CHAPTER V
NATURAL CONDITION OF TUXPAN INDUSTRIAL PORT

Project Site

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1. Meteorological Condition

1-1 Temperature

Monthly means for daily maximum, minimum and average temperatures from 1977 to 1981 observed in Tuxpan are compared with those observed in Mexico DF in Fig. V-1-(1). From the figure, followings can be understood.

1) The temperatures in Tuxpan are considerably higher than those of Mexico DF by almost 10°C for the daily maximum, 5°C for the daily minimum and 9°C for the daily average.
2) Seasonal temperature differences in Tuxpan are larger than those in Mexico DF. In Tuxpan, the temperatures are very high from May to August, and somewhat cool from November to February.

It is obvious from the above that temperatures in Tuxpan are fairly high. As already mentioned in Chapter IV-2, with the progress of the Project, the population within the Area can be expected to rapidly increase. But the high temperatures of the Area may prove somewhat of an obstacle to further immigration into this area. The degree to which these high temperatures may prove an obstacle cannot be estimated, but all we can do is to compare the temperatures in Tuxpan with those of large cities in the world.

Fig. V-1-(2) shows a comparison of the monthly average temperatures of Tuxpan with those of Bangkok and Cairo. It can be seen in this figure that Tuxpan's temperature lies between those of Cairo and Bangkok. Thus it is likely that although the temperatures of Tuxpan are higher than those in other cities situated on the highland in Mexico, they will not be a severe problem hindering immigration into the Area from outside.

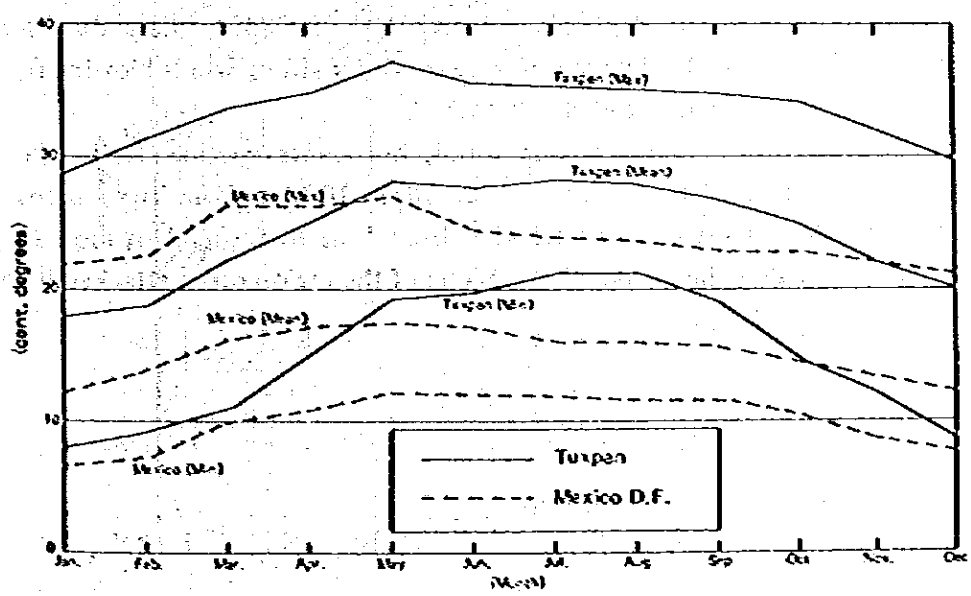


Fig. V-1-(1) Comparison of the Temperatures in Tuxpan with those in Mexico DF

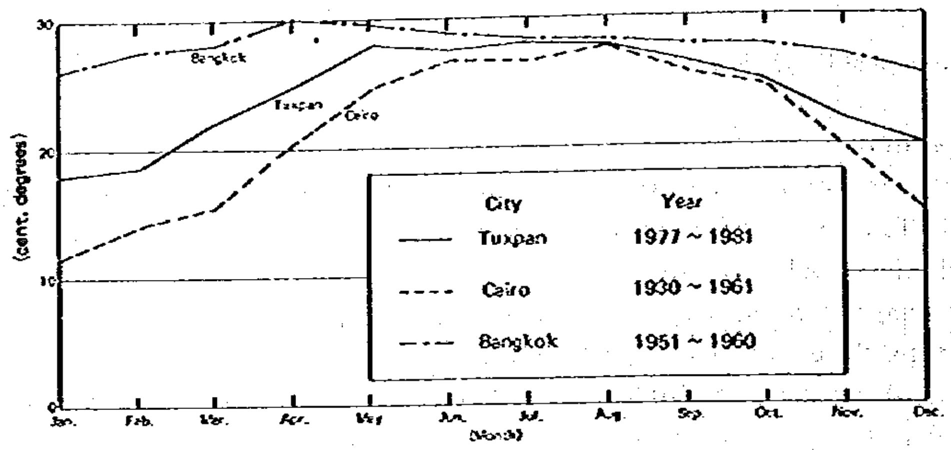


Fig. V-1-(2) Comparison of the Temperatures in Tuxpan with those of Cairo and Bangkok

1-2 Wind

(1) Strong wind

Table V-1-(1) shows monthly muximum wind velocities and their directions observed in Tuxpan for ten years from 1971 to 1980. The strongest wind observed in this period was 42 m/sec with the northern direction in January 1978. Fig. V-1-(3) is occurrence frequencies of these strong wind directions with parameters of several wind speed scales. It is seen that the predominent direction of the strong winds is North. Winds whose velocity is more than 20 m/sec are also frequent from North. To say the seasonal characteristics of the strong winds are as follows. In winter and spring from October to May, the strong winds usually blow from North, while in summer from June to September, North East to South East direction are also predominent in addition to North. The reason why in winter strong winds blowing from North is due to the influence of the monsoon called "northern".

Here as an another cause of the strong winds, hurricanes will be dealt. There were 27 hurricanes in number whose center passed through within 100 km from Tuxpan city during 26 years from 1952 to 1977. Most of them occurred from June to September, most frequently in July. This fact indicates that the proposed site is one of the region often attacked by hurricanes.

Table V-1-(1) Monthly Maximum Wind Velocity and Direction in Tuxpan

(Unit: m/sec.)

Month \ Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
January	N 15.0	N 24.5	N 22.0	N 16.0	N 20.0	N 12.0	N 22.0	N 42.0	N 31.0	N 19.0
February	N 16.0	N 26.0	N 20.0	N 18.0	N 23.0	N 20.0	N 33.0	N 24.0	E 23.0	N 29.0
March	N 21.0	N 16.0	NE 17.0	N 16.0	N 19.0	N 19.0	N 26.0		N 26.0	N 26.0
April	N 12.5	SE 17.0	N 20.0	N 20.0	N 22.0	N 14.0	N 36.0	SSE 24.0	N 20.0	N 26.0
May	N 9.0	N 22.0	N 25.0	E 12.0	NE 19.0	N 12.0	E 20.8	N 32.0	N 28.5	WSW 33.0
June	E 11.0	E 18.8	SE 12.0	N 14.0	N 12.0		SE 20.0	S 30.0	N 26.0	NE 19.5
July	N 10.0	E 14.0	SE 9.0	SE 10.0	E 12.0	SE 12.0	SE 30.0	ESE 18.0	SE 21.5	SE 19.0
August	SE 14.0	NE 18.0	SE 9.0	SE 12.0	N 9.5		ESE 23.0	N 26.0	SE 24.0	SE 27.0
September	NNE 12.0	NE 15.0	N 10.0	N 22.0	N 12.0		S 33.0	NE 22.0	NNW 21.0	
October	NW 12.9	N 6.0	SE 12.0	N 14.0	SE 8.2	N 15.0	N 26.0	W 19.0	N 22.0	W 32.0
November	N 16.0	N 18.0	N 14.0	N 28.0	N 20.0	N 10.0	N 40.0	W 21.0	N 20.0	N 26.0
December	N 20.0	N 21.0	N 16.0	N 12.0	N 14.0	N 25.0	N 32.0	N 30.0		N 22.0

(Source: Observed data in Tuxpan, SARH)

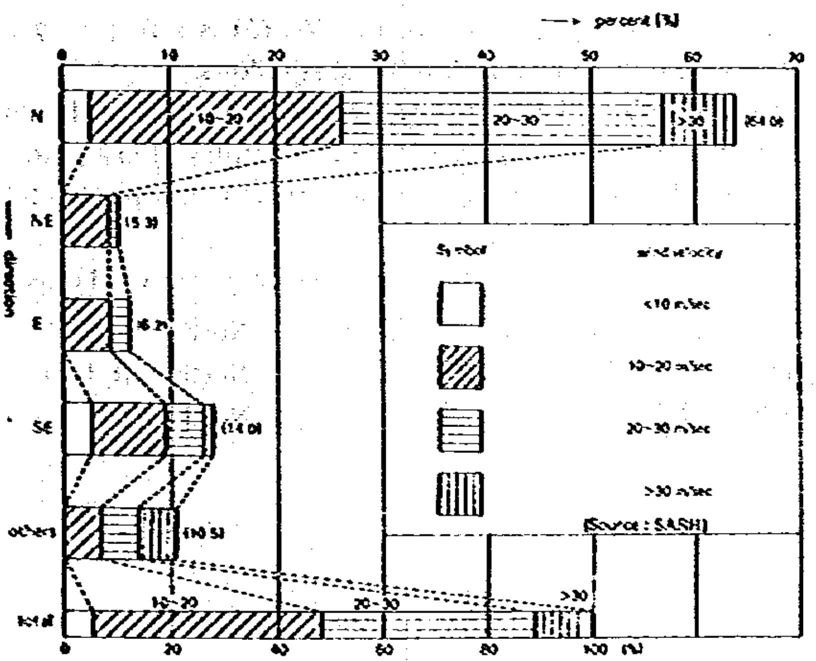


Fig. V-1-(3) Occurrence of Monthly Maximum Wind Direction and Velocity

Fig. V-1-(4) is a course and observed meteorological factors (atomospheric pressure and wind velocities) in Tampico of Hurricane HILDA in 1955, which was one of the biggest hurricane struck on the coast of the site.

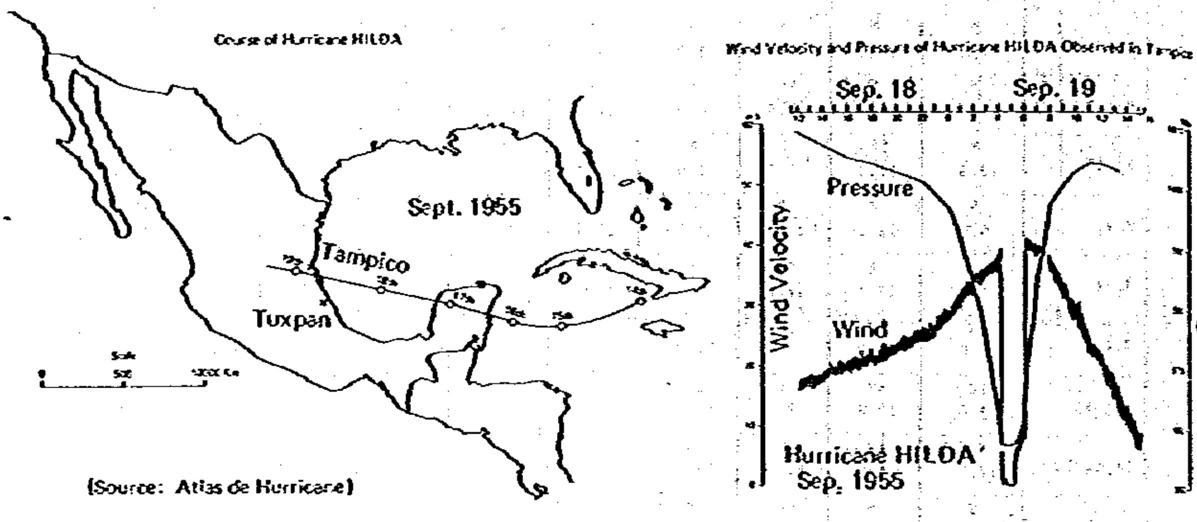


Fig. V-1-(4) Course of Hurricane HILDA and Meteorological Data Observed in Tampico

(2) Ordinary wind

Table V-1-(2) shows monthly average wind velocities and predominant wind directions in Tuxpan for the same period of strong winds. Fig. V-1-(5) is a frequency distribution of the ordinary winds. From the table and figure, it is found as follows.

1) The wind speeds averaged for ten years are within values of 4.5 to 7.5 m/sec. Wind velocities in January or February are in general the strongest in a year.
2) Predominant wind directions throughout the year are summarized as follows.

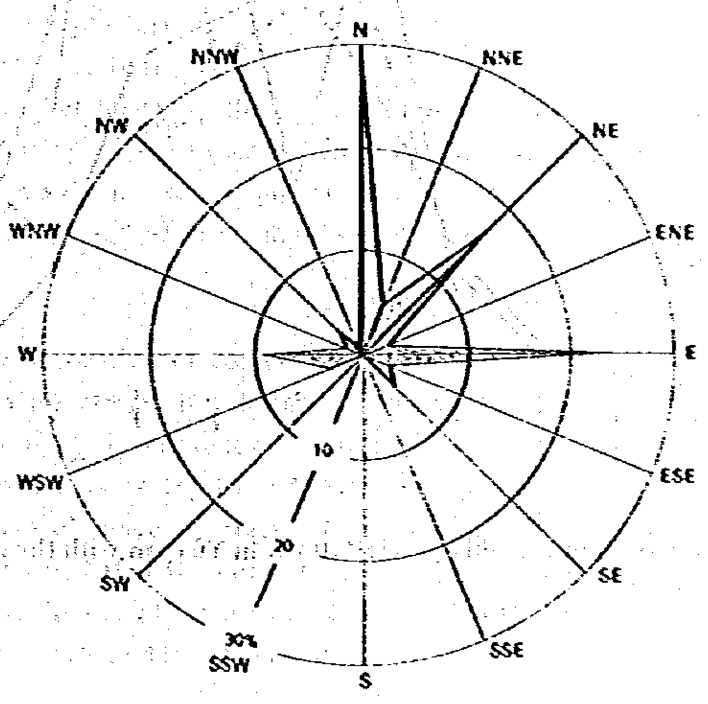
Month	Predominant wind direction
December – March	North
April – September	North East, East
October, November	North, West

Table V-1-(2) Predominant Wind Velocity and Direction in Tuxpan

(Unit: m/sec.)

Month \ Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Average
January	N 3.9	N 7.2	N 7.7	N 4.4	N 6.6	N 6.8	N 7.1	N 10.8	N 12.7	NE 5.6	7.3
February	N 3.4	N 7.2	N 17.5	N 5.9	N 8.6	E 4.4	W 4.2	N 10.1	N 8.9	WSW 5.0	7.5
March	N 6.3	E 4.3	NE 4.5	SE 6.0	N 8.4	N 6.8	N 9.7	/	NNE 7.3	E 10.6	6.9
April	E 4.0	E 4.1	N 4.7	SE 3.7	N 6.7	E 6.3	ESE 8.4	E 9.5	NNE 7.2	E 10.6	6.5
May	E 3.5	E 4.0	SE 3.3	SE 4.0	SE 5.1	SE 3.5	ESE 10.2	SSE 8.8	/	ESE 9.9	5.8
June	E 3.3	E 3.7	E 3.0	NW 3.5	SE 3.7	SE 3.5	ESE 8.3	SSE 6.9	ENE 10.6	E 10.7	5.4
July	E 3.5	E 4.4	NE 3.0	NE 4.1	NE 3.6	E 3.8	E 10.2	ENE 8.4	SE 8.7	E 11.2	6.1
August	NE 4.6	E 4.5	NE 2.6	NE 3.5	NE 3.8	W 1.5	E 11.4	SSE 8.1	SE 5.5	E 10.8	5.7
September	E 3.5	SE 3.6	NE 2.2	NE 3.1	N 5.2	N 3.4	E 10.0	E 8.0	SSW 9.2	SE 7.0	5.5
October	E 3.3	NW 2.6	N 3.2	SW 2.6	W 3.1	W 2.4	N 7.2	W 7.4	NNE 5.8	W 7.1	4.5
November	W 2.7	W 3.4	SE 2.4	SW 2.8	E 3.3	W 2.3	S 13.7	N 8.0	WSW 6.5	SSW 6.5	5.2
December	N 7.1	W 2.1	N 4.3	W 2.1	N 5.9	N 7.1	SSW 6.0	WSW 4.7	WSW 5.4	N 11.6	5.5

(Source: Observed data in Tuxpan SARH)



(Source : Observed data by SARH)

Fig. V-1-(5) Frequency Distribution of the Prevailing Wind Direction

1-3 Precipitation

According to the observation data in Tuxpan for 5 years from 1977 to 1981, annual precipitation varied considerably from 630 mm (year 1977) to 2,040 mm (year 1981). Average annual precipitation in this period was 1,271 mm. Average monthly precipitations in Tuxpan were compared with those in Tampico and Mexico DF in Fig. V-1-(6).

1) Annual precipitation in Tuxpan is much more than that of Mexico DF (almost 75 percent up) and nearly equal to that in Tampico.
2) Precipitations from June to November are so substantial that they comprise close to 80 percent of the annual total.

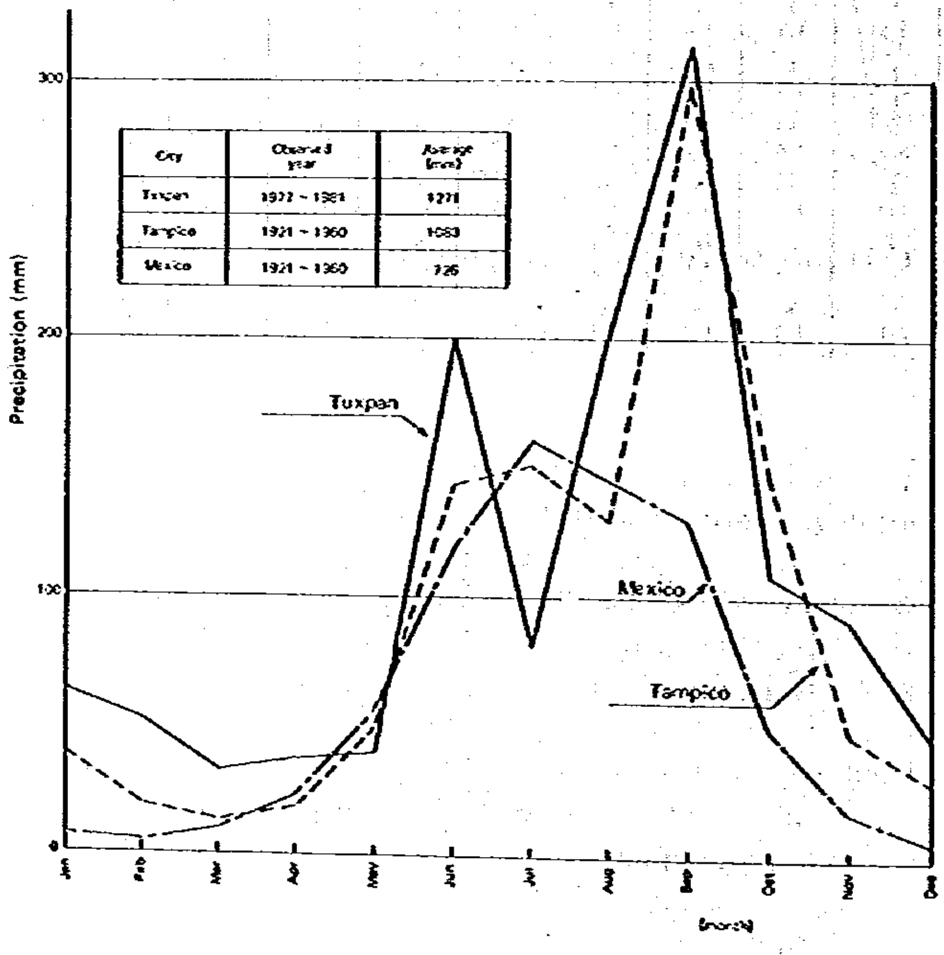


Fig. V-1-(6) Comparison of monthly precipitations in Tuxpan with those in Mexico DF and Tampico

2. Sea Conditions

2-1 Tide Level

According to the Tide Table, tide levels in Tuxpan are described as follows.

	(meter)
Probable maximum high water	0.833
Mean high water	0.219
Mean water	0
Mean low water	−0.284
Probable minimum low water	−0.782

These values show tide levels only caused by astronomical effect. So, herein, extraordinary high tide level will be calculated assuming that tide elevation caused by a hurrine will be piled up upon the mean monthly highest water level.

At first, from the Tide Table in 1981, mean monthly highest water level was obtained as 61 cm above the mean water level. Then, tide elevation due to the attack of the hurricane might be well assumed to be a sum of atomospheric depression setup ζ and wind setup τ as shown in equation (V-1).

$$\Delta h = \zeta + \tau = 0.99\,\Delta p + k\frac{F}{h}(U\cos\alpha)^2 \quad \cdots\cdots \quad \text{(V-1)}$$

where
- Δp: Depression of atomospheric pressure (mb)
- k: Coefficient
- F: Fetch length (km)
- h: Water depth (m)
- U: Wind velocity (m/sec)
- α: Angle between wind direction and normal to the coastline (degree)

Now, suppose a hurricane having such dimension as $\Delta p = 40$ mb, $U = 30$ m/sec, and $\alpha = 0$, $k = 4.8 \times 10^{-2}$ (Colding's value), water depth as shown in Fig. V-3-(3), then $\Delta h = 100$ cm was obtained. Therefore, the extraordinary high tide level is supposed to become nearly 160 cm.

2-2 Coastal Current

Fig. V-2-(1) shows a location of coastal current field observation carried out by SCT in 1982 together with current directions. Results are altogether summarized in Table V-2-(1). Current speeds at the point of upper layer (about a quarter of the water depth below the surface), middle layer (about a half of the water depth) and lower layer (about three quarters of the water depth from the surface) were observed by tracing floaters positions at every 15 minutes. From the table, it can be understood that the current flows southward regardless of the tide (flood tide, ebb tide) with the velocities less than 0.5 m/sec, almost less than 0.35 m/sec. Upper layer current speeds are faster than middle and lower layer speeds.

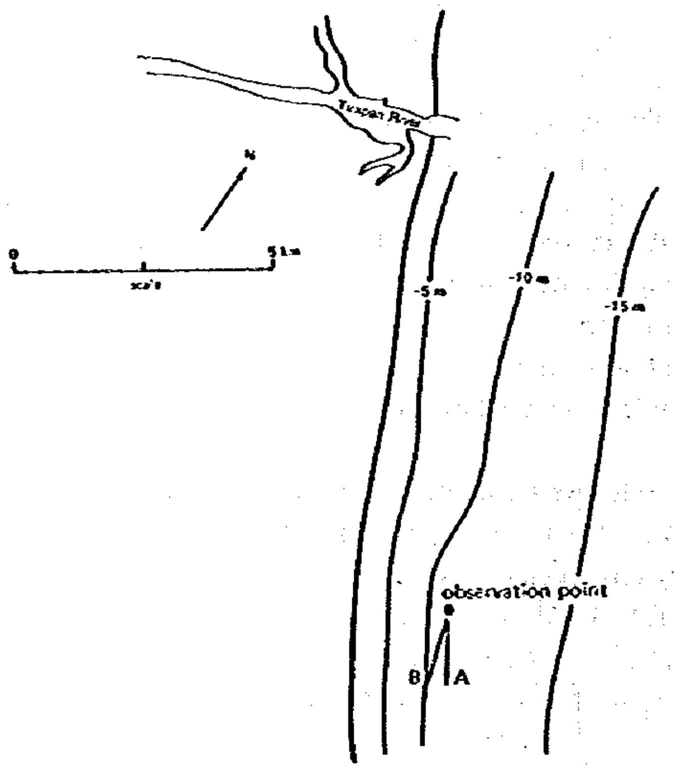


Fig. V-2-(1) Location of Current Observation and Current Direction

Table V-2-(1) Result of Coastal Current Observation

Trial	Date	Test	Time	Tide	Layer	Direction	Velocity Range (m/sec)	Average (m/sec)
I	24 March 1982	1	10:10 ~ 11:50	flood	Upper	A	0.30 - 0.43	0.34
					Middle	A	0.25 - 0.35	0.29
					Lower	A	0.16 - 0.26	0.21
		2	12:00 ~ 15:25	flood ebb	Upper	A	0.18 - 0.32	0.26
					Middle	A	0.11 - 0.21	0.18
					Lower	B	0.08 - 0.19	0.14
		3	15:30 ~ 17:10	ebb	Upper	B	0.13 - 0.20	0.17
					Middle	B	0.10 - 0.14	0.12
					Lower	B	0.05 - 0.08	0.07
	25 March 1982	1	10:40 ~ 13:35	flood	Upper	B	0.24 - 0.38	0.27
					Middle	B	0.23 - 0.29	0.25
					Lower	A	0.13 - 0.25	0.16
		2	13:45 ~ 16:25	flood ebb	Upper	B	0.33 - 0.40	0.36
					Middle	A	0.21 - 0.31	0.27
					Lower	A	0.15 - 0.20	0.17
II	7 June 1982	1	10:55 ~ 13:46	ebb	Upper	A	0.14 - 0.19	0.16
					Middle	A	0.06 - 0.11	0.08
					Lower	A	0.06 - 0.11	0.08
		2	13:50 ~ 18:45	ebb	Upper	A	0.19 - 0.25	0.22
					Middle	A	0.10 - 0.15	0.12
					Lower	B	0.02 - 0.11	0.07
III	10 August 1982	1	8:23 ~ 10:53	ebb	Upper	A	0.19 - 0.23	0.21
					Middle	A	0.14 - 0.20	0.17
					Lower	A	0.14 - 0.20	0.16
		2	11:05 ~ 15:30	ebb flood	Upper	B	0.14 - 0.18	0.15
					Middle	B	0.12 - 0.20	0.14
					Lower	B	0.10 - 0.14	0.13
		3	15:42 ~ 18:52	flood	Upper	B	0.08 - 0.20	0.16
					Middle	B	0.08 - 0.13	0.11
					Lower			

(Source: SCT)

2-3 Waves

As already mentioned in Chapter III-5, the existing Tuxpan port locates inner of the Tuxpan river. Therefore as protective facilities from wave intrusion, there only exist a pair of small scale training jetties at the river mouth. However for the new port site related with the Project, as described later, it will inevitably locate outside of the river in respect of the scale, where constructions of breakwaters will be indispensable. In the design of breakwater, it is the most important to estimate properly a scale of maximum acting wave (design wave). Generally such step is used in determing the design waves as:

1) Wave data collection: measurement or hindcasted data
2) Statistical analysis
3) Determination of deepwater waves dimension
4) Calculation of wave deformation

However, no wave measurement has been carried out in the site, following method was used in determing the design waves.

1) First, a model hurricane which will cause the most dangerous wave to the site will be supposed.
2) Based upon the data of the hypothetical hurricane, offshore wave height and period will be decided using SMB method.
3) Wave heights for water depths relevant to designing port facilities will be obtained by taking into consideration wave attenuation caused by sea bottom friction and wave deformation such as wave refraction, shoaling and breaking.

To simplify the calculation, followings were assumed.

1) Hurricane HILDA already mentioned in Chapter V-1 was adopted as a model. Based on the observed meteorological data in Tampico shown in Fig V-1-(4), wind velocity of 35 m/sec, time duration of 6 hours and fetch length of 200 km were assumed.
2) Wave direction coincides with wind direction. When recalling the predominant strong winds directions mentioned in Chapter VI-1, wind directions accompanied by the hurricane will be more probable from North. However, in our calculation wind (wave) direction was assumed to be constant from North East, that is more dangerous in designing the port facilities. This direction has an angle of 25° from the normal to the coast line.
3) The sea bottom has straight contour lines parallel to the coast. Water depths offshore from the coastline is indicated in Fig. V-3-(3) shown later.

Assuming the aboves, deepwater wave height and period obtained from the wave hindcasting diagram by SMB method were as follows.

Wave height	Ho = 9 m
Wave period	To = 13 sec

In order to verify the values, a following comparison was made. Fig. V-2-(2) shows a relation of significant wave height and non-exceeding probability of wave occurrence at the Area 15 and 22 extracted in the Ocean Wave Statistics (OWS). Offshore wave height 9 m corresponds to the occurrence probability of 0.01 percent and 0.06 percent respectively. If the data in OWS were obtained from daily observation, these probabilities correspond to occur once for 27 years and 4.6 years respectively. This fact might prove the validity of the offshore wave height hindcasted above.

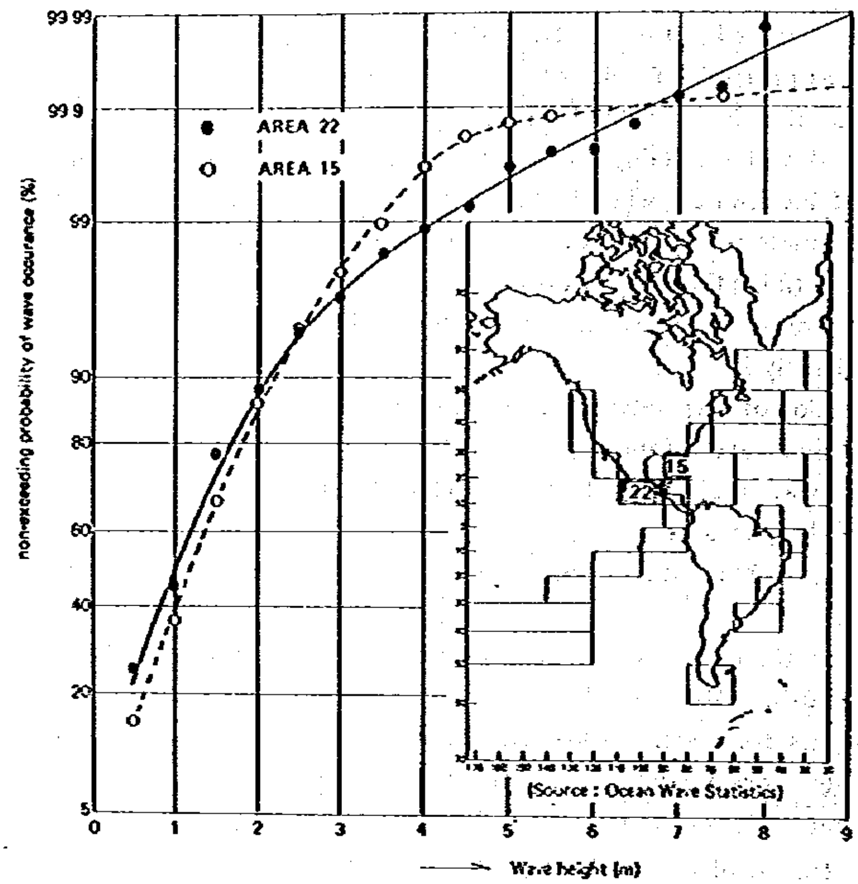


Fig. V-2-(2) Non-Exceeding Probability of Wave Occurrence

Wave attenuation due to the sea bottom friction was calculated by the following Bretschneider and Reid's equation.

$$K_f = \frac{H_2}{H_1} = \left[1 + \frac{64}{3}\,\frac{\pi^3}{g^2}\,\frac{fH_1\Delta X}{h^2}\left(\frac{h}{T^2}\right)^2 \frac{K_s^2}{\sinh^3(2\pi h/L)}\right]^{-1} \quad \cdots\cdots\cdots\cdots\cdots \text{(V-2)}$$

Where K_f: Wave attenuation coefficient

H_1: Before attenuating wave height (m)

H_2: Attenuating wave height after propagating ΔX m (m)

f: Bottom friction coefficient (= 0.01)

h: Water depth (m)

T: Wave period (sec)

L: Wave length at the water depth h (m)

K_s: Shoaling coefficient

Offshore wave height 9.0 m will attenuate to 7.8 m when the wave progresses from offshore till 30 m of the water depth for about 20 km distance. Finally Fig. V-2-(3) is a result of significant wave height at the relevant water depth, which was derived from taking into account wave deformation due to wave refraction, shoaling and breaking under the extraordinary high tide level +1.6 m.

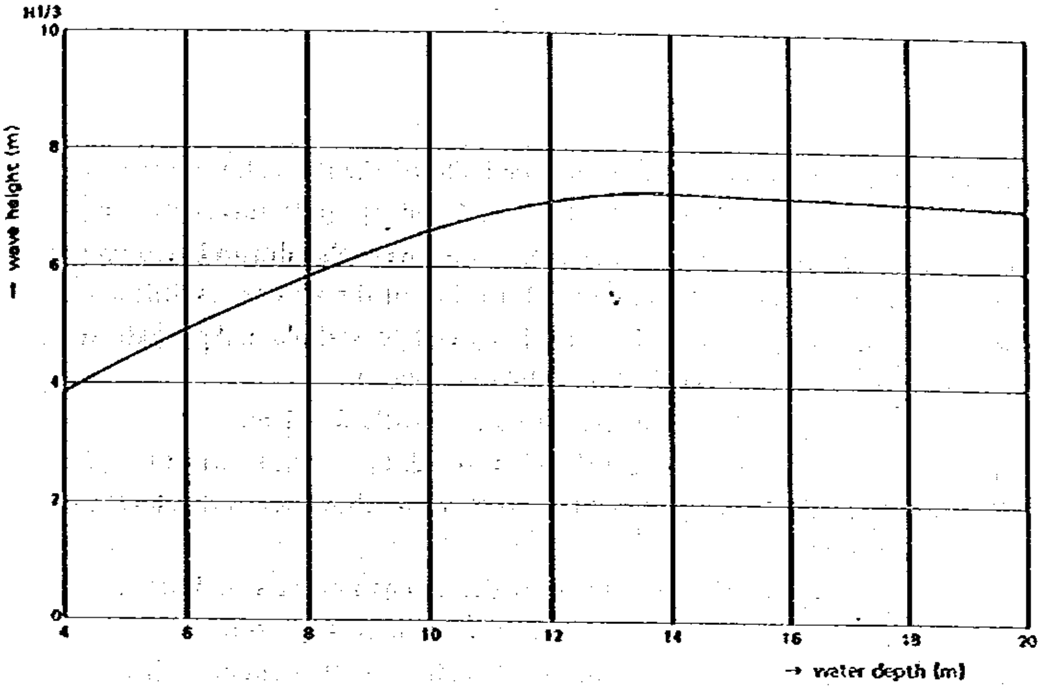


Fig. V-2-(3) Design Wave Height

3. Topography, Soil Condition and Littoral Drift

3-1 Topography

(1) Land

Fig. V-3-(1), topographical map of the proposed site of the Project, was made by combining an existed map with the results obtained by the aerial photographic survey executed by SCT in 1982. In this figure, the contour lines in the coastal area were also drawn based on the sounding survey carried out by SCT in 1982. Topographical features of the area are as follows.

1) In southern part of the Tuxpan estuary, lies a vast coastal plain. Approximate size of the plain is 12 km (N-S direction) and 7 km (E-W direction).
   The altitude of the plain is almost less than 5 m, mostly 0 – 1 m.
2) A stream named Tumilco pours into the sea through the central part of the plain.
3) There is a group of hills whose height is 30 – 40 m above sea water level in Tumilco at the center of the plain.
4) In the swampy area, on the right bank of the Tuxpan estuary and around the Tumilco stream, mangrove grow and slightly higher areas are used as pastures.
5) Except for the coastal plain area, the land undulates. It is supposed that this area was formed by erosion of sedimentary surface layers.

Fig. V-3-(1) Topographic map SCALE 1:50,000

(2) Beach

The following are summaries of the beach profile for the proposed site based on the topographical beach survey executed by SCT.

1) Beach width ranges from 30 to 50 m. Beach slope is somewhat steep, with inclination ranging from 1/7 – 1/10.
2) Height of the beach cliff is 3 to 5 m above sea level.
3) Just behind the beach lies a series of sand dunes whose height are 4 – 6 m.

Fig. V-3-(2) shows the beach profile about 10 km southward from the Tuxpan river.

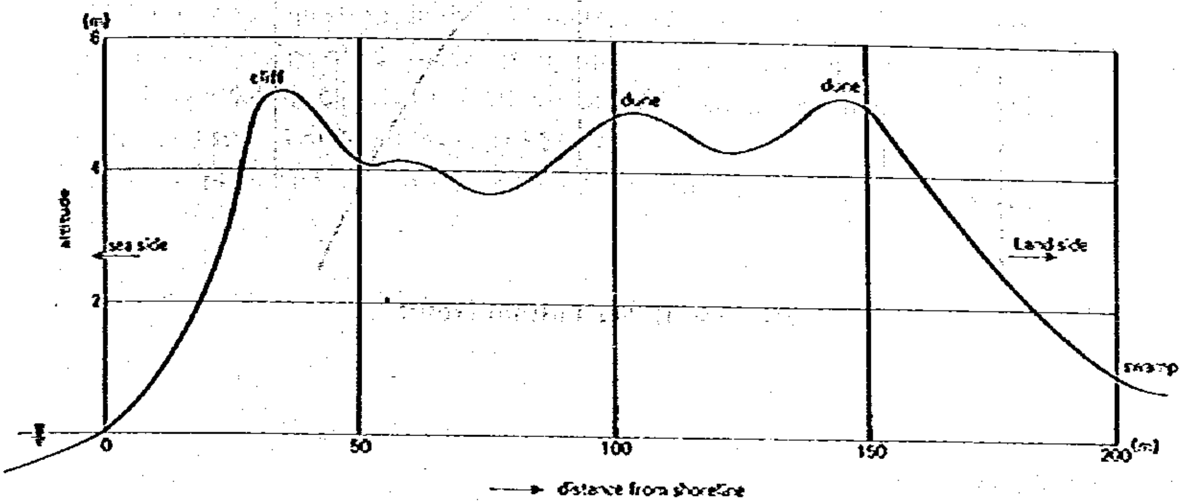


Fig. V-3-(2) Beach Profile

(3) Sea bottom

Contour lines of the proposed site are shown in Fig. V-3-(1). It seems that there is no reef in the sea area of the proposed site because there are no abrupt changes in the sea bottom configuration. Water depth, distance from the shoreline, and bottom slope are listed as follows:

Water depth	Distance from shoreline	bottom slope
–5m	0.5 km	1/100
–10	1.5 km	1/200
–15	4 km	1/500
–20	6 km	1/400
–25	9 km	1/600

Fig. V-3-(3) shows the relation of water depth and distance offshore.

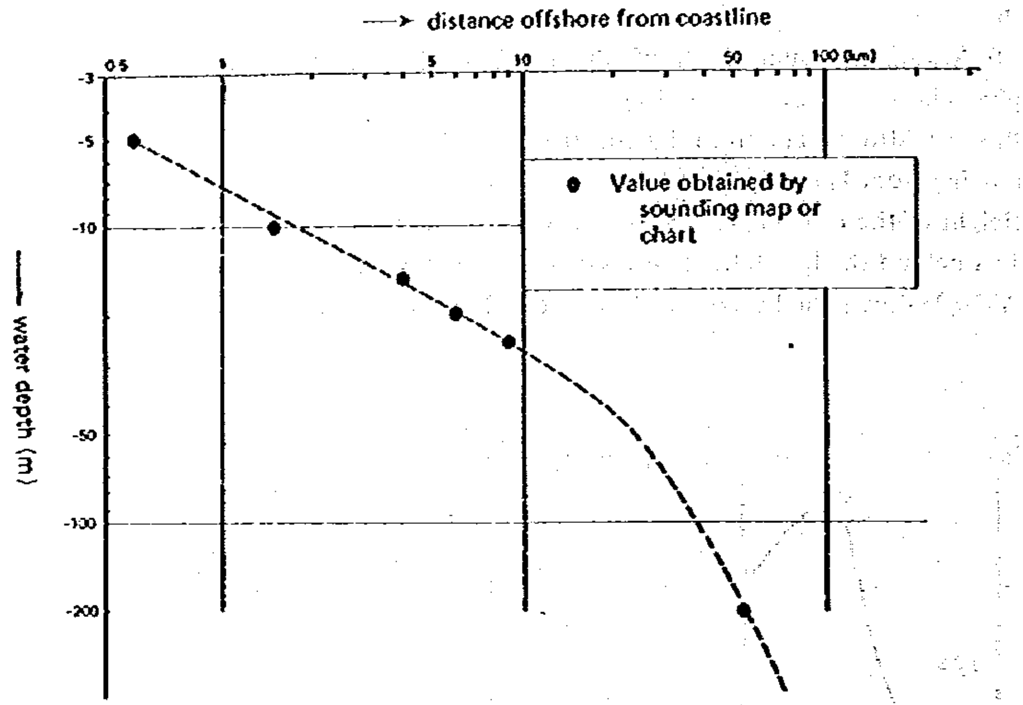


Fig. V-3-(3) Sea Bottom Profile

3-2 Soil Condition

The location of borehole surveyed by SCT in the proposed site is shown in Fig. V-3-(4). Typical soil profiles are shown in Fig. V-3-(5), V-3-(6) respectively. Outline of soil condition is as follows.

Soils are classified as CL (sandy clay – silty clay) and CH (clay) in accordance with plasticity chart (shown in Fig. V-3-(7)) of J.U.S.C.S. (Japanese Unified Soil Classification System).

According to the soil profile, N-value and plasticity chart, it is estimated that the upper layer is alluvium cohesive soil and the lower layer is diluvium cohesive soil.

The upper clay layer shows a high plasticity and a large N-value as compared with Japanese typical alluvium cohesive soil.

The lower silty clay layer, more than 50 in N-value, seems to be adequate as the bearing stratum of the structures such as quay wall, revetment, etc. Fig. V-3-(8) through V-3-(10) shows mutual relations of clay, water content – liquid limit, water content – plastic limit, water content – plasticity index. In these figures a correlation of alluvium cohesive soil in Japanese port is also shown for reference.

From these figures, the following can be seen.

The plastic limit agrees approximately with the correlation of Japanese cohesive soil while the liquid limit and plasticity index show a large value as compared with Japanese cohesive soil.

Fig. V-3-(11) shows the distribution of bearing stratum (N-value more than 50) in the proposed site.

The depth to the bearing stratum from the surface in the proposed site is as follows.

Name of area	depth
Tumilco and its surrounding	5 – 10 meters
beach of the Tumilco river	10 – 15 meters
from Los Naranjos to Paises Bajos	10 – 20 meters
from Punta de Piedra to La Antigua	5 – 10 meters
other areas	more than 25 meters

According to the boring data of Muelle de Altura, the bearing stratum from the mouth of Tuxpan river to Cobos appears more than 25 meters below the surface.

From the outline described above, it is necessary to pay greater attention to structure construction in the following areas from the mouth of Tuxpan river to Cobos, in the basin of the Tumilco river, and from Los Naranjos to the beach.

For detailed plan and design, unconfined compression and Consolidation test etc. are required.

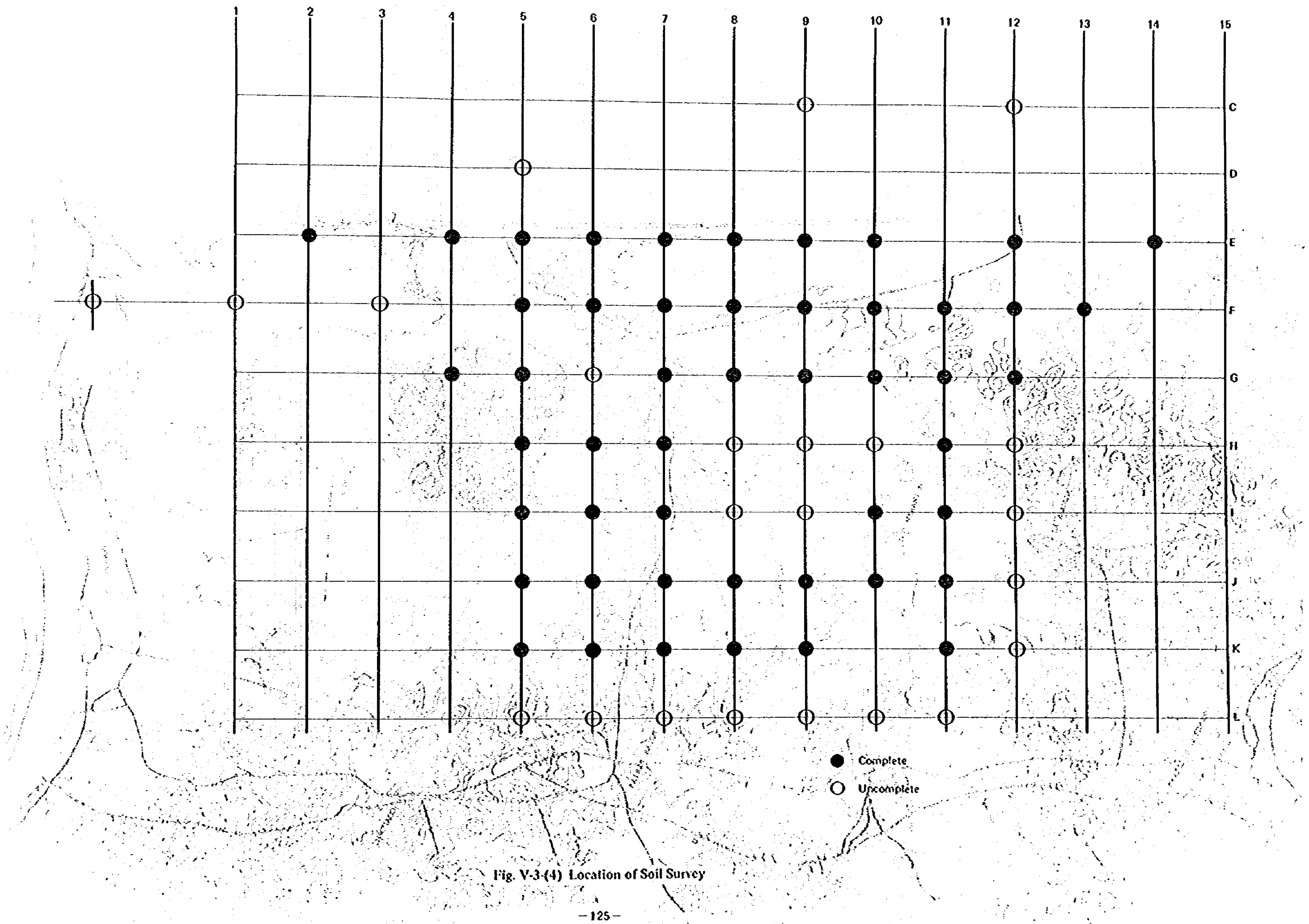


Fig. V-3-(4) Location of Soil Survey

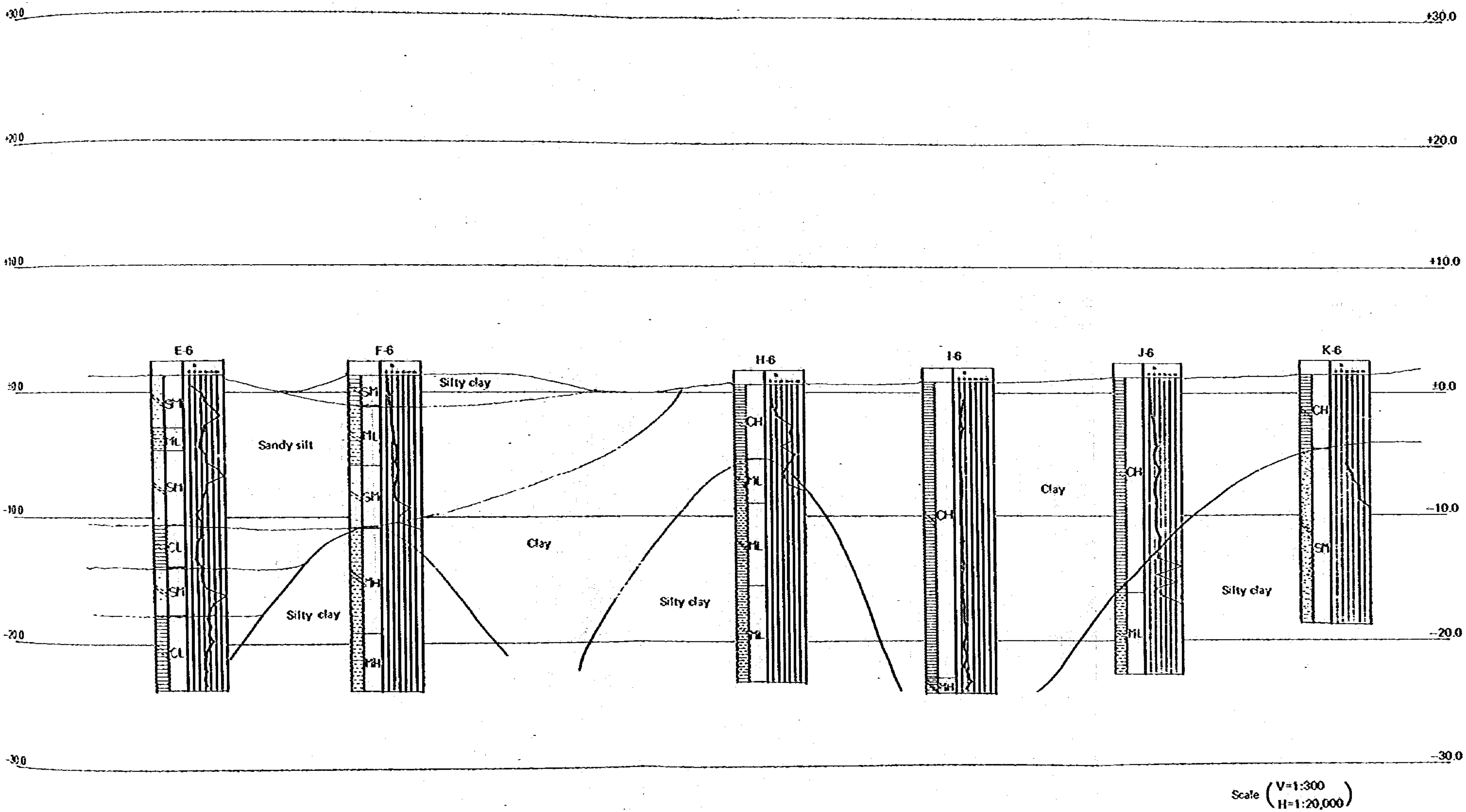


Fig. V-3-(5) Soil Profile 6–6 Section

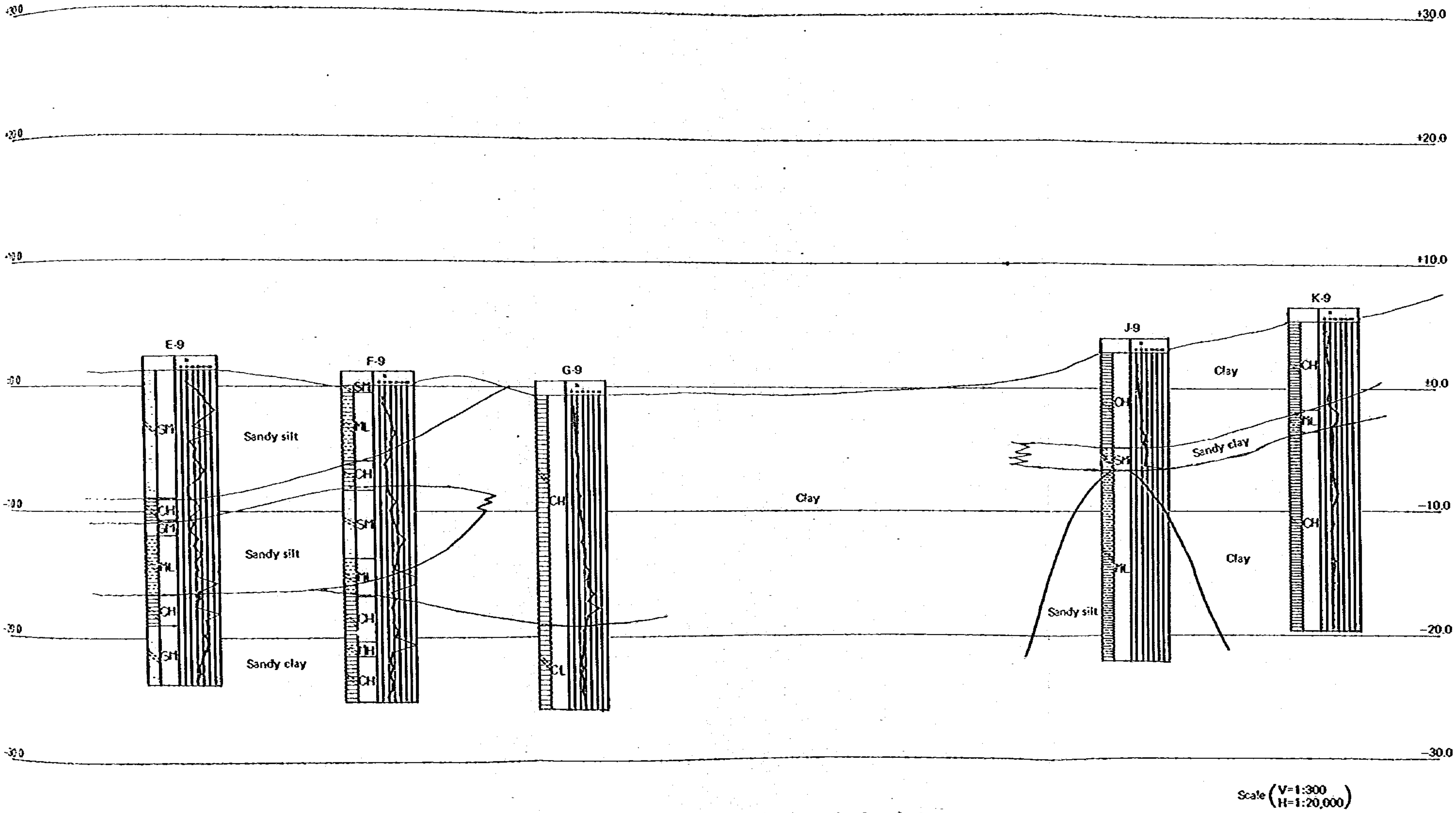


Fig. V-3-(6) Soil Profile 9-9 Section

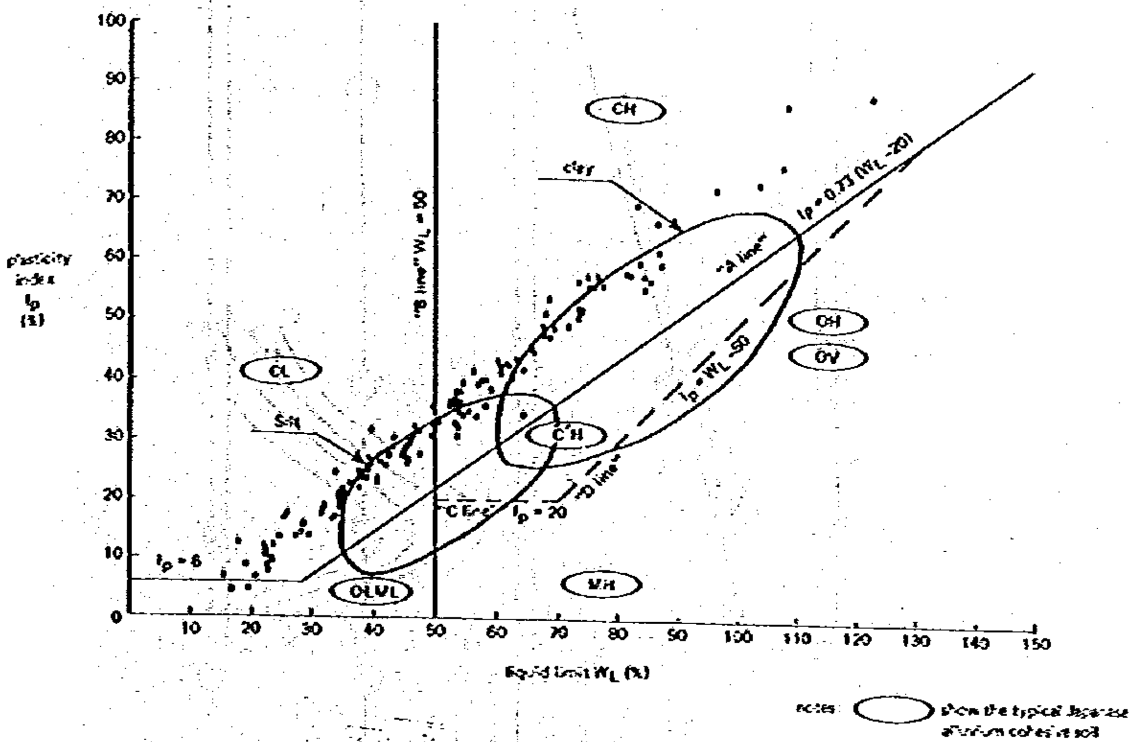


Fig. V-3-(7) Plasticity chart

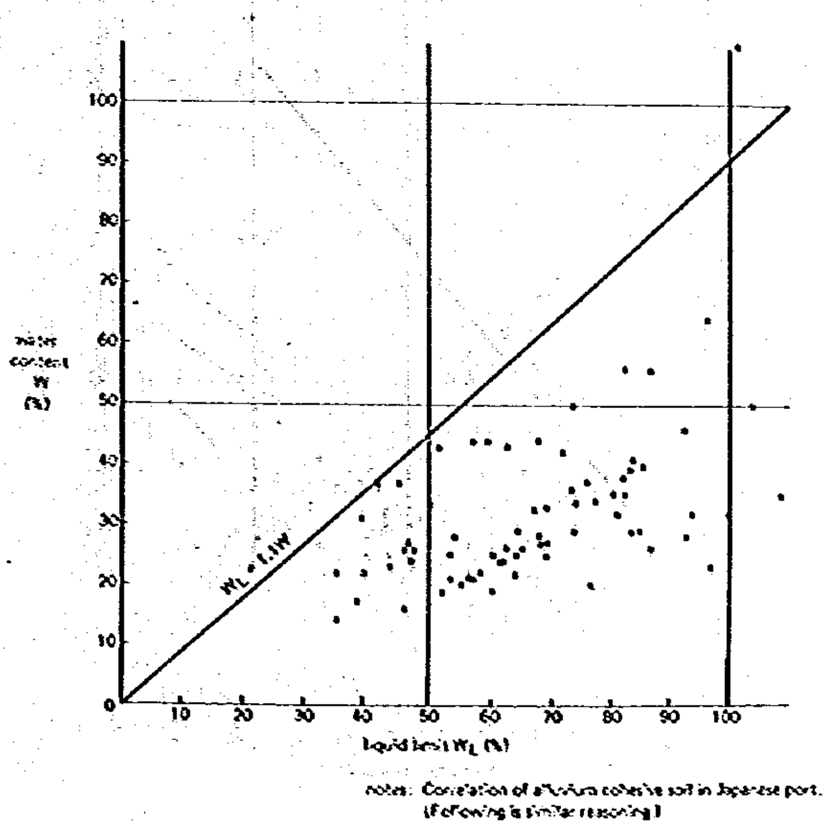


Fig. V-3-(8) Water content-liquid limit

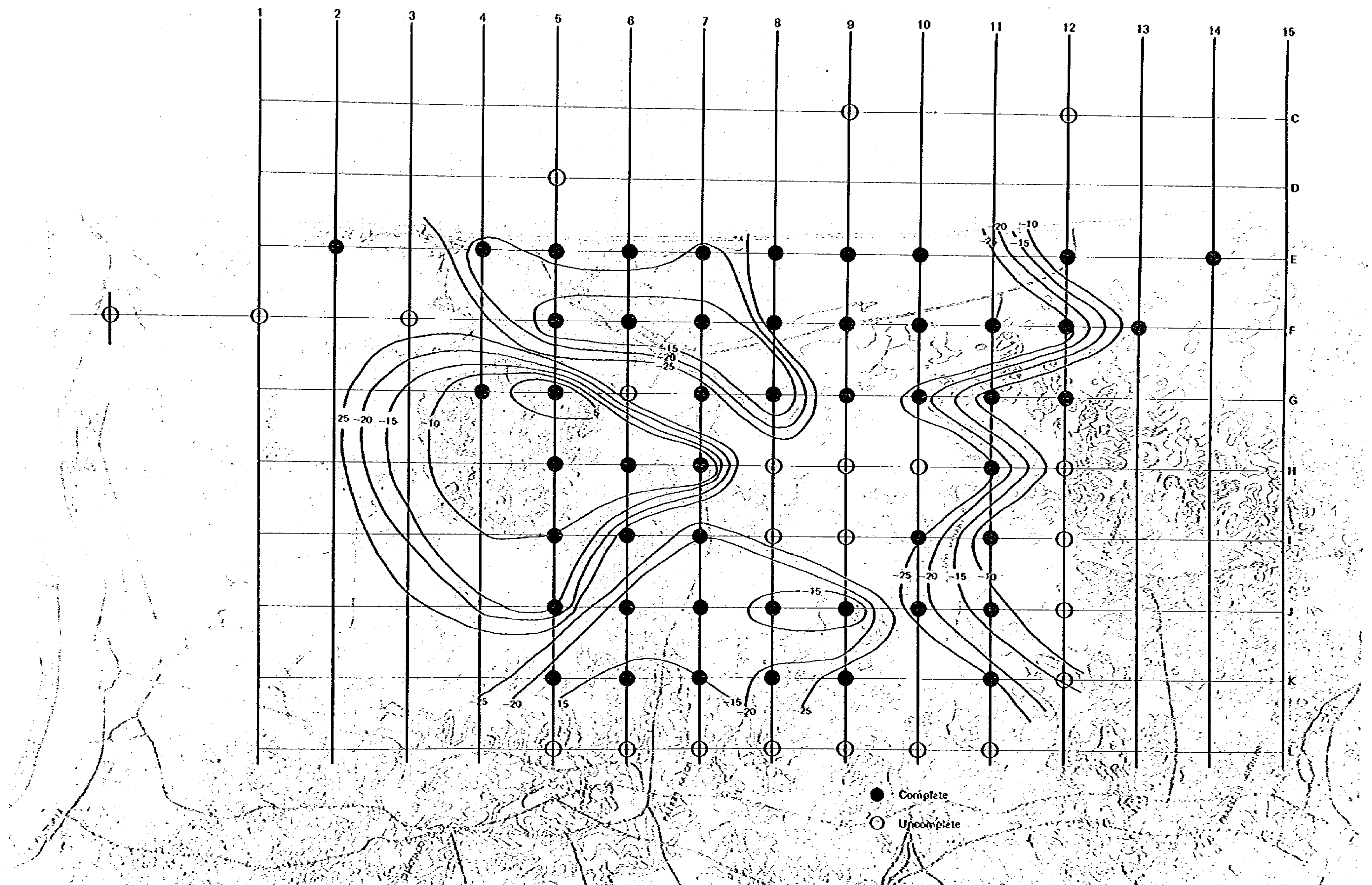


Fig. V-3-(11) Bearing stratum (N-value more than 50) contour

3-3 Beach Material

Beach material investigations at the proposed site were carried out by SCT along the coast, 5 to 15 km southward from the Tuxpan river at 0.5 km intervals. Beach materials were sampled at six points respectively normal to the coastline, i.e., dune, backshore, foreshore, and water depths of −1, −5, −10 m. Grain size and specific gravity were measured for all sampled beach materials.

Fig. V-3-(12) shows average sizes of medium grain diameter at different sampling points. From the figure, it can be seen as follows.

1) Grain sizes are about 0.2 mm (fine sand).
2) Grain sizes in the surf zone (−1 m) are a little larger than those at other points. Specific density is around 2.7 − 2.8.

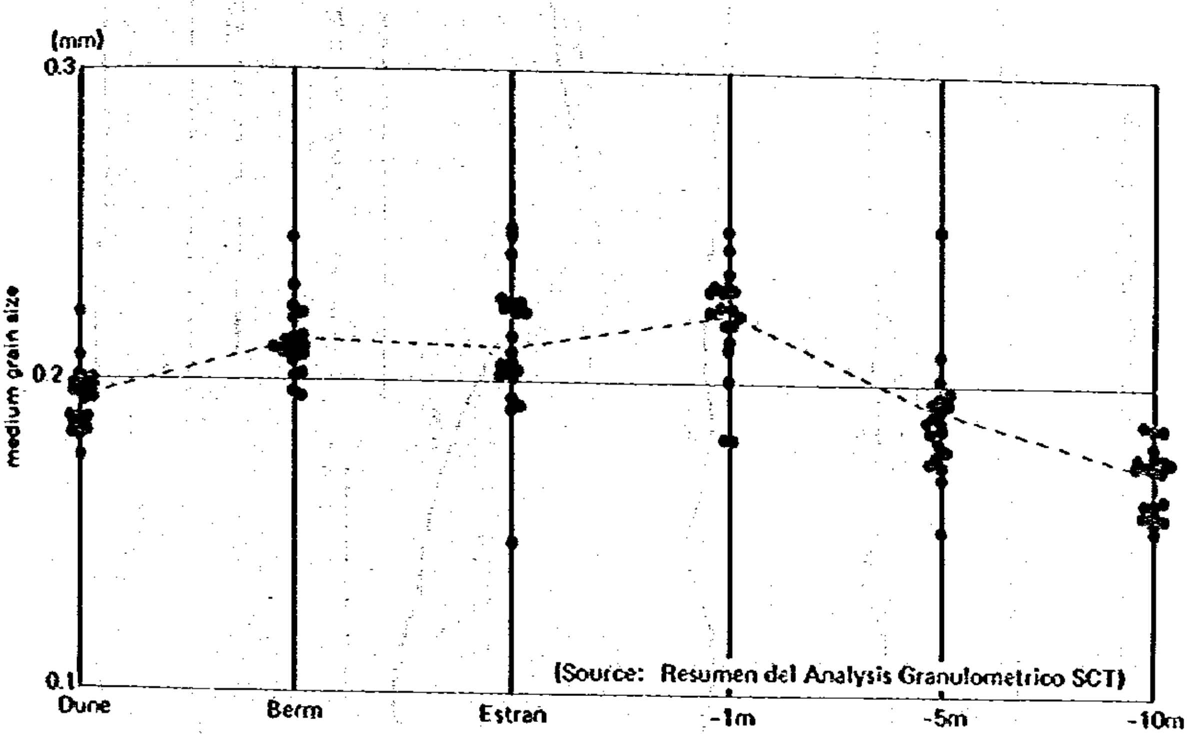


Fig. V-3-(12) Grain Distribution

3-4 Littoral Draft

It is necessary to do a number of studies and investigations to evaluate the characteristics of littoral drift at a beach. However, in the case of the shore at the proposed site, little data is available. Therefore, using what data does exit, and based on the site inspection, littoral drift along the coast of the proposed site will be examined.

It appears that the direction of sediment transport along the shoreline is from North to South. This can be deduced from the following facts.

1) The sand spit extension in the Gulf of Mexico seems to be in a southward direction.

2) The north beach of the Tuxpan river is wider than the south beach

3) Strong winds blow predominantly from North, so that the waves generated by these winds are also predominantly from North.

4) The coastal current flows North to South.

Fig. V-3-(13) shows the contour changes obtained from the soundings in January and July 1982 carried out by SCT in the area from 5 to 15 km southward from the Tuxpan river. It is obvious that the contours shifted coastward, meaning erosion, in the period from January to July 1982. The reason why such contour shift occurred is not clear, whether it resulted from seasonal variation or simply survey errors.

Estimates of the actual volume of littoral drift along the coast are not now possible because of insufficient data.

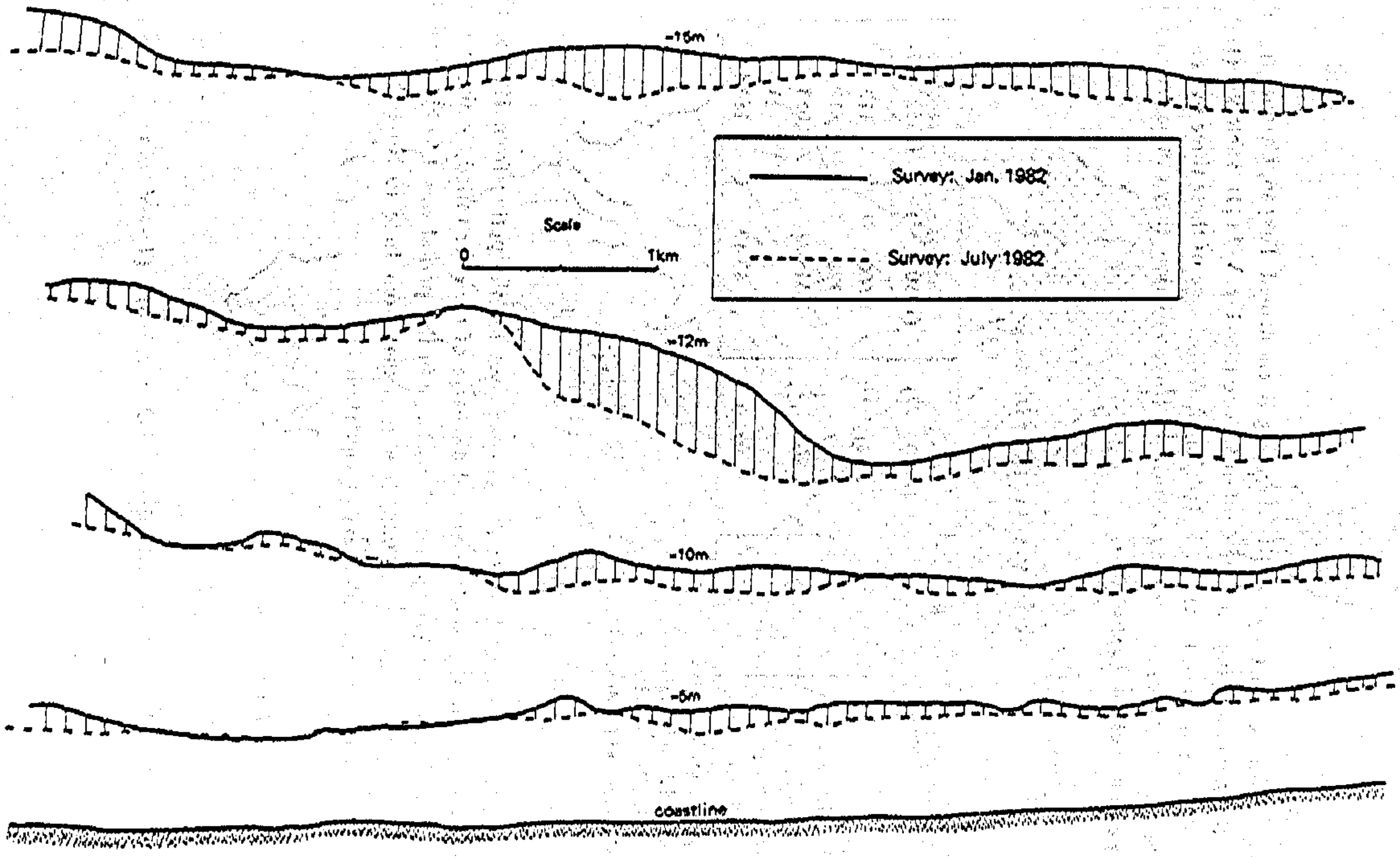


Fig. V-3-(13) Sea Bottom Topographical Change

4. River, Channel Siltation

4-1 River

(1) River discharge

As already mentioned in Chapter II-1, three big rivers named Tuxpan, Cazones, Tecolutla flow through the Area and pour into the Gulf of Mexico (See Fig. V-4-(1)). Table V-4-(1) shows the discharge characteristics of these rivers. Total annual discharge of these three rivers amounts to about 10 billion m^3. As for annual and monthly discharge variation, they can be deduced from the following example of the Tuxpan river.

Table V-4-(1) River Discharge

River		Tuxpan (1960 – 77)	Cazones (1950 – 77)	Tecolutla (1962 – 77)
Drainage	km^2	4,341 1)	1,600 2)	7,112 3)
Annual discharge	million m^3	2,869	1,371	5,817
Maximum discharge	m^3/sec	1,905	1,448	3,053
Minimum discharge	m^3/sec	4	3	27
Average discharge	m^3/sec	89.70	43.47	184.47

Note: 1) Till Alamo station
2) Till Poza Rica station
3) Till Remolino station
(Source: Proyects Chicontepec)

Fig. V-4-(2) is annual discharges in the Tuxpan river for the period from 1960 to 19[illegible] observed at Alamo observation station. Annual discharge of the river varied greatly, from 1.[illegible] billion m^3 to 3.45 billion m^3. Average annual discharge in this period was 2.57 billion m^3. Fig. V-4-(3) shows monthly discharges in 1966. It is seen that from June to November monthly discharges are large in accordance with heavy precipitation.

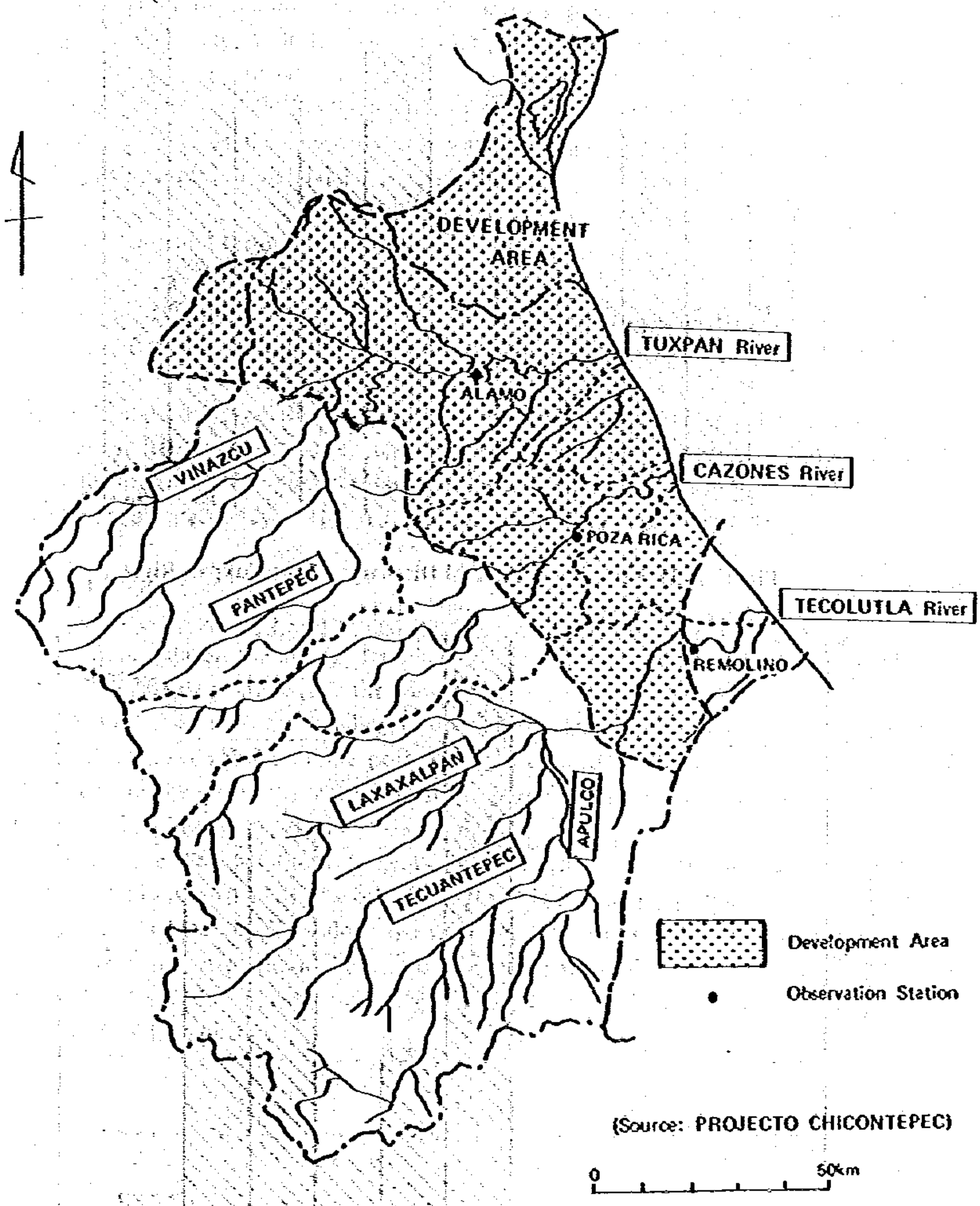


Fig. V-4-(1) Drainage Area of the Rivers in the Development Area

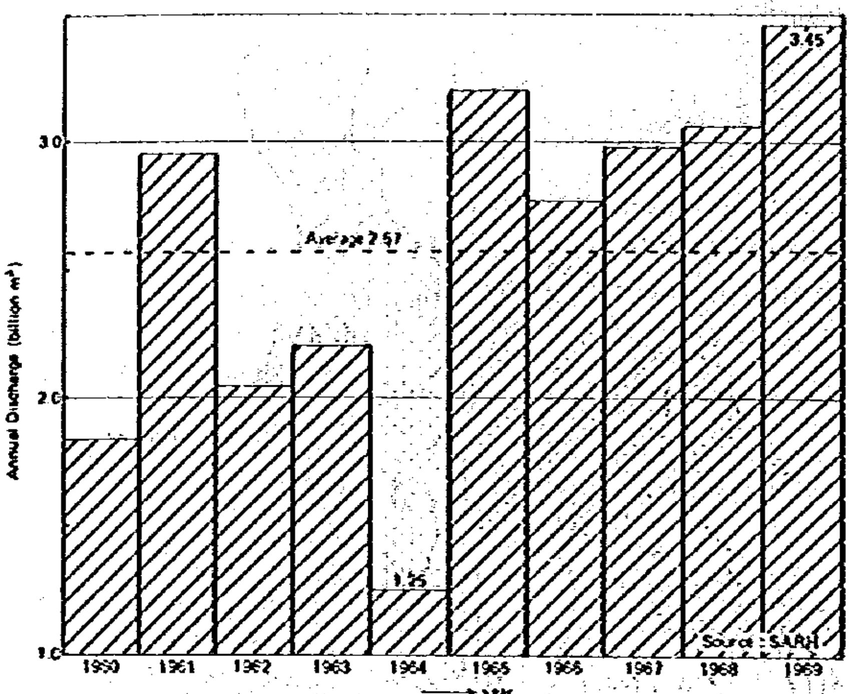


Fig. V-4-(2) Variation of Annual Discharge of the Tuxpan River

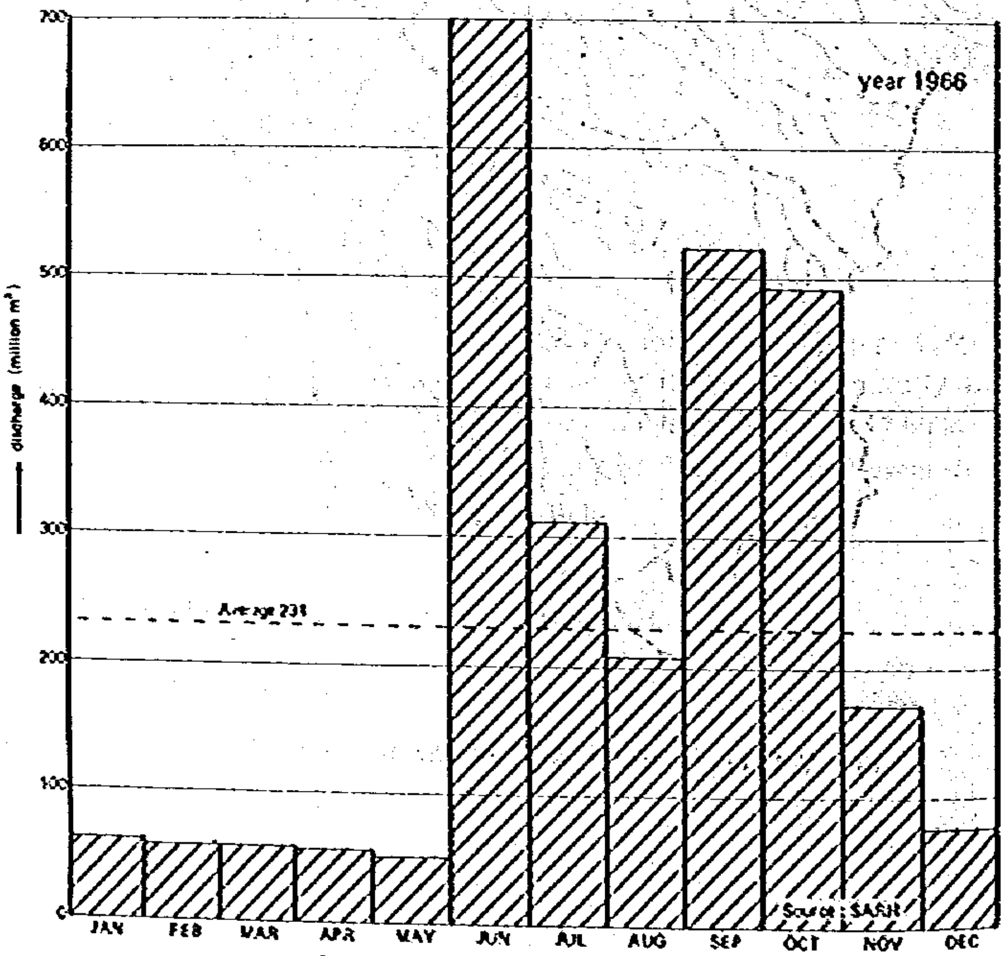


Fig. V-4-(3) Variation of Monthly Discharge of the Tuxpan River

(2) Maximum utilizable water

Let's estimate the maximum annual utilizable water volume from these three rivers, assuming dam construction. Firstly, if it is assumed that up to 30% of the annual total discharge is utilizable, the maximum utilizable water will amount to 3 billion m^3/year and in the Tuxpan river about 860 million m^3. Secondly, according to a brochure of the Chicontepec Project, the total utilizable volume of the water per year was taken to be 6 billion m^3 under assuming the construction of 37 multipurpose dams.

(3) Present situation and future plan of water utilization

At present, very little of the water in the rivers is utilized. According to the SARH information, about 32 million m^3 water has been used for irrigation. Potable water has been collected from Cazones river (Poza Rica) and from Tuxpan river (Tuxpan) with small scale facilities.

Little information is available on the future prospects of river water utilization. But in the Tuxpan river, SARH has a plan to construct a reservoir dam with the capacity of 350 million m^3 water storage, from which an annual total of 800 million m^3 of water will be utilizable and some 50 thousand hectares of fields will be irrigated.

4-2 Channel Siltation

There is no available data concerning the siltation in Tuxpan Port, so a rough estimate has been made from data on the annual dredging volume in the existing port by assuming that the annual siltation volume nearly equals the annual dredging volume in the port.

Table V-4-(2) shows annual dreading volume at Tuxpan port from 1977 to 1982. From this table, annual siltation volume at the port has been calculated at nearly 720 thousand m^3, of which siltation in the water channel between the port entrance and the fiscal wharf amounts to 550 thousands m^3, nearly 76 percent of the total.

To appraise the local siltation volume, two charts, before and after dreading, were compared. One is the chart in August 1981, the other is in May 1982. Differences in area between these two charts, at intervals of 250 meters along the river, are shown in Fig. V-4-(4). From this figure, it can be seen that in part of the harbour entrance and at the outlet of Tampamachoco lagoon, a large amount of siltation has occurred. Calculations for the volume of siltation come to about 810 thousand cubic meters.

Table V-4-(2) Annual Dredging Volume in Tuxpan Port

(m^3)

Dredging Place \ year	1977	1978	1979	1980	1981	1982	Total
Access Channel till Fisical	371,448	280,222	625,727	731,109	893,201	420,625	3,322,332
Celasa			57,550	51,778	29,949		139,277
Dragas		27,500	18,900	37,071	119,698	7,360	210,529
Fiscal		77,500		30,692	46,990		155,182
Tabuco				20,002	175,711		195,713
Pemex				4,680			4,680
Yates					3,210		3,210
Tecnical Peeguère					12,730		12,730
Pequenas Embarcasiones					31,934		31,934
Muracanes del Pacifico					11,745		11,745
Tecomar	15,926	2,147					18,073
Pesca	150,800						150,800
Etileno	5,125		85,155				90,280
Total	543,299	387,369	787,332	875,332	1,325,168	427,985	4,346,485

(Source: SCT)

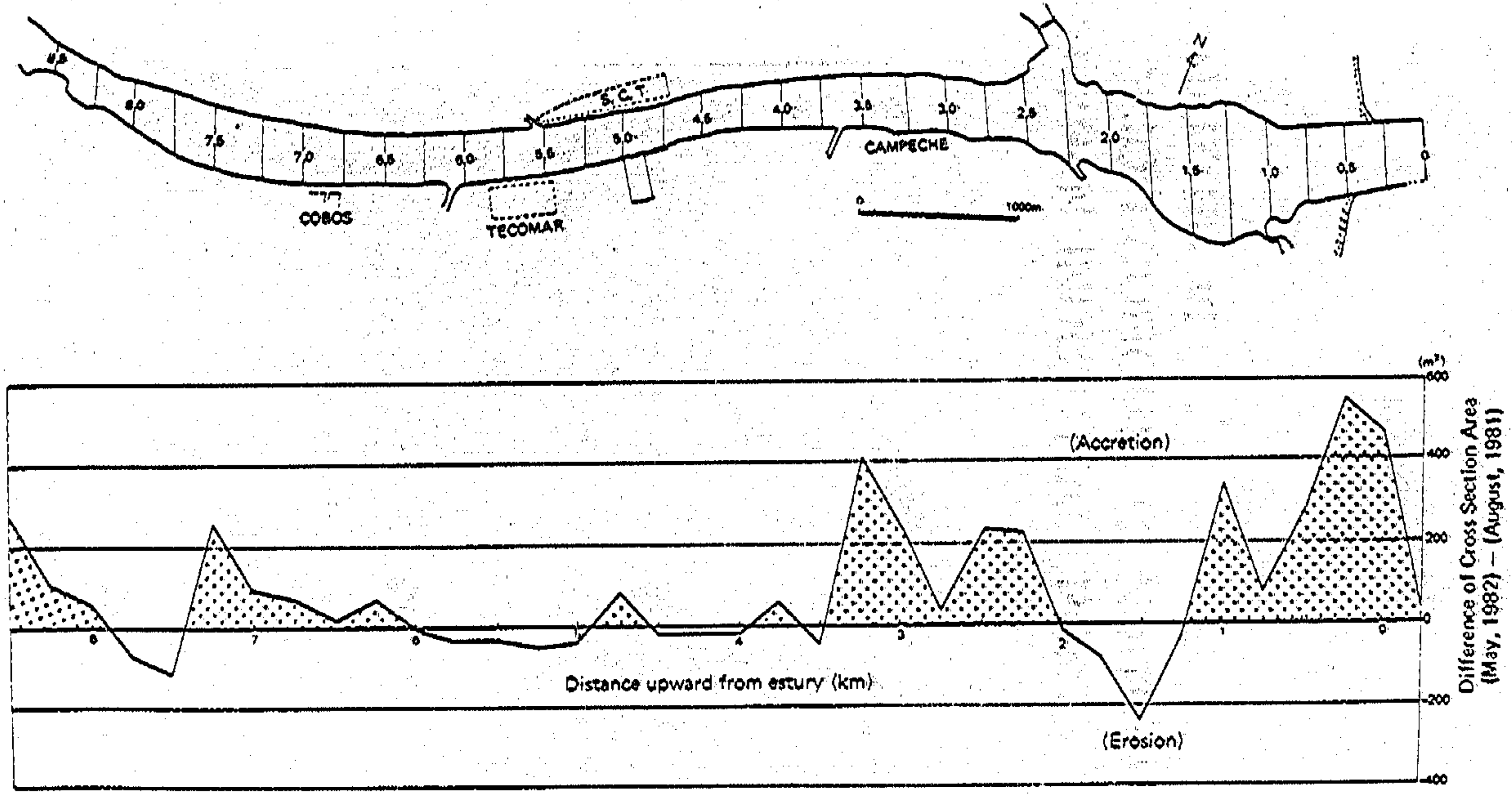
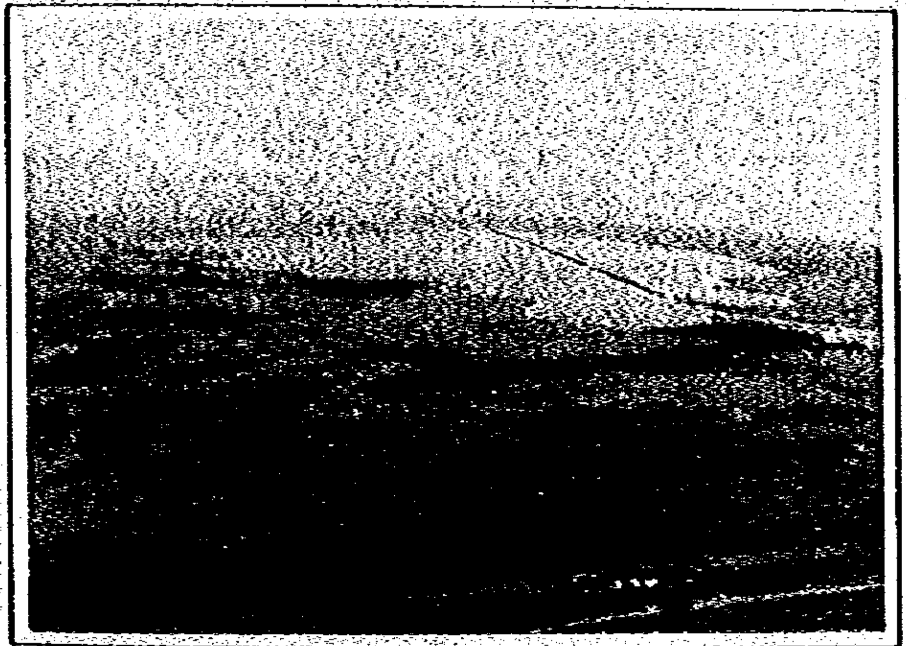


Fig. V-4-(4) Difference of Cross Sectional Area

CHAPTER VI
SOCIO-ECONOMIC CONDITION OF TUXPAN INDUSTRIAL PORT



Tampamachoco Lagoon

CHPTER VI. SOCIO-ECONOMIC CONDITION OF TUXPAN INDUSTRIAL PORT

1. Location of Industries

This section's task is to study and select the industries located in the Tuxpan Industrial Port in accordance with the following procedures (see Fig. VI-1-(1)).

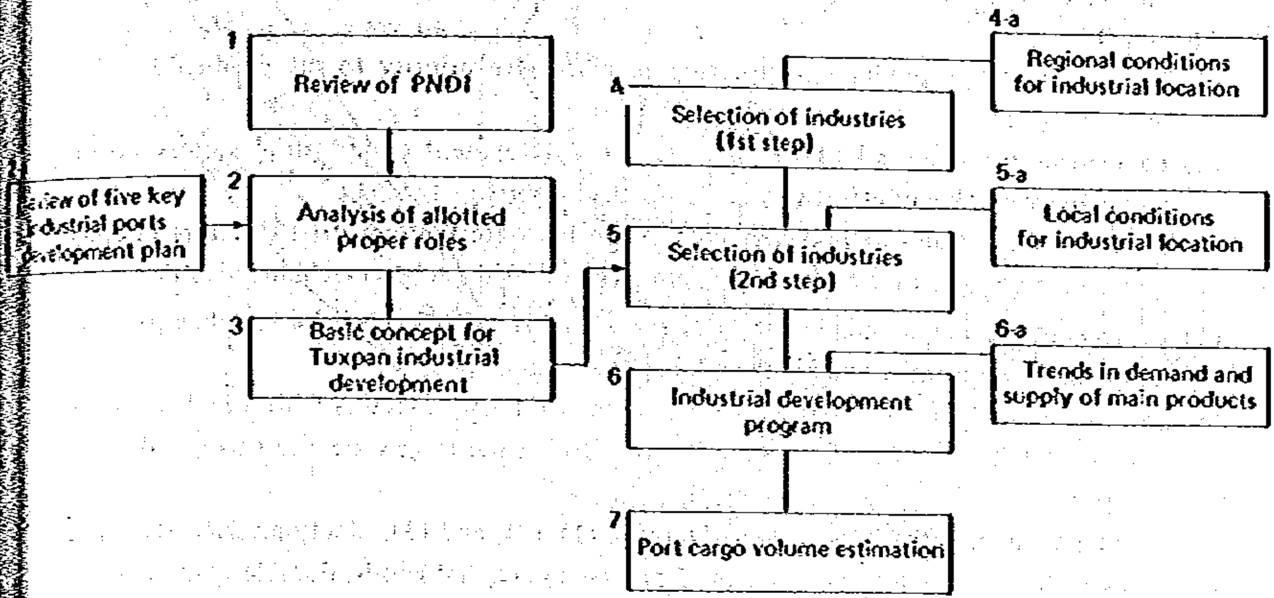


Fig. VI-1-(1) Flow Chart of Location of Industries

(1) Reviewing the PNDI the basic strategic targets and the Tuxpan's position in the national policy are clarified.

(2) Reviewing the existing plan for the five key industrial ports, the significance of Tuxpan Industrial Port development is clarified in light of integrated industrial development policy in Mexico.

(3) Based upon the above reviews, the basic concept of the Tuxpan Industrial Development is fixed.

(4) Industries located in the Tuxpan Industrial Port are selected by two processes. In the primary selection, regional conditions for industrial location are asessed and industries meeting these conditions are selected.

(5) In the secondary selection, first the local conditions for industrial location are asessed and industries meeting these conditions are selected from the industries picked up in the primary selection. Then, Industries also meeting the basic concept of industrial development are selected from the industries meeting these regional and local conditions for industrial location.

(6) The industrial development program for the Tuxpan Industrial Port is formed for the industries remaining after the secondary selection. In this program, the production scale of

plants and the time to start operation are set in consideration for trends in the supply and demand of main products, the scale merit of plants and their unit scale.

(7) Finally, the volume of Tuxpan industrial port cargo is estimated by domestic and foreign trade separately, based on the consideration of cargo characteristics their origins and destinations, and the basic principle of model split in transportation.

1-1 Review of National Industrial Development Plan

The PNDI has established the following five basic strategic targets, already mentioned in Chapter II.

(1) To reorganize the production structure so as to give priority to the production of basic consumer goods.

(2) To expand the exports and to promote the development of industrial sectors with high productivity capable of effectively replacing the imports.

(3) To utilize the nation's natural resources and to innovate the industrial structure in order to develop the industrial sectors with high gross value added such as machine industries.

(4) To decentralize the economic activities regionally and to channel the investments into the coastal, national frontier and other undeveloped areas.

(5) To avoid the oligopolistic grouping tendencies in industrial sectors with a high growth rate and to establish the close interconnections between the large-scale and small/medium-scale enterprises.

In order to achieve the basic strategic targets, (1), (2), and (3), ninety priority-development industries such as agricultural and sea food processing, capital goods, durable consumer goods, etc. have been designated. Also, the primary areas for industrial development are chosen to achieve the target (4) and to develop the priority-development industries.

Tuxpan Industrial Port is one of the areas to be primarily developed for industries, along with other key industrial ports such as Altamira, Ostion and so on. Thus, the industrial types located around the Tuxpan Industrial Port will be examined on the basis of the priority-development industries.

1-2 Analysis of Allotment of Industrial Functions

In this section, significance of industrial types located around Tuxpan is studied in the light of the integrated policy of industrial development in Mexico.

Most of the industrial functions are concentrated in the Mexico City metropolitan area, which has a share of about 50 percent (on GDP base), and it is one of the most important policy goals to reduce this level by industrial decentralization. As one of the main steps toward this target, development of industrial ports in the coastal area is taken up.

As for the coastal industrial development, there exists a difference in the industrialization process between the Pacific and the Gulf coast. Adding the existing Central Highlands industrial zone, there are three kinds of industrialized and potentially industrialized zones each having their own characteristics. (see Fig. VI-1-(2)).

In the Gulf Industrial Axis (I), such industrial ports as Altamira, Ostion, Tuxpan, Dos Bocas and Cobah are planned, making use of their own locational conditions. In the Pacific Industrial Axis (III), such industrial ports as Ensenada, Topolobampo, Lazaro Cardenas and Salina Cruz are planned. In the Central Highlands Axis (II), existing industrial zones of Mexico City, Monterrey and Guadalajara are found.

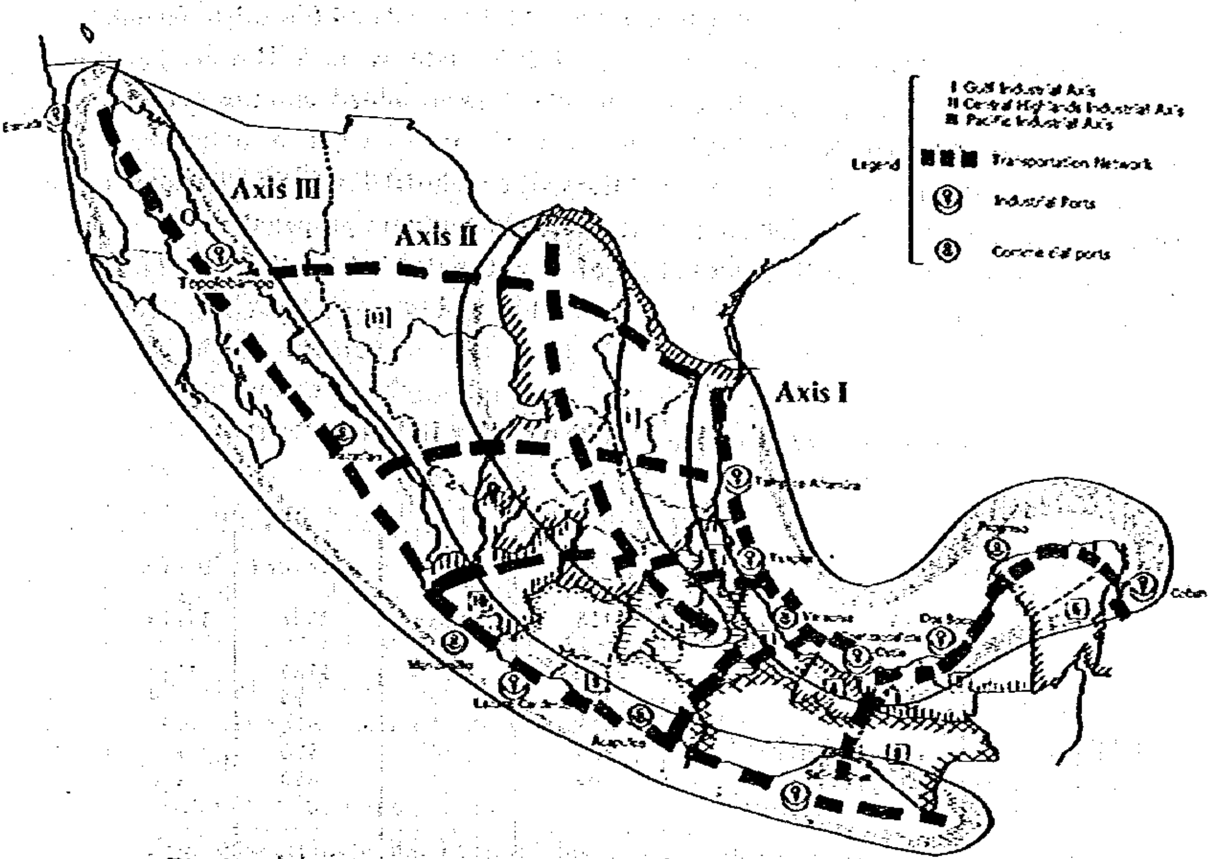


Fig. VI-1-(2) Three Axes of National Industrial Development (Conception)

An allotment of industrial functions among these three Axes is recognized as a subject for further study. However, it should be pointed out that two principal types of transportation networks, vertical transportation lines through three Axes and horizontal transportation lines connecting them with each other, are required in order to support this concept. As for the vertical transportation lines in Axis I and III, coastal shipping is expected to play an important role, and an establishment of a national transport plan in the industrial development policy is strongly desired.

There exists great difference in the industrialization process between Axis I and Axis III, because distribution of natural resources and market conditions are quite different.

The preceding five industrial port development plans are reviewed from the viewpoint mentioned above, as shown in Table VI-1-(1).

In Axis III, Altamira and Ostion are mainly focused on the large scale coastal industries of iron and oil refining, while Dos Bocas is devoted to oil refining and petrochemicals. In the Tuxpan industrial port, much attention should be paid to the proximity to Mexico City, which is one of the most important locational conditions.

With respect to proximity to Mexico City, which is the largest consuming market in Mexico, Altamira is very close to Mexico City at a distance of 550 km. On the other hand, Tuxpan is at a distance of about 380 km, closer to Mexico City than Altamira. Tuxpan has the best market condition of industrial ports.

With respect to the population of capital cities in the hinterland, Tampico, in the hinterland of Altamira has the largest population, about 650 thousand, and many urban facilities, but others have relatively small population ranging from 60 to 120 thousand and few urban facilities.

The population of Tuxpan is about 89 thousand. It is relatively small. However, it amounts to 341 thousand, if Poza Rica and Temapache within the Area are added, and this size of population is second to that of Altamira's hinterland.

Considering the excellent market conditions, the industrial types in Tuxpan should be determined in order to have a well-coordinated development with proper allotment of industrial functions among other industrial ports in light of the integrated industrial development policy in the Gulf.

Table VI-1-(1) Development Plan of Key Industrial Ports

		Lázaro Cárdenas	Salina Cruz	Altamira	Ostion	Dos Bocas
CONDITIONS FOR INDUSTRIAL LOCATION	Total area (ha)	4166	6548	8987	11270	4,093
	Plant area (ha)	2729	2608	5185	6580	4,093
	Fresh water (m^3/sec)	25	25	25	8	-
	Water depth (m)	-16	-14	-18	-14	-23
	Distance from DF (km)	750	800	550	750	850
	Population of capital city (10^3 persons)	60	-	650	120	-
TYPES OF KEY INDUSTRIES	Feedstuffs, Foodstuffs	o		o	o	o
	Pulp, paper and related products				o	o
	Petroleum refining	(o)	o			o
	Basic petrochemicals, including derivatives	(o)	o	o	o	o
	Chemical fertilizers	o	o			o
	Synthetic rubber, plastics, tyres			o	o	
	Cement and related products	o				o
	Pig iron and steel with blast furnaces and rolling facilities	o		o		
	Secondary steel processing	o		o		
	Non-ferrous metals and products			o		o
	Industrial machinery	o			o	
	Household electrical appliances				o	
	Motor vehicles					
	Shipbuilding	o			(o)	
	Plastic products	o				
	Fabricated construction products	o		o	o	

Note; O; Industry already located or proposed in each industrial port.
( ); not concreted in the plan
- ; no available data

1-3 Basic Concept of Tuxpan Industrial Development

(1) The roles of industries located in Tuxpan are as follows.

(a) Contribution to decentralization of socio-economic activities

(b) Contribution to innovation of industrial structure

(c) Utilization of local resources and encouragement of local industry

(d) Promotion of the replacement of imports and expansion of exports.

(2) The industries corresponding to each role can be considered as follows.

(a) Decentralization of socio-economic activities

In order to expand economic activities by promoting the industries in local areas and increasing employment, various kinds of industries in Tuxpan are considered as follows.

1) Industries oriented to the local demands such as molt liquors, cement based construction materials, etc.

2) Industries oriented to the local resources such as processing of agricultural products, etc.

More definitely, industries to be located are as follows:

1) Industries which are oriented to the resources such as petroleum refining, petrochemicals, etc.

2) Capital goods industries which make considerable use of the port such as construction machinery, heavy electric machinery, etc.

3) Industries which process the materials handled at the port such as wheat flour, feed stuff, etc.

(b) Innovation of industrial structure

Industrial development has been mainly carried out for the intermediate goods industries such as petroleum refining, petrochemicals and steels (refer to Table VI-1-(2)). However, the machine industry and secondary petrochemical industries with high added values and utilizing the materials produced by the intermediate goods industries have a great potentiality for future growth.

It is required in the future to encourage the industries capable of having high added values in close relation to the intermediate goods industries.

Thus, location of those industries whose requirements for location will fit the conditions of the Area can be considered.

Table VI-1-(2) Share of Industrial Products

(%)

	1965	1972	1977
Consumer goods	60.2	56.1	52.8
Intermediate goods	24.5	26.8	29.5
Metals and machineries	15.3	17.1	17.7
Total	100.0	100.0	100.0

Source: Banco de Mexico and Pemex.

(c) Utilization of local resources and encouragement of local industry

Since Chicontepec oil field, with a huge amount of oil deposits and natural gas, lies within the Area, the location of such industries as crude oil exporting base, petroleum refining, petrochemicals and chemical machinery can be considered. Also, the promotion of agroindustry which processes the agricultural and fishery products available in the Area and its vicinity can be considered.

(d) Promotion of replacement of imports and expansion of exports

Products such as heavy machinery, machine tools and electronic equipment which require high technology and have high added values are mostly imported at present (refer to Table VI-1-(3)). However, in order to save foreign currencies and to promote balanced development of industries in future, these products have to be produced domestically. In addition, the production technologies in the petrochemical and automobile industries are approaching or have the potential to approach, high international levels so that they can become future strategic industries for export. Thus, location of those industries whose requirements for location will meet the conditions of the Area can be considered.

Table VI-1-(3) Import and Domestic Demand of Some Capital Goods

Type of Industry	Import/ Demand (%)	Source
Machine tool	98	American Machinist, Economic Hand Book, Machine Tool Industry (1975)
Heavy electric machinery	50	NAFINSA-UNIDO Report (1977)
Construction machinery	85	" (1977)

(3) Among these industries, port-oriented industries which can utilize the function of the large-scale port are considered desirable.

1-4 Selection of Industries

Selection of located industries is executed by two steps as follows, while considering their complience with basic concepts shown in 1-3.

1) First step (Primary selection)

Industries located in the Area are selected by examining their eligibility under the Tuxpan region's conditions for industrial location.

2) Second step (Secondary selection)

Industries located around the Tuxpan Industrial Port are selected from primarily selected industries by examining their eligibility under the Port area's local conditions for industrial location.

(1) Primary selection

(a) Criteria for selecting industrial types

Among the Area's regional conditions, the attractive conditions for industrial location are as follows.

1) Being located along the Gulf of Mexico from which trade with the east coast of U.S.A. and the European Continent is very convenient.
2) Being the port closest to Mexico City which has the most concentrated population and industries.
3) Being located at the mid point between Altamira and Ostion along the Gulf.
4) Being located near the Chicontepec oil field with a huge amount of oil deposits and also near areas with plenty of agricultural and fishery products.

By taking account of the above points, the following criteria for selecting the industrial types can be considered.

1) Industrial types having the functions of producing and processing the goods capable of utilizing the port functions for foreign trade.
2) Industrial types having the functions of producing and processing the goods required for supporting hinterland cities such as Mexico City.
3) Industrial types having the functions of producing and processing the products related to the industrial production in key industrial ports facing the Gulf, or the industrial types having the functions of producing and processing the goods supporting the industrial production of key industrial ports facing the Gulf. (2 items involved)
4) Industrial types having the functions of producing and processing the products utilizing the local resources and products, or the industrial types having the functions of producing and processing the goods supporting the production of local resources and products. (2 items involved)

(b) Primarily selected industries

Conformity with the criteria for selecting the industrial types is examined in the case of industrial types to which high priority was given in accordance with the PNDI and in the case of industrial types designated in "Tuxpan Industrial Port Plan" prepared by CPD* (groups of these industrial types called the groups of fundamental industrial types).

As a result, the industrial types which meet the criteria well, that is, the types capable of effectively utilizing the Area's regional conditions for industrial location, have been selected. The industrial types selected must meet at least two out of six of the criteria items. However, for the port-oriented industries, even the industrial types meeting only one of the criteria items are selected since they correspond to the basic condition of the industrial port. Also, the industrial types preselected by CPD* plan are selected even if they do not fully satisfy the criteria since it is considered that they were preselected in view of local locational conditions and in accordance with local needs.

Among the groups of fundamental industrial types, fifty three well suited industrial types are selected, as shown in Table VI-1-(4).

* Coordinacion de Proyectos de Dessarrollo.

Table VI-1-(4) List of Primarily Selected Industries

Industrial type	Priority in the PNDI	Products capable of utilizing the port functions for foreign trade	Products required to support hinterland cities	Products related to the key industries ports: Supporting products	Products related to the key industries ports: Related products	Products related to the regional resources & production: Supporting products	Products related to the regional resources & production: Related products	Industries selected in CPD report	Remark
A. Port & coastal area oriented industries									
1. Sea food products	I		O				O	O	
2. Marine animal meal	I					O	O	O	
3. Wheat flour	I	O	O				O		Food industry complex (3.–6.)
4. Vegetable oils and fats	I	O	O				O		
5. Feedstuffs	I	O				O	O		
6. Sugar products	I		O				O		
7. Agricultural chemicals (chemical fertilizers)	I	O			O	O			
8. Machinery and equipment for land and sea prospecting and drilling	I I			O		O		O	Machine industry complex for the oil and petro-chemical industry (8.–12.)
9. Valves, valvetrees, connections, etc.	I			O				O	
10. Motor pumps, motor compressors etc.	I			O				O	
11. Tubular heaters	I			O					
12. Drilling, street and processing pipes	I			O					
13. Machinery and equipment for the generation, conduction etc.	I			O				O	Machine industry complex for the electrical industry (13.–15.)
14. Boiler injection and high volume pump	I			O					
15. Machinery and equipment for the construction industry etc.	I		O	O		O			
16. Diesel engines, tractor trucks, etc.	I	O	O					O	
17. Motor vehicles	I	O	O					O	
18. Shipbuilding	I	O			O			O	
19. Parts and components for the ship-building industries	II				O				
20 Heavy bending, machining and welding equipment	I		O	O					
21 Industrial boilers and heat exchangers	I			O				O	
22 Soaps and detergents	II		O				O	O	
23 Paper and cardboard	II		O				O		
24 Fibers derived from petrochemicals	II	O	O		O			O	
25 Widely used intermediate petro-chemicals	II	O			O			O	
26 Synthetic rubber and resins, etc.	II	O			O			O	
27 Inorganic acid and salts	II				O				
28. Plate glass for construction	II		O					O	
29. Pressboard and plywood	II		O				O		
30. General sawing		O	O				O		
31. Iron and steel		O			O			O	
32. Cement		O	O				O	O	
33. Petroleum refining		O	O				O		

Table VI-1-(4) (continued)

Industrial type	Priority in the PNDI	Products capable of utilizing the port functions for foreign trade	Products required to support hinterland cities	Products related to the key industries ports: Supporting products	Products related to the key industries ports: Related products	Products related to the regional resources & production: Supporting products	Products related to the regional resources & production: Related products	Industries selected in CPD report	Remark
B. Other industries									
1. Natural milk, cream etc.	I		O				O	O	
2. Processing, packing and packaging of meat	I		O				O	O	
3. Processing of fruits and vegetable	I		O				O		
4. Ingredients for the preparation of food stuffs	I		O				O		
5. Machinery and equipment for food processing	I		O			O		O	
6. Wheeled tractors, harvesters, etc.	I					O		O	
7. Pumps, valves, connections, etc.	I			O				O	
8. Yarns, textiles, finished products made from cotton, etc.	II		O					O	
9. Dress garments and domestic use garment, etc.	II		O					O	
10. Leather goods	II		O				O	O	
11. Cardboard, glass, plastic or tinplate	II		O			O		O	
12. Equipment and instruments for medical and hospital use	II		O					O	
13. Pharmaceutical products, etc.	II		O		O				
14. Plastic products for construction	II		O		O			O	
15. Bricks, roof tiles, etc.	II		O					O	
16. Cement based construction materials	II		O				O	O	
17. Clay, tile or porcelain bathroom furniture	II		O				O	O	
18 Malt liquors and soft drinks			O				O	O	
19 Crackers and food paste	I		O				O	O	
20 Motor vehicles parts and accessories	II		O		O			O	

Note; Type I is given higher priority than type II in the PNDI.

(2) Secondary selection

Based upon the results of primary selection, the industries to be located around the Tuxpan Industrial Port are selected by taking account of the conditions peculiar to the Industrial Port area.

Among the local conditions of the Industrial Port area, the attractive conditions for industrial location are as follows.

(a) Exclusive use of a wharf with a large depth should be possible

(b) Large-scale flat land should be available.

(c) A large volume of fresh water should be available with construction of a dam as prerequisite, the site of which has not yet been studied.

(d) Sea water should be available.

(e) Development of other infrastructures such as roads and railways should be carried out in parallel.

Industries conforming to the above conditions are the large-scale port-oriented industries with requirements for transportation of large quantities of raw materials and products, and for the existence of large amounts of industrial area and water. Also the industries for processing raw materials of port cargo are considered acceptable. Thus, the industries specially requiring to use the port and coastal lands have been selected.

Now, the industries also meeting the basic concept of industrial development should be selected from the industries already selected up to here.

The industries for the Tuxpan Industrial Port are as follows, as shown in Table VI-1-(5).

1) Sea foods products	2) Wheat flour, vegetable oil, etc.
3) Paper and cardboard	4) Petroleum refining
5) Petrochemicals	6) Iron and steel
7) Fabricated metals for ocean use	8) Construction machinery
9) Chemical machinery	10) Heavy electric machinery
11) Motor vehicles	12) Shipbuilding

As for the industries selected in primary selection but not selected in secondary selection, these industries which are not specially requiring the port area for their location, such as livestock products, fibers, leather, medicines, plastic products, construction materials, etc. may be developed in the inland of the Area while maintaining a certain relationship with the Tuxpan Industrial Port area.

Table VI-1-(5) Conformity to the Basic Concept of Industrial Development

Type of industry	Basic concept of industrial development			
	A	B	C	D
Sea food products	O		O	
Wheat flour	O		O	
Vegetable oil	O		O	
Feedstuff	O		O	
Paper and cardboard	O		O	O
Petroreum refining	O		O	O
Petrochemicals	O		O	O
Iron and steel	O			O
Fabricated metals for ocean use	O	O		O
Construction machinery	O	O		O
Chemical machinery	O	O		O
Heavy electric machinery	O	O		O
Motor vehicles	O	O		O
Shipbuilding	O	O		O

Note: A: Decentralization of socio-economic activities
B: Innovation of industrial structure
C: Utilization of local resources and encouragement of local industry
D: Promotion of replacement of imports and expantion of exports
O: Conformed to the basic concept

1-5 Industrial Development Program

The industrial development program estimates the scales of production, time to start the operation, industrial area, number of employees and amount of fresh water for the industries located around the Tuxpan Industrial Port. The scales of production and the time to start operation are set in consideration for trends in demand and supply of main products, the scale merit of plants and their unit scale, as shown in Table VI-1-(6). Based on the production scales, the necessary industrial area, number of employees and required fresh water volume are determined, as shown in Table VI-1-(7) by referring Japanese and Mexican plant examples shown in Table VI-1-(8).

The total industrial area is about 4,000 ha including 1,500 ha for iron and steel and 1,000 ha for petroleum refining.

The number of workers is large in the machinery industry which heavily depends on manpower. The total number is 42,000 including 10,000 for motor vehicles, 7,500 for iron and steel, 5,500 for chemical machinery and 5,000 for petrochemicals.

Fresh water consumption is by far the largest in the cases of paper and cardboard, petroleum refining, petrochemicals and iron and steel, which together account for 97 percent of the total consumption. The daily consumption is $1,239 \times 10^3$ m^3.

Electric power required for the located industries is roughly estimated as about 750 to 950 MW.

Table VI-1-(6) Assumptions of Scales of Production

Industrial type	Unit	Demand in 1988	Supply in 1988	Capacity of production with economic scale merit	Unit scale of plant	Scales of production in Tuxpan industrial complex: Before 1988	Scales of production in Tuxpan industrial complex: After 1988
1. Sea food products	1,000MT/Y	*1 45	*2 -	*3 -	*3 -	45	100
2. Wheat flour	1,000MT/Y	*4 30 - 80	-	116	*7 60	60	116
3. Vegetable oil	1,000MT/Y	-	-	26	*7 26	0	26
4. Feedstuff	1,000MT/Y	*4 100-200	-	120	*7 60	60	120
5. Paper and cardboard	1,000MT/Y	4,230	-	500	*7 175	175	500
6. Petroleum refining	1,000BPSD	*5 680	351	500	*8 200 -	250	500
7. Petrochemicals	1,000MT/Y	*6 1,400	2,332	500	*8 300 -	0	500
8. Iron and steel	1,000MT/Y	19,559	11,200	5,000	*6 1,900 -	2,500	5,000
9. Fabricated metals for ocean use	1,000MT/Y	-	-	24	*3 -	24	24
10. Construction machinery	UNIT/Y	12,700	-	4,000	*7*8 2,000 -	2,000	4,000
11. Chemical machinery	1,000MT/Y	1,060	-	30	*7 30	30	30
12. Heavy electric machinery	UNIT/Y	-	-	80	*7 80	80	80
13. Motor vehicles	1,000UNIT/Y	700	700	360	120	0	360
14. Shipbuilding	1,000DWT/Y	-	-	250	250	0	250

Remarks:

*1 Fish catch for processing in the Tuxpan administrative region
*2 No available data
*3 Plant scale is very small
*4 Development Area and part of Mexico City Metropolitan Area
*5 Refining volume with Chicontepec oil field
*6 Ethylene base
*7 Mean value of the modern factories
*8 "A - " means "over A"

Table VI-1-(7) Industries Located Around the Tuxpan Industrial Port

Type of Industry	Capacity of production	Area(ha)	Number of employees (persons)	Fresh water (1000 m³/day)
Sea food products	100 x 10³MT/Y	20	1,700	7
Wheat flour	116 x 10³MT/Y			
Vegetable oil	26 x 10³MT/Y	100	300	1
Feedstuff	120 x 10³MT/Y			
Paper and cardboard	500 x 10³MT/Y	200	3,500	340*
Petroleum refining	500 x 10³BPSD	1,000	1,500	200**
Petrochemicals	500 x 10³MT/Y	500	5,000	320**
Iron and steel	5,000 x 10³MT/Y	1,500	7,500	350**
Fabricated metals for ocean use	24 x 10³MT/Y	30	1,500	1
Construction machinery	4,000 UNIT/Y	60	1,500	2
Chemical machinery	50 x 10³MT/Y	80	5,500	9
Heavy electric machinery	80 UNIT/Y	30	1,000	1
Motor vehicles	360 x 10³UNIT/Y	220	10,000	17***
Shipbuilding	250 x 10³DWT/Y x 5 ship/y	200	3,000	1
Total	-	3,940	42,000	1,239

Note: 1. Retrieval ratio *: 40%, **: 60%, ***: 90%

Table VI-1-(8) Scale of Plant Example

Type of Industry	Example	Capacity Production	Area (ha)	Employees (persons)	Note
Food processing	Model				
	silo	150 x 10³	3.9	30	Unit: capa.(MT)
	wheat floor	150 x 10³	2.3	30	Unit: MT/year
	soy bean oil	53 "	5.0	50	
	feed stuff	240 "	4.8	20	
	Total		16.0	130	
	Mexico				
	silo	80 x 10³	150	600	capacity (MT)
	wheat floor				
	vegetable oil				
	pasta				
Petroleum refining	Model	1,000 x 10³	1,000	420	Unit: BPSD
	Jap. A	180 "	250	560	
	" B	300 "	220	1,200	
Petrochemicals	Model	20 x 10³"	700	5,250	Unit: MT/year Ethylene base
	Jap. C	1.6 "	160	1,700	
	" D	3 "	100	1,900	
	Mexico A	5 "	1,000		
Iron and steel	Model	20 x 10⁶	1,650	10,000	Unit: MT/year
	Jap. E	9 "	920	11,700	
	" F	12 "	920	10,300	
	Mexico B	1.3 "		2,500	
	" C	2 "	1,000	3,700	
Motor vehicles	Model	360 x 10³	150	10,100	Unit:
	Jap. plan	500 "	300	10,000	
	Mexico D	80 "	40	3,000	planning
Shipbuilding	Model	300 x 10³ DWT x 4 ship/year	100	1,800	
	Japan G	250 x 10³ x 6	86	1,800	
	H	250 x 10³ x 5	77	1,350	
	Mexico E	44 x 10³ x 4	40	3,050	
	F	80 x 10³ x 4	120		Planning

As for the time to start operation, such industries as fabricated metals for ocean use, chemical machinery and heavy electrical machinery are expected to be in full operation soon because they are closely related to development projects on the Gulf. Further, the petroleum refining and iron and steel industries are likely to be partially in operation soon in accordance with supply/demand trends.

Following are the considerations by type of industry.

(1) Sea food products

Fishery in Mexico is expected to grow larger, foreseeing that in the long run potential fishery resources will be fully utilized after introducing the new fishery techniques.

Fish catches in Tuxpan administrative region will be forecast in Chapter VI, 2 of this report. 45,000 tons in 1988 and 95,000 tons in 2000 are the figures for catches of fish for processing. Sea food plants corresponding this amount are expected to be located.

(2) Wheat flour, vegetable oil, and feedstuff

Every year Mexico imports a large amount of food, mainly wheat and corn. The importing of food at this level seems likely to continue for many years to come because of various reasons.

Therefore, the formation of a foods complex, consisting mainly of silos for imported grain for producing wheat flour, vegetable oil and feedstuff, can be expected since Tuxpan is the nearest port to the large market of Mexico City.

The following tables show trends of demands of wheat flour and feedstuff, main products of the food industrial complex, in accordance with per-capita consumption and population for Table VI-1-(9), and per-capita livestock consumption and livestock number of head for Table VI-1-(10).

Table VI-1-(9) Demand for Wheat Flour in the Hinterland

	1988	2000
Demand (1,000 MT/Y)	30 – 80	90 – 130
Population (1,000 Person)	1,200	1,700

Note: Population is the total of the Area and part of Mexico City Metropolitan area.

Table VI-1-(10) Demand for Feedstuff in the Hinterland

	1988	2000
Demand (1,000 MT/Y)	100 – 200	400 – 600
Livestock (1,000 Head)	500 – 900	900 – 1,200

Based upon this demand as prerequisite, the following production complex can be established by taking account of the optimum production scale in terms of the scale merit for each plant of wheat flour, vegetable oil and feedstuff.

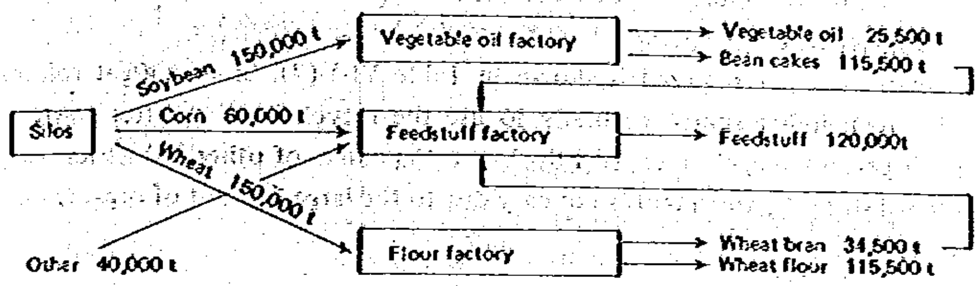


Fig. VI - 1 - (3) Food Industry Complex

It is assumed in accordance with demand trends that plants producing flour and feedstuff will start operation by 1988 at one half of their final production scale. As for vegetable oil, the scale merit will drastically decrease if the plant operates at one half of the final production scale. So, it is decided that it will start operation at 25,500 t/year when other plants start full operation after 1988.

(3) Paper and cardboard

Future trends in the national demand for paper in the PNDI are as follows. The demand will increase by about 1,700 x 10^3 tons during the period from 1982 to 1988, as shown in Table VI-1-(11). And to cope with this demand increase, it will be necessary to construct several large plants.

Table VI-1-(11) Demand for Paper in the Country

	1979	1982	1988
Demand (1,000 MT/Y)	2,028	2,520	4,230

In the medium term, 28 x 10^6 m^3 of wood for paper and cardboard is expected to be produced annually in Mexico. Therefore it is considered that the domestic resources are sufficient for paper and cardboard production.

The Area has poor forestry resources. However, as one of the types for consuming-place-preference location, it is very likely that a large-scale paper plant will be constructed in Tuxpan which is very close to the large consuming area, Mexico City.

The optimum production capacity of 500 x 10^3 tons per year (150 x 10^3 tons of high-quality papers, 350 x 10^3 tons of newspapers) capable of having the scale merits are determined from the case studies on factories in Japan.

The time to start operation is set as follows. It is assumed that high quality paper will be produced until 1988 because of presumably limited supply of raw materials due to the condition that infrastructures for transportation of wood are inadequate in the southern provinces expected to provide raw materials for the plant.

Volume of fresh water required is shown in Table VI-1-(7). Since a great volume of fresh water will be used, it is assumed naturally to use the recycled water, after waste treatment. However, a 40 percent recycle rate, slightly lower than that of other industries using a lot of water, is assumed since the treatment is not easy due to the large amount of organic matter in the waste water.

(4) Petroleum refining

The future trend of petroleum production is reviewed, based upon the Energy Plan (November 1980) and PEMEX documents, and the results of review are shown in Table VI-1-(12).

Table VI-1-(12) Demand and Supply of Petroleum

(1,000 BPSD)

Year	Crude oil	Export	Domestic use
1981	2,370	1,098	1,272
1985	3,500	1,500	2,000
1988*	3,840	1,500	2,340
1999	4,100	1,500	2,600
2000*	6,000	1,500	4,500

Note: *: Estimation in this report

The oil deposits confirmed at the end of 1981 were 72,008 million barrels in the whole country. And about 24.4 percent of them or 17,598 million barrels are expected at Chicontepec. The assumed scale of production of crude oil in 1990, corresponding to the oil deposits confirmed at Chicontepec, is found to be 1,000 x 10^3 BPSD, and the required capacity of the refineries is 740 x 10^3 BPSD. The capacity of the proposed refinery in the Tuxpan Industrial Port is determined to be 500 x 10^3 BPSD by taking account of the necessity of keeping a production scale capable of having scale merits in order to secure price-competitiveness in exports and to share the output with the nearby existing Madero refinery.

The time to start operation is set as follows. The petroleum refining capacity corresponding to crude oil production at Chicontepec in 1988 is 680 x 10^3 BPSD. This, minus the capacities of the Madero and Poza Rica petroleum refineries, is about 300 x 10^3 BPSD. Since the unit production scale corresponding to the final scale of 500 x 10^3 BPSD is 250 x 10^3 BPSD, production scale of 250 x 10^3 BPSD is proposed for the period until 1988.

The following relation can be considered between the refinery and other industries located around the Tuxpan Industrial Port.

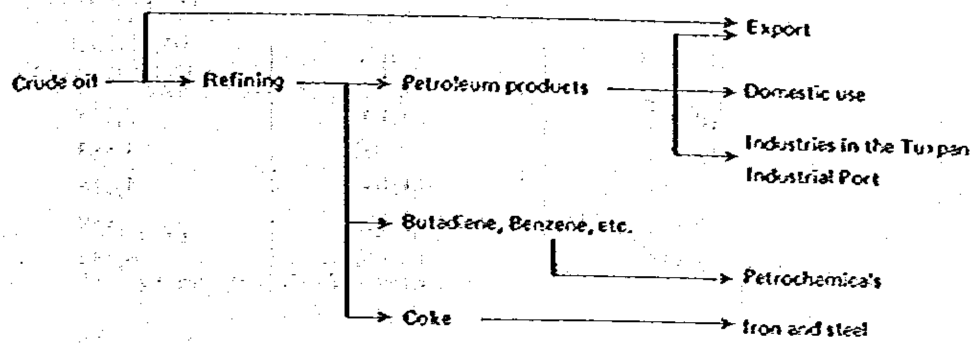


Fig. VI-1-(4) Relation Between Petroleum Refining and Other Industries

(5) Petrochemicals

The supply/demand relation of ethylene, one of the chemicals basic to the production of petrochemicals, is as follows, according to the demand forecast in PNDI and the plant construction plan is indicated in PEMEX data.

Table VI-1-(13) Demand and Supply of Petrochemicals

(1,000 MT/Y)

Year	Demand	Supply	Gap between demand and supply
1980	366	432	-66
1988	1,400	2,332	-932

Anticipating the completion of projects at Moreros, Cangrajera, Ostion and Dos Bocas, etc., there is no need to construct new production facilities till 1988. But after 1988, a new large petrochemical complex must be constructed if the high rate of growth of until 1988 somehow continues after 1988.

Ethylene production is set at 500 x 10^3 ton/year in consideration of the condition that petrochemicals must have large production capacity to realize a scale merit in order to secure price-competitiveness in the export of products.

The time to start operation would be after 1988 in view of the above supply/demand trends.

(6) Iron and steel

According to the information shown in the Medium-Term Iron and Steel Industry Promotion Plan (1982) and others, demand and supply of iron and steel is as follows.

Table VI-1-(14) Demand and Supply of Iron and Steel

(1,000 MT/Y)

Year	Demand	Supply	Gap between demand and supply
1982	10,898	8,400	2,498
1984	13,183	9,600	3,583
1986	15,818	11,200	4,618
1988	19,559	11,200	8,359
1990	23,574	16,740	6,834

Even if the operation of Altamira starts, a gap between demand and supply exceeding $4,000 \times 10^3$ tons will be expected in 1986, which suggests the necessity of a fourth steel works following Altamira. The production capacity is determined to be 5 million tons/year by taking account of the scale merits and the production allotment among preceding steel works such as Lazaro Cardenas and Altamira.

The relation between the iron and steel and the other industries is as indicated below.

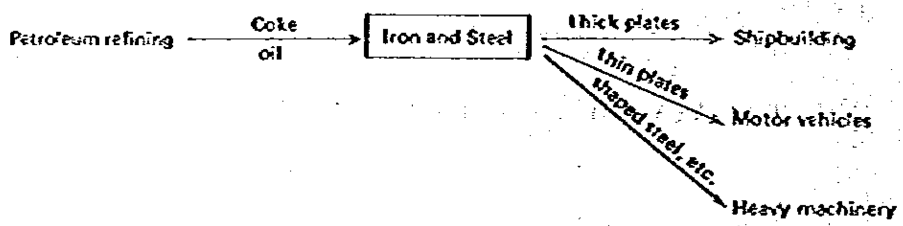


Fig. VI-1-(5) Relation Between Iron and Steel and Other Industries

As far as the supply/demand relation is concerned, operation must be started early, however, considering the period of construction of the industrial port and the plant,sthe plant operation will be only partially started by 1988.

(7) Fabricated metals for ocean use

No quantitative forecast of demand and supply has been made for fabricated metals for ocean use such as platforms. However, the oil prospecting activities have progressed from land to sea in recent years and this tendency will continue further in future.

Tuxpan is already a base for constructing the fabricated metals for ocean use and servicing the platforms, so that the activities are expected to become more vigorous in future as ocean drilling for petroleum progresses further.

It is assumed to concentrate the existing production facilities in order to improve productivity.

(8) Construction machinery

Future demand of construction machinery is forecast by the data of demand increase rate in the PNDI, as shown in Table VI-1-(15).

Table VI-1-(15) Demand for Construction Machinery

	1977	1982	1988
Demand (UNIT/Y)	3,000*	5,500	12,700

Source: * Report by NAFINSA and ONUDI

Most of the supply is imported at present. To achieve self-sufficiency in the future, production capacity must be expanded to more than 10,000 units per year by 1988. If demand grows at this pace, several larger plants will have to be constructed.

Large-scale construction works such as Altamira and Ostion in the Gulf may occur more frequently in future, and thus the demand for large construction machinery will be greatly increased in the coastal region. Also, Tuxpan is located most closely, at the Gulf coast, to Mexico City where the machinery industry is concentrated and thus it has many advantages for production.

The scale of production for bulldozers and powershovels is determined to be 4,000 units per year by taking account of scale merits and production allotment among the Gulf, the Pacific coast and the inlay area.

As for the time to start operation, operation to produce a half of the final production scale will be started by 1988 in consideration of demand trends and the share by the above three regions.

(9) Chemical machinery

Future demand trends for chemical machinery are forecast by the data of demand increase rate in the PNDI, as shown in Table VI-1-(16).

Table VI-1-(16) Demand for Chemical Machinery

	1975	1982	1988
Demand (1,000 MT/Y)	180*	510	1,060

Source: * Report by NAFINSA and ONUDI

An impressive demand increase of 880,000 ton per year can be seen for the period from 1975 to 1988. If the demand grows at this pace after 1988, further drastic demand increase will be expected from 1988 to 2000.

Various large-scale industries such as petrochemicals and petroleum refining have become greatly concentrated along the Gulf coast in recent years, so that coastal machinery factories capable of fabricating large plants and of smoothly offering services for these plants are greatly needed. Also, Tuxpan of the cities along the Gulf is located most closely to Mexico City where the machinery industries are concentrated and, thus, has many advantages in production. The scale of production is set to 50×10^3 tons per year from the case studies on standard large-scale factories. The time to start operation is set to be before 1988 since it must correspond to the construction of the petrochemical complex such as Moreros, Ostion and Altamira.

(10) Heavy electric machinery

According to CFE's Expansion Plan for Electric Power Generation, which will greatly affect the production of heavy electric machinery, it is planned to increase the power capacity at an annual rate of 9.2 percent or 1,400 MW annually on the average from 1976 to 1986 and at an annual rate of 13.5 percent or 4,000 MW annually in average from 1986 to 1990.

In the investment for increasing the power generating capacity, the share of heavy electric machinery such as turbine generators, steam turbines and high-voltage power transformers is the highest, but turbine generators and medium or large-size steam turbines for power plants will be imported and the most of large-size transformers will be also imported. However, a great demand is expected for large-size transformers and, thus, construction of new factories for large-size transformers is planned.

On the other hand, along the Gulf coast, huge energy resources of petroleum are concentrated, and a great increase in demand for electric power is expected as the large-scale industrial bases such as Altamira, Ostion and Tuxpan are completed. Also, the coastal portion along the Gulf has many advantages in securing a huge amount of cooling water and in disposing of radioactive waste, so that new large-scale power plants are most likely to be located in the coastal region.

To respond to the location of such large-scale power plants, the advisability of factories producing large-size heavy electric machinery in the coastal region is very high in view of the advantages in transportation.

These factories will produce large transformers (larger than 100,000 KVA) and a standard production scale of 80 units annually is determined from the case studies on factories. The time to start operation is determined to be before 1988 in view of the trends in demand.

(11) Motor vehicles

The number of motor vehicles produced in 1980 including passenger cars, trucks and buses was 482×10^3. The demand was expected to be about 1 million cars in the last half of 1980's since many people wanted to buy cars. However, because of the trend of business decline in recent year, the motor vehicles industry has revised the forecast of demand to 700×10^3 cars in 1988.

On the other hand, many automobile manufacturers plan to expand production facilities. Mexico Nissan Motor plans an increase of 360×10^3 cars, and VW, GM and Chrysler plan to build new engine factories. Also, VW will soon begin to produce engines for exports and the Big three have a scheme to build a base for producing the popular world cars, and manufacturers also intend to export the cars under the governmental guidance.

Table VI-1-(17) Demand and Supply of Motor Vehicles

(1,000 UNIT/Y)

Year	Demand	Supply	Gap between demand and Supply
1980	482*	482	0
1988	700	700	0
2000	1,200	700	500

Source: *, Mexico Automobile Manufacturers Association.

As long as sufficient labor is available and various kinds of incentives are fully arranged, Tuxpan has a great potential to become one of the most important sites for automobile production since it offers several merits such as more convenience for importing parts and exporting products, height adjustment not necessary for exporting products because of its location in a low land, and being coastal land located most closely to the concentrated parts industries near Mexico City.

The scale of production is determined to be 360 x 10^3 passenger cars annually by taking account of the expansion plans by principal corporations and the scale capable of having the scale merits. The time to start operation is set to be after 1988 since the existing facilities are almost able to respond to the increased demand of 700 x 10^3 cars expected by in 1988.

(12) Shipbuilding

The number of vessels owned by Mexico is small, about 30 in the case of tankers, and the gross tonnage is 400 x 10^3 tons. This is a very short supply for coping with the increasing amount of oil transport, while general cargoes as well are increasing considerably. Therefore, the government began to promote the shipbuilding industry, provided 60 percent of the capital in Astilleros Unidos, and is carrying out construction projects for shipyards, such Veracruz to be completed in 1985 with a shipbuilding capacity of 44 x 10^3 DWT x 4 vessels annually, and Lazaro Cardenas to be completed in 1985 with a shipbuilding capacity of 80 x 10^3 DWT x 4 vessels annually.

As the exports of petroleum products increase in the future, demand for building large vessels, mainly tankers, will continue to increase as well and, thus, it will be necessary to construct other large-scale shipyards even after Lazaro Cardenas.

Tuxpan has a great potential to become one of the most important sites for iron and shipyards. Since it is a selected site for iron and steel industry, thick steel plate materials will be easily available there, and specific waterfront may be formed in order to launch large vessels smoothly.

The scale of production is determined to be 250 x 10^3 DWT x 5 vessels annually by taking account of the scale capable of corresponding to the demand for large tankers and of providing international competitiveness. The time to start operation is set to be after 1988 by taking into account the plans for Lazaro Cardenas and others and the closely related operation of the iron and steel industry.

1-6 Port Cargo Volume Estimation

With respect to the industrial types assumed to be located in the industrial port area, the material flow corresponding to each production scale is forecast based upon the case studies made previously on main factories in Japan, and then the total concentration and generation cargo movements are calculated for raw materials and products.

A marine transport rate is set for each cargo item and a volume of handled cargoes of the port is calculated. The marine transport rate is set as follows.

Raw materials: The distribution and volume of domestic resources and their availability for transport to Tuxpan are studied and from the above results raw materials required for plant operations are divided into imports and domestic resources. Regarding domestic resources, the marine transport rate is set by considering the expected sources of resources and the proper allotment among the alternative transportation modes between Tuxpan and those places.

Products: Products are divided into the two categories, those for overseas markets and those for domestic markets. Regarding the products for domestic markets, the marine transportation rate is set by considering the distribution of markets and the proper allotment among the alternative transportation modes between Tuxpan and the places of markets.

It is assumed naturally, that all imports and exports at Tuxpan depend on marine transportation.

The results are shown in Table VI-1-(18) and Table VI-1-(19).

Table VI-1-(18) Industrial Cargo

(1,000 t/y)

Type of industry	Concentration cargo		Generation cargo	
	Item	Volume	Item	Volume
Sea food products	Fish	100	Sea food products	93
Wheat flour	Soybean	150	Vegetable oil	26
Vegetable oil etc.	Maize	60	Bean cakes	154
	Wheat	150	Feedstuff	128
	Others	40	Wheat flour	115
	Sub Total	400	Wheat bran	26
			Sub-Total	351
Paper and cardboard	Wood, chip	760	Paper, cardboard	500
Petroleum refining	Crude oil(for export)	13,600	Crude oil	13,600
	" (for refining)	23,000	Petroleum products(for export)	4,800
	Sub-Total	36,600	" (for domestic demand)	17,000
			Sub-Total	35,400
Petrochemicals	Butadiene, Benzene, etc.	1,050	Petrochemical products	1,450
	Salt	310		
	Sub-Total	1,350		
Iron and steel	Iron ore	7,000	Steel	4,000
	Coal	2,800		
	Limestone	950		
	Scrap iron	100		
	Scale	100		
	Heavy oil	450		
	Sub-Total	11,400		
Fabricated metals for ocean use	Steel, etc	26	Fabricated metals for ocean use	24
Construction machinery	Steel, parts, etc.	120	Bulldozer, etc.	118
Chemical machinery	Steel, parts, etc.	66	Chemical machinery	52
Heavy electric machinery	Steel, electric wire, etc.	20	Large-scale transformer	15
Motor vehicles	Steel, parts, etc.	450	Motor vehicles	338
Shipbuilding	Steel, parts, etc.	210	Ship	238
Total		51,522		42,613

Table VI-1-(19) Industrial Port Cargo Volume Handled at Tuxpan

(1,000 MT/Y)

Item / Commodity	Type of packing	Foreign Trade Imp.	Foreign Trade Exp.	Foreign Trade Total	Domestic Trade In.	Domestic Trade Out.	Domestic Trade Total	Total	Private or Public
Agricultural and fishery products									
Fish	G				50		50	50	
Grain	B	324		324				324	○
Forestal products									
Chip	B				760		760	760	○
Petroleum-products									
Oil	L.B		4,800	4,800		1,700	1,700	6,500	○
Petrochemical products									
Petrochemical products	L.B		100	100		100	100	200	○
Petrochemical products	B		45	45		45	45	90	○
Minerals and crude oil, etc.									
Salt	B				248		248	248	○
Crude oil	L.B		13,600	13,600	4,000		4,000	17,600	○
Iron ore	B	7,000		7,000				7,000	○
Coal	B	2,240		2,240				2,240	○
Limestone	B	760		760				760	○
Scrap iron	B	50		50				50	○
Scale	B	80		80				80	○
Iron and steel									
Steel	B		1,200	1,200		800	800	2,000	○
Consumer goods									
Sea food products	G		9	9				9	
Paper	G					50	50	50	
Capital goods									
Industrial machinery	G	3		3				3	○
Fabricated metals for ocean use	G					22	22	22	○
Machine equipment and parts	G	12		12				12	○
Construction machinery	G					33	33	33	○
Parts of chemical machinery	G	9		9				9	○
Chemical machinery	G					20	20	20	○
Parts of heavy electric machinery	G	2		2				2	○
Heavy electric machinery	G		2	2		6	6	8	○
Parts of motor vehicles	G	90		90				90	○
Motor vehicles	G		1,800	1,800		360	360	2,160	○
Parts of shipbuilding	G	42		42				42	○
Total		10,612	21,556	32,168	5,058	3,136	8,194	40,362	

Note: ○: Handled on the private berths
G: General Cargo
B: Bulk Cargo
L.B: Liquid Bulk Cargo

2. Demand Forecast

2-1 Commercial Port Cargo

(1) Procedures for forecast

The procedures for forecast are shown in Fig. VI-2-(1).

The procedures are broken down into several steps as follows.

Step 1. Definition of the hinterland

Step 2. Economic frame of the hinterland

Step 3. Method for functional allotment in the competitive hinterland

Step 4. Method for estimating the shift in cargo traffic away from US Gulf ports

Step 5. Demand/supply analysis by goods

Step 6. Estimation of Tuxpan port traffic

The technical details are explained in the following paragraphs.

The basic flow of the steps is from the defining of the hinterland, then economic frame of the hinterland and lastly estimation of Tuxpan port traffic.

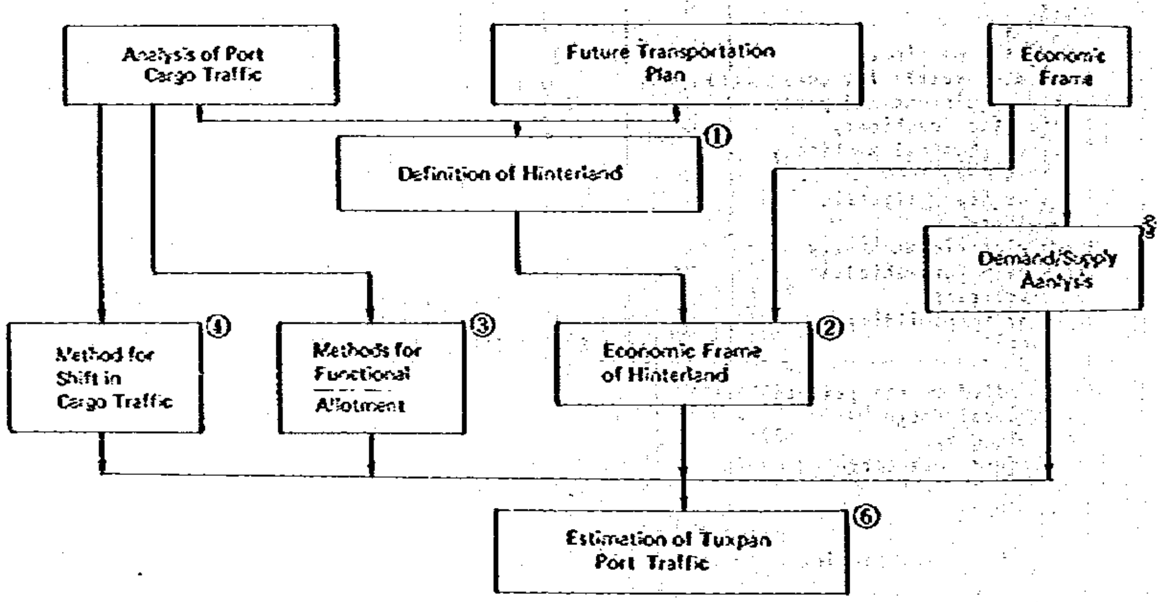


Fig. VI-2-(1) System Chart for Forecasting Tuxpan Port Traffic

(2) Methods for forecast

(a) Definition of the hinterland

Based on the analysis of present port cargo traffic and future transportation plans including the railway plan between Tuxpan and D.F.*, the hinterland of Tuxpan industrial port is defined as the zone consisting of part of Veracruz State and the six ports' competitive area which consists of D.F., Mexico, Puebla, Tlaxcala, Morelos and Hidalgo State, as shown in Table VI-2-(1) and Fig. VI-2-(2). The latter is the area of overlap in the hinterlands of Coatzacoalcos-Ostion, Veracruz, Tuxpan, Tampico-Altamira, Salina Cruz and Acapulco-Lazaro Cardenas.

*; D.F. is "Federal District" which includes Mexico City.

Table VI-2-(1) Definition of Hinterlands

Zone	Ports / States	Gulf: Progreso	Gulf: Dos Bocas	Gulf: Coatzacoalcos-Oation	Gulf: Veracruz	Gulf: Tuxpan	Gulf: Tampico-Altamira	Pacific: Salina Cruz	Pacific: Acapulco -Lazaro Cardenas	Pacific: Manzanillo	Pacific: Mazatlan, Guaymas	Remarks
1	Coahuila						○					
	Neuvo-Leon						○					
	Tamaulipas						○					
	San Louis Potosi						○					
	Veracruz (part)						○					(5%)
	Zacatas						○					
	Aguascalientes						○					
	Cuanajuato						○					
	Queretaro						○					
2	Veracruz (part)					○						(25%)
3	Veracruz (part)				○							(40%)
4	Veracruz (part)			○								(30%)
5	Campeche		○									
	Tabasco		○									
	Chiapas (part)		○									(20%)
6	Yucatan	○										
	Quintana Roo	○										
7	Mexico			○	○	○	○	○	○			six ports competitive zone
	D.F.			○	○	○	○	○	○			
	Puebla			○	○	○	○	○	○			
	Tlaxcala			○	○	○	○	○	○			
	Morelos			○	○	○	○	○	○			
	Hidalgo			○	○	○	○	○	○			
8	Chiapas (part)							○				(80%)
	Oaxaca							○				
9	Michoacan								○			
	Guerrero								○			
10	Jalisco									○		
	Colima									○		
11	Chihuahua										○	
	Durango										○	
	Sonora										○	
	Sinaloa										○	
	Nayarit										○	
	B. California N.										○	
	B. California S.										○	

Note: It may be natural to consider the relatively large overlap between the two hinterlands of Oation and Salina Cruz. But in this study, the two hinterlands are seperated clearly to simplify the problem.

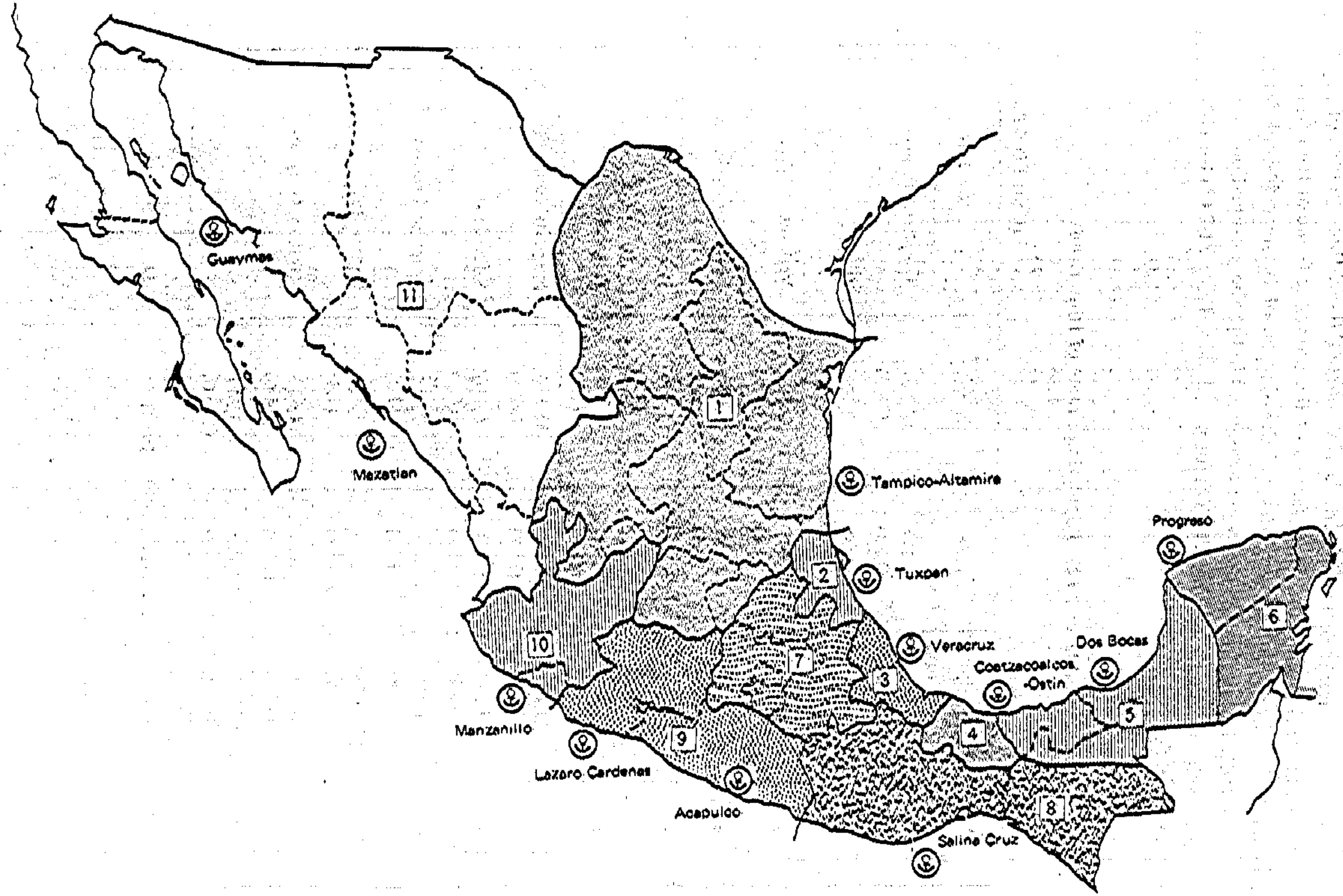


Fig. VI-2-(2) Definiton of Hinterlands

(b) Economic frame of the hinterland

The economic frame of the hinterland is estimated about three indices of population, GDP and industrial production. Three factors of the economic frame of the nation shown in Chapter IV, present economic activities and distribution of future industrial development areas in PNDI's decentralization policy are considered in the above estimation.

The results are shown in Table VI-2-(2) for population, Table VI-2-(3) for GDP and Table VI-2-(4) for industrial production.

Table VI-2-(2) Population Frame of Hinterlands

(Unit: 1,000 Persons)

Zone \ Year	1980	1988	2000	Remarks
1	13,309 (19.8)	15,389 (18.3)	18,346 (18.3)	Tampico-Altamira
2	1,315 (2.0)	1,779 (2.1)	2,306 (2.3)	Tuxpan
3	2,106 (3.1)	2,847 (3.4)	3,509 (3.5)	Veracruz
4	1,579 (2.3)	2,135 (2.5)	2,606 (2.6)	Coatzacoalcos-Ostion
5	1,942 (2.9)	2,609 (3.1)	3,409 (3.4)	Dos Bocas
6	1,244 (1.8)	1,506 (1.8)	1,905 (1.9)	Progreso
7	23,182 (34.4)	28,421 (33.8)	32,380 (32.3)	Six ports' competitive zone
8	4,196 (6.2)	5,233 (6.2)	6,416 (6.4)	Salina Cruz
9	5,223 (7.8)	6,012 (7.1)	7,318 (7.3)	Acapulco-Lazaro Cardenas
10	4,636 (6.9)	6,066 (7.2)	7,418 (7.4)	Manzanillo
11	8,653 (12.8)	12,193 (14.5)	14,636 (14.6)	Mazatlan, Guaymas
Total	67,386 (100.0)	84,190 (100.0)	100,249 (100.0)	

( ): %

(Source: Mexico Demografico, Breviario 1979 – 1980)

Table VI-2-(3) GDP Frame of Hinterlands

(Unit; 1970 Billion Pesos)

Zone \ Year	1980	1988	2000	Remarks
1	165.0 (19.6)	329.2 (18.6)	846.2 (18.3)	Tampico-Altamira
2	12.6 (1.5)	31.9 (1.8)	92.5 (2.0)	Tuxpan
3	21.0 (2.5)	49.6 (2.8)	138.7 (3.0)	Veracruz
4	17.7 (2.1)	38.9 (2.2)	111.0 (2.4)	Coatzacoalcos-Ostion
5	33.7 (4.0)	70.8 (4.0)	175.7 (3.8)	Dos Bocas
6	12.6 (1.5)	28.3 (1.6)	78.6 (1.7)	Progreso
7	346.9 (41.2)	670.8 (37.9)	1,627.6 (35.2)	Six ports' competitive zone
8	29.5 (3.5)	76.1 (4.3)	245.1 (5.3)	Salina Cruz
9	37.0 (4.4)	102.6 (5.8)	309.8 (6.7)	Acapulco-Lazaro Cardenas
10	60.6 (7.2)	127.4 (7.2)	342.2 (7.4)	Manzanillo
11	105.2 (12.5)	244.2 (13.8)	656.6 (14.2)	Mazatlan, Guaymas
Total	841.9 (100.0)	1,769.8 (100.0)	4,623.8 (100.0)	

( ); %

Note; Future projection of each zone is set so as to correct the gap of per-capita GDP among zones.

Table VI-2-(4) Industrial Production Frame of Hinterlands

(Unit; 1970 Billion Pesos)

Zone \ Year	1975	1988	2000	Remarks
1	58.4 (21.0)	336.0 (22.0)	1,011.4 (21.1)	Tampico-Altamira
2	1.1 (0.4)	6.8 (0.4)	47.0 (1.0)	Tuxpan
3	4.7 (1.7)	22.9 (1.5)	81.5 (1.7)	Veracruz
4	3.9 (1.4)	24.4 (1.6)	95.9 (2.0)	Coatzacoalcos-Ostion
5	0.8 (0.3)	10.7 (0.7)	81.5 (1.7)	Dos Bocas
6	2.2 (0.8)	10.7 (0.7)	33.6 (0.7)	Progreso
7	162.5 (58.4)	866.0 (56.7)	2,564.6 (53.5)	Six ports' competitive zone
8	1.7 (0.6)	15.3 (1.0)	100.7 (2.1)	Salina Cruz
9	2.8 (1.0)	18.3 (1.2)	105.5 (2.2)	Acapulco-Lazaro Cardenas
10	18.4 (6.6)	97.8 (6.4)	297.2 (6.2)	Manzanillo
11	21.7 (7.8)	119.1 (7.8)	373.9 (7.8)	Mazatlan, Guaymas
Total	278.3 (100.0)	1,527.4 (100.0)	4,793.6 (100.0)	

( ); %

Note; Excluding extraction and refinery of petroleum and basic petrochemical industry.

(c) Method for functional allotment in the competitive hinterland

(i) Modal split of inland cargo traffic from Tuxpan

To estimate the modal split of inland cargo traffic from Tuxpan, a mathematical modal choice model can be used. This model is shown as follows.

$$\log (P_c/P_f) = \alpha + \beta (X_f - X_c) \quad \text{(VI-1)}$$

where P_c = the share of road transportation (%)

P_f = the share of railway transportation (%)

X_c = the tariff of road transportation (pesos/ton)

X_f = the tariff of railway transportation (pesos/ton)

α, β = parameter

In our study, this model is applied to cargo traffic between Tuxpan and D.F. in the center of the Mexico City metropolitan area.

The present modal splits of inland cargo traffic from the four ports are shown in Table VI-2-(5). But this table shows the modal split data of cargo traffic between the four ports and all inland origins/destinations of each port.

Table VI-2-(5) Present Modal Split of Inland Cargo Traffic

(Unit: %)

Port	Imp.		Exp.	
	Railway	Road	Railway	Road
Tampico	91.2	8.8	78.6	21.4
Tuxpan	–	100.0	–	100.0
Veracruz	79.0	21.0	35.6	64.4
Coatzacoalcos	92.4	7.6	95.4	4.6

Note: 1) Based on the total cargo traffic, not on the cargo traffic between D.F. and each port.

2) Excluding pipeline as transportation mode

(Source: SCT)

The present tariff of each mode of transportation between D.F. and the four ports in 1980 is shown in Table VI-2-(6). Based on the rough assumption that the modal split data between D.F. and the four ports will be nearly the same as Table VI-2-(5), the parameters α, β of import/export separately are estimated from Table VI-2-(5) and VI-2-(6).

Table VI-2-(6) Present Tariff between Each Port and D.F.

(1980 prices)

Item \ Port	Tampico	Tuxpan	Veracruz	Coatzacoalcos	Remarks
Railway Distance to D.F. (km)	753	-	413	613	Mexico National Railway Data
Railway Tariff (Pesos/ton)	195	-	134	170	
Road Distance to D.F. (km)	468	330	424	590	Road Distance Table
Road Tariff (Pesos/ton)	375	308	354	435	

Note; Tariffs on the assumption of the transportation of machinery
Source; Tarifa Unica de Carga y Express (Ferrocarriles Nacionales de Mexico)
Tarifa General de Autotransporte Federal de Carga, 1980

The railway between D.F. and Tuxpan will not be completed by 1988, but will be in operation by 2000. The length of this railway will be about 350 kilometers and the tariff will be 119 pesos/ton at 1980 prices.

By these data, the future modal split between Tuxpan and D.F. is estimated as follows.

	Imp.		Exp.	(%)
	(Railway)	(Road)	(Railway)	(Road)
1980	0	100	0	100
1988	0	100	0	100
2000	78.0	22.0	22.6	77.4

(ii) Functional allotment in the competitive hinterland

It is very difficult to consider the functional allotment between two Pacific ports and four Gulf ports in the competitive hinterland, shown in Table VI-2-(1), because the available data are few.

Therefore in this study, functional allotment among the four Gulf ports will be considered. As for the functional allotment between the Pacific and the Gulf, it is supposed that the Pacific has about 20 percent and the Gulf has about 80 percent to the total cargoes of which origins and destinations are in the competitive hinterland.

The present cargo traffic to the competitive hinterland is shown in Table VI-2-(7).

Table VI-2-(7) Present Cargo Traffic to Competitive Hinterland

1975 year
(Unit: 1,000 tons)

States \ Port	Tampico		Tuxpan		Veracruz		Coatzacoalcos		Total	
	Exp.	Imp.	Exp.	Imp.	Exp.	Imp.	Exp.	Imp.	Exp.	Imp.
D.F.	36.0	799.0	–	18.4	47.0	1,098.7	–	70.2	83.0	1,986.3
Mexico	9.7	3.1	–	–	20.5	80.6	–	138.7	30.2	222.4
Puebla	–	0.2	–	36.8	22.0	30.2	4.1	51.4	26.1	118.6
Tlaxacala	14.1	–	–	–	9.7	0.7	–	19.9	23.8	20.6
Morelos	–	–	–	–	2.9	0.9	–	9.0	2.9	9.9
Hidalgo	199.8	0.7	–	–	2.9	59.2	–	11.3	202.7	71.2
Total	259.6 (70.4)	803.0 (33.1)	–	55.2 (2.2)	105.0 (28.5)	1,270.3 (52.3)	4.1 (1.1)	300.5 (12.4)	368.7 (100.0)	2,429.0 (100.0)

A mathematical route choice model can be used to consider functional allotment among the four Gulf ports. Needless to say, the routes considered are between D.F. and each of the four ports.

This model is shown as follows.

$$\log (P_i/P_j) = \alpha_j - \alpha_i + \beta (X_j - X_i) \quad \text{(VI-2)}$$

where P_i = the share of the ith route (%)

P_j = the share of the jth route (%)

X_i = the tariff of the ith route (pesos/ton)

X_j = the tariff of the jth route (pesos/ton)

$\alpha_i, \alpha_j, \beta$ = parameters

The tariff of a route is calculated by weighting the road and railway tariffs of the route with respective cargo traffic volume shown in Table VI-2-(5).

The results are shown in Table VI-2-(8).

Table VI-2-(8) Weighted Tariff of Inland Cargo Traffic

(Unit: 1980 Pesos/ton)

D.F. – Ports	Exp.	Imp.
Tampico	231	210
Tuxpan	308	308
Veracruz	276	180
Coatzacoalcos	182	190

Note: From Table VI-2-(5) and Table VI-2-(6)

It is impossible to estimate mathematically the parameters α_i, α_j, β, because the number of variables is more than the number of equations obtained from the formula (VI-2).

Therefore these parameters are estimated on assumptions from highly technical considerations. The tariffs in the future are shown in Table VI-2-(9), considering the railway between D.F. and Tuxpan.

Table VI-2-(9) Weighted Future Tariff of Inland Cargo Traffic

(Unit: 1980 Pesos/ton)

D.F. – Ports	1980		1988		2000	
	Exp.	Imp.	Exp.	Imp.	Exp.	Imp.
Tampico	231	210	231	210	231	210
Tuxpan	308	308	308	308	265	161
Veracruz	276	180	276	180	276	180
Coatzacoalcos	182	190	182	190	182	190

Note: 1) The three ports excepting Tuxpan have no changes in the tariff and modal split in the future.
2) The future modal split of Tuxpan is the result of (i).
3) D.F. – Tuxpan Railway is 350 km and the tariff is 119 pesos/ton at 1980 prices.

The parameters α_i, α_j, which are recognized to represent the degree of inconvenience for utilization of each port, are supposed to become much smaller after the progress of the new industrial ports – Altamira port for Tampico and Ostion port for Coatzacoalcos. Taking this factor into consideration, future route choice or functional allotment among the four ports are estimated, as shown in Table VI-2-(10).

Table VI-2-(10) Future Route Choice between D.F. and the Gulf Ports

(Unit: %)

D.F. – Ports	1980		1988		2000	
	Exp.	Imp.	Exp.	Imp.	Exp.	Imp.
Tampico	70.4	33.1	61.0	34.4	43.3	26.9
Tuxpan	–	2.2	13.4	9.6	42.0	36.3
Veracruz	28.5	52.3	24.4	43.0	13.9	26.9
Coatzacoalcos	1.1	12.4	1.2	13.0	0.8	9.9
Total	100.0	100.0	100.0	100.0	100.0	100.0

(d) Method for estimating the shift in cargo traffic away from US Gulf Ports

Followings are the suppositions for the estimation of the shift in cargo traffic.

1) The domestic destinations of import cargoes through US Gulf ports are assumed to be only D.F. and Monterrey.
2) The cargo traffic on the route of Monterrey – Nuevo Laredo – Corpus Christi or Houston will not be changed after the completion of Tuxpan industrial port project.
3) The cargo traffic on the route of D.F. – Nuevo Laredo – Houston will switch its import transportation route partly to the route of D.F. – Tuxpan after the completion of Tuxpan industrial port project.
4) The functional allotment between US Gulf ports and Veracruz port is not considered, and only the allotment among US Gulf ports, Tampico – Altamira and Tuxpan is considered.
5) Nuevo Laredo and Houston are recognized as the typical customs point and the typical US Gulf port respectively.

According to these suppositions, the present cargo traffic is estimated by the results of Chapter III-4. The results are shown in Table VI-2-(11).

Table VI-2-(11) Import Cargo Traffic through US and Mexico Gulf Ports

(1978 Year)

Destination	Route	Cargo Volume (1,000 ton)	Distance (km)
To Monterrey	Houston, Corpus Christi – Nuevo Laredo	60	650[1]
	Tampico	55	530
	Total	115	–
To D.F.	Houston – Nuevo Laredo	358 (38.5)	1,800
	Tampico	572 (61.5)	470
	Total	930 (100.0)	–

Note: 1) The average distance of Monterrey-Houston and Monterrey-Corpus Christi
2) The cargo volume through Tampico port is estimated by the inland cargo traffic data in Chapter III, 4.
3) ( ); %

To estimate the shift in cargo traffic, a mathematical route choice model can be used. This model is shown as follows.

$$\log(P_i/P_j) = \alpha + \beta(X_j - X_i) \quad \text{(VI-3)}$$

where P_i = the share of the ith route (%)

P_j = the share of the jth route (%)

X_i = the average distance of road and railway from the port to D.F. on the ith route (km)

X_j = the average distance of road and railway from the port to D.F. on the jth route (km)

α, β = parameters

The parameters α, β are estimated by the data of Table VI-2-(11). In 2000, the distance from the Mexican Gulf ports to D.F. will be much smaller because of the completion of Tuxpan-D.F. railway. By using these data, future route choice for the total traffic imported through the US Gulf ports and the Mexican north-east Gulf ports is estimated by the formula (VI-3).

The results are as follows.

(%)

	Route	1978	2000	
To D.F.	Houston – Nuevo Laredo	38.5	34.0	
	Tampico (Altamira)	61.5	66.0	61.5
	Tuxpan	–		4.5
	Total	100.0	100.0	

It is quite natural to think that increase in the share of Tampico and Tuxpan from 1978 to 2000 will be attributed to the completion of Tuxpan Industrial Port. Therefore, 4.5 percent of the total import traffic will be through Tuxpan port in 2000. In 1988 2.0 percent will be through Tuxpan port according to interpolation between 1978 and 2000.

(e) Demand/supply analysis by goods

Demand/supply analysis is done by reviewing the Le Havre Port Authority report*, using the new data and documents.

(f) Estimation of Tuxpan port traffic

The total foreign and domestic cargo volume which is needed for the Tuxpan port's hinterland is estimated from the economic frame of the hinterland and the demand/supply analysis, (e). Then the cargo volume of Tuxpan port is forecast by the (c) method in case of estimating the functional allotment to Tuxpan from the competitive hinterland, and the (d) method in case of estimating of the shift in cargo traffic away from US Gulf ports.

(3) Results of forecast

(a) Iron and steel products

(i) iron and steel

(Imp.)

According to PNDI, the annual growth rate of import from 1979 to 1988 is assumed to be 11 percent, which corresponds to 1.13 of elasticity of import cargo volume to GDP. Assuming that the elasticity will fall into 1.08 because of expected increase of industrial added value after 1988, the growth rate of import will be 9.0 percent per year on the basis of GDP's growth of 8.3 percent shown in Chapter IV-1. Therefore national import volume will be as follows, supposing that the ratio of overland and maritime import transportation modes will not change in the future;

*; This report was submitted to Mexican Government by Le Havre Port Authority in 1981, and it contains the cargo volume forecast of new industrial ports.

	1979	1988	2000	(1,000 tons)
iron & steel	381	974	2,740	

Import cargo volume of Tuxpan will be calculated by spliting the total imports between each port, in proportion to the demand of each hinterland which is defined by industrial production.

In the competitive hinterland, the method in (2) (c) will be used.

	1988	2000	(1,000 tons)
Tuxpan	57	559	

(Exp.)

Commercial port cargo is not considered.

(ii) steel pipes and tubes

(Imp.)

This is only consumption by PEMEX. In the future, domestic production will increase. In our study, the predictions in PNDI from 1979 to 1985 will be quoted as level of the Le Havre report. After 1985 level of the imports is assumed to be about the same as the level of 1985 because of increased domestic production and saturation of domestic demands.

	1979	1985	1988	2000	(1,000 tons)
steel pipes and tubes	461	896	850	850	

Tuxpan will import a relatively high share because of the Chicontepec crude oil development project, and its share is assumed to be about 30 percent in 1988 and 20 percent in 2000.

	1988	2000	(1,000 tons)
Tuxpan	255	170	

(b) Non-ferrous ore

(i) salts

(Imp.)

The inward cargo from Ostion will be expected. The total inward cargo volume of Tuxpan and Tampico-Altamira will be 200 thousand tons in 1988, based on the several plans of related companies, and after 1988 it is assumed that the volume will grow at the same rate as the population growth of the hinterlands, which is 1.1 percent per year from the Chapter IV-1.

	1988	2000	(1,000 tons)
Tuxpan & Tampico-Altamira	200	228	

The volume of Tuxpan is estimated from the import shares of the two ports in Table VI-2-(10).

	1988	2000	(1,000 tons)
Tuxpan	44	131	
Tampico-Altamira	156	97	

(ii) other non-ferrous ore*

(Imp.)

The import growth rate from 1979 to 1988 is supposed to be in proportion to the growth rate of the outputs of iron and chemical industries, which are the big consumers of non-ferrous ore. On the basis of the growth rate of the two industries listed in PNDI, the import growth rate is shown as follows.

1979 – 82 . . . . . 10%

1982 – 90 . . . . . 13%

From 1990 to 2000 the growth rate is assumed to be smaller, about 5 percent, which corresponds to elasticity of 0.6 to GDP growth. Therefore, national import cargo volume is calculated as follows.

	1979	1988	2000	(1,000 tons)
other non-ferrous ore	179	500	1,020	

Considering the scale and location of the iron and chemical industries of Tuxpan, Altamira and Lazaro Cardenas, the Tuxpan's share will be 40 percent in 1988 and 35 percent in 2000. And the share of Tampico-Altamira is assumed to be 45 percent in 1988 and 2000.

	1988	2000	(1,000 tons)
Tuxpan	174	359	
Tampico-Altamira	225	459	

(Exp.)

The exports are assumed to occur only at Tampico-Altamira.

(c) Fertilizers

(In. and Imp.)

By reviewing the forecasts of FERTIMEX and Le Havre, inward and import cargo volume of Tampico-Altamira and Tuxpan was figured out, as shown in Table VI-2-(12).

From 1990 to 2000 self-sufficiency ratio will become much higher, but demands for agricultural production will become larger due to the expected population increase. Therefore the growth rate during this period is assumed to be 5.4 percent. The Tuxpan's share is estimated to be about 10 percent in 1988 and about 20 percent in 2000. Considering the

*) excluding almina and bauxite

advantageous position of Tampico-Altamira, most of these fertilizers will be delivered to northern agricultural regions though Tampico-Altamira.

Table VI-2-(12) Import and Inward Cargo Volume of Fertilizers of Tuxpan and Tampico-Altamira

(Unit: 1,000 Tons)

Fertilizer	Imp. or In	1988	2000
Ammonium Sulphate	Imp.	190	323
Ammonium Nitrate	Imp.	160	272
Urea	In.	400	680
Single and Triple Superphosphate	Imp.	80	136
Ammonium Phosphate	Imp.	160	176

Table VI-2-(13) Cargo Volume of Fertilizers of Tuxpan

(Unit: 1,000 Tons)

Fertilizer	Imp. or In.	1988	2000
Ammonium Sulphate	Imp.	19	65
Ammonium Nitrate	Imp.	16	54
Urea	In.	40	136
Single and Triple Superphosphate	Imp.	8	27
Ammonium Phosphate	Imp.	16	35
Total		99	317

(d) Agricultural products

(i) grain

(Imp.)

This is considered as industrial port cargo and was already discussed in Chapter VI-1.

(ii) other agricultural products

(Exp.)

The export growth rate is assumed to be 3 percent, considering the growth rate of agricultural production and the progress in quality of life. The agricultural products are classified as liquid bulk and general cargo.

	1979	1988	2000	(1,000 tons)
Liquid Bulk	544	712	1,015	
General Cargo	582	759	1,082	
Total	1,126	1,471	2,097	

The share of Tuxpan and Tampico-Altamira is supposed to be at the same level as 1979 for liquid bulk cargo, and for general cargo it is supposed to rise to 15 percent in 1988 and 20 percent in 2000 from the present level of 6.3 percent. The cargo volume of Tuxpan can be calculated by Table VI-2-(10), as shown in Table VI-2-(14).

Table VI-2-(14) Cargo Volume of Agricultural Products

(Unit: 1,000 Tons)

Commodity	Ports	1979	1988	2000
Liquid Bulk	Tampico-Altamira	53	58	52
	Tuxpan	–	13	50
General Cargo	Tampico-Altamira	37	93	110
	Tuxpan	–	21	106
Total	Tampico-Altamira	90	151	162
	Tuxpan	–	34	156

(e) Cement

(In.)

The Area's demand for cement will become much greater, due to various big projects.

By reviewing the estimates of the Le Havre report, we see that inward cargoes are expected from Tampico-Altamira. But most of these cargoes will be carried by overland transportation.

Therefore inward cargoes of Tuxpan are assumed to be at about the same level as the domestic cargoes from Tampico to Ostion, already shown in the Le Havre report.

The results are as follows.

	1988	2000	(1,000 tons)
Tuxpan	250	300	

(f) General cargo

After reviewing the prediction results of national total cargo volume in the Le Havre report, these results seem to be reasonable up to 1990. The growth rate of cargo volume is shown as follows, including the assumed growth rate between 1990 – 2000.

	1979 – 1985	1985 – 1990	1990 – 2000
(Imp.)			
Capital goods	16%/year	4%/year	4%/year
Consumer goods	10%/year	13%/year	13%/year
(Exp.)			
Consumer goods	12%/year	18%/year	16%/year

The national total cargo volume shipped by seaway is shown in Table VI-2-(15), and is based on the above growth rates.

Table VI-2-(15) Total Cargo Volume of General Cargo in Mexico

(Unit: 1,000 Tons)

Commodity	1979	1988	2000
Imp.			
Capital goods	281	770	1,233
Consumer goods	987	2,526	10,937
Exp.			
Consumer goods	359	1,163	7,124

The cargo volume of Tuxpan can be determined by the size of demand in the hinterland. In the competitive hinterland of the metropolitan area, the methods shown in (2), (c) are introduced. In this case the share of Gulf ports is assumed to be 80 percent of the total import/export cargoes which are produced or consumed in the competitive hinterland. The demand for import/export cargoes in the hinterland is assumed to be proportional to, industrial production in the case of importing capital goods, to population in that of importing consumer goods and GDP when considering exports of consumer goods.

The cargo volume of Tuxpan is shown in Table VI-2-(16).

Table VI-2-(16) Volume of General Cargo of Tuxpan

(Unit: 1,000 Tons)

Commodity	1988	2000
Imp.		
Capital goods	37	204
Consumer goods	119	1,277
Exp.		
Consumer goods	74	985

(g) Shift in cargo traffic from US Gulf ports

Basic methods are already shown in (2), (d).

It is assumed that the total import cargo going into D.F. in 1978 can be divided into capital goods and consumer goods, in the same ratio as found for capital and consumer goods in the total national import cargo.

Other types of cargo are not considered for D.F. concentrate. The growth rate of D.F. import cargo is supposed to be the same as the national level, shown in (f):

The shift in cargo traffic from US Gulf ports to Tuxpan is calculated by the mathematical model shown in (2), (d), and the results are shown in Table VI-2-(17).

Table VI-2-(17) Estimation of Shift in Cargo Traffic

(Unit: 1,000 Tons)

	Commodity	1978	1988	2000
Total Import Concentration Cargo to D.F.	Capital goods	206	567	904
	Consumer goods	724	1,931	8,023
Shift in Cargo Volume to Tuxpan	Capital goods	–	11	41
	Consumer goods	–	39	361

Note: The total import concentration cargo to D.F. includes both cargoes through US Gulf ports and through Tampico-Altamira and Tuxpan

(h) Estimation of container cargo

Containerization ratio of Tuxpan, which is defined as container cargo volume/total general cargo volume, has been very high for the last five years, as shown in Table VI-2-(18). Generally it is very difficult to foresee the progress of containerization, however the containerization ratio can be set as shown in Table VI-2-(19), considering Japanese prediction examples and Table VI-2-(18).

Table VI-2-(18) Containerization Ratio of Tuxpan (1976 – 1980)

		1976	1977	1978	1979	1980
Imp.	Total general cargo (tons)	42,455	33,327	77,006	96,242	201,013
	Container cargo (tons)	38,982	10,571	67,753	85,772	148,640
	Containerization Ratio (%)	91.8	31.7	88.0	89.1	73.9
Exp.	Total general cargo (tons)	20,968	22,513	26,430	35,253	62,700
	Container cargo (tons)	20,968	6,995	26,430	35,189	62,688
	Containerization Ratio (%)	100.0	31.1	100.0	99.8	100.0

(Source: SCT)

Table VI-2-(19) Setting of Containerization Ratio

		1988	2000	Remarks
Imp.	Capital goods	0.6	0.65	
	Consumer goods	0.9	0.95	
Exp.	Consumer goods	0.9	0.95	
	Agricultural products	0.9	0.95	General cargo

In this study, three kinds of general cargo – capital goods, consumer goods and agricultural products – are selected as containerizable cargo. Based on Table VI-2-(19), container cargo volume is estimated as Table VI-2-(20).

Table VI-2-(20) Forecast of Container Cargo

(Unit: 1,000 Tons)

Year / Commodity	1988			2000		
	Total	Exp.	Imp.	Total	Exp.	Imp.
Agricultural products	18	18		101	101	
Capital goods	51		51	159		159
Consumer goods	327	124	203	2,492	936	1,556
Total	396	142	254	2,752	1,037	1,715

(i) Summery of cargo volume forecast

The total cargo volume of Tuxpan is shown again in Table VI-2-(21) and Table VI-2-(22), summerizing the results of (a) – (h).

Table VI-2-(21) Commercial Port Cargo Volume of Tuxpan (1)

(Unit: 1,000 tons)

	1988							2000						
	Foreign Trade			Domestic Trade			Total	Foreign Trade			Domestic Trade			Total
	Exp.	Imp.	Total	Out.	In.	Total		Exp.	Imp.	Total	Out.	In.	Total	
(1) Industrial Products														
Iron and Steel		57	57				57		559	559				559
Steel Tubes & Pipes		255	255				255		170	170				170
Salt					44	44	44					131	131	131
Non-ferrous Ore		174	174				174		359	359				359
Fertilizer		59	59		40	40	99		181	181		136	136	317
Cement					250	250	250					300	300	300
Capital Goods		48	48				48		245	245				245
Consumer Goods	174	158	232				232	985	1,638	2,623				2,623
(2) Agricultural Products														
Liquid Bulk	13		13				13	50		50				50
Other Agricultural Products	21		21				21	106		106				106
Total	108	751	859		334	334	1,193	1,141	3,152	4,293		567	567	4,860

Table VI-2-(22) Cargo Volume of Tuxpan (2)

(Unit: 1,000 Tons)

	1988							2000						
	Foreign Trade			Domestic Trade			Total	Foreign Trade			Domestic Trade			Total
	Exp.	Imp.	Total	Out.	In.	Total		Exp.	Imp.	Total	Out.	In.	Total	
(1) Bulk Cargo														
Non-ferrous Ore		174	174				174		359	359				359
Fertilizer		59	59		40	40	99		181	181		136	135	317
Cement					250	250	250					300	300	300
(2) General Cargo														
Iron & Steel		57	57				57		559	559				559
Steel Tubes & Pipes		255	255				255		170	170				170
Salt					44	44	44					131	131	131
Capital Goods		19	19				19		86	86				86
Consumer Goods	7	16	23				23	49	82	131				131
Agricultural Products	15		15				15	55		55				55
(3) Container Cargo														
Capital Goods		29	29				29		159	159				159
Consumer Goods	67	142	209				209	936	1,556	2,492				2,492
Agricultural Products	19		19				19	101		101				101
Total	108	751	859		334	334	1,193	1,141	3,152	4,293		567	567	4,860

2-2 Forecast of Fish Catch

Direct human consumption of fish per person recorded a remarkable increase of 9 percent per year from 3.5 kg/person/year in 1970 to 8.3 kg/person/year in 1980. Considering that the actual growth rate of per-capita GDP was 3.1 percent for this period, it is expected that consumption of fish will grow larger in the future as per-capita GDP grows. In our study this growth rate is assumed to be 5 percent until 1988 (0.74, elasticity to GDP), and 3 percent up to 2000 (0.41, elasticity to GDP).

(1,000 tons)

	1980	1988	2000
direct human consumption	560	1,032	1,751
	(8.3 kg/person/year)	(12.3 kg/person/year)	(17.5 kg/person/year)

And the total processing volume of indirect human consumption and industrial use are supposed to be 88 percent of the direct human consumption, using the actual data for 1980.

Veracruz State and Tuxpan administrative region will have larger shares of the national total as the fishery developments along in the Gulf proceed.

The forecast is shown in Table VI-2-(23). The Tuxpan administrative region has three fishing ports-Tuxpan, Cazones and Tamiahua. In Tamiahua improvement of fishing port facilities is not planned. The fish catch of Tuxpan will be 112 thousand tons, supposing that the shares of Tamiahua, Cazones and Tuxpan are 40 percent, 10 percent and 50 percent respectively.

Table VI-2-(23) Forecast of Fish Catch

(Unit: 1,000 Tons)

Area	Use	1976	1980	1988	2000
Mexico	Direct human consumption	280	560	1,032	1,751
	Processing	245	493	908	1,540
	Total	525	1,053	1,940	3,291
Veracruz State	Direct human consumption	–	69	155	350
	Processing	–	1	100	285
	Total	30	70	255	635
Tuxpan administrative region	Direct human consumption	–	–	41	128
	Processing	–	–	45	95
	Total	–	3	86	223

Note: –; no available data

2.3 Forecast of Recreational Visitors

Enough data can not be obtained for an accurate forecast of recreational visitors. The growth rate of total visitors to Tuxpan is assumed as follows, considering the growth of per-capita GDP of the hinterland and suggestions of the Tuxpan office of "Secretaria de Turismo".

1980 – 1988 . . . . . 2.7%/year
1988 – 2000 . . . . . 1.4%/year

The results are shown in Table VI-2-(24).

The ratio of marine recreational visitors to total tourist visitors would be 40 – 60 percent, judging from discussions with the Tuxpan office of "Secretaria de Turismo".

Supposing it is 50 percent, the marine recreational visitors in the year 2000 will be as follows:

(1,000 persons)

Mexican 167
Foreigner 4
Total 171

As for pleasure boat visitors, 60 percent of the Mexican visitors and 100 percent of foreign ones are considered to be in this category.

The results are as follows.

(1,000 persons)

Mexican 100
Foreigner 4
Total 104

Table VI-2-(24) Forecast of Tourism Visitors

(Unit; Persons)

Nationality	Purpose	1977	1978	1979	1980	1981	1988	2000
Mexican	all purposes	336,566	152,149	145,013	332,304	145,840	407,000	482,000
	tourism*	-	-	-	231,000	101,600	283,000	335,000
Foreigner	all purposes	5,934	5,271	4,017	4,350	5,260	8,000	10,000
	tourism*	-	-	-	3,000	3,000	5,600	7,000
Total	all purposes	342,480	157,420	149,030	336,654	151,100	415,000	492,000
	tourism*	-	-	-	-	-	288,600	342,000

Note; *; Based on the estimation (69.5 percent to all purposes in 1979 on the national base)