bulk cargo, the trend toward bigger ships is expected to affect the port of Manzanillo.

The mineral bulk cargo expected to be handled at Manzanillo Port in the year 2000 is:

| | |
|---|---|
| Cement | 383,000 tons |
| Fertilizer | 220,000 tons |

as described in Chapter VI.

According to corporate sources, exports of cement by 10,000 to 15,000 DWT vessels are being considered. Taking into account the worldwide trend toward larger ships, the bulk cargo wharf at Manzanillo Port should be able to accommodate 20,000 DWT vessels for cement and 40,000 DWT vessels for other mineral bulk cargo. Table VII-24 lists the dimensions of the berths which would be necessary.

Table VII-24 Dimensions of Proposed Mineral Bulk Berths

| Purpose | Ship Size (DWT) | Size of Berths | |
|---|---|---|---|
| | | Length (m) | Water Depth (m) |
| For Cement | 20,000 | 200 | 12.0 |
| For Other Bulk | 40,000 | 300 | 13.0 |

(2) Required number of berths

Considering the quantity of cargo handled, the number of berths at the mineral bulk cargo wharf at Manzanillo Port in the year 2000 is determined as two, one for cement and the other for fertilizer.

(3) Cargo handling and storage facilities

As described before, the commodities of mineral bulk cargo handled at Manzanillo Port are cement and fertilizer, but only cement will pass through storage facilities.

The storage facilities and handling equipment for cement are now being planned by a private cement company. So, the required size of the storage facility and the handling equipment for cement are not considered in this report.

The other mineral bulk will be handled with ship gear and the following equipment directly at shoreside as shown in Table VII-25.

Table VII-25 Cargo Handling Equipment for Mineral Bulk

| Equipment | Capacity | Number of Machines | Remarks |
|---|---|---|---|
| Payloader | 3.5 $m^3$ | 4 | For use in ship's hold; including a reserve |
| Hopper | 50 $m^3$ | 4 | |
| Mobil Crane | 9 t | 2 | For setting hoppers |

### 2-2-8 Domestic Trade Wharf

(1) Determination of ship and berth size

In general domestic trade ships are smaller than foreign trade ships. At Manzanillo Port, the average discharging/loading volume for domestic trade varies depending on the type of cargo. In 1983, the average volume per ship for general cargo was 1,871 tons and for mineral bulk cargo the average volume was 18,032 tons. So, the ship size for which the domestic trade wharf is designed is:

| | |
|---|---|
| General cargo | 10,000 DWT class |
| Mineral bulk cargo | 20,000 DWT class |

(2) Required number of berths

For calculating by the method considering the frequency of ship entry and handling capacity, the following conditions are assumed:

① As for the volume of domestic trade cargoes handled in 2000, general cargo amounts to 39 thousand tons and mineral bulk cargo to 293 thousand tons, totaling 332 thousand tons.

② Average per ship cargo handling capacity is assumed to be:

| | |
|---|---|
| General cargo | 80 tons/hour |
| Mineral bulk cargo | 160 tons/hour |

Working efficiency is presumed to be 0.8.

③ The average per ship discharging/loading volume is as follows:

| | |
|---|---|
| General cargo | 2,500 tons |
| Mineral bulk cargo | 18,000 tons |

④ Berths are assumed to be available for use 330 days per year. The cargo handling hours per day are assumed to be 18 hours.

⑤ Days necessary for purposes other than cargo handling are presumed to be 1.0 day per ship.

Based on the above assumptions, the necessary number of domestic trade berths in 2000 is calculated as follows.

Number of calling ships:

(General cargo) $\frac{39,000}{2,500} \doteqdot$ 16 ships

(Mineral bulk cargo) $\frac{293,000}{18,000} \doteqdot$ 17 ships

Total: 33 ships

Per-ship average days of mooring:

(General cargo) $\frac{2,500}{18 \times 80 \times 0.8} + 1.0 \doteqdot$ 3.2 days

(Mineral bulk cargo) $\frac{18,000}{18 \times 160 \times 0.8} + 1.0 \doteqdot$ 8.8 days

Per ship average days of mooring are 6.1 days by the weighted average of general and mineral bulk cargo ships.

Total number of mooring days = 33 ships x 6.1 days $\doteqdot$ 202 ship days

The berth occupancy ratio by the number of berths is shown in Table VII-26.

**Table VII-26 Berth Occupancy Ratio by Number of Berths**

| Number of Berths | Berth Occupancy Ratio | Estimate |
|---|---|---|
| 1 | 0.61 | O |
| 2 | 0.31 | X |

According to this method, the number of berths required as domestic trade berths is one.

But, just as for the grain berth, the berth occupancy ratio is a rather high value compared with the standard value. So, two cases for simulation tests, that is with one and two berths, are prepared.

(3) Cargo handling and storage facilities

1) Flow of cargo at Manzanillo Port

The movement of domestic trade cargoes at the Port in the year 2000 is forecast as shown in Table VII-27.

Table VII-27 Volume of Cargoes Passing through Storage Facilities in 2000

(Unit: '000 t)

| Type of Cargo | Total Cargo Volume | Direct Cargo | | | Indirect Cargo | | |
|---|---|---|---|---|---|---|---|
| | | Railway | Truck | Sub-total | Storeyard | Storage Facilities | Sub-total |
| Domestic Trade | 332 | – | 232 | 232 | 23 | 77 | 100 |

2) Size of storage facilitie

The necessary area of storage facilities is calculated as follows.

$$\frac{77{,}000}{20 \times 0.5 \times 1.5} = 5{,}134 \text{ m}^2$$

The required total area of new storage facilities is estimated as follows:

Required total area = $5{,}134/0.75 \fallingdotseq 6{,}850 \text{ m}^2$

3) Size of the storeyard

The necessary area of open storeyards is determined as follows.

$$\frac{23{,}000}{10 \times 0.7 \times 2.0} = 1{,}643 \text{ m}^2$$

### 2-2-9 Estimate of the Number of Berths Using the Method of Simulation by Queuing Theory

The main aims of using the simulation tests are to evaluate port operation efficiency in terms of ① : port congestion and ship waiting time; and ② : the influence of ship arrival irregularity and berthing time irregularity. The results of such simulations are more sophisticated than these results based only on the berth allotment method making use of a simple berth occupancy ratio.

As shown in Table VII-28, two cases of simulation tests based on different numbers of berths in the year 2000 have to be carried out.

Table VII-28 Two Simulation Test Cases

(Unit: berths)

| Type of Cargo | Case-1 | Case-2 |
|---|---|---|
| Foreign Trade Berths | 10 | 8 |
| General Cargo | 5 | 4 |
| Agricultural Bulk | 2 | 1 |
| Mineral Bulk | 2 | 2 |
| Container | 1 | 1 |
| Domestic Trade Berths | 2 | 1 |
| Total | 12 | 9 |

(1) Simulation cases

In order to determine the appropriate number of berths required in 2000, the following matters have to be examined by the simulation tests.

① Is the number of berths required as general cargo berths 4 or 5?

② Is the number required as grain cargo berths 1 or 2?

③ Is the number required as domestic trade cargo berths 1 or 2?

(2) Premises for the simulation

The simulation tests for these cases are carried out under the following assumptions:

① Ships can enter and leave at any time.

② Service time is estimated by the type of cargo and a per-ship cargo volume based on the cargo handling capacity in 2000 shown in Table VII-4.

③ General cargo ships use general cargo berths, in principle. But general cargo ships can also use the mineral bulk berth or the grain berth, if these are unoccupied.

④ Ships loading cargoes other than general cargo have to use the berths designed for their specific type of cargo.

(3) Input data

The following Table VII-29 shows the simulation test input data by each case and type of berth.

**Table VII-29 Simulation Input Data**

| Item | Type of Berth | Ship Size (DWT) | Number of Ships | Service Time (hours) | Number of Berths | |
|---|---|---|---|---|---|---|
| | | | | | Case 1 | Case 2 |
| Foreign Trade | General Cargo | ~ 10,000 | 37 | 33.6 | 5 | 4 |
| | | 10,000 ~ 20,000 | 204 | 64.8 | | |
| | | 20,000 ~ 30,000 | 111 | 67.2 | | |
| | | 30,000 ~ 40,000 | 11 | 84.0 | | |
| | | 40,000 ~ | 7 | 136.8 | | |
| | Agricultural Bulk Cargo | 20,000 ~ 30,000 | 27 | 127.2 | 2 | 1 |
| | | 30,000 ~ 40,000 | 5 | 144.0 | | |
| | | 40,000 ~ | 2 | 158.4 | | |
| | Mineral Bulk Cargo | 20,000 ~ 30,000 | 31 | 112.8 | 2 | 2 |
| | | 30,000 ~ 40,000 | 6 | 148.8 | | |
| | | 40,000 ~ | 2 | 153.6 | | |
| | Container Cargo | ~ 10,000 | 40 | 21.6 | 1 | 1 |
| | | 10,000 ~ 20,000 | 40 | 31.2 | | |
| | | 20,000 ~ 30,000 | 23 | 40.8 | | |
| | | 30,000 ~ 40,000 | 12 | 60.0 | | |
| Domestic Trade | (General Cargo) | ~ 5,000 | 10 | 45.6 | 2 | 1 |
| | | 5,000 ~ 10,000 | 4 | 84.0 | | |
| | | 10,000 ~ 15,000 | 2 | 136.8 | | |
| | (Mineral Bulk Cargo) | 5,000 ~ 10,000 | 4 | 108.0 | | |
| | | 10,000 ~ 15,000 | 2 | 148.8 | | |
| | | 15,000 ~ 20,000 | 1 | 201.6 | | |
| | | 20,000 ~ | 10 | 252.0 | | |

(4) Simulation test results

The results of simulation tests are shown in Table VII-30.

The output data of the simulation tests include the berth occupancy ratio, the ratio of the number of waiting ships to ship entry, the ratio of waiting time to mooring time and waiting time per ship.

**Table VII-30 Results of Simulation Tests**

| Type of Cargo | Case 1 | | | | Case 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Average Berth Occupancy Ratio | Ship Waiting Ratio (%) | | Per Ship Waiting Time (hours) | Average Berth Occupancy Ratio | Ship Waiting Ratio (%) | | Per Ship Berth Time (hours) |
| | | * Waiting Ships to Ship Entry | Waiting Time to Mooring Time | | | * Waiting Ships to Ship Entry | Waiting Time to Mooring Time | |
| (Foreign Trade) | | | | | | | | |
| General Cargo | 0.44 | 5.2 | 2.3 | 1.5 | 0.54 | 23.8 | 13.6 | 8.6 |
| Agricultural Bulk | 0.36 | 16.0 | 6.2 | 8.1 | 0.48 | 48.7 | 60.6 | 79.2 |
| Mineral Bulk | 0.40 | 27.8 | 17.7 | 21.0 | 0.50 | 39.3 | 28.7 | 34.0 |
| Container | 0.30 | 16.2 | 15.3 | 5.0 | 0.40 | 43.1 | 65.9 | 21.6 |
| (Domestic Trade) | | | | | | | | |
| General Cargo | } 0.21 | 7.6 | 6.9 | 4.8 | 0.39 | 38.4 | 103.9 | 70.7 |
| Mineral Bulk | | 15.6 | 11.8 | 22.7 | | 16.7 | 11.0 | 21.0 |
| Total | | 9.9 | 6.7 | 4.6 | | 30.2 | 27.4 | 18.9 |

Note: * The ratio of "waiting ships to ship entry" is equal to the number of vessels that are waiting for berths over the total number of vessels at the port, including those vessels which are waiting for berths and those vessels that are presently at at berth.

In order to propose the optimum plan as the Master Plan, the following criteria are considered.

① Berth occupancy ratio should be 0.4 ~ 0.7.

② The desirable ratio of waiting time to mooring time is 10% or less.

③ Desirable waiting time per ship is less than half a day, with a maximum of one day.

Juding from these criteria, Case 1 is selected as the most appropriate plan.

## 2-2-10 In Conclusion

All the wharves necessary to handle cargoes in 2000 are listed in Table VII-31. And Table VII-32 shows the proposed scale for the storage facilities to be newly constructed.

## Table VII-31 Berths Proposed in the Master Plan

| Type | Cargo Volume ('000 t) | Number of Berths | Size of Berths | | | Cargo Volume Handled per Meter (t/m) |
|---|---|---|---|---|---|---|
| | | | Length (m) | Water Depth (m) | Total Length (m) | |
| General Cargo Berths | | 1 | 180 | 11.0 | 180 | |
| | | 1 | 200 | 11.0 | 200 | |
| | | 2 | 200 | 12.0 | 400 | |
| | | 1 | 250 | 12.0 | 250 | |
| Sub-total | 926 | 5 | | | 1,030 | 900 |
| Container Berth | 516 | 1 | 300 | 13.0 | 300 | 1,720 |
| Grain Berths | 705 | 2 | 300 | 13.0 | 600 | 1,175 |
| Mineral Bulk Berths | | 1 | 200 | 12.0 | 200 | |
| | | 1 | 300 | 13.0 | 300 | |
| Sub-total | 603 | 2 | | | 500 | 1,206 |
| Domestic Trade Berths | | 1 | 170 | 9.0 | 170 | |
| | | 1 | 200 | 11.0 | 200 | |
| Sub-total | 332 | 2 | | | 370 | 898 |
| Total | 3,082 | 12 | | | 2,800 | 1,100 |

## Table VII-32 Scale of Storage Facilities to be Newly Constructed

(Unit: $m^2$)

| Type of Cargo | Calculated Required Scale in 2000 | Proposed Scale in the Master Plan |
|---|---|---|
| General Cargo | | |
| General cargo | 20,540 | 21,400 |
| Heavy weight cargo | 7,540 | 8,100 |
| Agricultural Bulk | 35,000 t Silo | 35,000 t Silo |
| Domestic Trade Cargo | 6,850 | 8,000 |

## 2-3 Fishery Port

### 2-3-1 Volume to be Handled

As described in Chapter VI, the estimated fish catch to be handled at Manzanillo Port in the year 2000 is 156,000 tons.

### 2-3-2 Size of Fishing Boats

As described in Chapter III, the majority of fishing boats currently operating in the Manzanillo region are medium-size fishing boats of the 10 ~ 60 gross tons class and small-size fishing boats less than 5 gross tons. However, if development and improvement of fishing ports advances to permit stabilized fishing operations, fishing boats are expected to get bigger and bigger. Development and improvement of Manzanillo Port is underway to create facilities with a water depth of 7.0 m for large fishing boats.

One of the ultimate goals of the improvement of Manzanillo Port is to promote offshore ocean-oriented fishery with emphasis placed on tuna fishery. In view of this primary objective, the maximum size of fishing boats in 2000 will reach 500 gross tons class.

### 2-3-3 Basic Facilities Plan

(1) Projected use of the fishing port in the year 2000

For planning, the size of fishing ports is determined based on estimated "standard days". Thus, one of the most important things in planning fishing ports is to predict the standard day. To estimate the future standard day, we compare previous annual data and standard days for prior years.

Concretely, by "standard day", we mean a day showing the typical use of the port which is used to determine the size of the planned facilities. The standard day is calculated as shown in Fig. VII-13.

| |
|---|
| Make a list of monthly landing volume for the past 3 years |
| ↓ |
| Select the two continuous months with the largest landing volume |
| ↓ |
| From the selected consecutive two months, choose the 10 days with the largest daily landing volume.<br>Using the average landing volume of the 10 days, determine the number of fishing vessels for the standard day |

**Fig. VII-13 Method of Determining the Standard Day**

As for Manzanillo Port, none of the data is available. So, the standard day is calculated based on the past results in Japan. The ratio between landing volume per standard day (hereafter called standard landing volume) and annual landing volume varies, depending on type of fish, fishing seasons and type and size of vessels.

Generally, the ratio of annual landing volume to standard landing volume is 100 ~ 200. Applying this concept to Manzanillo Port for the year 2000, if we presume a ratio of 150, the annual landing volume divided by 150 equals a standard landing volume of 1,040 tons.

Based on this value, predictions are made on the number of fishing boats used per standard day.

The ratio of different tonnage-class fishing boats at Manzanillo Port is estimated as in Table VII-33 from the 1981 ratio considering new fishing methods and the trend towards larger boats.

**Table VII-33 Estimated Ship Size**

| Year | Item | Ship Size (G/T) | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | ~5 | 5 ~ 20 | 20 ~ 50 | 50 ~ 100 | 100~500 | 500 ~ | |
| 1981 | Number of Boats | 160 | 23 | 7 | 58 | 14 | — | 262 |
| | Share (%) | 61 | 9 | 3 | 22 | 5 | — | 100 |
| 2000 | Share (%) | △6%<br>55 | +1%<br>10 | +2%<br>5 | 22 | 5 | +3%<br>3 | 100 |

When the total number of boats in 2000 is represented as X and the number of boats by tonnage-class as in the above Table, the average landing volume per boat, the average number of operating days, and the standard day landing volume are related as the following Table VII-34.

**Table VII-34 Relation between Number of Boats and Landing Volume**

| Item | Sign | Ship Size (G/T) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | ~5 | 5 ~ 20 | 20 ~ 50 | 50~100 | 100 ~ 500 | 500 ~ | Total |
| Number of Fishing Boats per Year (boats) | A | 0.55X | 0.10X | 0.05X | 0.22X | 0.05X | 0.03X | X |
| Average Landing Volume (t) | B | 0.6 | 3 | 12 | 24 | 60 | 150 | |
| Voyage Days (days) | C | 1 | 3 | 5 | 10 | 30 | 60 | |
| Number of Boats per Standard Day (boats) | D = A/C | *0.44X | *0.027X | 0.01X | 0.022X | 0.0017X | 0.0005X | |
| Landing Volume (t) | E = Dx B | 0.264X | 0.081X | 0.12X | 0.528X | 0.102X | 0.075X | 1.17X |

Note: * Boats less than 20 G/T are presumed to be at port 80% of the time.

In other words, the standard landing volume is 1.17 from which we can calculate the total number of boats.

$$1.17X = 1{,}040 \text{ t/day}$$
$$X \fallingdotseq 900 \text{ boats}$$

The annual figure of 900 boats is used to estimate the number of different size fishing boats per standard day.

The results are shown in Table VII-35.

**Table VII-35 Number of Fishing Boats and Landing Volume in 2000**

| Item | Sign | Ship Size (G/T) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | ~ 5 | 5 ~ 20 | 20 ~ 50 | 50~100 | 100 ~ 500 | 500 ~ | Total |
| Number of Fishing Boats per Year (boats) | A | 495 | 90 | 45 | 198 | 45 | 27 | 900 |
| Average Landing Volume (t) | B | 0.6 | 3 | 12 | 24 | 60 | 150 | |
| Voyage Days (days) | C | 1 | 3 | 5 | 10 | 30 | 60 | |
| Number of Boats per Standard Day (boats) | D = A/C | *396 | *24 | 9 | 20 | 2 | 1 | 452 |
| Landing Volume (t) | E = D x B | 238 | 72 | 108 | 480 | 120 | 150 | 1,168 |

Note: * Boats less than 20 G/T are presumed to be at port 80% of the time.

Incidentally, the ratio of landing of 1,168 tons/day to the annual landing volume of 156,000 tons is 133.

(2) Wharf Requirements

Required facilities for fishing boats vary depending on the type of boats and fishing methods used. Fig. VII-14 through VII-16 show the results of a survey in Japan.

The specifications of the necessary facilities are calculated based on the results of this survey.

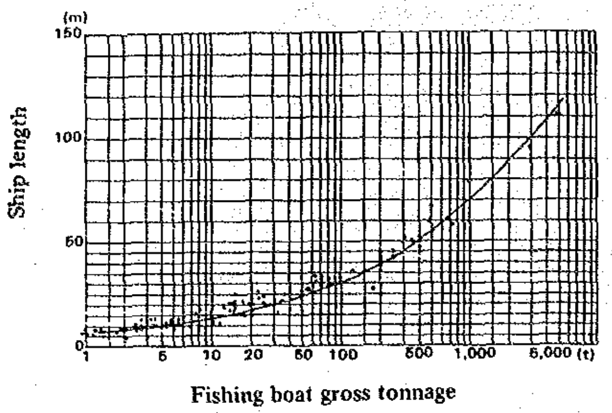



Fig. VII-14 Fishing Boat Tonnage – Length

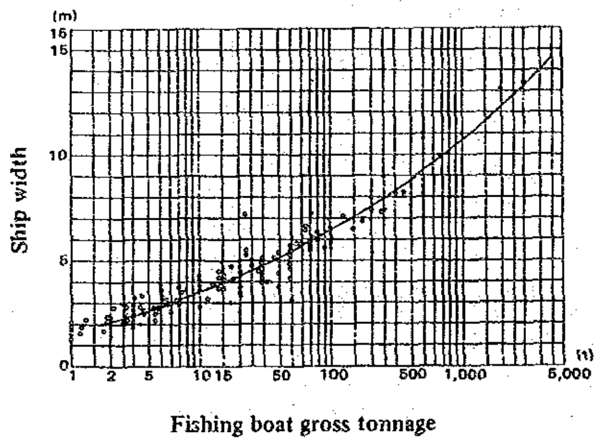



Fig. VII-15 Fishing Boat Tonnage – Width

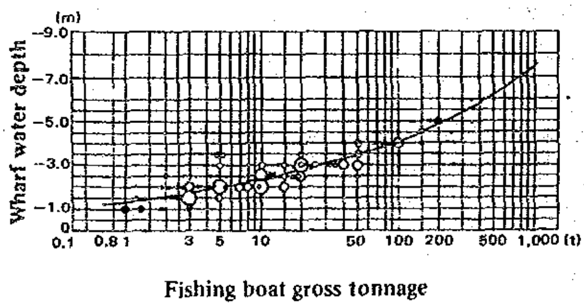



Fig. VII-16 Fishing Boat Tonnage – Wharf water depth

1) Landing Wahrf

Landing wharf calculations are made assuming that the amount of time available for unloading fish at each berth is a maximum of 6 hours per day, which is the same as the number of hours the fish market is open. This assumption is made for calculation purposes. We also assume that large fishing boats (over 5 gross tons) discharge fish catch from the boat side, and that small fishing boats (less than 5 gross tons) can discharge fish catch from the boat head. Further, we assume that small fishing boats can complete their landing within 2 hours. The results are shown in Table VII-36.

**Table VII-36 Landing Wharf Calculation**

| Water Depth (m) | Ship Size (G/T) | Standard Ship Size ① (G/T) | Maximum Draft (m) | Ship Length (m) | Berth Length ② (m) | Number of Boats ③ (boats) | Assumed Time Available for Fish Landing ④ (hours) | Landing Time per Boat ⑤ (hours) | Turnover ⑥=④/⑤ | Proposed Number of Berths ⑦=③/⑥ | Total Length of Berths ⑧=②×⑦ (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| below −2.0 | ~ 5 | 2 | 0.7 | 9 | 3 | 396 | 2 | 0.3 | 6 | 66 | 198 |
| −2.0~−3.0 | 5~ 20 | 10 | 1.6 | 16 | 20 | 24 | 6 | 1.0 | 6 | 4 | 80 |
| −3.0~−4.0 | 20~ 50 | 40 | 2.5 | 22 | 30 | 9 | 6 | 2.0 | 3 | 3 | 90 |
| −4.0~−5.0 | 50~100 | 80 | 3.1 | 29 | 35 | 20 | 6 | 3.0 | 2 | 10 | 350 |
| −5.0~−6.0 | 100~500 | 200 | 3.6 | 40 | 45 | 2 | 6 | 6.0 | 1 | 2 | 90 |
| over −6.0 | 500~ | 500 | 4.9 | 56 | 60 | 1 | 6 | 11.0 | 0.55 | 2 | 120 |
| Total | | | | | | | | | | | 928 |

2) Preparatory Wharf

The preparatory wharf is designed for fishing boats over 5 gross tons as shown in Table VII-37. The time required to prepare each boat was calculated from actual results in Japan.

**Table VII-37 Preparatory Wharf Calculation**

| Water Depth (m) | Ship Size (G/T) | Standard Ship Size ① (G/T) | Maximum Draft (m) | Ship Length (m) | Berth Length ② (m) | Number of Boats ③ (boats) | Assumed Time Available for Preparatory ④ (hours) | Preparatory Time per Boat ⑤ (hours) | Turnover ⑥=④/⑤ | Proposed Number of Berths ⑦=③/⑥ | Total Length of Berth ⑧=②×⑦ (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| below −2.0 | ~ 5 | − | − | − | − | − | − | − | − | − | − |
| −2.0~−3.0 | 5~ 20 | 10 | 1.6 | 16 | 20 | 24 | 8 | 1 | 8 | 3 | 60 |
| −3.0~−4.0 | 20~ 50 | 40 | 2.5 | 22 | 30 | 9 | 8 | 2 | 4 | 3 | 90 |
| −4.0~−5.0 | 50~100 | 80 | 3.1 | 29 | 35 | 20 | 8 | 2 | 4 | 5 | 175 |
| −5.0~−6.0 | 100~500 | 200 | 3.6 | 40 | 45 | 2 | 8 | 4 | 2 | 1 | 45 |
| over −6.0 | 500~ | 500 | 4.9 | 56 | 60 | 1 | 8 | 4 | 2 | 1 | 60 |
| Total | | | | | | | | | | | 430 |

3) Rest Wharf

The rest wharf is designed for fishing boats to moor with their head to the wharf. As for small boats less than 5 gross tons, calculations are made assuming that a third of the boats moor outside the port, half of the remaining boats rest deep inside the port and the remaining half are moored at the wharf in two rows. The results are shown in Table VII-38.

**Table VII-38 Rest Warf Calculation**

| Water Depth (m) | Ship Size (G/T) | Standard Ship Size ① (G/T) | Maximum Draft (m) | Ship Width (m) | Ship Width + Allowance ② (m) | Number of Boats ③ (boats) | Required Length of Wharf ④=②×③ (m) |
|---|---|---|---|---|---|---|---|
| below -2.0 | ~ 5 | 2 | 0.7 | 2.3 | 3.0 | 66 | 198 |
| -2.0 ~ -3.0 | 5 ~ 20 | 10 | 1.6 | 3.5 | 4.0 | 24 | 96 |
| -3.0 ~ -4.0 | 20 ~ 50 | 40 | 2.5 | 5.1 | 6.0 | 9 | 54 |
| -4.0 ~ -5.0 | 50 ~ 100 | 80 | 3.1 | 6.1 | 7.0 | 20 | 140 |
| -5.0 ~ -6.0 | 100 ~ 500 | 200 | 3.6 | 7.6 | 8.5 | 2 | 17 (20m) |
| Over -6.0 | 500 ~ | 500 | 4.9 | 9.4 | 10.5 | 1 | 10.5 (20m) |
| Total | | | | | | | 528 |

Note: Figures in parentheses represent a proposed length for the Master Plan.

4) Anchorage basin

The anchorage basin includes space for landing, preparation, rest and ship operation as shown in Table VII-39.

**Table VII-39 Anchorage Basin**

| Purpose | Area ($m^2$) | Details of Calculation |
|---|---|---|
| For Landing | 16,704 | 928 m (required length of wharf) x 18 m (length of boats less than 5 tons x 2.0) |
| For Preparation | 4,515 | 430 m (required length of wharf) x 10.5 m (width of boats more than 500 tons + 1 m) |
| For Resting | 52,800 | 528 m (required length of wharf) x 100 m (average boat length x 2.5) |
| Total | 74,019 | |

### 2-3-4 Functional Facilities

The necessary size of the major facilities is calculated as follows:

(1) Fish handling shed

The size of the fish handling shed can be obtained from the following equation.

$$S = \frac{N}{R \cdot \alpha \cdot P} \quad \cdots\cdots \text{(VII-5)}$$

where, S : Required area for shed ($m^2$)

N : Planned handling volume per day (kg/day)

R : Turnover (times/day)

$\alpha$ : Occupancy rate: standard is 0.5

P : Handling volume per unit are a ($kg/m^2$)

The value of R, $\alpha$, P for Manzanillo cannot be easily determined due to the complicated factors involved, so actual results in Japan are used for calculation the required area.

| | |
|---|---|
| Planned handling volume per day | N = 1,168,000 kg/day |
| Turnover | R = 2 times/day |
| Occupancy rate | $\alpha$ = 0.5 |
| Handling volume per unit area | P = 75 $kg/m^2$ (in bulk) |

$$S = \frac{1,168,000}{2 \times 0.5 \times 75} = 15,573 \text{ m}^2$$

(2) Ice-making and Ice-storage facilities

Ice-making and ice-storage facilities at fishing ports are installed to produce and store ice used for chilling fish in fishing boats, fish handling sheds and fish boxes used for shipping.

The ice-making facilities at fishing ports are roughly divided into ① block ice-making facilities (block ice system) and ② fully automatic ice-making facilities (plate ice system).

In this plan, the size of a block ice-making facility is calculated.

The ratio of fish catch to ice requirements differs according to kinds of fish, seasons, local customs, etc. In the event that there is no data for a particular district, ice requirements can be assumed to be 1 ton per unit fish haul, judging by actual results in Japan.

It would be advisable to estimate the necessary ice-making capacity from the following equation:

$$\text{Ice-making capacity (tons/day)} = \frac{\text{Annual ice requirements (annual catch)}}{365 \times 0.7}$$

0.7 is the operating rate.

Assuming that ice storage life is 5 days, the required size is calculated as follows:

$$\text{Ice-making facility capacity (tons/day)} = \frac{156,000}{365 \times 0.7} \fallingdotseq 610 \text{ t/day}$$

| | |
|---|---|
| Ice-storage capacity (tons) | 610 t/day x 5 days = 3,050 t |
| Facility area | 1,900 $m^2$ (according to Japanese examples) |

(3) Cold storage facility

The required area for large cold storage facilities is calculated using the following equation.

$$\text{Refrigerated area } (m^2) = 4.5 \times \frac{\text{Capacity}}{\text{Effective height}} \quad \cdots\cdots\cdots\cdots \text{(VII-6)}$$

$$\text{where, Capacity} = \frac{\text{Shipping quantity to refrigerator (tons/year)}}{\text{Turnover (times/year)}}$$

Turnover = Three times a year is the standard turnover.

Effective height = The standard effective height is 3 to 5 m.

To begin with, the shipping quantity to the refrigerator must be figured out. Of the estimated haul at Manzanillo Port in 2000 of 156,000 tons, 79,000 tons are destined for industrial use. Part of the remaining 77,000 tons is intended for direct consumption.

Direct consumption is divided as follows.

Direct Consumption ─┬─ Fresh ─┬─ Local ........ Ⓐ
                    │         └─ Foreign ....... Ⓑ
                    └─ Refrigerated ................. Ⓒ

According to the actual results in Japan in 1978, the rate of refrigeration, that is to say, Ⓒ/ (Ⓐ + Ⓑ + Ⓒ) is about 40%. It would not be advisable to apply this 40% to Manzanillo Port considering that the Japanese people eat a great deal of fish. In the case of Manzanillo Port, a rate of 20% is presumed.

$$\text{Capacity: } \frac{77{,}000 \text{ t} \times 0.2}{3} \fallingdotseq 5{,}200 \text{ t}$$

The refrigerated area works out to be $4.5 \times \frac{5{,}200}{5} = 4{,}680 \text{ m}^2$

(4) Parking Lot

For calculating the necessary area of the parking lot, the following conditions are assumed:

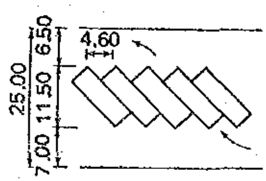
| | |
|---|---|
| Standard landing volume | 1,168 tons/day |
| Vehicle loading rate | 0.8 |
| Large truck loading capacity | 4 tons/truck |
| Small truck loading capacity | 2 tons/truck |

The ratio of large trucks to small trucks is assumed as 50%.

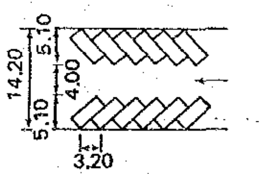
| | |
|---|---|
| Number of large trucks | 460/4 = 115 trucks |
| Number of small trucks | 460/2 = 230 trucks |

The required area for the parking lot is calculated as follows:

Required area for parking lot $(m^2) = 115 \times 115 + 230 \times 22.7 = 18{,}446 \text{ m}^2$ (See Fig. VII-17)




(a) 45° Angle parking (large trucks)




(b) 45° Angle parking (small trucks)

**Fig. VII-17 Parking Lot Plan**

## 2-3-5 Wharf and Facilities Plan

The overall plan is shown in Table VII-40 and Table VII-41.

Although the proposed length for preparatory and rest functions is shorter than the calculated length, this should present no problem because the wharf will be utilized cooperatively.

**Table VII-40 Fishery Wharf**

(Unit: m)

| Type of Wharf | Length of Wharf | | | | Proposed Total Length |
|---|---|---|---|---|---|
| | Landing Wharf | | Preparatory and Rest Wharf | | |
| | Calculated | Proposed | Calculated | Proposed | |
| -4m | 368 | 370 | 498 | 430 | 800 |
| -7m | 560 | 560 | 460 | 410 | 970 |

**Table VII-41 Proposed Functional Facilities for the Fishery Port**

(Unit: $m^2$)

| Facility | Calculated Area | Proposed Area |
|---|---|---|
| Fish Handling Shed | 15,573 | 16,900 |
| Ice Making and Ice Storage Facility | 1,900 | 14,300 (according to the ratio of land to buildings) |
| Cold Storage Facility | 4,680 | |
| Parking Lot | 18,446 | 23,900 |

## 2-4 Passenger Terminal and Marina

### 2-4-1 Passenger terminal

(1) Ship size of cruising vessels and dimension of berths

"Muelle Fiscal" in the outer pot will be used as a berth for large cruising vessels. As shown in Tabel III-15, "Muelle Fiscal" is a large berth. Each side has a length of 231 m and a water depth of 11 m.

When this berth is used as a facility for cruising vessels, the maximum gross tonnage of the cruising vessels could be 30,000 G/T, judging by the water depth of the present berth.

As shown in Table III-42 and Fig. VII-18, such large vessels as the Queen Elizabeth-2, the Camberra and the Roterdam are the only vessels cruising the Pacific Ocean which exceed 35,000 G/T: the vast majority of ships are below 30,000 G/T.

Needless to say, there is every likelihood that cruising vessels will be larger and larger in future. However, in view of the ship size of present cruising vessels, facilities for 30,000 G/T vessels should be sufficient to accommodate all cruising vessels which are likely to call at the Port.

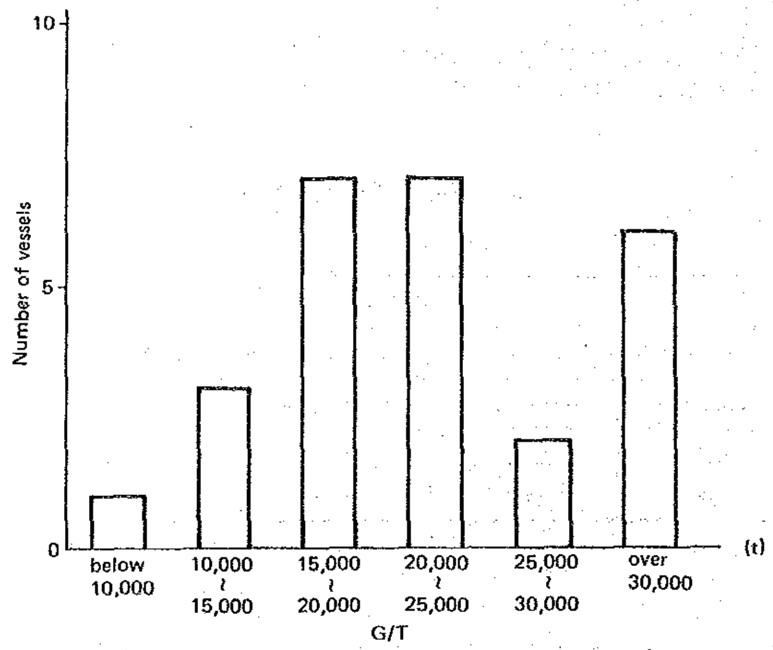



Fig. VII-18 Ship Size of Present Cruising Vessels

The dimensions of the touristic berth are shown in Table VII-42.

**Table VII-42. Dimensions of the Touristic Berth at "Muelle Fiscal"**

(Unit: m)

| Gross Tonnage (G/T) | Berth Size | |
|---|---|---|
| | Length | Water Depth |
| 30,000 | 230 | 11.0 |

(2) Facilities plan

1) Size of passenger terminal

The required area of passenger terminals is usually estimated based on the following equation:

$$A = an N \alpha \beta \quad \cdots\cdots \quad (VII\text{-}7)$$

where, a : Required area per person (1.2 $m^2$/person)

n : Fixed number of passengers

N : Number of departure/arrival vessels in the same period of time

$\alpha$ : Rate of concentration
(all-day average 1.0, fluctuating 1.6, temporarily concentrating 3.0)

$\beta$ : Rate of fluctuation (annual average 1.0, fluctuating 1.2)

As for Value N in the above equation, it is figured out as N=1, since more than one tourist vessel almost never arrives and departs in the same period of time even in the year 2000. Assuming that a 30,000 G/T vessel is capable of transporting 1,600 passengers, the size of passenger terminal suitable for use at Manzanillo Port in 2000 would be as follows:

$$A = 1.2 \times 1{,}600 \times 1 \times 1.0 \times 1.0 = 1{,}920 \ m^2$$

Thus, the present transit shed with an area of 4,995 $m^2$ can be used effectively as a passenger terminal and shopping center.

2) Size of parking lot

The required area for parking lots is usually estimated based on the following equation:

$$A = a \times n \times \alpha \times \beta \quad \cdots\cdots \quad (VII\text{-}8)$$

where, a : Required area per vehicle
Passenger car 30 $m^2$/car
Large bus 90 $m^2$/bus

n : Number of vehicles

$\alpha$ : Rate of concentration (standard is 0.8)

$\beta$ : Rate of fluctuation (all-day average 1.0, fluctuating 1.6)

The fixed number of passengers for a 30,000 G/T cruising vessel is 1,600. We expect that

50% of these passengers will get on or off the vessel at Manzanillo. Half of these passengers (1,600 x 0.5 x 0.5 = 400) use large vehicles (busses), 10% (1,600 x 0.5 x 0.1 = 80) use small vehicles (mostly taxis), and the other 40% use other modes of transit. If we assume an average of 2 passengers per small vehicle and 30 passengers per large vehicle, the area of the parking lot is calculated as follows:

$$A = (30 \times 80 \times 1/2 + 90 \times 400 \times 1/30) \times 0.8 \times 1.0 = 1{,}920\ m^2$$

2-4-2 Marina

(1) Boat size and number of accommodations

According to the Tourist Bureau, a large-scale private marina at Santiago Bay is under consideration. As described above, about 30 launches currently anchor in the sea area of the outer port due to a lack of proper mooring facilities. Furthermore, it is said that about 50 vessels anchor in the sea area when the trawling season comes.

In order to solve this problem and cope with future demand, improvements will be made with the following considerations:

① As for berth facility improvements for yachts, they will be left to a private marina project. Our marina project is intended for launches in the outer port area.

② The purpose of the marina is to accommodate safely all the launches that are presently anchoring in the sea area and will anchor in the future.

③ So as not to get behind future demand, facilities should be constructed with sufficient room for further development.

The marina project is for launches with the specification given in Table VII-43.

**Table VII-43 Specification of Launches**

(Unit: m)

| Average Length | Average Width | Draft |
|---|---|---|
| 12.0 | 4.0 | 2.0 |

The number of vessels to be accommodated in the year 2000 is determined based on the forecast value of tourists estimated to take part in coastal leisure activities in the Manzanillo region.

The number of these tourists is estimated at 240 thousand persons as mentioned in Chapter VI. Assuming that 50% of these tourists will use the launches as a coastal leisure activity, the number of tourists that use launches per day on the average is calculated as follows.

(240 thousand persons x 0.5)/365 days ≒ 330 persons

Further, assuming that 5 persons will use each launch, that daily variation is 1.6, that half of the tourists will use the launches for only half-days and that the others will use the launches for whole days, the number of launches required per day is estimated as follows:

$$330 \times 1.6/5 \times (0.5 + 2 \times 0.5) = 70 \text{ boats}$$

Accordingly, the number of launches to be accommodated in the year 2000 will be 70.

(2) Facilities plan

1) Required waterline length

The required waterline length is calculated as follows.

| (Number of Boats) | | (width + allowance) |
|---|---|---|
| 70 | x | (4.0 + 1.5) m = 385 m |

2) Boat yard

Assuming that on the average 90% of launches are always kept on the sea surface, the boat yard area is given below.

$$70 \text{ boats} \times 0.1 \times 80 \text{ m}^2/\text{boat} = 560 \text{ m}^2$$

3) Parking lot

Assuming that the average number of cars per boat is 1.5 and the utilization rate is 0.4, parking lot area is given below.

$$70 \text{ boats} \times 1.5 \text{ cars/boat} \times 0.4 \times 30 \text{ m}^2/\text{car} = 1{,}260 \text{ m}^2$$

4) Clubhouse

Assuming that the average number of persons using each boat is 5 persons for boats 20 feet or more, and the utilization rate per day is 0.5, the total number of persons using the clubhouse is 175 persons: namely,

$$70 \text{ vessels} \times 0.5 \times 5 \text{ persons/vessel} = 175 \text{ persons}$$

Assuming that one person uses an area of 4 $m^2$ of the clubhouse, the required area would be as:

$$175 \text{ persons} \times 4 \text{ m}^2/\text{person} = 700 \text{ m}^2$$

If the building-to-land ratio is 60%, a total compound of about 1,200 $m^2$ is required for the clubhouse.

5) Other Facilities

Probably, space for simple repair and maintenance and electric wiring work is required.

## 2-5 Harbor Facilities

Harbor facilities are a very important part of the Master Plan. In the case of Manzanillo Port, which has been developed utilizing the San Pedrito Lagoon, topographical restrictions have to be considered when planning harbor facilities.

The five zones which must be examined for planning harbor facilities at the Port are shown in Fig. VII-19.

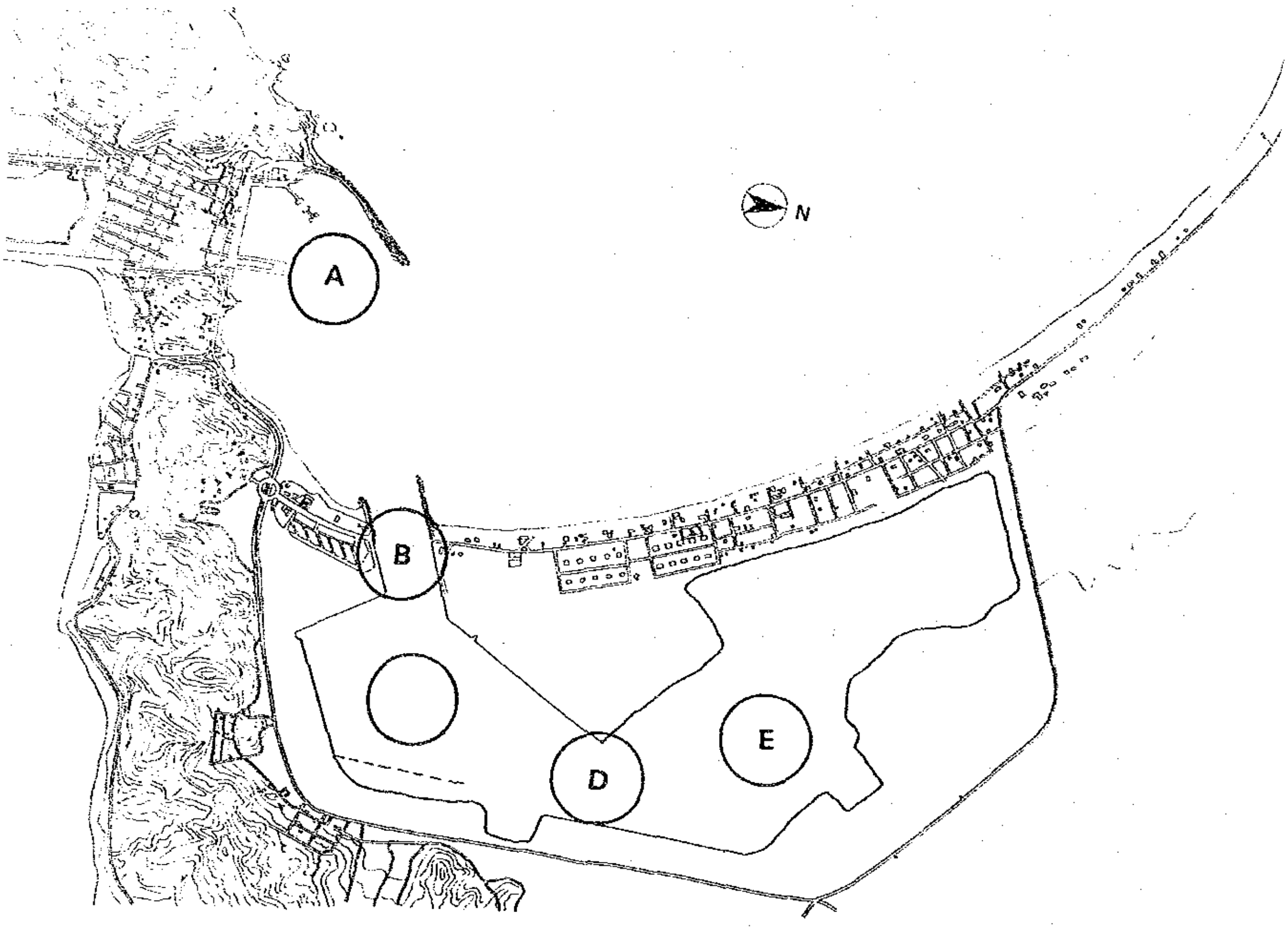



**Fig. VII-19 Study Zones of Harbor Facilities Plan**

### 2-5-1 Outer Port (A Zone)

The passenger terminal will be located in the outer port. The oil handling facilities operated by PEMEX are located adjacent to the passenger terminal. Ideally, a separate channel and basin should be secured for the tourist vessels and the tankers. Unfortunately, due to topographical limitations this is not possible. The area for turning is extremely limited and tugboats will have to be utilized to a great extent.

Furthermore, entrance and exit from the Port will have to be strictly controlled. It is not possible for both tourist vessels and tankers to enter and exit the zone at the same time, so traffic will have to be regulated.

As for the passenger terminal, tourist vessels should keep as much distance as possible from the mooring facilities of PEMEX. Tourist vessels should try to utilize the berth facing the inner port as much as possible and avoid using the berth facing the PEMEX facilities.

### 2-5-2 Entrance Channel to the Inner Port (B Zone)

Considering natural conditions, such as waves and winds, and the opinions of pilots and others, changing the channel line is not necessary. Presently, the channel is 100 m wide at the bottom. A plan to enlarge the bottom width to 150 m will soon be carried out.

But considering that many ships over 150 m in length will pass through this channel in the future, a width of 150 m is not sufficient. It is desirable to enlarge the channel as much as possible. If both seawalls are stabilized, the channel can be enlarged to about 200 m. Thus, we recommend that the seawalls be stabilized and the channel expanded to 200 m width. There is no problem with channel depth as the current depth of 14 m is sufficient.

### 2-5-3 Inner Port Basin (C and E Zones)

In zones C and E, there should be suffiient space for vessels to turn around when they berth and de-berth from the wharves. Unfortunately, due to topographical limitations, the available space is insufficient for the largest ships which will call at the Port to turn. Thus, tugboats will have to be used to turn these vessels.

### 2-5-4 Narrowest Portion of the Inner Port (D Zone)

When drafting the harbor facilities plan, the problem with D zone is to secure safe passage through the zone and the safe utilization of the mooring facilities located on one side of the zone. The necessary, or safe, width through the narrowest portion of this zone is calculated as:

(Necessary width for berthing and cargo handling) + (Necessary width for safe passage of vessels) + (Allowance)

The width necessary for berthing and cargo handling must be wider than the actual width of ships themselves. When the space required for mooring and cargo handling are taken into account, the total width for berthing and cargo handling is considered to be 50 m. The width necessary for safe passage of vessels should be equivalent to the overall ship length of the largest ships which will pass through. This would be about 250 m, the length of the largest container ships expected to use the zone. The allowance represents the necessary distance between vessels passing through and the naval facilities located on the opposite side of D zone. An allowance of 50 m is recommended.

Thus the necessary width at the narrowest portion of zone D is:

50 m + 250 m + 50 m

a total of 350 m.

## 3. Layout Plan

### 3-1 Outer Port

For economy, the layout of the outer port is made in accordance with the following criteria:

① Alleviating current problems while changing the current facilities as little as possible

② Using sites for the same functions as at present when possible

③ Reclaiming as little land as possible

Usable sites include extant warehouses, railways, and a narrow road which runs along the back of the outer port. The warehouses will be reconstructed. The road will be expanded and a park provided for tourists, workers, and local residents. As for railway facilities, the passenger station will be reconstructed and will serve as the terminal for buses and taxies. The current railway line, which is a single track and too narrow to function as a road, will become a promenade.

Leisure facilities, including a club house and a parking lot, will be constructed around the present launch moorings. This construction will primarily take place on existing land, reclaiming as little land as possible.

A seawall will be constructed to protect the shore from the touristics wharf to San Pedrito Seashore. The 900 m promenade and launch moorings will be constructed along this part of the shoreline. The facility will be long enough to provide launch moorings in the future. From Fig. VII-20, the three cross sections show that the promenade has 3 pedestrian levels. Then, tourists and inhabitants will be able to enjoy the port from various veiwpoints.

The parking lot will be located between the passenger terminal and the terminal for buses and taxies. The lot will be for the general use of passengers of touristic vessels, launches, buses, etc.

The Master Plan and two images of the Outer Port are presented as Fig. VII-21 and Fig. VII-22.

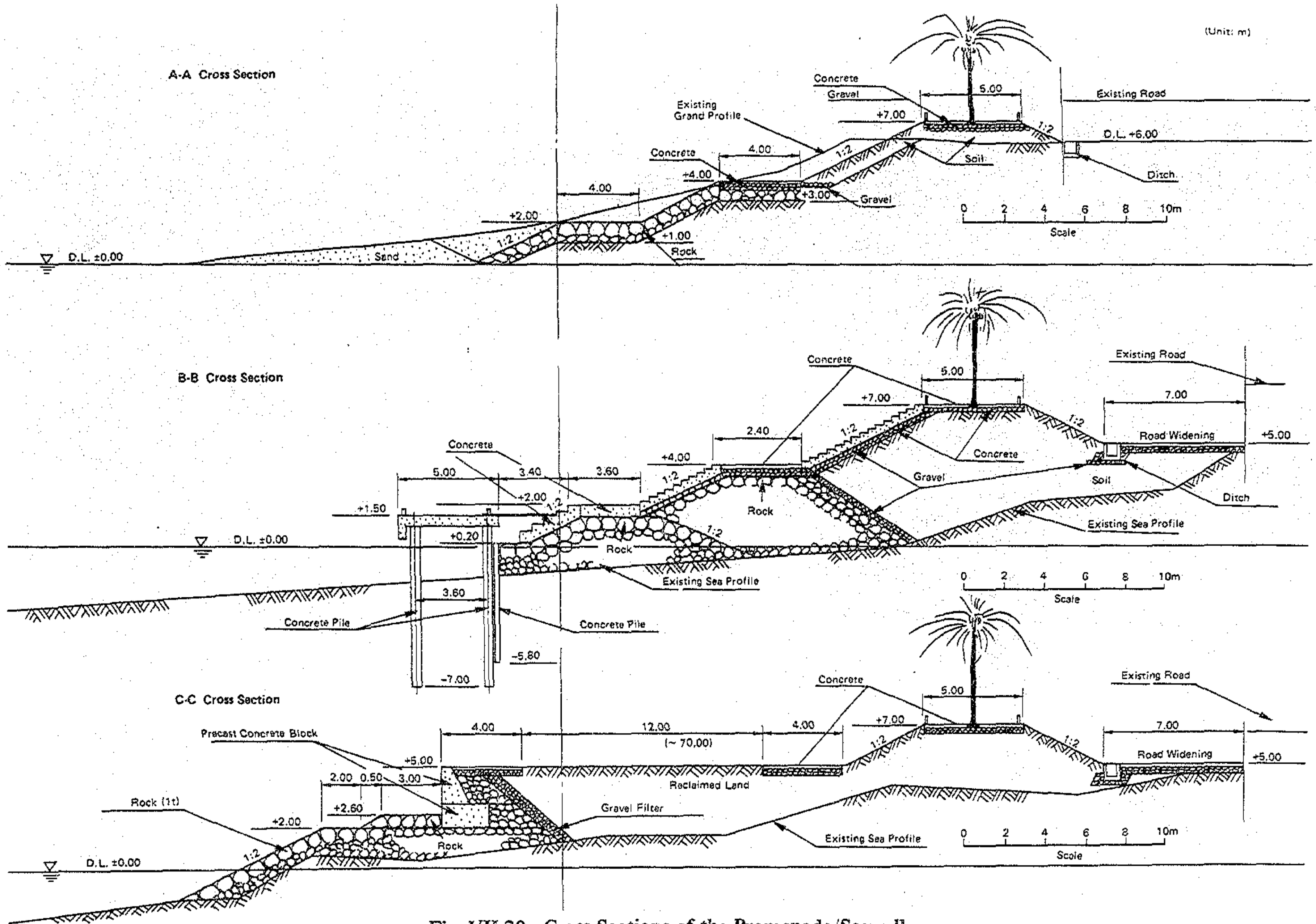



Fig. VII-20 Cross Sections of the Promenade/Seawall

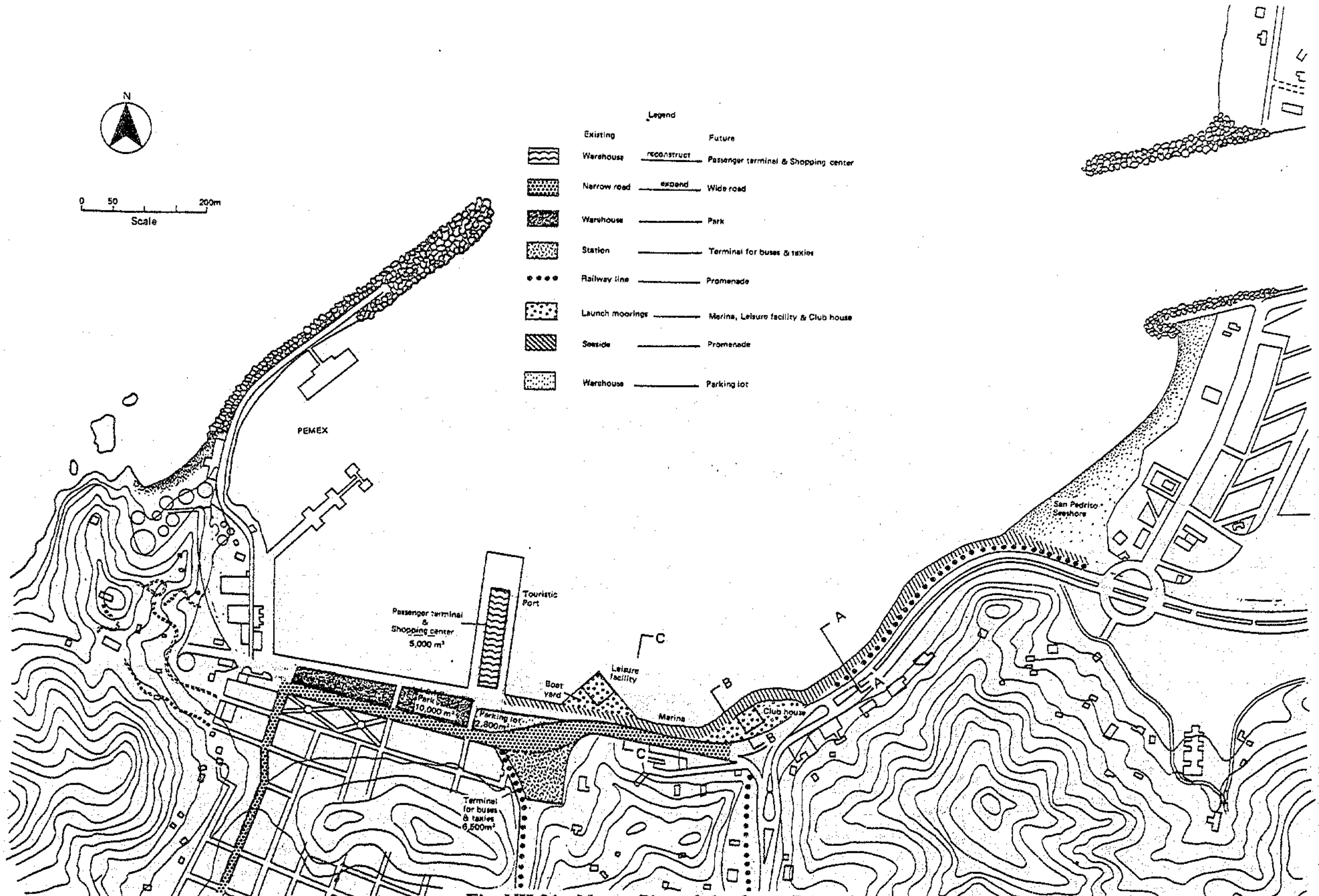



Fig. VII-21 Master Plan of the Outer Port

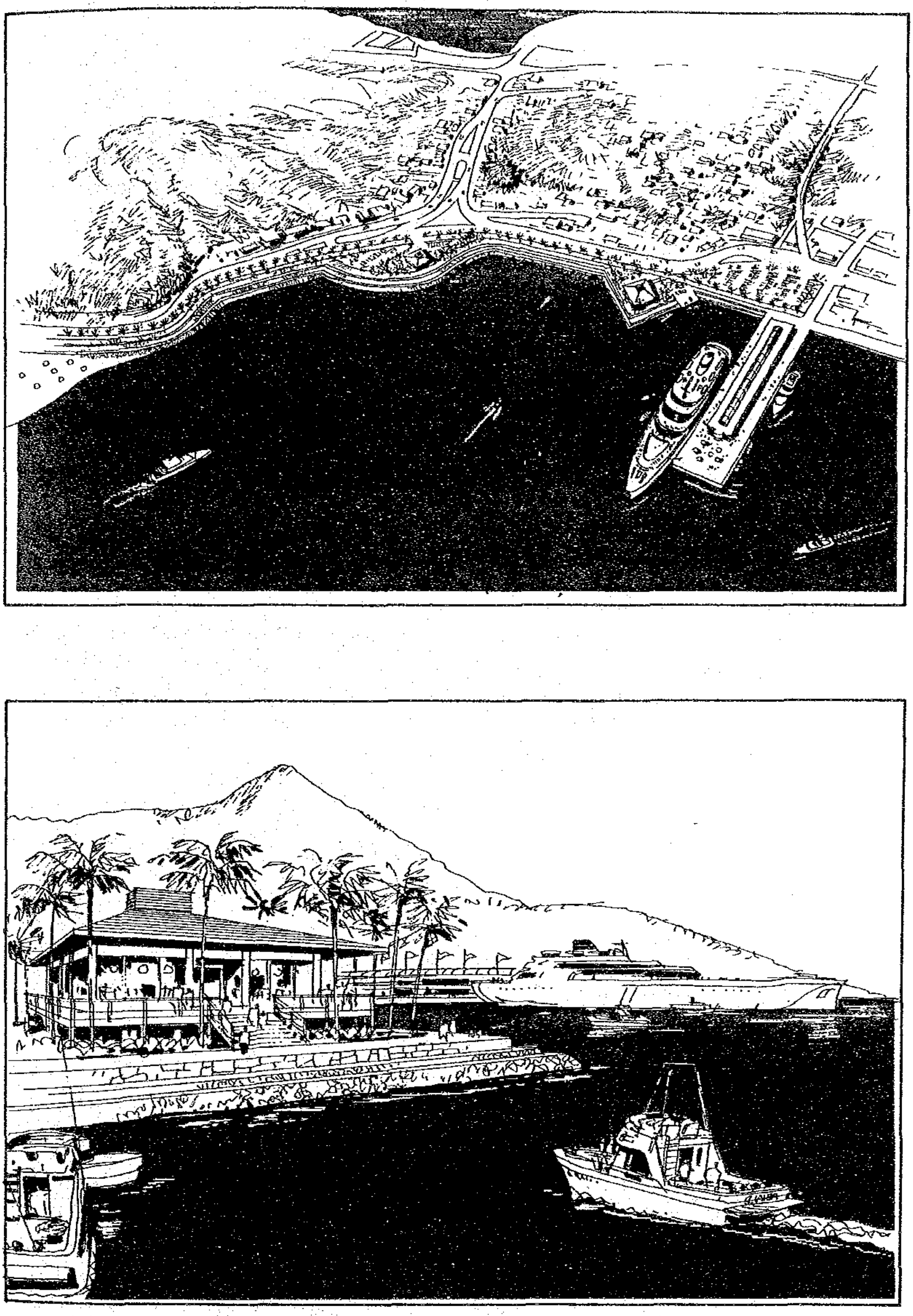


Fig. VII-22 Image Sketches of the Outer Port

## 3-2 Inner Port

### 3-2-1 Premises of the Commercial Port Facilities Layout

The layout plan of the commercial port facilities is made based on the following premises:

① Existing port facilities and port facilities under construction should be used effectively.

② The water depth of the present wharf cannot be increased, since it may well be that such an increase would create a structural problem.

③ A new 600 m long berth connecting with the existing berth is under construction in the inner port.
The location of this new berth essentially determines the face line of the entire Master Plan. The logical location for new facilities is between the berth which is under construction and the fishing facilities located towards the northern end of the San Pedrito Lagoon.
The only other possibility would be to cut into the land between the new berth and the fishing facilities, but as the hills are located quite close to the shore and the flat area along the shore is quite narrow, this is not a realistic option. Accordingly, the new facilities will all be located between the 600 m wharf currently under construction and the fishery facilities.

④ Since especially heavy cargoes and heavy weight cargo handling equipment like container cranes would cause structural difficulties at the existing wharf and at the wharf which is under construction, all the facilities for handling such cargoes will have to be located on the newly planned wharf.

These areas are shown in Fig. VII-23.

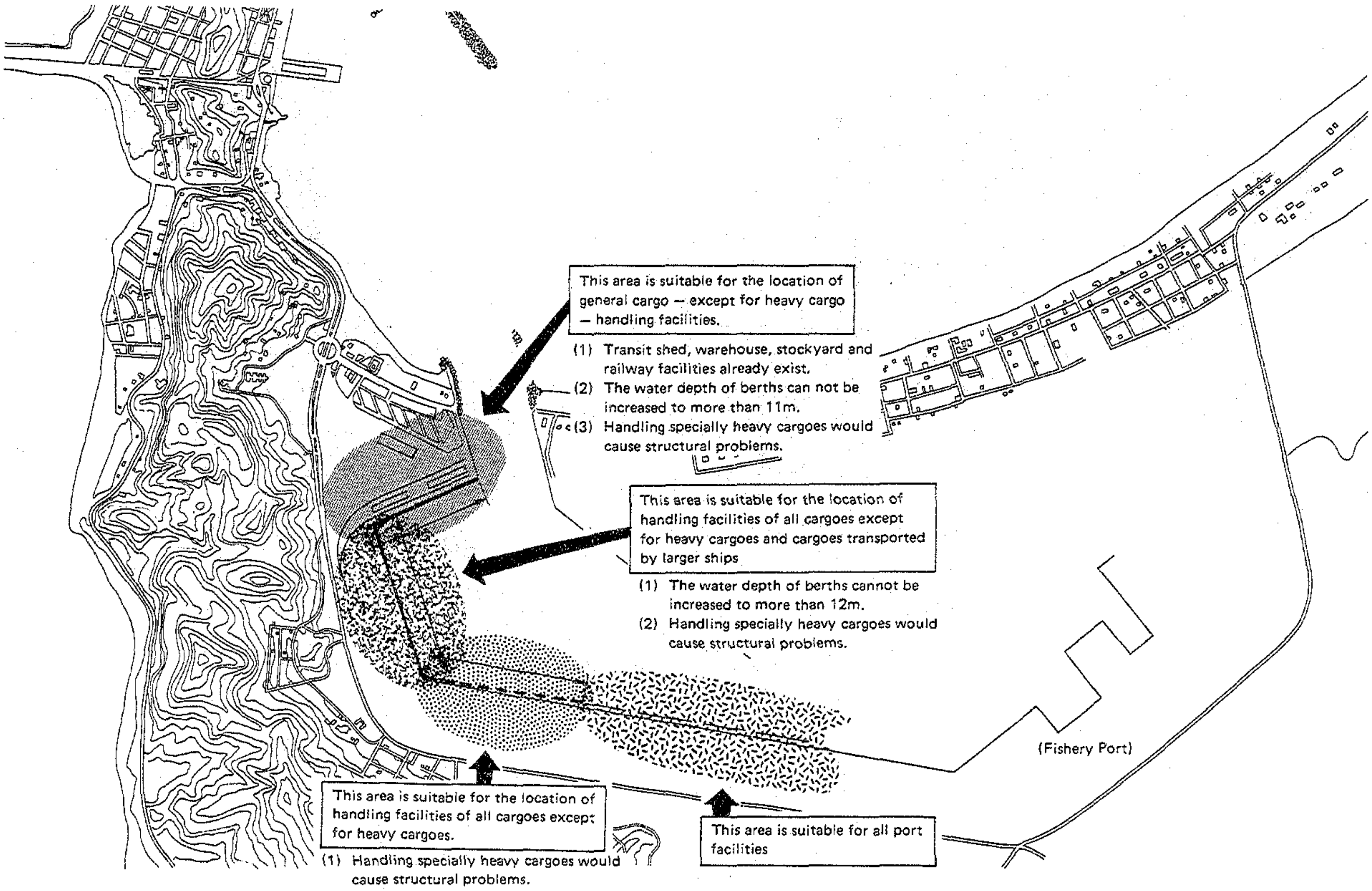



Fig. VII-23 Concept of the Commercial Port Facilities Layout

### 3-2-2 Premises of the Fishing Port Facilities Layout

The face line of the fishery wharf is determined according to the drawings we obtained in Mexico.

The layout is indicated in Fig. VII-24.

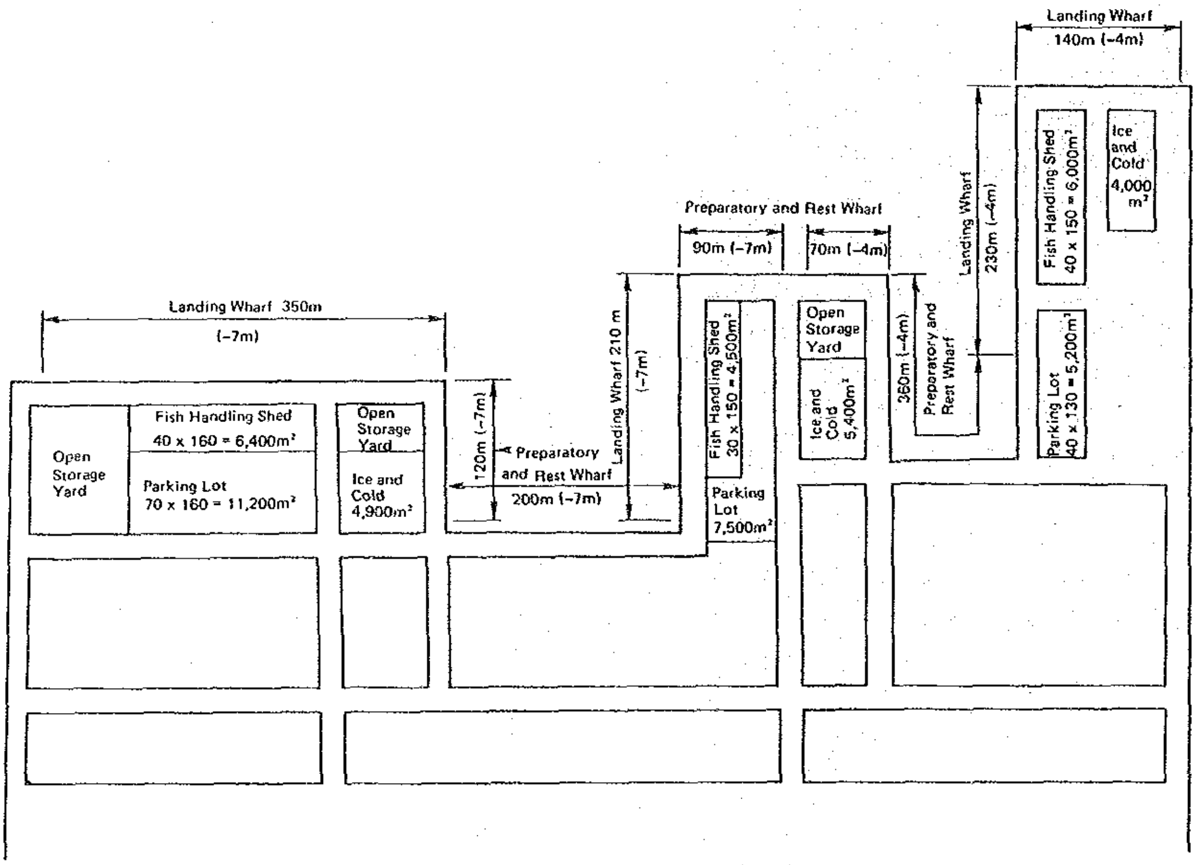
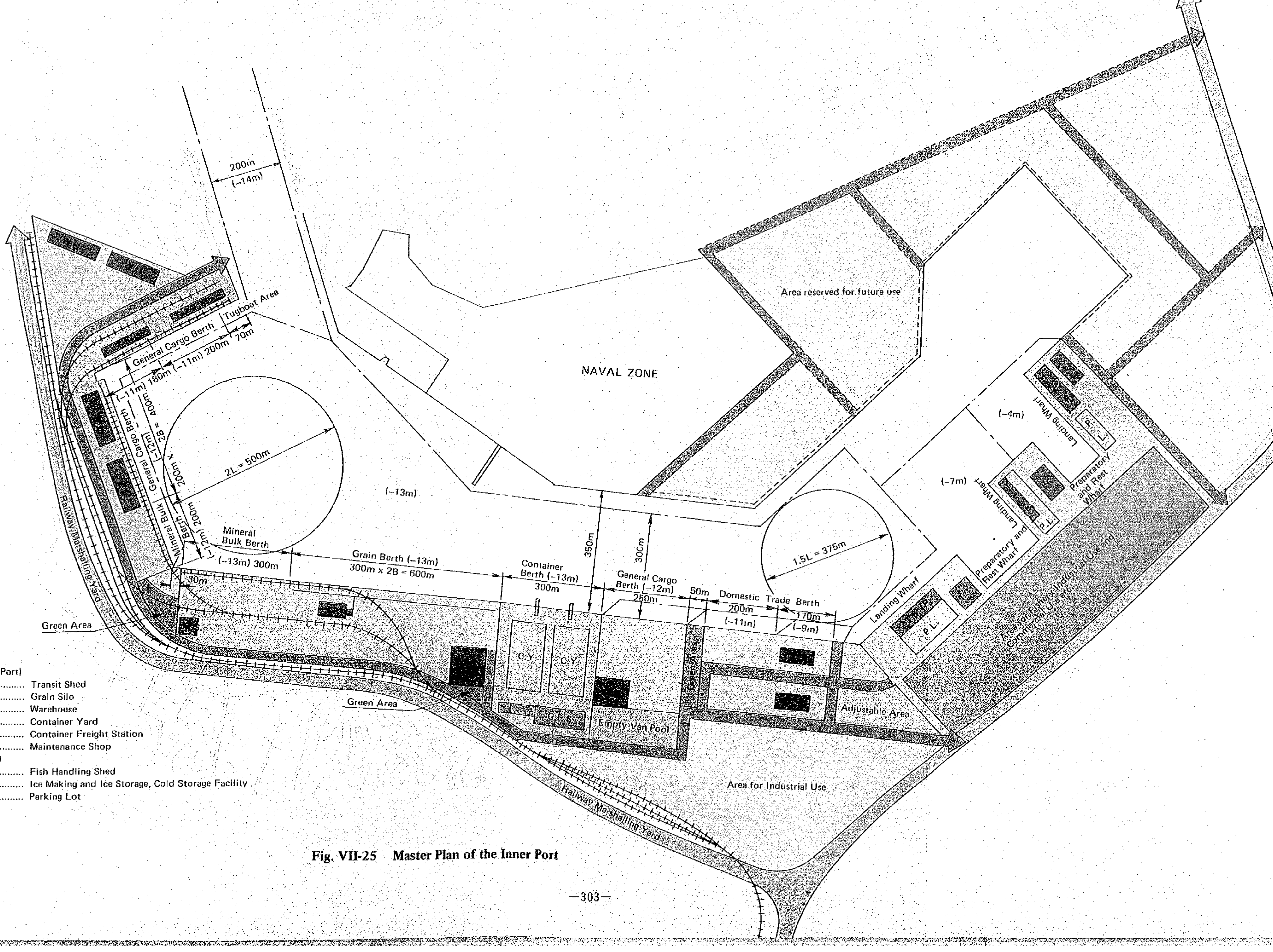



**Fig. VII-24 Fishery Port Facilities Layout**

### 3-2-3 Master Plan of the Inner Port

Fig. VII-25, the layout plan of the inner port, was made based on the above premises.




(Commercial Port)
T.S. ................ Transit Shed
Silo ................ Grain Silo
W.H. ................ Warehouse
C.Y. ................ Container Yard
C.F.S. ................ Container Freight Station
M.S. ................ Maintenance Shop
(Fishery Port)
T.S.(F) ................ Fish Handling Shed
I.C. ................ Ice Making and Ice Storage, Cold Storage Facility
P.L. ................ Parking Lot

**Fig. VII-25 Master Plan of the Inner Port**

## 4. Other Facilities

### 4-1 Supply Facilities

In this section, water supply, sewage, drainage, electric power and fuel supply are considered.

#### 4-1-1 Water Supply and Demand

The demand for water is estimated for the Manzanillo Metropolitan Zone and for the commercial port. The main water supply network within the commercial port is also planned.

(1) Water supply and demand in the Manzanillo Metropolitan Zone

1) Potable water demand

The demand for potable water can be estimated based on the per capita per day method, as follows:

$$\left.\begin{aligned} MPW &= MW \times P \\ APW &= MPW \times \alpha \\ mpw &= MPW \times \beta/24 \\ apw &= APW \times \beta/24 \end{aligned}\right\} \quad \cdots\cdots \quad \text{(VII-9)}$$

Where,
- MPW : Maximum demand per day ($m^3$/day)
- MW : Maximum demand per capita per day (0.35 $m^3$/capita·day)
- P : Population supplied potable water (360,000)
- APW : Average demand per day ($m^3$/day)
- $\alpha$ : Average demand factor (0.8)
- mpw : Peak demand per hour ($m^3$/hr)
- $\beta$ : Peak demand factor (1.3)
- apw : Average demand per hour ($m^3$/hr)

Using the above equations:

MPW = 126.0/day (Unit: thousand $m^3$)
APW = 100.8/day
mpw = 6.8/hr
apw = 5.5/hr

2) Water demand available for fighting fires

It is estimated that it is necessary to have available 21 $m^3$/min of water for firefighting purposes, assuming a population of 360,000. This is approximately equivalent to 30,200 $m^3$/day, or 1,260 $m^3$/hr.

3) Water for industrial use

The amount of water necessary for industrial use is estimated as 100,400 $m^3$/day. This estimate is based on the size of the industrial zones in land-use plans, and on surveys of the amount of fresh water used for industrial purposes at leading Japanese plants.

4) Total fresh water required

From the above, we see that the average fresh water demand will be 100,800 $m^3$/day for potable water, 30,200 $m^3$/day for fighting fires, and 100,400 $m^3$/day for industrial use. Then, the total fresh water demand is estimated as 231,400 $m^3$/day. 43% of this total will be for industrial use.

5) Water supply

As explained in Chapter III, Section 2-5, the current potable water supply is 524 ℓ/sec. A project which is underway to bring water from the Armeria River will supply an additional 500 ℓ/sec. Further, four new wells are currently being bored. Although the actual amount of water which will come from these wells is still unknown, based on past experience at other wells, we estimate that each of these wells will produce 100 ℓ/sec. Thus the total potable water supply will be 1,424 ℓ/sec. This figure is equivalent to 123,000 $m^3$/day, enough to supply 94% of the estimated demand for drinking water and for fighting fires.

The estimated supply from these projects is almost enough to fulfill the estimated demand for drinking water and for fire fighting. However, these projects clearly will not be able to supply water for industrial use. Supply for industrial use will have to come from other sources, possibly from additional wells, or from the Armeria River, or from both sources. If additional water is taken from the river, the project will have to be closely coordinated with other development projects including the agricultural development plan. The overall water supply and demand situation will have to be studied further.

(2) Demand for potable water in the commercial port

The demand for potable water in the commercial port includes the water for the use of port staff, longshoremen, etc. as well as the water for the vessels calling at port.

1) Population and vessels that will be supplied

Water will be supplied to the following two groups:

| | |
|---|---|
| Port staff | 150 people |
| Longshoremen, etc. | 2,300 people |

And water will be supplied to all the vessels which call at port.

2) Estimating the volume of water demand and supply

a) Potable water

Each person uses a different volume of water per day. For planning purposes, we estimate that each person will use 0.35 $m^3$/day.

| | | |
|---|---|---|
| Port staff | 0.35 $m^3$/day x 150 persons ≑ | 55 $m^3$/day |
| Longshoremen, etc. | 0.35 $m^3$/day x 2,300 persons = | 805 $m^3$/day |
| | Total | 860 $m^3$/day |

b) Water supply to vessels

The volume of water to be supplied to vessels calling at port is estimated as follows:

$$W = \frac{N\alpha}{D} \times w \ (m^3/day) \quad \cdots\cdots \quad (VII\text{-}10)$$

Where, $N$ : Number of vessels in the port

$\alpha$ : Daily variation (1.5)

$D$ : Number of working days (330)

$w$ : Average water supply per vessel (200 $m^3$/vessel)

According to Chapter VII, Section 2-2, the number of vessels calling at the Port in the year 2000 is 591. Using the above equation, we calculate that water supplied to vessels will average 540 $m^3$/day.

c) Total water demand in the port

The demand for water in the port is 860 $m^3$/day for port staff, longshoremen, etc. and 540 $m^3$/day for the vessels calling at port. Thus the total demand is 1,400 $m^3$/day.

d) Water supply network

The water supply network is planned based on the estimated water demand as calculated above. Water for the vessels will be supplied through hydrants located every 50 m along the wharves. The main water supply network for the commercial port is presented in Fig. VII-26.

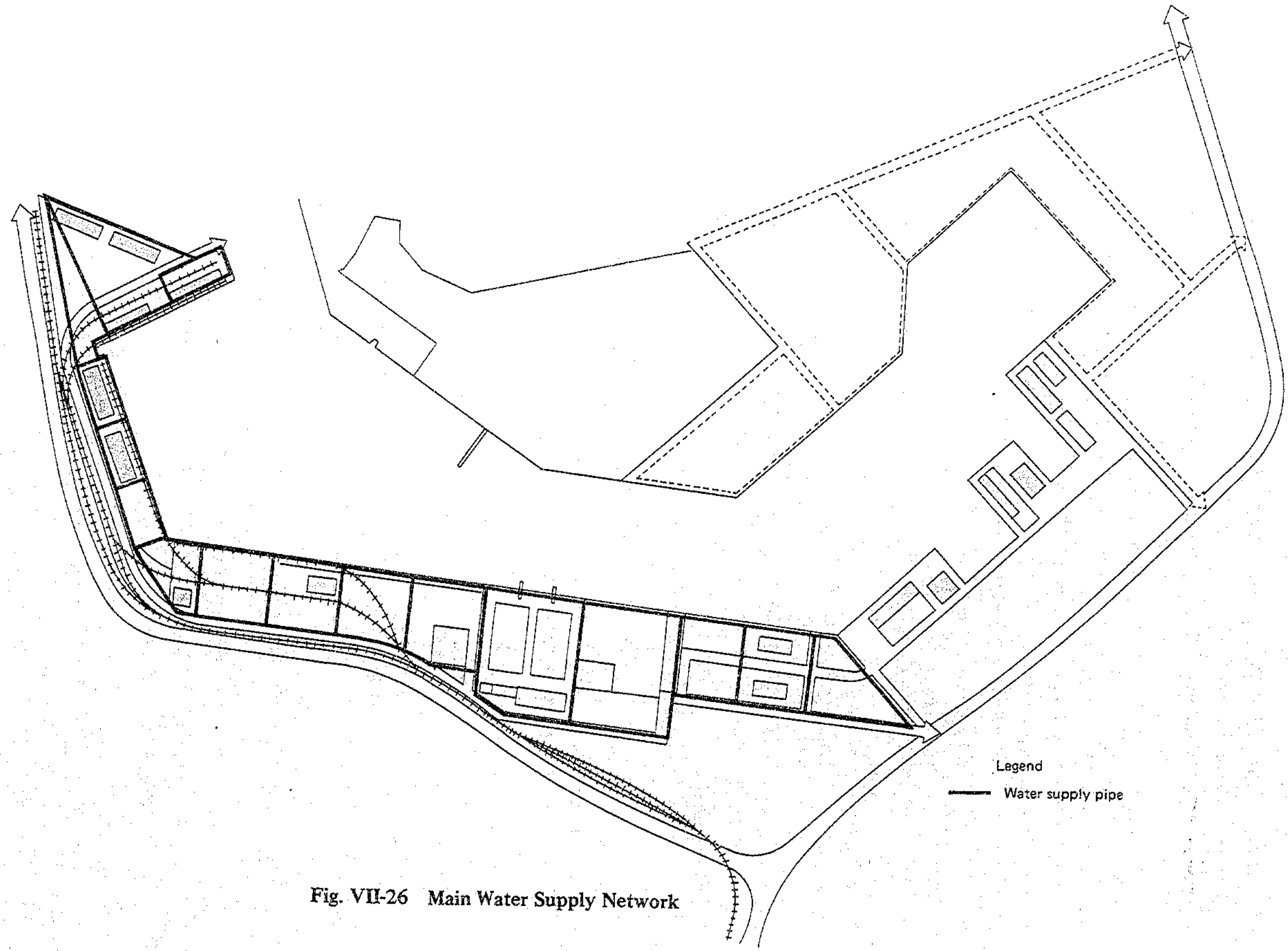



Fig. VII-26 Main Water Supply Network

### 4-1-2 Sewage

As for sewage disposal in the Manzanillo Metropolitan Zone, two sewage disposal plants are planned at Valle de Las Garzas and Tapeixtles next to the area for industrial use.

In the commercial port, sewage will come from offices, warehouses, and other structures. The volume of sewage from each source is relatively small, and the sources are spread out. The most efficient way of treating these small volumes of sewage is to build individual septic tanks at each structure, and then to move the treated sewage through the drainage network into the sea.

### 4-1-3 Drainage

Run-off rain water will flow into drainage mains with manholes. Estimates of the maximum amount of run-off rain water are calculated using the following equation.

$$Q = \frac{1}{360} CIA \quad \cdots\cdots \quad (VII\text{-}11)$$

Where, Q : Maximum flow ($m^3$/day)

C : Coefficiency of flow

| Water Surface | Roof | Roads | Parks |
|---|---|---|---|
| 1.0 | 0.9 | 0.85 | 0.15 |

I : Average rainfall intensity (mm/hr)

A : Catchment area (ha)

Over the past 20 years (1961 ~ 1980), 225 mm was the greatest amount of monthly rainfall, occurring in September. This figure is equal to 7.5 mm/day, which in turn is equivalent to a maximum hourly precipitation of about 7.5 mm/hr. As the random variable is selected as 1.9, the per hour value for I is estimated at 14.3 mm. Separating the commercial port into 9 blocks, the catchment area and the maximum flow are calculated as follows:

A = 7.8 ha

Q = 0.26 $m^3$/sec

Emplying these values in the Manning formula, the drain pipe sizes and the main drain network in the commercial port are designed as presented in Fig. VII-27.

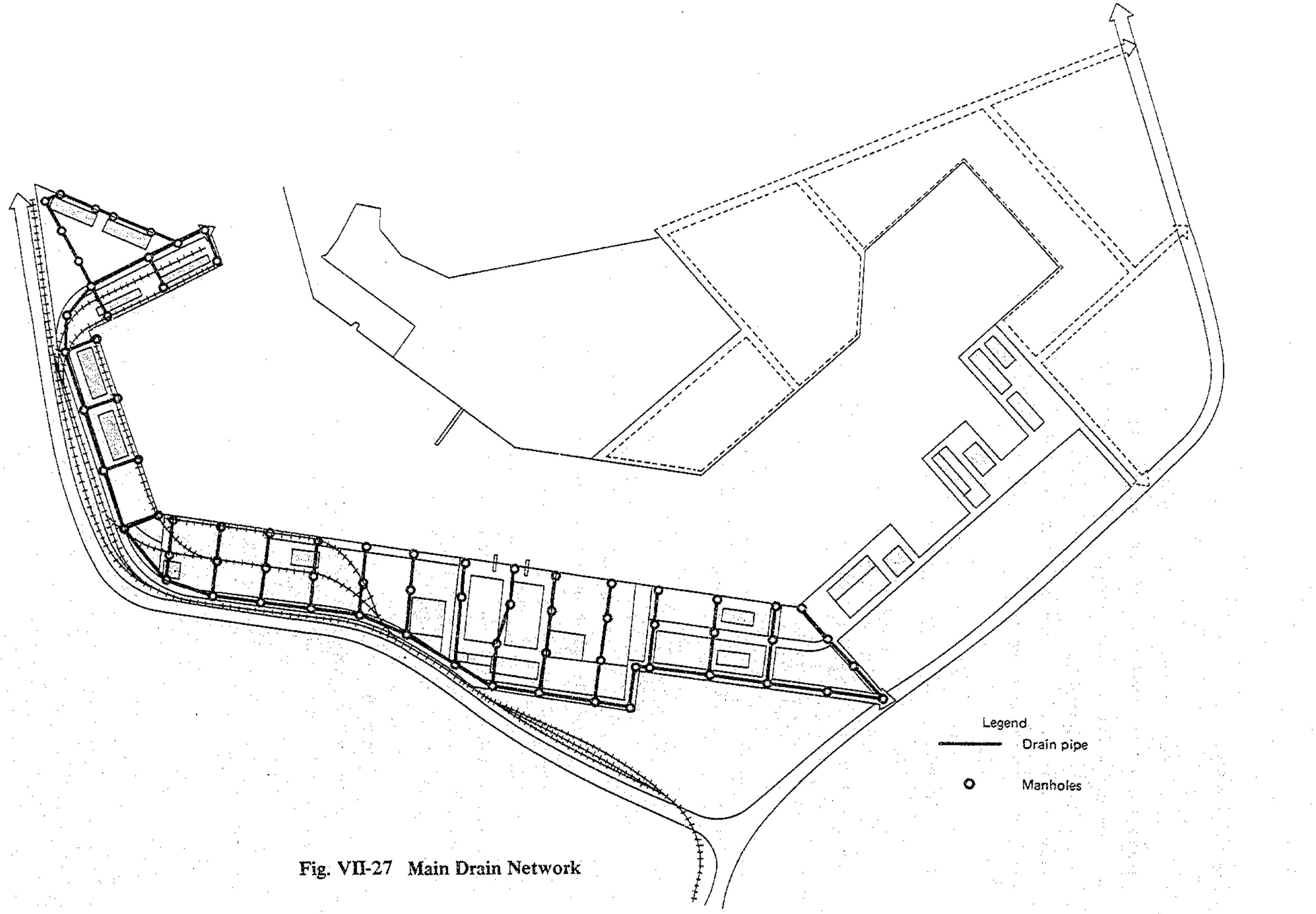



Fig. VII-27 Main Drain Network

### 4-1-4 Electric Power

The electric power demand is estimated for the Manzanillo Metropolitan Zone including the commercial port. The main electric power supply network for the commercial port is also laid out.

(1) Electric power demand in the Manzanillo Metropolitan Zone

1) Electric power demand

The per capita domestic electric power demand is estimated at about 0.2 ~ 0.3 KVA. Thus, for a population of about 360,000, the total domestic electric power demand is estimated at about 100 MVA.

The total electric power deand for industrial use in the Manzanillo Metropolitan Zone is estimated at about 200 MVA based on a survey of electric power use at leading Japanese plants.

From the above, the total electric power demand in the Manzanillo Metropolitan Zone is estimated at about 300 MVA.

2) Electric supply

According the Chapter III, Section 2-5, the thermo-electric plant which has a generating capacity of 1,200 MW will be expanded, and will have a capacity of 1,900 MW in 1988. Thus the electric supply will be far more than enough to satisfy the total local demand, including the demand for both domestic and industrial use.

However, the 4 sub-stations only provide a total of 61.375 MVA. Thus other sub-stations will have to be built or the existing sub-stations will have to be expanded before the construction of the commercial port and of the various industrial areas.

(2) Electric power demand in the commercial port

The electric power demand in the commercial port is estimated as follows:

| | | | | | | |
|---|---|---|---|---|---|---|
| ① | Container yard | | | | | |
| | Container cranes | 750 kw | x | 2 | = | 1,500 kw |
| | Freezing containers (20′) | 5.5 kw | x | 100 | = | 550 kw |
| | (40′) | 11 kw | x | 100 | = | 1,100 kw |
| | Yard lighting | 10 kw/ha | x | 10 ha | = | 100 kw |
| ② | General yard | | | | | |
| | Yard lighting | 10 kw/ha | x | 23 ha | = | 230 kw |
| ③ | Buildings | | | | | |
| | Lighting | 20 w/m² | x | 70,000 m² | = | 1,400 kw |
| | Powering | 20 w/m² | x | 70,000 m² | = | 1,400 kw |
| ④ | Cargo handling equipment | | | | | |
| | Belt conveyers | 55 kw | x | 2 | = | 110 kw |
| | Chain conveyers | 55 kw | x | 2 | = | 110 kw |

| | | | | |
|---|---|---|---|---|
| 5 | Road Lighting | 50 kw/km × | 4 km = | 200 kw |
| 6 | Others | | | 2,900 kw |
| | | | Total | 9,600 kw |

9,600 kw ≒ 12.5 MVA

Based on the above, the electric power demand in the commercial port is estimated at about 12.5 MVA. The main electric supply network for the commercial port is presented in Fig. VII-28.

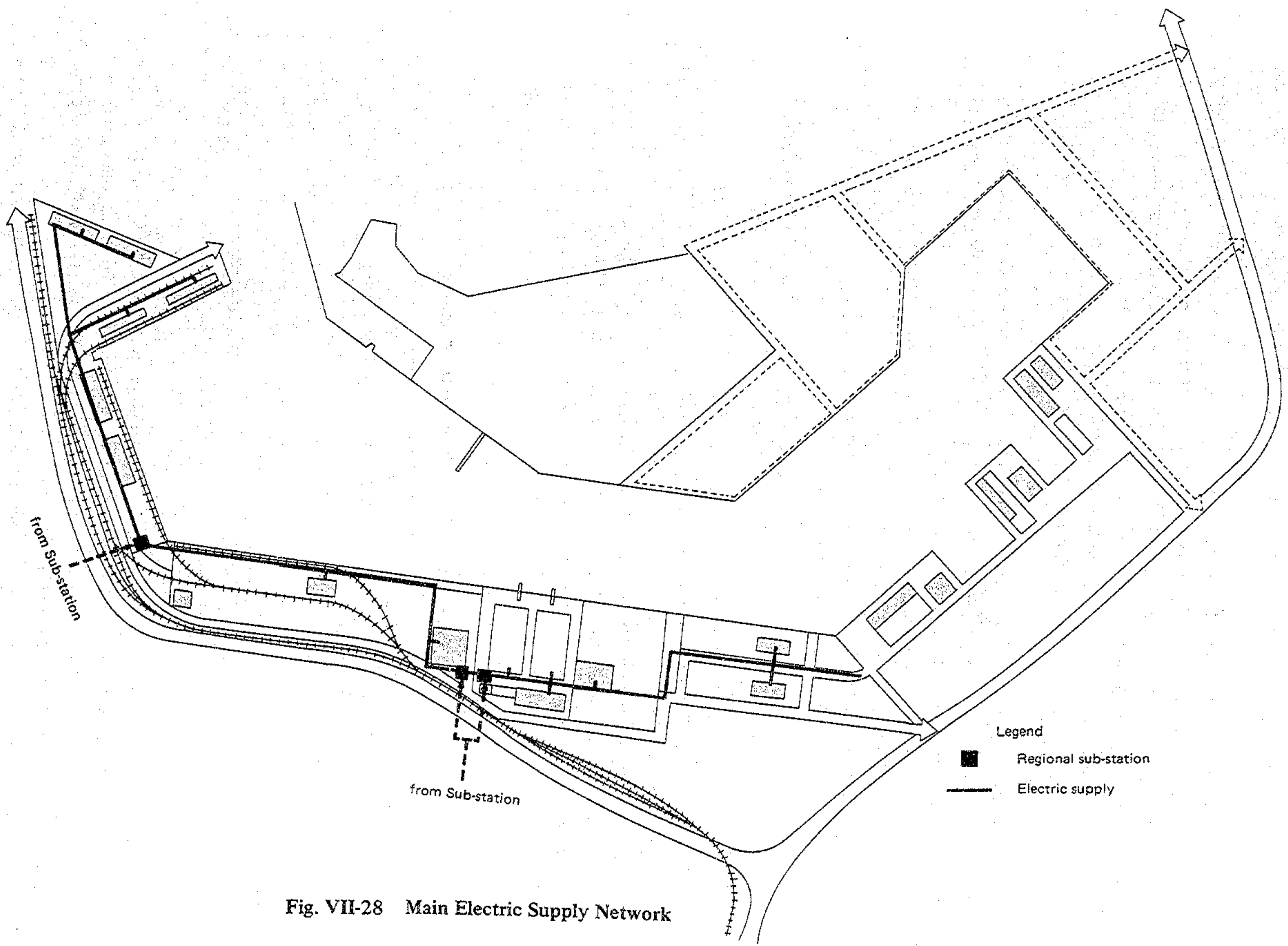



Fig. VII-28 Main Electric Supply Network

### 4-1-5 Oil Supply Facilities

In this section, only the oil demand for vessels in the commercial port is considered. The oil demand for fishery boats, leisure boats and vehicles is not taken into account.

According to Chapter VII, Section 2-2, the number of vessels calling at the Port in the year 2000 is estimated as follows:

Foreign trade: 558 vessels
Domestic trade: 33 vessels

The vessels which will be supplied oil are almost all Mexican vessels. As Mexican vessels will carry approximately 40% of foreign trade, 40% of the foreign trade vessels are assumed to be Mexican. Similarly, as 90% of the domestic trade will be carried by Mexican vessels, 90% of the domestic trade vessels are assumed to be Mexican.

Thus the number of Mexican vessels calling at the Port in the year 2000 is estimated as:

Foreign trade: 558 x 40% = 223 vessels
Domestic trade: 33 x 90% = 30 vessels

The volume of oil supply per vessel is assumed as follows:

| | Size of Ship (DWT) | Volume of Oil Supplied (kℓ) |
|---|---|---|
| Domestic Trade (Mineral bulk): | 20,000 | 1,000 |
| Domestic Trade (General bulk): | 10,000 | 500 |
| Foreign Trade | 17,000 | 850 |

As the Mexican vessels calling at Manzanillo can also obtain oil at the ports of Mazatlan and Lázaro Cárdenas, we assume that 30% of these vessels will obtain oil at Manzanillo Port.

From the above, the total volume of oil which will be supplied per year at the port of Manzanillo is calculated as shown in Table VII-44.

**Table VII-44 Total Oil Volume in 2000**

| Size of Ship (DWT) | Number of Mexican Vessels | Number of Supplied Vessels | Supplied Volume of Oil per Ship (kℓ) | Total Volume of Oil (kℓ) |
|---|---|---|---|---|
| 20,000 | 17 | 5 | 1,000 | 5,000 |
| 17,000 | 223 | 67 | 850 | 56,950 |
| 10,000 | 16 | 5 | 500 | 2,500 |
| Total | 256 | 77 | – | 64,450 |

Then, the total oil required per year is estimated as about 64,450 kℓ. This figure is equal to 1,240 kℓ/week. Each of the oil tanks (one of which will be used for oil for the vessels) which "Servicios Porutuarios" has completed has a capacity of 10,000 bls (1,590 kℓ). This capacity is equal to more than the average weekly demand.

As we assume that "Servicios Porutuarios" will use their own facilities efficiently, it is not necessary to plan any additional oil supply facilities for the commercial port.

## 4-2 Aids to Navigation

As for the aids to navigation in the year 2000, the facilities that are listed in Table VII-45 and shown in Fig. VII-29 will be required. Furthermore, it is assumed that the lighthouse located at Punta Campos and the light mark at the top of the breakwater (① in Fig. III-39) are sufficient to accmmodate the traffic in the target year.

Table VII-45 Aids to Navigation

| Aids | Color | Lantern Lens (mm) | Lamp | Light Character | *1 Location | *1 Symbol |
|---|---|---|---|---|---|---|
| *2 Light Mark | Green | – | – | Fℓ 3 Sec (3.0 + 3.0) | Ⓐ |  |
| | Red | – | – | Fℓ 3 Sec (3.0 + 3.0) | Ⓑ |  |
| Lighted Spar Buoy | Green | 200 | 12V 2.03A | Fℓ 6 Sec (0.5+0.5+0.5+4.5) | ① ③ |   |
| | Red | | | | ② ④ |   |
| Lighted Buoy | Green | 155 | 12V 10W | Fℓ 3 Sec (0.5+2.5) | ⑤,⑥,⑦,⑧,⑨ |  |
| | Red | | | | ⑩ |  |
| Lighted Buoy | Green | 155 | 12V 6W | Fℓ 4 Sec (4.0+4.0) | ⑪, ⑫ |  |
| Leading Light | White (Front) | 250 | 12V 3.05A | F | ⑬ |  |
| | White (Read) | | | | ⑭ | |

Note: *1: The location and symbol of aids are shown in Fig. VII-29.
*2: These light marks already exist.
Fℓ: Flashing, F: No flashing

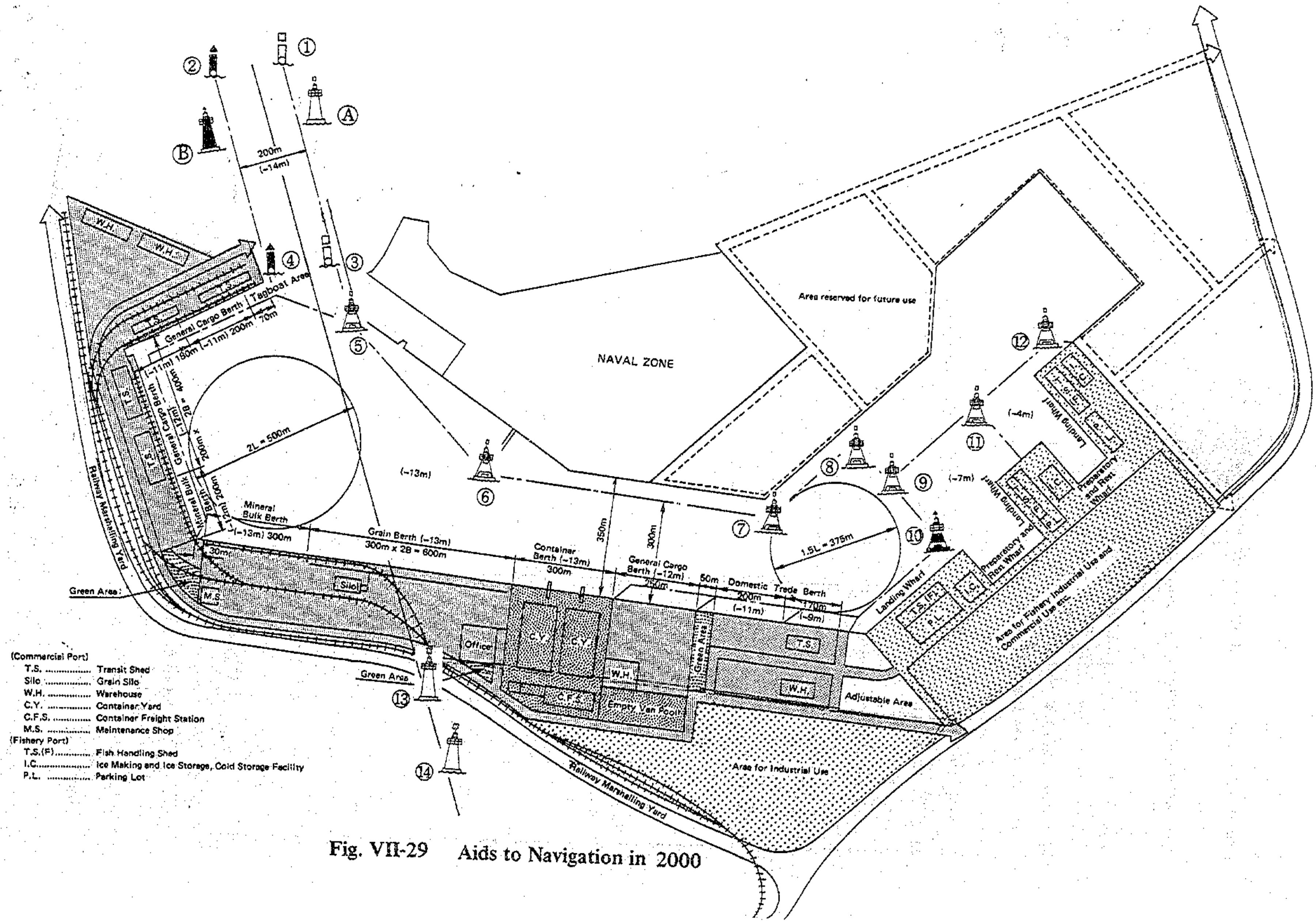



Fig. VII-29 Aids to Navigation in 2000

## 5. Environmental Aspect

### 5-1 General

Table VII-46 and Table VII-47 show the various effects upon the natural environment expected due to construction and operation of the large scale development in the Manzanillo Metropolitan Zone. During construction, the environment will be greatly affected by development factors such as logging, land reclamation, altering the courses of rivers and collection of soil for land fill.

During operation of the new facilities, the local air and water quality will be greatly affected by the presence of an industrial waste treatment station, a thermo-electric plant, an increased number of motor vehicles, etc.

This section will present a general survey of the impact of the project on various aspects of the natural environment, and will propose measures to minimize the harmful environmental effects.

## Table VII-46 Environmental Impact during Construction

| Affected Features of the Natural Environment \ Type of Environmental Impact | | A. Altering the Natural Geography | | | | | | B. Removal and Transportation of Material | | | | C. Construction | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | a. Cutting down trees | b. Dredging | c. Reclamation | d. River improvement | e. Waterway excavation | f. Drainage network reformation | a. Collection of sand and gravel for cement aggregate | b. Soil collection for land fills | c. Ocean transportation of materials | d. Land transportation of materials | a. Land cutting | b. Banking | c. Drilling and blasting | d. Foundation work and excavation | e. Pile driving | f. Concrete work | g. Pavement |
| 1. Land | (1) Topographic features | | | O | O | O | O | O | O | | | O | O | O | | | | |
| | (2) Soil | O | | | | | O | O | O | | | O | O | | | | O | O |
| 2. Water | (1) Surface water | O | | O | O | O | O | O | O | | | O | O | O | O | | O | O |
| | (2) Ground water | O | O | O | O | O | O | O | O | | | O | O | | O | O | O | O |
| | (3) Ocean | | O | O | | | | | | | | | | | | | | |
| | (4) Water quality | | O | O | | O | | O | O | O | | O | | | | | O | O |
| | (5) Water temperature | | O | | | | | | | | | | | | | | | |
| 3. Air | (1) Air quality | O | | | | | | O | O | | O | O | | O | | | | |
| | (2) Air temperature | O | | | | | | | | | | | O | | | | O | O |
| | (3) Wind direction and velocity | O | | | | O | | O | O | | | O | O | | | | | |
| | (4) Noise | O | | | | O | | O | O | | O | O | | | O | O | O | O |
| | (5) Vibration | O | | | | O | | O | O | | O | O | | | O | O | O | O |
| | (6) Offensive odors | | O | | | | | | | | O | | | | | | | O |
| 4. Geophysical and Meteorological Mechanisms | (1) Rainfall run-off system | O | | O | O | O | O | O | O | | | O | O | | | | O | O |
| | (2) Land vibration system | O | | | | | | O | O | | O | O | O | | O | O | | |
| | (3) Micro-meterological situation | O | | O | O | O | O | O | O | | O | O | O | O | | | O | O |
| 5. Flora | (1) Natural forest | O | | | O | O | O | O | O | | | O | | | | | | |
| | (2) Artificial forest | O | | | O | O | O | O | O | | | O | | | | | | |
| | (3) Agricultural products | | | | O | O | O | | O | | | O | O | | | | | |
| 6. Fauna | (1) Wind animals | O | | O | O | | O | O | O | | | O | O | | | | | |
| | (2) Birds | O | | O | O | O | O | O | O | | | O | | | | | | |
| | (3) Fish | | O | O | O | O | O | O | | | | | | | | | | |
| 7. Ecosystem | (1) Forest ecosystem | O | | | O | | O | O | O | | | O | | | | | | |
| | (2) Arable land ecosystem | | | | | | O | | | | | | O | | O | | | O |
| | (3) Rivers and lakes ecosystem | | O | O | O | O | O | O | | | | | | | | | | |
| | (4) Sea ecosystem | | O | O | | | | | | | | | | | | | | |
| 8. Natural Scenery | (1) Mountainous land | O | | | | | | O | | | | | | | | | | |
| | (2) Plateau and hilly land | O | | | | | | O | O | | | O | O | | | | | |
| | (3) Lowland and arable land | | | | O | O | O | O | O | | | O | O | O | | | O | O |
| | (4) Rivers and lakes | | | O | O | O | | O | O | | | | | | | | O | O |
| | (5) Seashores | | | O | | O | | | | O | | | | | | | O | O |
| | (6) Ocean | | | | | | | | | O | | | | | | | | |

## Table VII-47 Environmental Impact during Operations

| Affected Features of the Natural Environment \ Type of Environmental Impact | | | A. Industry: a. Marine products and foods industry | A. Industry: b. Iron and steel | A. Industry: c. Light industry region | B. Port: a. Excavated channels and anchorages | B. Port: b. Breakwaters | B. Port: c. Ships | B. Port: d. Port roads and railway | C. Urban Area: a. Sewage disposal plant | C. Urban Area: b. Garbage disposal plant | C. Urban Area: c. Marine recreational base | C. Urban Area: d. Motor vehicles | C. Urban Area: e. Roads and railway | D. Others: a. Thermo-electric plant | D. Others: b. Power transmission facilities | D. Others: c. Industrial waste treatment plant | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Air | (1) Air quality | SOx | O | O | O | | | O | | | O | | O | | O | | O | Mainly $SO_2$ and $SO_3$ |
| | | NOx | | O | O | | | | | | O | | O | | O | | O | Mainly NO and $NO_2$ |
| | | CO | | O | | | | | | | | | O | | | | | |
| | | Dust | O | O | O | | | | | O | O | | | | O | | O | |
| | | HC | | O | | | | | | | | | O | | | | | |
| | (2) Noise | | | O | | | | | | | | | O | | | | | |
| | (3) Vibration | | | O | | | | | | | | | O | | | | | |
| | (4) Offensive odors | | O | | | | | | | | O | | | | | | O | |
| | (5) Air temperature | | O | O | O | O | | | O | O | O | O | | O | O | | O | |
| | (6) Wind direction and velocity | | O | O | O | O | | | O | O | O | O | | O | O | | O | |
| 2. Water | (1) Water quality | PH | | | | | | | | | | | | | | | | Normalized by treatment |
| | | COD | O | O | | | | | | | | | | | | | | |
| | | SS | O | O | | | | | | | | | | | | | | |
| | | Colitis germ | | | | | | | | O | | | | | | | | |
| | | Oils | | | | | | O | | | | | | | | | | |
| | | Transparency | O | O | | | | | | | | | | | O | | | |
| | (2) Warm water drainge | | | | | | | | | | | | | | O | | | |
| | (3) Ground Water | | | | | O | | | | | | | | | | | | Change in ground water level and conversion into salt water |
| | (4) Tidal current | | | | | O | O | | | | | | | | | | | |
| 3. Land | (1) Soil | | | | | | | | | | | | | | | | O | |
| 4. Flora | (1) Natural forest | | | O | | O | | | | | | | O | | O | | | Mainly airborne salts and soot |
| | (2) Agricultural products | | | O | | O | | | | | | | O | | O | | | |
| 5. Fauna | (1) Mammals | | | | | | | | | | | | | | | | | |
| | (2) Birds | | | | | | | | | | | | | | | | | |
| | (3) Aquatic animals | | O | O | | O | | | | | | | | | | O | | Warm drainage, dredging (fish, shells, eggs, young fish, plankton) |
| 6. Natural Scenery | | | O | O | O | O | O | | O | O | O | O | | O | O | O | O | |

## 5-2 Impact of Industries on the Environment

This section studies the amount of pollution that will be caused by the industries in the Manzanillo Metropolitan Zone, and the extent to which it is possible to minimize this pollution by means of control equipment. As factors affecting air quality, Sulfuric Oxide (SOx) and soot are investigated. As factors affecting water, the Chemical Oxygen Demand (COD) and Suspended Solids (SS) are investigated.

### 5-2-1 Impact on Air Quality

Quantities of SOx and soot are indicated in terms of the amount of annual emissions (ton). These quantities are estimated based on surveys of SOx and soot emission prior to filtration through air purification equipment at leading Japanese plants.

Results are shown in Table VII-48.

The largest quantity of SOx is emitted through fuel consumption at the thermo-electric plant. This plant accounts for 65% of the total quantity. Soot pollution primarily comes from "Peña Colorada" and light industry. These two industries alone account for 84% of the total quantity.

**Table VII-48 Estimates of Air Pollutants**

(Unit: t/year)

| Industry | SOx | Soot and Dust |
|---|---|---|
| Peña Colorada | 980 | 3,900 |
| PEMEX | 1,120 | 140 |
| Thermo-electric Plant | 18,700 | 950 |
| Heavy Industry | 920 | 380 |
| Light Industry | 5,700 | 5,950 |
| Seafood Products | 660 | 200 |
| Food Industry Complex | 630 | 190 |
| Total | 28,710 | 11,710 |

### 5-2-2 Impact on Water Quality

Quantitites of COD and SS are indicated in terms of daily emissions (ton). These estimates of pollution quantitites are based on surveys of the levels of COD and SS in water prior to filtration through purification equipment at leading Japanese plants multiplied by the volume of discharge water (which is estimated from fresh water consumption). The results are shown in Table VII-49.

The largest quantity of COD is discharged from light industry. The food industry complex and seafood products are also large sources of COD pollution. Together, these three industries account for over 90% of total COD discharge.

As for SS discharge, the largest amount comes from the food industry complex. This industry alone accounts for over 34% of the total quantity. "Peña Colorada", light industry, and seafood products are also major sources of SS pollution. They account for 26.5%, 21.5% and 12.7% of total SS pollution, respectively.

Table VII-49 Estimates of Water Pollutants

(Unit: t/day)

| Industry | COD | SS |
|---|---|---|
| Peña Colorada | 5.4 | 15.9 |
| PEMEX | 1.3 | 1.6 |
| Thermo-electric Plant | – | – |
| Heavy Industry | 0.6 | 1.3 |
| Light Industry | 30.9 | 12.9 |
| Seafood Products | 10.7 | 7.6 |
| Food Industry Complex | 28.8 | 20.6 |
| Total | 77.7 | 59.9 |

### 5-3 Environmental Protection Measures

Quantities of air and water pollution calculated in the above studies are not, of cource, the actual quantities of pollution discharges. It is common practice to remove major quantities of pollutants before dischrge. The following sub-sections present a study on the methods for pollution control, pollutant removal rates, and the investment required. Figures regarding SOx emissions and COD discharges are based upon Japanese environmental protection measures.

#### 5-3-1 Air Pollution Control

Japanese industries employing advanced techniques of air pollution control have been able to reduce SOx and soot levels by 90 ~ 95%, in other words, emissions of those pollutants have been reduced to 1/10 ~ 1/20 of former levels. The techniques that have enabled this degree of air pollution control can be summarized as follows:

In thermo-electric plants, SOx is found largely in exhausts produced from combustion of fuel oil used for power generation. SOx can be removed from these exhausts by flue-gas desulfurization.

In the iron and steel industry, SOx and soot are found largely in exhausts from sintering furnaces, heating furnaces and boilers. Soot can be extracted from these exhausts by wet and dry EP (Electrostatic Precipitation) methods, while SOx can be removed by flue-gas desulfurization.

In light industry, large amounts of SOx are emitted from some kinds of boilers. From these exhausts, SOx is removed by flue-gas desulfurization, while soot is removed by an electrical dust collector.

In order to remove 90! of the SOx load, the investment for air pollution control will amount to 3 ~ 4% of the total construction investment. If the SOx removal rate is increased to 95%, then the investment for air pollution control will increase to 7 ~ 15%.

Past experience in Japan has shown that strict environmental standards can be met by first treating emissions by the methods explained above, and then exhausting the gas from a tall smokestack, thereby facilitating diffusion of the pollutants. (See Table VII-50)

**Table VII-50 Required Air Quality Level (Daily Average)**

| Nation | $SO_2$ (ppm) | Suspended Particulate Matter ($mg/m^3$) |
|---|---|---|
| Japan | 0.04 | 0.10 |
| Canada | 0.06 | 0.12 |
| Finland | 0.10 | 0.15 |
| Italy | 0.15 | 0.30 |
| U.S.A. | 0.14 | 0.26 |
| West Germany | 0.06 | – |
| France | 0.38 | 0.35 |
| Sweden | 0.25 | – |

Source: For $SO_2$ and suspended particulated matter: Wemer-Martin and Arthur C. Steam, "The Collection, Tabulation, Codification and Analysis of the World's Air Quality Management Standards", School of Public Health, University of North Carolina at Chapel Hill, N.C., U.S.A., October 1974.

## 5-3-2 Water Pollution Control

Japanese industries employing advanced techniques of water pollution control have been able to reduce COD loads by 90 ~ 98% and SS loads by 97 ~ 98%, in other words, emissions of these pollutants have been reduced to 1/10 ~ 1/20 and 1/20 ~ 1/30 of their former levels, respectively.

COD is removed by the combined use of the activated charcoal process, the activated sledge process and ozone oxidation. SS is removed by either aggregated pressuring combined with the flotation process or by the aggregated filtration process.

The investment for water pollution control is only 0.4 ~ 0.6% of the total construction investment, assuming a COD removal rate 90 ~ 95%. If the COD removal rate is increased to 94 ~ 98%, then the investment for water pollution control would increase to 15 ~ 20%.

Past experience in Japan shows that high quality water standards can be achieved through the above-mentioned methods.

## 5-4 Spread of Water Pollution

The inner port of Manzanillo is almost a closed water area and is seriously influenced by water pollution, so the spread of COD water pollution is estimated by means of numerical simulation using a computer.

### 5-4-1 Conditions for the Estimate

(1) COD quantity at present

The quantity of COD at present is supposed negligible, because the factories in the fishery port and industrial zone are barely operated.

(2) COD quantity in the future

The quantity of COD in the future is estimated as follows:

① The COD quantity in the stream from Las Garzas Lagoon is negligible.

② The COD quantity which is directly drained into the inner port is only estimated from the fishery port and the reclaimed area for industrial use in Tapeixtles Lagoon.

③ The industrial location is supposed as follows:

The fishery Port: Seafood products

The reclaimed area in Tapeixtle Lagoon: Food industry complex

④ The COD quantity is indicated in terms of daily emissions (ton).

The estimation of COD emissions is based on surveys of COD levels in water prior to filtration through purification equipment at leading Japanese plants multiplied by the volume of discharge water.

The calculation result is as follows:

| | |
|---|---|
| The Volume of Discharge Water | 125,500 $m^3$/day |
| COD Quantity | 3.95 tons/day |
| COD Level | 315 ppm |

As mentioned before, water pollution control has been able to reduce COD load to 1/10 ~ 1/20 of the former level. Then, we employ the two quantities of COD in the future as shown in Table VII-51.

Table VII-51 COD Level in the Future

| Case | The Volume of Discharge Water ('000 $m^3$/day) | COD Quantity (t/day) | COD Level (ppm) |
|---|---|---|---|
| Case 1 | 125.5 | 4 | 32 |
| Case 2 | 125.5 | 2 | 16 |

### 5-4-2 Simulation Model

The computer simulation is conducted as follows:

① Both X and Y spans of grid are 100 m.

② The simulation model is two dimensional.

③ Tidal wave is as follows:

Tidal cycle: 24 hr

Sinusoidal wave with 70 cm wave height

④ Spreading ratio (Ko) is $10^4$ $cm^2/sec$.

⑤ Bottom friction is 0.0026.

### 5-4-3 Simulation Results

The results estimated by means of the numerical simulation are shown in Fig. VII-30(a) and Fig. VII-30(b).

As there are no national COD pollution standards in Mexico, we consider the Japanese standards for water pollution for COD as follows:

| | |
|---|---|
| Fishery (1st grade), Swimming | less than 2 ppm |
| Fishery (2nd grade), Industrial use | less than 3 ppm |
| Environment protection | less than 8 ppm |

In conclusion, the discharge water from the industrial area to the inner port should be treated.

## 5-5 Measures in the Future

The environment of the Manzanillo Metropolitan Zone is seriously influenced by the "Peña Colorada" iron pellet plant and the thermo-electric plant. Specifically, the thermo-electric plant emits SOx, and the iron pellet emits soot. Compared with these plants, the port area creates little air pollution.

As for water pollution, the sewage from the Manzanillo urban area is a serious problem. In the future, the volume of sewage is going to increase along with the rapid growth of the population of the area. Thus, the water pollution will become more severe. Furthermore, the discharge water from the fishery port and industrial area, which are considered above, will also contribute to the pollution of the sea area. The port operations will further pollute the water through discharge of ballast water, bilge, sewage, and waste water from the wharves and other port facilities.

In order to minimize the water pollution from the Port, a standard for discharge water will have to be established and a monitoring system arranged in advance.

However if the water pollution gets worse, other measures may be necessary. For example, fresh seawater from Manzanillo Bay could be introduced to the inner port using pumps by running a pipe from the north end of the inner port to the Bay.

Case 1 (COD loads 4 t/day)

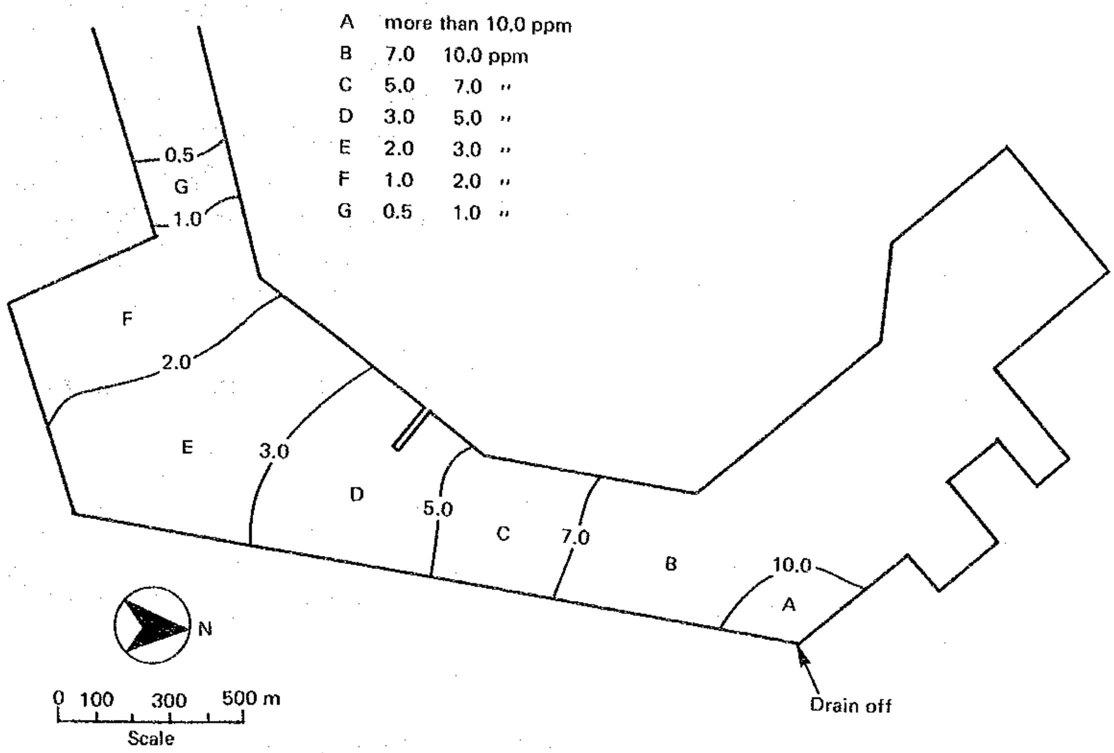



Fig. VII-30(a) Spread of Water Pollution (1)

Case 2 (COD loads 2 t/day)

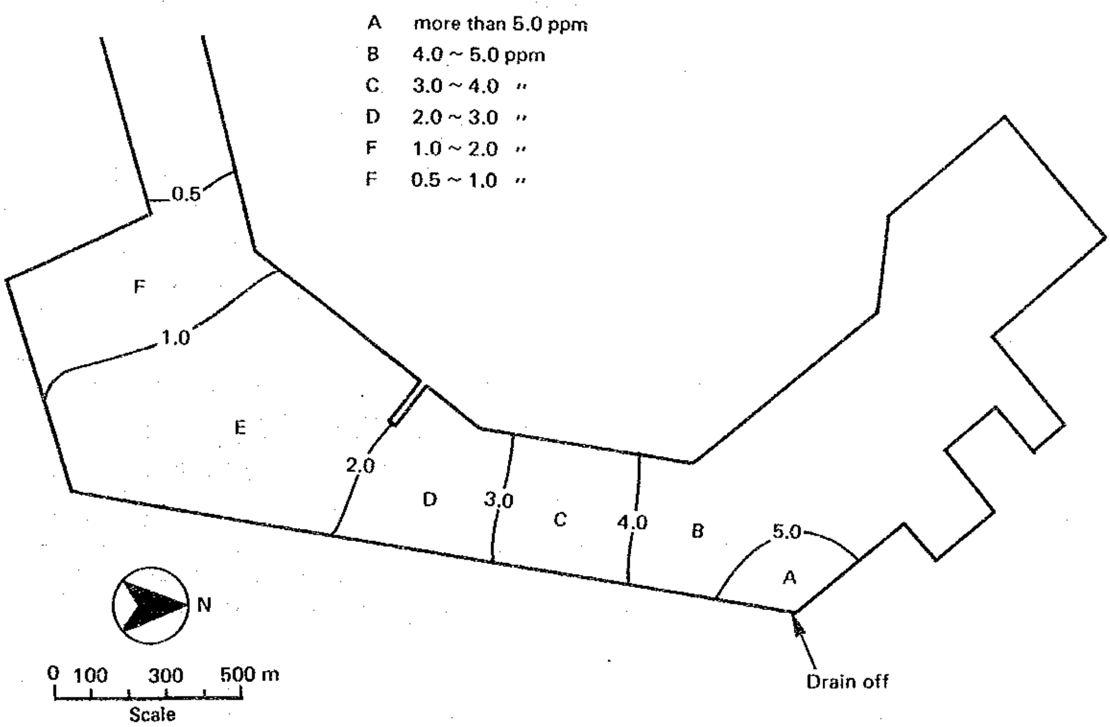



Fig. VII-30(b) Spread of Water Pollution (2)