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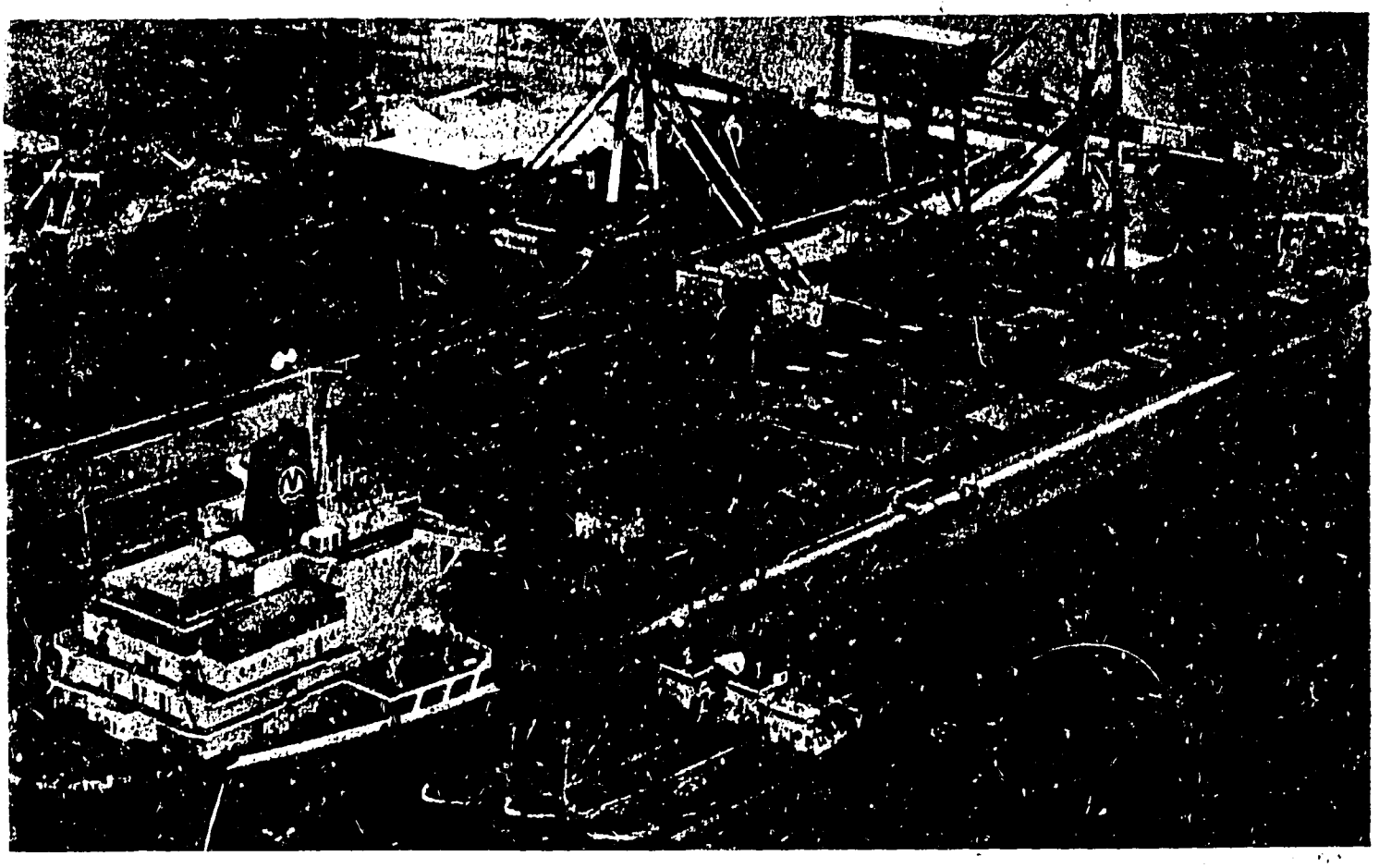
FINAL REPORT

VUNG TAU PORT STUDY

PREPARED FOR THE:

UNITED STATES AGENCY
for
INTERNATIONAL DEVELOPMENT
Mission to VIETNAM

Contract No. AID 730-3603



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Gentlemen:

We are pleased to present herewith in accordance with the Scope of Work detailed in USAID Contract No. AID-730-3603 Twenty five copies of the Final Report for the Vung Tau Port Study.

The members of the project team which conducted these studies are grateful for the fine assistance and cooperation extended to them by representatives from USAID and from the various agencies of the Government of the Republic of Vietnam without which the project could not have been completed.

Very truly yours,

LYON ASSOCIATES, INC.

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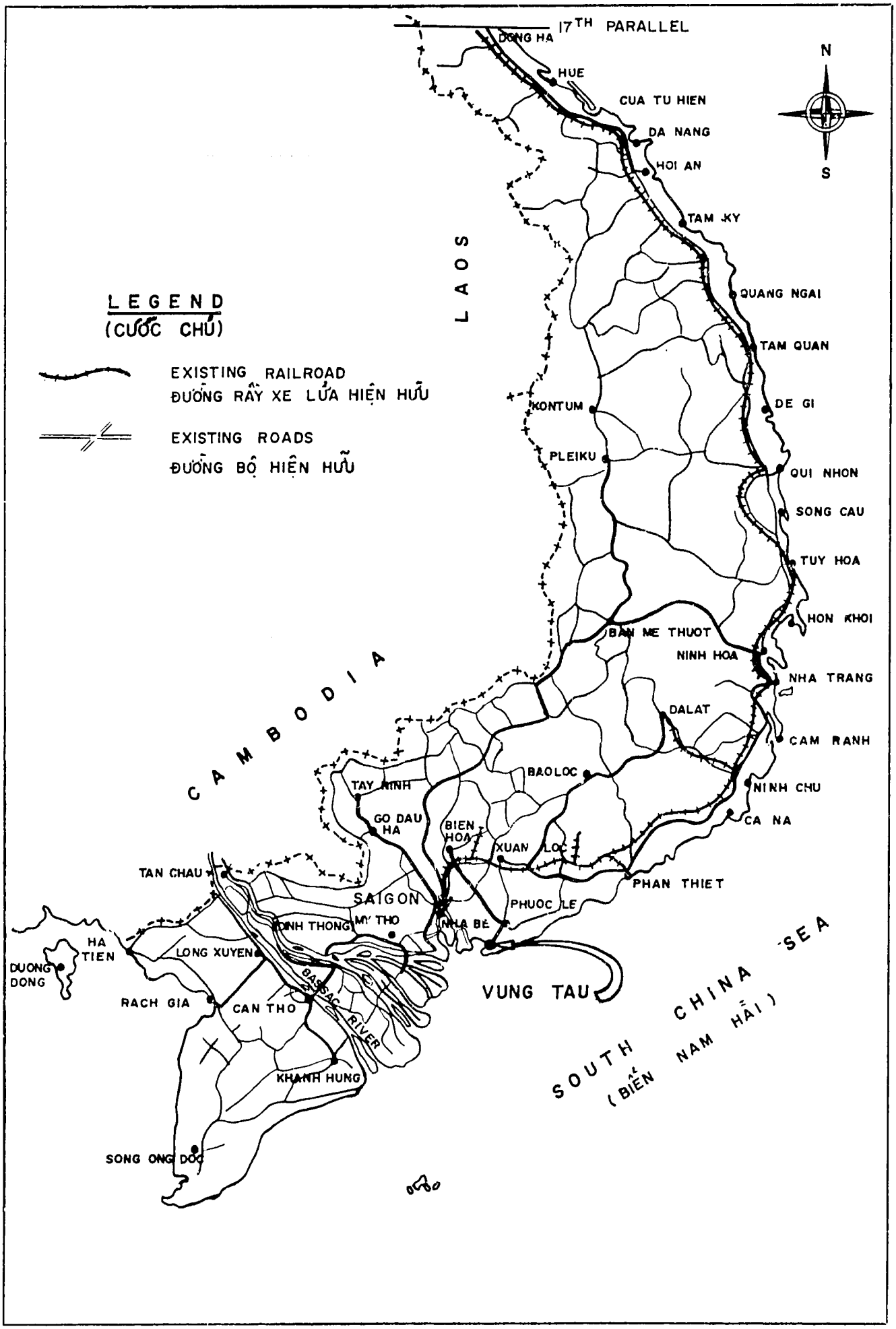

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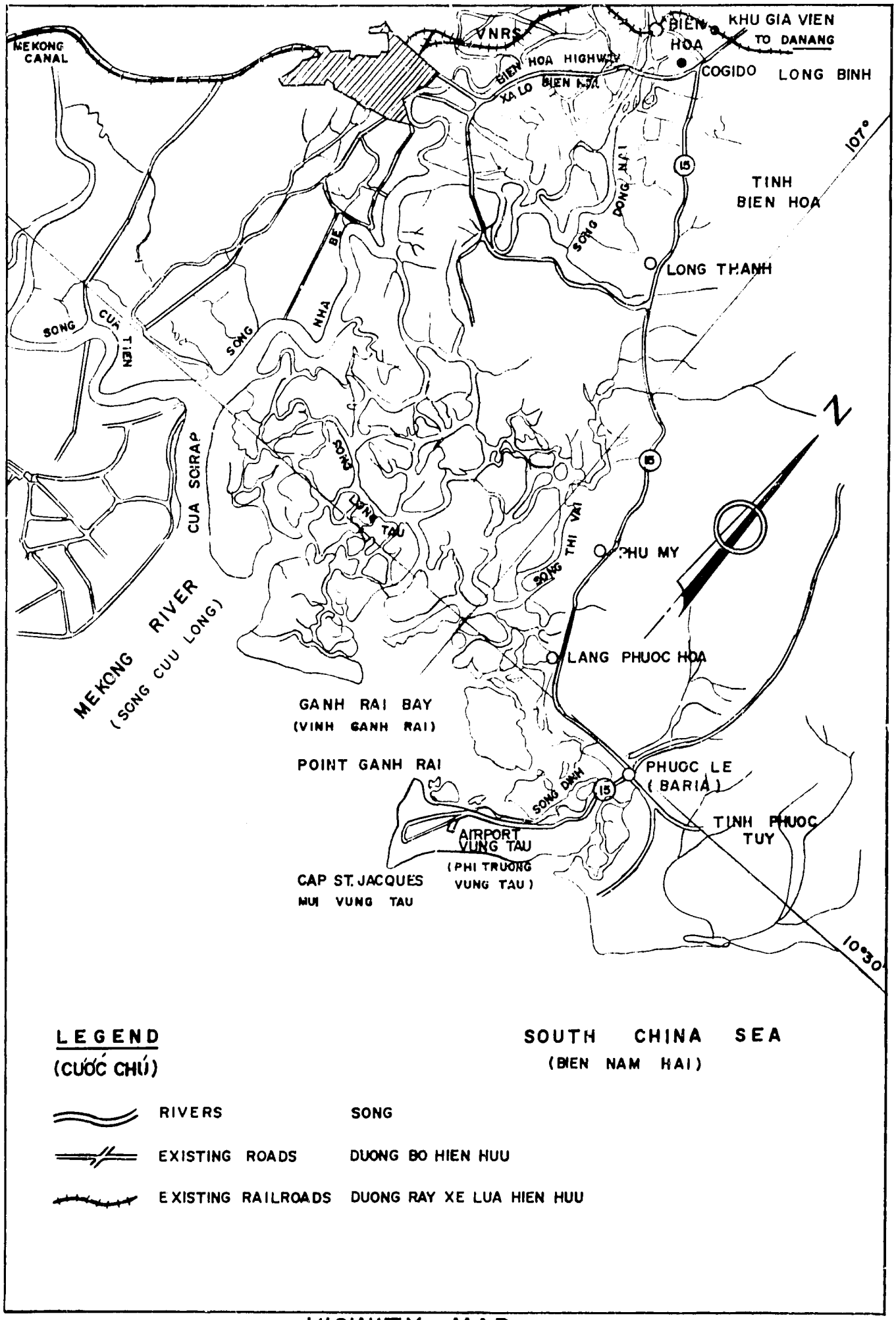

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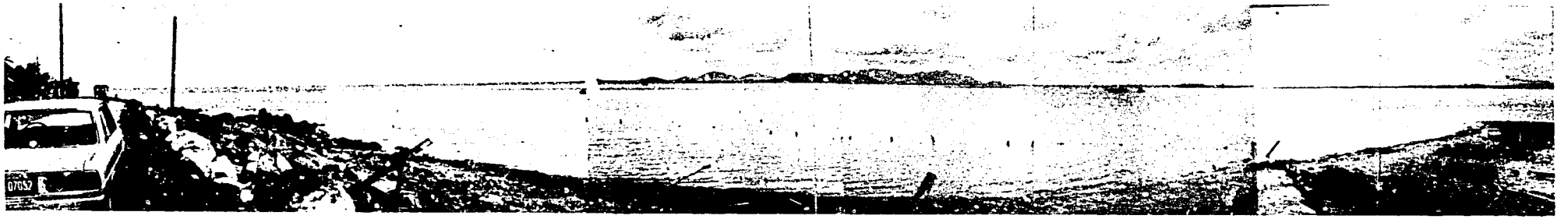

Views of Proposed Commercial Port Area
Hình Ảnh Vùng Thương Cảng Đề Nghị

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SECTION I

GENERAL CONSIDERATIONS

A. INTRODUCTION

In response to U.S. Agency for International Development Contract No. AID-730-3603, Lyon Associates, Inc., has undertaken a study having two separate parts. One part consists of performance of an analysis of the technical problems and approaches in the development of the port of Vung Tau, South Vietnam, as a general deep water commercial cargo port, as a port for a commercial fisheries industry or as a combination deep water commercial cargo port and fishing port. The other part consists of determining the technical and economic feasibility and the operational advantages of building a railroad spur between the Sumpco Quarry located to the northeast of Saigon and the Saigon main rail line for the purpose of hauling rock from the quarry to points of use or further shipment. Since the two studies are essentially unrelated, they have been presented in separate volumes entitled Vung Tau Port Study and Sumpco Quarry Rail Spur Feasibility Study.

The developments in modern cargo handling techniques, equipment and transportation systems have had a major influence on the functional layout and design of ports. Due to these developments the entire cargo transportation and transfer network has become a high capital cost intensified system. Therefore the investment decision making process involves engineering and economic studies resulting in determination of

total transport system costs which include investment in the port and in inland and ocean transport sectors. Since the key parameter in these studies is the traffic forecast, which is not within the scope of this project, the objective of the Vung Tau Port Study is to develop a series of alternative port development concepts which are based only on assumed inputs and to evaluate the technical practicability of constructing these facilities.

Thus the conception plans shown in this report should not be taken as specific recommendations for development of a port at Vung Tau. These concepts show what could be considered to be a reasonable course of development for the port. However, since every attempt has been made to consider all aspects of development for the varied traffic that could be expected at Vung Tau, these development concepts could be readily adapted to the traffic requirements determined by an economic feasibility study. Furthermore the estimates of costs given in this report cannot be considered to be budgetory costs of construction but are only order of magnitude cost estimates which include only the preliminary cost of building wharfage, reclaimed backup areas and of dredging. The costs of such port facilities as cargo handling equipment, storage areas and sheds, buildings, and other superstructure and utilities are not included in the figures given.

This report contains the results of all analyses, the methods of approach utilized, and the conclusions arrived at by the consultant. Previous reports and studies have been reviewed and all necessary

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subsurface investigation and oceanographic surveys have been performed to develop the preliminary alternate port concepts presented in this study. The study includes methods for the disposal of the soil deposits generated by dredging taking into account the proposed port development, reclamation of land for industrial purposes adjacent to the port, and possible sale of the reclaimed land, with due consideration given to the ecological effect on the area. Also included is an assessment of availability of electric power and of fresh water and recommended land access routes including rail.

B. METHODOLOGY

In general the port development concepts shown in this report were based on the characteristics of an assumed series of vessels which could be expected to use the ports. For the commercial cargo port two alternative ship drafts were assumed: 9.1m (30 feet) and 10.7m (35 feet). Drafts deeper than these were eliminated because of the shoalness of the fairway approaches to Vung Tau (this subject is dealt with in detail in Section V.B.). Depths of basins, channels, and berths in alternative concepts were based on these drafts.

In preparing port plans a two phased construction sequence of port facilities was assumed. The extent of the first phase and of the overall port facility was essentially arbitrarily determined on the basis of that size of port which could be reasonably built within the available area. The first phase of construction was assumed to consist of five berths. The length of these berths took into consideration, the probability that a mixture of different types and sizes of vessels would be utilizing the docking facilities. Backup area, however, was set at only a single specific standard size based on commonly accepted requirements for general cargo handling inasmuch as no data on cargo type were available.

One important consideration in formulation of the development concepts was the possibility that a primary function of a port at Vung Tau might be to act as an inland water transshipment port. Past studies indicate that considerable cargo might move into and out of the Mekong Delta regions on barge or small craft and that this cargo might be

efficiently transferred to and from ocean going ships at a port located at Vung Tau. An important commodity in this catagory would be rice which, before the Vietnam hostilities, was an important export commodity. Although the production of rice has fallen to the extent that it must now be imported, in the event that stability returns to the country, rice could once again be an important export item. Most of this rice would probably come from the Delta area and would be carried to the port by small craft. It is also possible that with a major port at Vung Tau, transfer of cargo by barge between the port and Saigon might prove to be economical in terms of overall transport cost. Conceptual port plans therefore reflect the possibility of development of Vung Tau as an inland water cargo transfer port.

The project commenced with a study of existing charts, the results of previously conducted hydrographic and topographic surveys, soils investigations and other engineering studies. Although in some cases these data were sufficient, field investigations were also carried out to supplement existing information. In order to plan the field program, one of the first tasks of the project was to prepare a preliminary series of port development layouts. These layouts formed the basis for the alternative development concepts presented in this report.

Field investigations consisted of a soils and subsurface program and a study of oceanographic conditions at the site. Formal topographic and hydrographic field surveys were not undertaken on the grounds that sufficient survey data were already in existence. However, some topo-

graphic survey work in the form of measurement of elevations in the site area was carried out in order to help verify existing data and to provide an insight into the extent of change with time of topography of offshore islands and shoals which is characteristic of the region.

The primary purposes of the field studies were to identify and quantify problems which might affect the design and layout of the port, to provide design criteria for port structures including soil foundation conditions, type of dredged material and its suitability for use as hydraulic fill, maximum wave forces, tidal heights, current speeds, and sedimentation patterns and quantities, and to describe operating conditions which could be expected to be encountered by users of the port. Upon completion of the field analysis, alternative port layouts which had been prepared early in the study were modified in response to the findings of these analyses and preliminary design using the criteria provided by these analyses was begun. This work consisted of evaluating alternative structural design approaches and selection of the best approach in the light of the design criteria provided. On the basis of preliminary design work an order of magnitude cost of each alternative port development concept employing the various approaches to structural design considered was calculated.

SECTION II

CONCLUSIONS

A. GENERAL

The overall general finding of this study is that no major technical barrier exists in the construction and operation of either a commercial general cargo port or a commercial fishing port at Vung Tau with the exception of annual sedimentation in the entrance channel and turning basin of the proposed cargo port. For first phase construction the estimated sedimentation could amount to about 0.6 million cubic meters per year and twice this amount might occur when the port facilities are fully developed. The resulting annual dredging maintenance costs are considered to be excessive when compared to other ports around the world.

No other major problems appear to be imposed by the physical environment. Wave heights are not excessive. Currents are swift and the tide range is large but these factors will not seriously hamper port construction or operation.

The characteristics of the soils underlying the proposed port facilities indicate that foundation conditions are not as good as might be desired. Furthermore, the dredged material which would be used as hydraulic fill consists mostly of soft marine clays which are not especially well suited for this purpose because of the difficulty in consolidation of the soil. However, tested engineering techniques

capable of overcoming these difficulties have been utilized in the preparation of the conceptual plans presented in this report although their use will result in a somewhat higher cost of construction of planned facilities. The extra cost is not excessive in consideration of the overall cost of port development.

B. CLIMATIC AND OCEANOGRAPHIC CONDITIONS

1. Design Criteria

Wind - It is recommended that maximum winds associated with storms having a 50 year return period be utilized in design considerations. The recommended sustained wind speed is 33 m/sec (65 knots) with peak gusts up to 56 m/sec (104 knots).

Sea Level - A design still water level (i.e. astronomical tide plus storm surge) of 4.7 meters above Approximate Lowest Low Water datum, having a return period of about 40 years, is recommended for design of southward facing structures in the proposed commercial cargo port locations at Vung Tau. For northward facing structures and for all structures at the proposed commercial fishing port site, a design still water level of 4.15 meters is recommended.

Waves - A significant wave (Hs) having a height of 1.7 meters and a maximum wave (Hmax.) having a height of 3.2 meters are recommended for design of structures in the proposed commercial port. For southward facing structures these waves would have a period of about 10 seconds and for northward facing structures the period would be about 5 seconds. For the proposed commercial fishing port a significant wave having a height of 1.0 meter, a period of 4.6 seconds, and an associated maximum wave height of 1.9 meters is recommended.

Currents - Assuming combined tidal, river, and storm generated currents act in the same direction, a maximum current speed of about 2 m/sec. (4 knots) is expected.

Sedimentation - Estimates based on a study of the hydrodynamic patterns of the project area and of successive hydrographic surveys of the entrance channel to the existing commercial port at Vung Tau indicate that annual sedimentation of the turning basin and entrance channel of the first construction phase of the proposed commercial port may be of the order of 0.6 million cubic meters and double this amount for facilities expanded as a result of second phase construction. Sedimentation in the vicinity of the proposed commercial fishing port will be minimal but sedimentation of an entrance channel to this port, should one be dredged, may be substantial.

2. Operating Conditions

Winds - Southwesterly winds of the Southwest Monsoon averaging 4 to 6 m/sec in speed can be expected to blow in the project area from June to September. From November to March winds of the Northeast Monsoon will blow at average speeds of 5 to 6.5 m/sec. April and May and October are months of transition between monsoonal seasons and winds may blow from any direction at these times. Calm periods are also more frequent during the transition periods.

Precipitation - The rainy season at Vung Tau extends generally from May to October. Two peaks occur, one in early summer and one in fall. Average annual amounts range from 1 mm in February to 216 mm in October.

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Visibility - Fog is rare at Vung Tau which experiences only 11 days of fog on the average per year. Visibility may be obscured by heavy precipitation for short periods.

Tides - Tides at Vung Tau are mixed with large differences in height between successive low tides. The range of tide is of the order of 3 meters (10 feet) and the largest ranges and greatest heights occur during the late fall and winter months. The highest tide level likely to be reached during a typical year is 4.15 meters (13.6 feet).

Waves - Waves during a typical year will approach the site from the northeastern quadrant during the winter monsoonal period and from the southwestern quadrant during the summer monsoon. Waves above the height of 1.0 meter can be expected at the proposed commercial port site 2 to 4% of the time during a typical year. Waves above 0.5 meter can be expected as much as 15% of the time during the winter monsoonal period and up to 20% of the time during the summer monsoonal period. Wave heights at the proposed commercial fishing port site are expected to exceed 0.5 meter only 1 to 3% of the time during a typical year.

It is unlikely that seiching will be a problem in the harbor areas.

Currents - Two current regimes exist in the project area; a north-south tidal and river flow in the western part of the area and an east-west flow in the eastern part. Current velocities as high as 1.0 m/sec have been observed in both areas. Turbulence is high in the region of confluence of the two flows and in general ebb flows, flowing westerly or southerly, are stronger than flood flows.

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3. Environmental Impact of Proposed Port Development

The local environment is expected to be affected by both construction and operation of a large port facility. The most important effect of construction will be covering of Ben Dinh Island, the large mangrove island adjacent to the proposed commercial port, with the attendent destruction of marine life and sources of feed for maturing marine life. The island is an important maturing ground for many species of marine life, notably some valuable shrimp species. It is recommended, therefore, that if possible, a portion of the island be saved from land fill operations and that circulation with the sea be left unblocked.

The primary consequence of operating the port will be pollution by petroleum and other toxic substances. Pollution is not expected to be serious because the strong currents characteristic of the region will flush away most substances. No evidence exists to date that petroleum is toxic to marine species in the region although some species may be sequestering poisonous substances which could be dangerous to humans eating these species. An oil or chemical spill could, of course, occur and could have disastrous effects on the environment. Effort should be made to minimize the chance of occurrence of such a spill.

C. GEOLOGIC AND SUBSURFACE CONDITIONS

1. General

In order to determine the foundation conditions of the in situ soils and to assess the suitability of the soils types for dredging and hydraulic fill for the proposed port sites, subsurface and soils testing investigations were carried out for these areas. In the proposed commercial general cargo port site a total of 34 holes were sunk in the area of which 18 were probes and 16 were drilled holes. Since sufficient soils data already existed for the proposed commercial fishing port site, no holes were drilled in this area. The locations of borings for both sites as well as associated soil profiles are shown on Plates 1 through 4. In addition to the subsurface investigations a soils testing program consisting of general classification tests, unconfined compression tests, and consolidation tests on undisturbed and remolded samples was performed in the Lyon Associates, Inc.'s laboratory in Saigon.

2. Commercial Port Area

Stratigraphy

Subsurface conditions may be generally considered to be a two layer system: an upper layer of soft to very soft gray marine clays (CH) varying in depth from 2 meters to 16 meters which shall be referred to as the Younger Sediments. This layer is underlain by a layer of heterogeneous and lenticular deposits of medium stiff to hard clays (CL, CH), poorly graded fine sands (SP), sandy clays (SC) and silty sands (SM). This layer will be referred to as Older Sediments. Rock was encountered in only one boring (VT-17) at an elevation of-10 m. (Approx. LLW).

The Younger Sediments are characterized by moisture contents ranging between 50 to 129%, an average shear strength of 9.8 kg/cm^2 and compression indices (Cc) ranging between 0.83 and 1.05 for the undisturbed samples and 0.65 and 0.75 for the remolded samples.

For the various sediment types making up the Older Sediments, the following soils parameters were determined as appropriate for preliminary calculations.

Classification (Unified Soils System)	Range of N-Values (Blows/30cm)	γnat kg/m^2	C kg/m^2	ϕ (degrees)
SP	7- 30	177-209	0	32-38
SM	13- 30	177-209	0	32-38
SC	18-105	177-217	1340-2680	29-36
CL	14- 25	177-201	2680-5360	0
CH	9- 41	164-193	3580-8940	0

Dredging

It is expected that most of the dredge material encountered will be soft clays with occasional ridges of more compact soils. Therefore, since no rock was found in the areas to be dredged most of the material can be removed by simple suction dredging although the stiff clays and compact silty sands will require the use of a suitable cutter head on the suction line.

Hydraulic Fill

It was assumed for this study that the hydraulic fill material will consist only of the soft clays which predominate and which can be satisfactorily analyzed using standard consolidation theory and laboratory testing. Fills of this type are highly compressible.

Based upon an average coefficient of consolidation (Cv) of 2.8×10^{-3} m^2/day and in consideration of the average thickness of in situ soils and hydraulic fill, it is expected that large settlements will take place over several years following the construction period. However, by using vertical sand drains, it is estimated that 90% of the consolidation,approximately 1.0 meters,can be accomplished in approximately 16 months without preloading. It should be noted that only the cost to consolidate the backup area, 200 meters in back of the wharf, has been included in the preliminary cost estimates presented in this report.

Foundation Conditions

By removing the upper soft clay layer the breakwater and the wharf berm can be built on the lower layer of stiff hard clay without stability problems. The perimeter dikes and access road can be constructed by displacement techniques on the in situ upper soft clay layer. However, the wharf and other heavy structures must be built on pile foundations which can be seated in the stiff hard clay layer.

3. Commercial Fishing Port

Stratigraphy

Stratification in the upper 9 to 14 meters is not well correlated between borings. Clayey sands, silty sands, lean clays and plastic silts are interwoven in a heterogenuous and lenticular manner. These soils are believed to be river levee and flood plain deposits and therefore represent a different deposition process from that found in the commercial cargo port area where soft marine clays are found. "N-values" in these

upper layers were low, in the range of 1 to 7 blows per foot.

Beneath the upper, weak soil complex, medium compact to compact silty sand overlies a very stiff to hard highly plastic clay. These lower layers appear to be part of the older sediment continuum found in the proposed commercial cargo port area as previously described.

Dredging

As seen on Plates 13 and 14 very little dredging is required for the Commercial Fishing Port area and this can be accomplished with a suction dredge.

Hydraulic Fill

Since the existing backup area is sufficient to accommodate the onshore facilities, no reclamation is required for the Commercial Fishing Port.

Foundation Conditions

Light structures can be founded on the existing fill area. However, heavy structures which have contact pressures greater that approximately 10,000 kg/m^2 may require pile foundations which can be seated in the stiff to hard clay layer.

4. Construction Materials

Construction materials for the breakwater, berms, sand fill and coarse aggregate are available in sufficient quantities in the Vung Tau area. However, sand for concrete and the sand drains must be obtained from the Bien Hoa area which is approximately 20 kilometers northeast of Saigon.

D. PORT PLANNING CONCEPTS

1. Commercial General Cargo Port

Three basic alternative development layout concepts were formulated for a proposed new commercial general cargo port at Vung Tau. These are shown on Plates 6-11. As can be seen the location chosen for all three alternatives is within the protected area formed by Point Ganh Rai. This location was chosen because there is ample space for port backup areas, for future port expansion, and for associated reclaimed land areas. It is also relatively well protected from storm and seasonal waves. Furthermore, most importantly, the location requires only a short entrance channel and the relatively deep water characteristic of the area will minimize dredging requirements for the turning basin and channel. It will further be noted that the port has been located seaward of the adjacent land area leaving an open waterway between the port and the land. This was done to allow continued access to the fishing villages along the shore. Also if a port were constructed adjacent to the land, land access would be costly due to the expenditures required in widening and improving the existing road or building a new road. In addition the backup area for the port would be restricted.

In view of the lack of knowledge of projected cargo type and volume expected to pass through a port at Vung Tau, the configuration and size of the alternative ports depicted in the layouts were based on the characteristics of assumed ship sizes which might be expected to call at the port. Two possibilities in regard to maximum ship size,

designated in terms of ship draft, were considered for each of the three alternative layout concepts. One series of port alternatives was developed to accommodate ships having a maximum draft of 10.7 meters and the other series for a maximum draft of 9.1 meters. The first of these drafts was determined on the basis of depth of water during high tide in the fairway approaches to Vung Tau. This maximum draft limitation was determined on the basis that the expenditures required to dredge and maintain the channel in the exposed approach would not be justified. The lesser draft was chosen because it is representative of ship sizes commonly in use in large numbers in world trade and a large proportion of the cargo moving into and out of Vietnam could be expected to be carried in ships of this size. In both cases it was assumed that a mixture of several types of ship including break bulk general cargo vessels, container vessels, and wet and dry bulk vessels would call at the port and characteristics of all of these vessels were utilized in the formulation of the alternative development concepts.

In view of the fact that forecast of traffic type and volume expected to pass through the port and determination of economic feasibility did not form a part of the scope of work for this project, the alternative development concepts discussed in this report cannot be considered to be specific recommendations for future port development. Rather they constitute a series of possible concepts which might be followed, either individually or in combination, in response to shipping and cargo traffic requirements which might develop. A major consideration in this regard is whether the port would function as a cargo transfer point both between

ocean going ships and land transport and between such ships and small coastal vessels and barges or whether this latter function would only occur to a minimal extent. Thus, of the three alternatives considered, Alternatives 2 and 3 were laid out specifically to accommodate the transfer of cargo between ocean and inland waterway transport and between ocean and inland land transport while Alternative Concept No. 1 was based on the assumption that transfer between ocean and inland waterway transport would be minimal. Of Alternatives 2 and 3, No. 3 is best suited to function as a combination inland waterway and inland land transport type port because it provides an all weather basin for small craft and barges engaged in cargo handling.

Thus, although recommendation of a specific alternative concept cannot be made, it can be stated that should it be determined that the transfer of cargo between ocean and inland waterway transport will be an important function of a new port at Vung Tau, development of a port similar to that of Alternative Concept No. 3 (Plates 10 & 11) would be advisable. Should this cargo transfer requirement be minimal, Alternative No. 1 would be the most favorable course for development.

2. Commercial Fishing Port

Plates 13 and 14 show the two alternative development concepts considered for a commercial fishing port at Vung Tau. The expressed purpose of this port will be to provide berthing, servicing, and unloading facilities for a fleet of fifty relatively large ocean going fishing vessels which would gather sea food primarily for export to other

countries. Thus it is recommended that this port be built in a location which would keep it separate from existing local fishing activities and which would allow easy access to land transport facilities. Separation of the commercial fishing port from other activities would allow more efficient operation of the port inasmuch as it would serve a different function than the local fishing activities. The local fishing industry should be maintained with as little interference as possible because it is the source of seafood for local consumption and is an important element of the local economy.

The location chosen was that of the existing general cargo port at Vung Tau. This site is well located in terms of access of land transport, it has sufficient backup area which would require little additional preparation for the necessary onshore facilities, it is well protected from wave action, and sedimentation of the harbor would be minimal.

The two alternative concepts considered are essentially similar except that one includes two finger piers, providing four berths, for unloading of vessels while the other indludes a marginal wharf, again providing four berths, for the same function. Inasmuch as the number and characteristics of vessels which will use the port and the nature of the cargo to be handled are known, it is possible to make a recommendation regarding which alternative development the port should take. The primary advantage of the finger pier approach is that it is somewhat less expensive than the marginal wharf approach and it could probably be built in a shorter period of time. The primary advantage of the

marginal wharf is that it would permit far more efficient handling and transfer of cargo to land transport. In view of the importance of cargo handling efficiency, the marginal wharf alternative is recommended.

3. Access and Utilities

Access to the proposed commercial cargo port would be provided by a dike built across the Ben Dinh mangrove island and intersecting the main Saigon-Vung Tau road in the vicinity of the existing cargo port. At present there is no rail connection at Vung Tau. The Saigon-Vung Tau Highway is adequate along most of its length to handle heavy truck traffic although some sections require widening and extensive repair. Should a rail connection to Vung Tau be built, a spur to the port could be laid along the road causeway.

Access to the proposed fishing port will be relatively simple inasmuch as the main Saigon-Vung Tau Highway, as well as prospective routes for a rail connection, passes very close to the recommended port site.

At present there is insufficient fresh water in Vung Tau to accommodate either a commercial cargo port or a new fishing port. Studies have, however, been completed which indicate that water from the Dinh River could be used to supplement existing supplies and it is likely that sufficient water for the needs of the ports could be supplied in this manner. It is understood that construction of new water supply facilities is now underway.

Electrical power is presently sufficient for the immediate and future needs of Vung Tau and vicinity. In addition government plans

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exist for supplementing this power supply by constructing a tie line with the Thu Duc power plant and by expansion of generating facilities at Nha Be. These plans will be implemented at the time that the need is established and will insure that sufficient power will be available for use by both proposed port facilities.

4. Disposal of Excess Dredged Material and Land Reclamation

It is recommended that material dredged from turning basins and entrance channels in excess of that used in reclaimed land for port use be used for additional reclamation adjacent to the commercial cargo port. This reclaimed land could then be used as a site for industrial development and there is reason to believe that substantial revenue over and above the cost of the reclamation project could accrue from sale or lease of this land and that this revenue might help to defray the cost of construction of port facilities. The disposal of excess dredged fill by simple spoiling within the estuary area, on land or in water, adjacent to the proposed port is specifically not recommended, even though it is probably the least costly method, because past experience in many countries has shown that sediment so disposed of will rapidly be returned to dredged areas by current and wave forces. The only reasonable alternative to use in a reclamation project is disposal at sea well outside the port limits, a costly solution to the problem.

E. ESTIMATED COST OF ALTERNATIVE CONCEPTS

The following tables give a summary of costs of the various alternative concepts for the proposed Commercial General Cargo Port and Commercial Fishing Port. Costs do not include buildings, surfacing, cargo handling equipment, navigation aids, utilities or other related facilities. Therefore, the costs presented should not be construed as being the total capital expenditure required for a fully operational port.

The cost of the various items of work that have been included in the estimate were based on 1973 prices. Although the estimates have been expressed in U.S. dollars, originally they were broken down into U.S. dollar and VN piastres where appropriate. The piastre costs were converted to U.S. dollars at the rate of 500 VN$ to one U.S. dollar.

COMMERCIAL GENERAL CARGO PORT

Item of Construction	ALTERNATIVE No. 1			
	10.7 m DRAFT		9.1 m DRAFT	
1. Port	Phase I Cost $(000)	Phase II Cost $(000)	Phase I Cost $(000)	Phase II Cost $(000)
a. Dredging	12,800	9,260	8,340	10,520
b. Wharf	10,342.3	10,950	8,032.3	13,215.56
c. Fill	1,236	1,458.5	971.5	1,713.5
d. Access Road	2,820.8	-	2,913.6	-
Subtotal 1	27,199.1	21,668.5	20,257.4	25,449.06
2. Reclamation	4,095.4	1,044	3,423	1,173
Subtotal 1+2	31,294.5	22,712.5	23,680.4	26,622.06
Contractor's Profit & Overhead 25%	7,823.62	5,678.1	5,920.1	6,655.51
Construction Contingency 15% approx.	4,681.88	3,409.4	3,499.5	4,022.43
Total 1+2	43,800	31,800	33,100	37,300
Total Phase I+II	75,600		70,400	
3. Estimated Annual Maintenance Dredging	1,020	2,040	1,020	2,040

COMMERCIAL GENERAL CARGO PORT

Item of Construction	ALTERNATIVE No. 2			
	10.7 m DRAFT		9.1 m DRAFT	
	Phase I Cost $(000)	Phase II Cost $(000)	Phase I Cost $(000)	Phase II Cost $(000)
1. Port				
a. Dredging	15,210	11,550	9,110	8,270
b. Wharf	20,099.6	10,645.5	18,630.1	11,427.7
c. Fill	1,791.25	1,458.5	1,591	1,526.5
d. Access Road	2,660.8	-	2,710.8	-
Subtotal 1	39,761.65	23,654	32,041.9	21,224.2
2. Reclamation	4,068.7	1,387.5	3,407.9	880.5
Subtotal 1+2	43,830.35	25,041.5	35,449.8	22,104.7
Contractor's Profit & Overhead 25%	10,957.59	6,260.37	8,862.45	5,526.17
Construction Contingency 15% approx.	6,612.06	3,698.13	5,287.75	3,269.13
Total 1+2	61,400	35,000	49,600	30,900
Total Phase I+II	96,400		80,500	
3. Estimated Annual Maintenance Dredging	1,020	2,040	1,020	2,040

COMMERCIAL GENERAL CARGO PORT

Item of Construction	ALTERNATIVE No. 3			
	10.7 m DRAFT		9.1 m DRAT	
	Phase I Cost $(000)	Phase II Cost $(000)	Phase I Cost $(000)	Phase II Cost $(000)
1. Port				
a. Dredging	10,240	8,680	6,860	9,370
b. Wharf	14,630.2	13,945.1	12,957.45	17,274.4
c. Fill	750	1,213.5	595.5	1,336
d. Access Road	2,560.8	-	2,660.8	-
Subtotal 1	28,181	23,838.6	23,073.75	27,980.4
2. Reclamation	3,695.2	1,017	3,355.9	1,090.5
Subtotal 1+2	31,876.2	24,855.6	26,429.65	29,070.9
Contractor's Profit & Overhead 25%	7,969.05	6,213.9	6,607.41	7,267.72
Construction Contingency 15% approx.	4,754.75	3,730.5	3,962.94	4,361.38
Total 1+2	44,600	34,800	37,000	40,700
Total Phase I+II	79,400		77,700	
3. Estimated Annual Maintenance Dredging	1,020	2,040	1,020	2,040

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COMMERCIAL FISHING PORT

Item of Construction	ALTERNATIVE No. 1			ALTERNATIVE No. 2		
	Quantity	Unit Price $	Cost $	Quantity	Unit Price $	Cost $
(1) Demolition	L.S.	L.S.	25,000	L.S.	L.S.	25,000
(2) Dredging	145,000 m^3	1.20	174,000	145,000 m^3	1.20	174,000
(3) Mooring Piers	390 m	743.59	290,000	390 m	743.59	290,000
(4) Fueling Pier & Trestle	L.S.	L.S.	52,000	L.S.	L.S.	52,000
(5) Unloading Piers or Wharf	120 m	1,000	120,000	145 m	2,496.55	362,000
(6) Fill & Roadwork	L.S.	L.S.	70,000	L.S.	L.S.	70,000
Subtotal			731,000			973,000
Contractor's Profit and Overhead 25%			182,750			243,250
Construction Contingency 15%			109,250			145,750
Total Construction Cost			1,023,000			1,362,000

Unit prices are averaged rounded values

Note: Maintenance dredging will be minimal and no cost for this is presented.

SECTION III

CLIMATIC AND OCEANOGRAPHIC CONDITIONS

A. INTRODUCTION

The following section presents the results of oceanographic investigations undertaken as part of the Vung Tau Port Study. The purpose of these investigations was to provide criteria for the location of port facilities, turning basins and channels and for the design of port structures and to describe typical conditions of the environment which might be expected by users and builders of the port.

The development of design criteria for structures or facilities generally consists of prediction of extreme events of various conditions of the environment as a function of their probabilities of occurrence. These probabilities are expressed as return periods; that is, the interval of time in years that an event of a certain intensity can be expected on the average to recur. In this report values of extreme conditions are presented for several return periods. This allows the engineer to select design criteria in terms of desired design life of a structure. Design alternatives may therefore be evaluated by comparing cost of construction versus risk of failure or maintenance cost for the various intensities of extreme events given.

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General operating conditions at the facility site are no less important than design criteria in that they indicate the conditions of the environment that the builder of the facility of the facility user is likely to encounter on an everyday basis. This information is also often presented in terms of probability of occurrence. But, inasmuch as these are conditions which can be expected during a typical year, the information is generally shown as percent frequency of occurrence of the event on a monthly, seasonal, or yearly basis. This information is important to the port users because it provides an indication of difficulties which might be imposed on port operations by the natural environment and of the amount of annual down time which might be expected. In some cases seasonal conditions may affect design and layout of facilities and, as will be seen in the case of maintenance dredging, may affect the overall feasibility of the project. In addition, using this information the builder of port facilities can select those times during the year when down time due to weather will be at a minimum, thus reducing overall cost of construction.

In conducting oceanographic investigations for this project both existing data of record and data obtained during a field measurement program were utilized. The data of record were obtained from the hydrographic and meteorological offices of Vietnam as well as such data repositories as the U.S. Naval Oceanographic Office and the U.S. National Oceanic and Atmospheric Administration. The field measurement program was undertaken by Lyon Associates, Inc., personnel and was conducted at Vung Tau from 12 September to 14 October 1973. Measurements were made by two teams of technicians. One team made measurements of wave height and period at

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two locations in the morning and afternoon of each day. This team also recorded meteorological and tidal data. The other team utilized a boat which occupied stations in the proposed harbor area taking measurements of current speed and direction at two depth levels over a full tidal cycle at each station. This team also took water samples which were analyzed for salinity and suspended sediment content and measured water temperature. Samples of bottom sediment were also obtained.

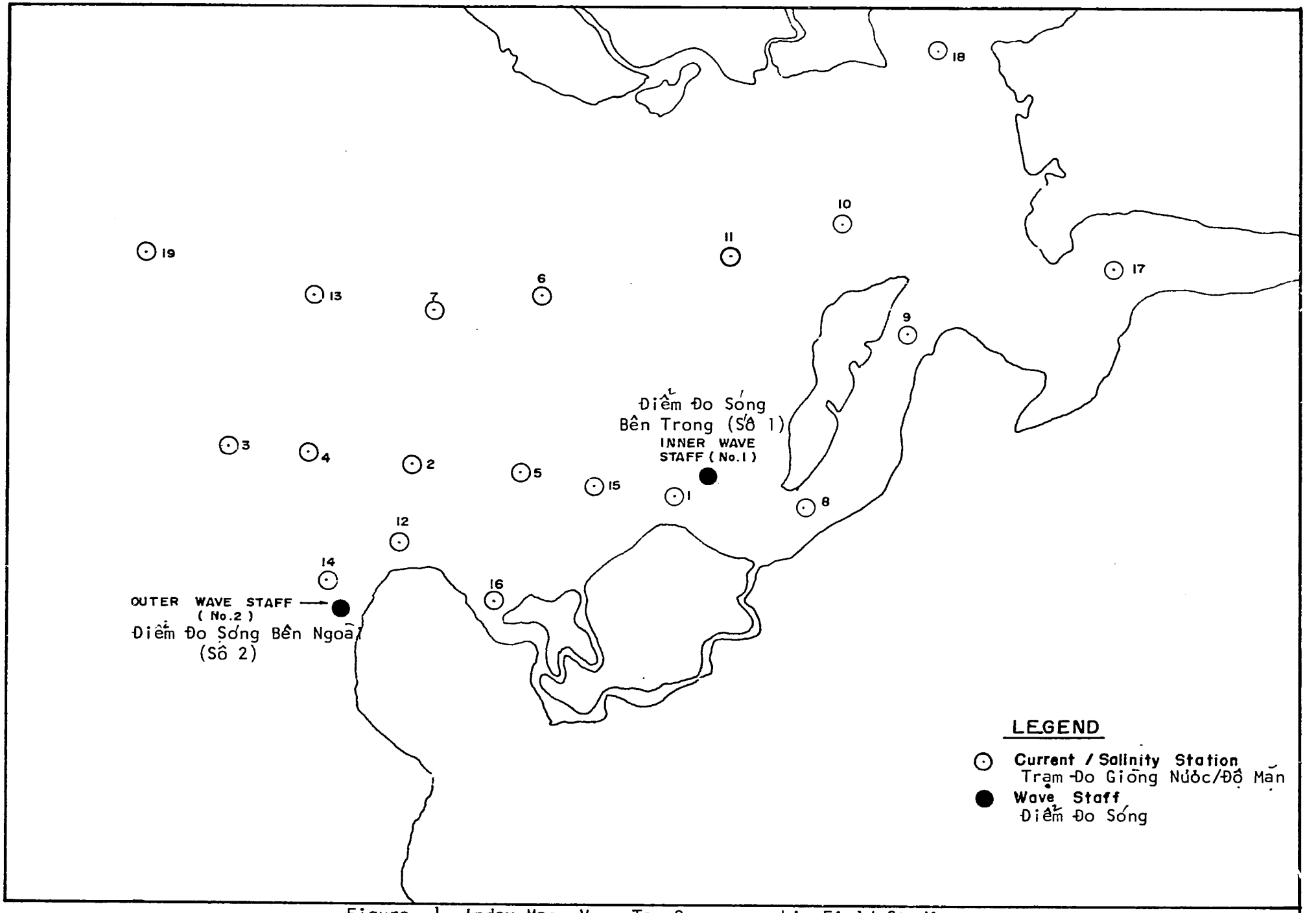
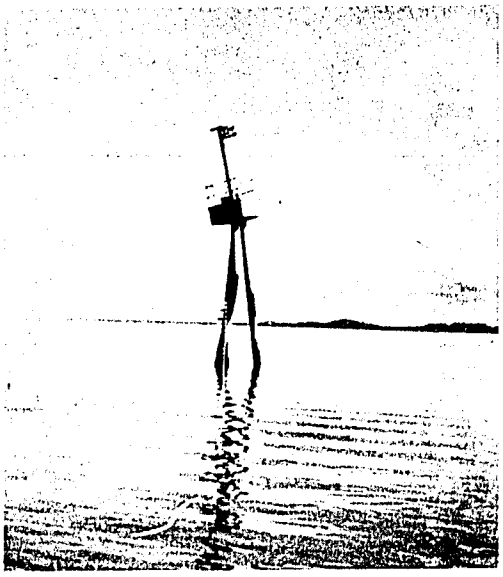
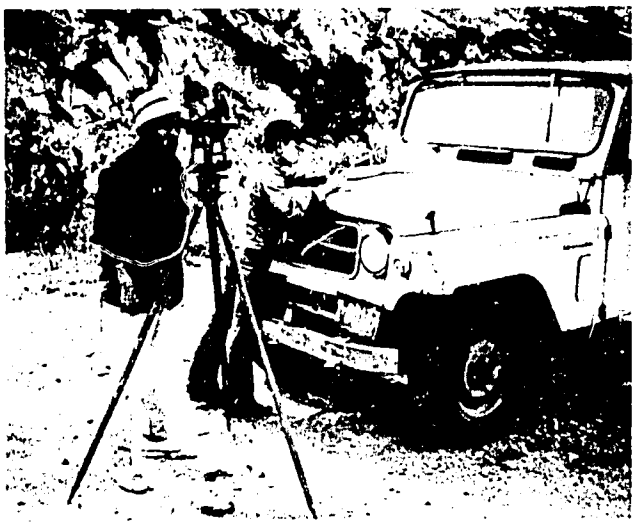


Figure 1 Index Map, Vung Tau Oceanographic Field Studies
Hinh 1 Bản đồ vị trí, Nghiên-cứu Hải-Dương-Học Vũng Tàu

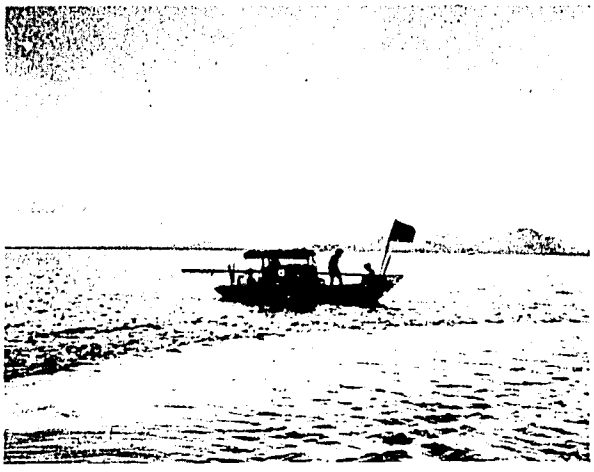


Wave Staff,
Điểm đo sóng



Making Wave Measurements
Đo Lường Gợn Sóng

Launching Current Drogue
Ha Neo giữa dòng nước



Oceanographic Boat
Tàu Viễn Dương

Retrieving Current Meter - Máy đo dòng nước chảy ngược

Figure 2. Views of Oceanographic Field Investigations
Hình 2 Hình Ảnh điều nghiên về lãnh vực hải dương học

B. CLIMATIC CONDITIONS

1. Wind

a. Typical Wind Regime

The typical wind regime of the coastal regions of Vietnam is dominated by the Northeast Monsoon in winter and the Southwest Monsoon in Summer. The Northeast Monsoon blows approximately from November to March and is steadiest and strongest in the months of January and February. It is characterized by northerly, northeasterly, and easterly winds blowing at speeds of 5 to 10 m/sec. These winds are caused by the winter cooling of the Asian land mass which causes a large high pressure area, known as the Siberian High, to form over Siberia and China. The Siberian High in conjunction with the semi-permanent high pressure areas of the sub-tropical North Pacific Ocean causes winds to blow from the characteristic northeasterly direction.

During April and May the Siberian High weakens and is displaced northward because of warming of the Asian land mass. As a result the northeasterly winds of the Northeast Monsoon diminish somewhat irregularly. At the same time a low pressure area begins to develop over northern India and Southeast Asia because of increased heating of the land mass. As a result a flow of southwest or south winds commences usually in April and May and these winds, the Southwest Monsoon, blow over the coast of South Vietnam with increased frequency. During this transition period the winds are somewhat variable in direction and speed.

In the months of June to September the prevailing southerly, southwesterly, and westerly winds become established as a result of the intensification of the low pressure area over north India and Southeast Asia. These winds are generally not as strong as those of the Northeast Monsoon and are characterized by average speeds of the order of 3 to 8 m/sec.

Beginning in September and continuing into October the low pressure area over southern Asia weakens and eventually dissipates because of decreased solar heating of the land mass. As the low weakens and moves southward, the Southwest Monsoon weakens and is displaced southward. At the same time the Siberian High is strengthening and transition from Southwest to Northeast Monsoonal conditions begins. During the October transition period the winds are somewhat irregular in direction and speed.

The above discussion describes average conditions and departures from the average that may occur from year to year, although seasonal changes will probably not vary more than one month from the times stated. Also at the site some variations in the patterns stated will be caused by land and sea breeze and topographic effects. These effects will be most pronounced in the early morning, late morning, and early afternoon.

Tables 1 and 2 provide a summary of typical winds at or near the site off the coast of Vietnam. Table 1 shows average wind conditions for Cap St. Jacques (Vung Tau) and is probably quite representative of wind conditions at the project site. Table 2 shows conditions for the South China Sea. Because the area represented by Table 2 is a relatively large

offshore ocean area, the percentages shown probably indicate somewhat higher wind speeds than those actually characteristic of the project site. Variations of more than a few percent are not likely, however.

TABLE 1

Percent frequency of occurrence of winds by direction and month and mean wind speeds for Cap St. Jacques (Vung Tau), Lat. 10° 20' N, Long. 107° 05'E

WIND Direction(%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
North	7	4	2	0	3	0	0	0	1	7	9	17	4
Northeast	54	49	41	28	13	12	0	0	2	27	40	50	26
East	28	38	41	32	7	3	2	1	4	14	22	23	18
Southeast	2	0	7	10	2	0	2	7	1	0	0	1	3
South	0	3	6	10	5	3	6	7	4	2	0	1	4
Southwest	0	4	1	15	38	54	61	52	49	12	1	0	24
West	1	0	0	3	18	13	13	28	20	18	12	1	10
Northwest	5	1	0	0	8	12	16	3	15	17	-	5	8
Calm	3	1	2	2	6	3	0	2	4	3	2	2	3
Mean speed (knots)	12.2	11.6	12.6	9.1	8.2	8.8	12.2	11.0	10.6	8.0	8.1	8.0	10.0
(m/sec)	6.3	6.0	6.5	4.7	4.2	4.5	6.3	5.7	5.5	4.1	4.2	4.1	5.2

TABLE 2

Percent Frequency Wind Force -- South China Sea

m/sec	<1.6	1.6-3.3	3.4-5.4	5.5-7.9	8.0-10.7	10.8-13.8	13.9-17.1	17.2-20.7	20.8-24.4
Beaufort Scale	<2	2	3	4	5	6	7	8	9
January	15	11	29	31	5	7	2	0	0
February	11½	20	29	25	12	3	<½	½	<½
March	17½	27	28	20	6	1	<½	0	0
April	34	33	22	8	2	1	0	0	0
May	29	35	25	8	2	<½	<½	0	0
June	18½	32	31	12	5	1	<½	0	0
July	10	21	35	24	7	2	<½	<½	0
August	11½	25	35	20	7	1	<½	0	0
September	16½	28	31	18	5	1	<½	0	0
October	25½	27	27	14	4	2	<½	0	0
November	18	29	29	14	6	2	1	<½	<½
December	6½	16	28	26	17	5	1	<½	0
Mean	18%	25%	29%	18%	7%	2%	3/4%	-	-

This table shows the percentage wind force for each month over an area centered on position 7°N, 108°E. The information is taken from the U.S. Marine Climate Atlas.

The data shown in the above tables are averages determined over several years of records. In order to help to establish the representativeness of the data shown for the project area and to provide correlation of winds with wave data presented later in this report, observations of wind speed and direction were made at the project site. Figure 3 is a wind rose showing percent frequency of occurrence of wind speed and direction and Table 3 gives percent frequency of speed for various times of the day during the 12 September to 14 October 1973 field measurement period. Comparison of Figure 3 with Table 1 will show that winds observed are essentially typical for the time of year. The Southwest Monsoon was dominant during the early part of the study period but toward the end of the period it began to give way to the Northeast Monsoon with the onset of the October transition period.

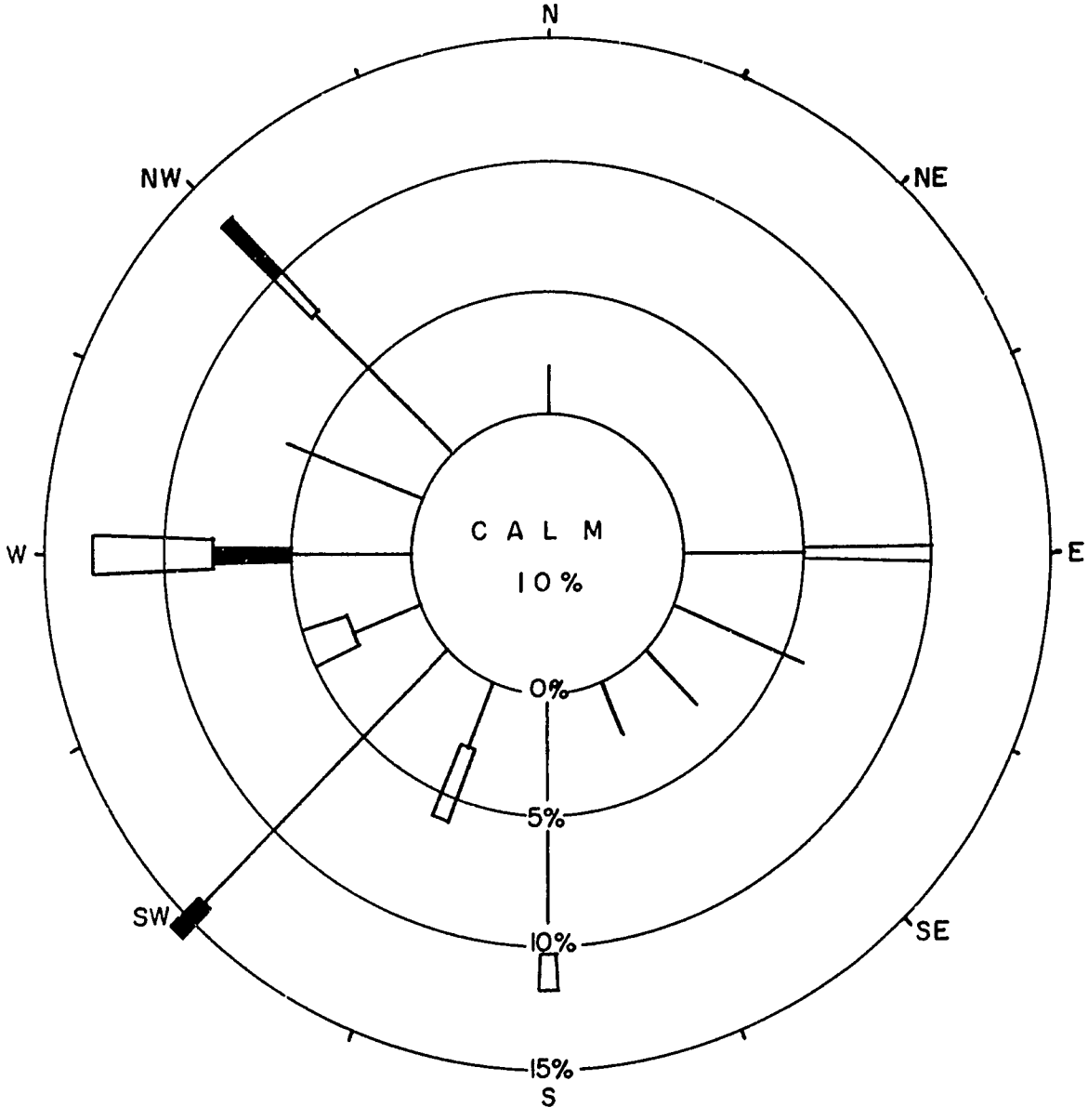
Comparison of Table 3 with Table 2 shows that frequency of higher wind speeds was greater than average during the study period. The reason for this was the occurrence of high winds during 5-10 October associated with Typhoon Opal which passed across the coast of Vietnam near Qui Nhon and Typhoon Nora which was responsible for severe damage in the Philippines before it dissipated over the South China Sea. Table 3 also shows that calms are more frequent during morning hours but, paradoxically, occurrence of higher wind speeds was also greater at this time.

TYPICAL WINDS

PORT OF VUNG TAU, SOUTH VIETNAM

PERCENT FREQUENCY OF OCCURRENCE OF DIRECTION AND SPEED

12 SEPTEMBER TO 14 OCTOBER 1973



NOTES: 1. Direction Frequency: Bars represent percentage frequency of wind observed from each direction.

2. Speed Frequency: Length of speed category represents percentage frequency of wind observed at that speed from the direction indicated.

Legend: Calm 0 m/sec — 0.0 - 1.0 m/sec — 1.0 - 5.0 m/sec — 5.0 -10.0 m/sec — Greater than 10.0 m/sec.

3. Scale: Each circle represents 5.0%.

Figure 3, Typical Winds, Cap St. Jacques, 12 September to 14 October 1973.

TABLE 3

Percent Frequency of Wind Speeds, Cap St. Jacques
12 September to 14 October 1973 (percent)

Time	Calm (0 m/sec)	0-1 m/sec	1-5 m/sec	5-10m/sec	>10 m/sec
Morning	16%	58%	10%	10%	6%
Afternoon	3	72	13	6	6
Day	10	65	11	8	6

b. Extreme Winds

An analysis of extreme winds is important for two reasons in the design of offshore structures. Not only must possible wind loading for structures be determined, but extreme wave forces must be calculated. It is the extreme winds, of course, which will generate these extreme waves.

Extreme winds in the area of interest will generally be caused by tropical storms or typhoons. Table 4 gives the frequency of typhoons in the South China Sea. The table shows typhoons only (that is, tropical disturbances with winds of 65 knots, i.e. 33 m/sec, or greater). Tropical storms (wind speeds 34-64 knots or 18-33 m/sec) are, on the average, about twice as frequent.

TABLE 4

Average Frequency of Typhoons, South China Sea
(45 years of record)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0.2	<0.1	<0.1	0.1	0.4	0.7	1.7	1.2	1.6	1.5	1.0	0.4	8.9

As can be seen, typhoons can occur at any time during the year but are most frequent from July to November. Table 5 indicates that typhoons which approach the Asia mainland are far less frequent in latitudes south of 10°N and they generally occur late in the year during the months of November or December. The probability that storm winds of true typhoon intensity would strike at the project site is even lower, of course, and probably would not occur more often than once each 50 years (as reflected by the extreme wind analysis summarized in Table 6).

TABLE 5

Total number of Typhoons with center striking or coming within 100 miles of the Asia Mainland, South China Sea in 50 years.

(Ref. 3)

	LATITUDE			
	5-10°	10-15°	15-20°	Above 20°N
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	0	0	0	0
May	0	1	2	6
June	0	1	2	14
July	0	0	9	43
August	0	0	6	32
September	0	3	29	37
October	0	14	20	17
November	3	16	6	7
December	1	2	0	0
Total	4	37	74	156

Although extreme winds will probably be caused by typhoons or tropical storms, high winds could also be caused by other types of disturbances in the project area. These include Northers which result from movement

of high pressure polar air masses southward or southeastward off the Asia Mainland and are most frequent from November to February. Northers are often associated with cold fronts or line squalls in which winds gusting to 60 knots (31m/sec) may develop. Other storms include extratropical cyclones, in which sustained winds up to 40 knots (21m/sec) may occur, squalls and thunder storms, which are of short duration but may cause gusts up to 70 knots (36 m/sec), and gradient intensification storms. In the last type the prevailing wind, usually the Northeast Monsoon, intensifies due to a steepening of the pressure gradients associated with the highs and lows causing the winds.

Table 6 presents extreme winds which can be expected in the project area as a function of their return periods. Wind values were derived using a statistical technique developed by H.C.S. Thom of the U.S. Weather Bureau. Thom's method consists of prediction of occurrences of extreme winds based upon statistical distributions of past occurrences of storms and high winds in various parts of the world. The basic prediction formula is:

$$G(V) = (1-P_T)\exp\left[-\left(\frac{V}{B}\right)^{-\gamma}\right] + P_T \exp\left[-\left(\frac{V}{B}\right)^{-\gamma}\right] \text{ where}$$

$G(V)$ = Probability that an extreme wind value is $\leq V$.

P_T = Probability that extreme winds are caused by a tropical storm, rather than some other type of storm.

γ = Constant defining the shape of the storm and wind occurrence distribution and varies with the type of storm.

B = Scale parameter depending on the mean monthly winds characteristic of a particular area.

V = Wind speeds for which probability is calculated

TABLE 6

Extreme wind speeds as a function of Return Period

Return Period (year)	Sustained Wind	Instantaneous (Gust) Speeds
10	49 kt (25 m/sec)	83 kt (43 m/sec)
25	55 kt (28 m/sec)	93 kt (48 m/sec)
50	65 kt (33 m/sec)	109 kt (56 m/sec)
100	71 kt (37 m/sec)	120 kt (62 m/sec)

In addition to the analysis described, wind speeds developed were compared to similar analyses carried out by other agencies and to various records of typhoons and storm frequency and measured wind speeds. Table 6 presents winds which have been calculated by the theory and calibrated and adjusted using the actual measured data and observations. The reason for this is that no theory yet devised can be relied upon to predict with 100 percent confidence the occurrence of a meteorological phenomenon at a particular place or time. Theoretical analyses are, therefore, always followed by an analysis of actual measurements or observations when data are available. Table 7 gives maximum wind speeds by year measured at Vung Tau.

TABLE 7

Maximum Sustained Wind Velocities by Year, Vung Tau

Date	Wind Speed (knots)	Direction	Date	Wind Speed (knots)	Direction
Feb 1956	37	E	Jul 1965	44	WSW
Mar 1956	37	ENE	Jan 1966	37	E
Aug 1957	52	WSW	Jul 1967	44	WSW
Jul 1958	44	WSW	Jan 1968	41	E
Jan 1959	37	ENE	Feb 1969	34	E
Dec 1959	37	NNW	May 1970	16	SW
Jul 1960	44	WSW	Oct 1971	14	ENE
Jul 1961	44	WSW	Apr 1972	19	E
Oct 1962	52	SW			

At this point an understanding of the term "Return Period" is important. A return period of, say, 10 years does not mean that a predicted event will occur every ten years. It means that if the event were recorded over a long period of time, say 500 years, it would be found to have occurred with an interval which could have been 10 years, i.e., 50 times in 500 years, on the average. Thus an event with a 10 year return period might occur once every year for 10 years but then not occur again for another 90 years. Regardless of the limitations imposed on predictions, however, presentation of events in terms of return period is useful as long as the limitations are understood.

The primary reason for the calculation of design wind speed for this project was in order to calculate design waves which would be generated by these winds. The reason for this is that, since the project does not include buildings or other superstructure, knowledge of wind loads would not be needed. However, for future design work it is recommended that a 50 year return period wind (i.e. sustained wind = 33 m/sec, peak gust = 56 m/sec) be used as a design criterion.

2. Precipitation

The rainy season at Vung Tau is associated with the Southwest Monsoon which means that it extends generally from May to October. Table 8 shows mean amounts of precipitation for both Vung Tau (Cap St. Jacques) and Saigon (Tan Son Nhut). As can be seen rainfall is somewhat lighter at Vung Tau than Saigon. Both stations are shown in order to help establish periods of maximum runoff for rivers and streams in the area,

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information which will be of considerable importance in analysis of the ocean and estuarine dynamics of the harbor area discussed later in this report. The data shown indicate two peaks in precipitation during the rainy season: One in early summer (July) and one in the fall (September-October). Precipitation generally occurs as a result of thunder showers or squalls, a number of which were observed during the field study period.

TABLE 8

Mean Monthly Precipitation in Millimeters

	J	F	M	A	M	J	J	A	S	O	N	D	Total
Cap. St. Jacques	2	1	5	31	191	207	215	170	184	216	73	23	1318
Saigon (Tan Son Nhut)	6	13	12	65	196	285	242	277	292	259	122	37	1806

3. Visibility

Knowledge of conditions of visibility is important to the operations of a port and to navigation and is a criterion for judging the suitability of a location for the establishment of a port. Table 9 gives visibility in terms of mean number of days of fog per year at Cap St. Jacques. In general fog is relatively rare at this location. It should be mentioned however, that heavy rains, which are frequent in the rainy season, often obscure local visibility for periods ranging from a few minutes to 2 to 3 hours.

TABLE 9

Visibility - Mean Number of Days with Fog
Cap St. Jacques

J	F	M	A	M	J	J	A	S	O	N	D	Year
0	0	0	0	3	2	1	1	2	2	0	0	11

C. OCEANOGRAPHIC CONDITIONS

1. Sea Level Elevation

a. Astronomical Tide

The tides of Cap St. Jacques are mixed type composed of both diurnal and semidiurnal components. Considerable diurnal inequality exists between heights of successive high and low waters. The tide has pronounced semidiurnal characteristics with considerable inequality, especially in the low tide levels, when the moon is near its maximum north or south declination, and a small inequality when the moon is near the Equator. Figure 4 shows typical hourly variations in the tide curve at Cap St. Jacques. Figure 5 gives a summary of tidal height data for Cap St. Jacques showing the relationship of various tidal levels with the Approximate Lowest Low Water Datum currently in use by the RVN Hydrographic Office and used for nautical charts and tide tables covering the Cap St. Jacques area. It is the datum used for this project.

In order to obtain daily tidal information, a number of sources may be utilized. Chief among these are tidal prediction tables published by various agencies; notably the U.S. Naval Oceanographic Office and the National Ocean Survey Section of the National Oceanic and Atmospheric Administration of the U.S. Dept. of Commerce (formerly the U.S. Coast and Geodetic Survey). In addition two tide gauges are presently being monitored at Vung Tau, one located on the sea side of Cap St. Jacques and one inside the point near the present fishing village. Records may be seen at the RVN Hydrographic Office in Saigon.

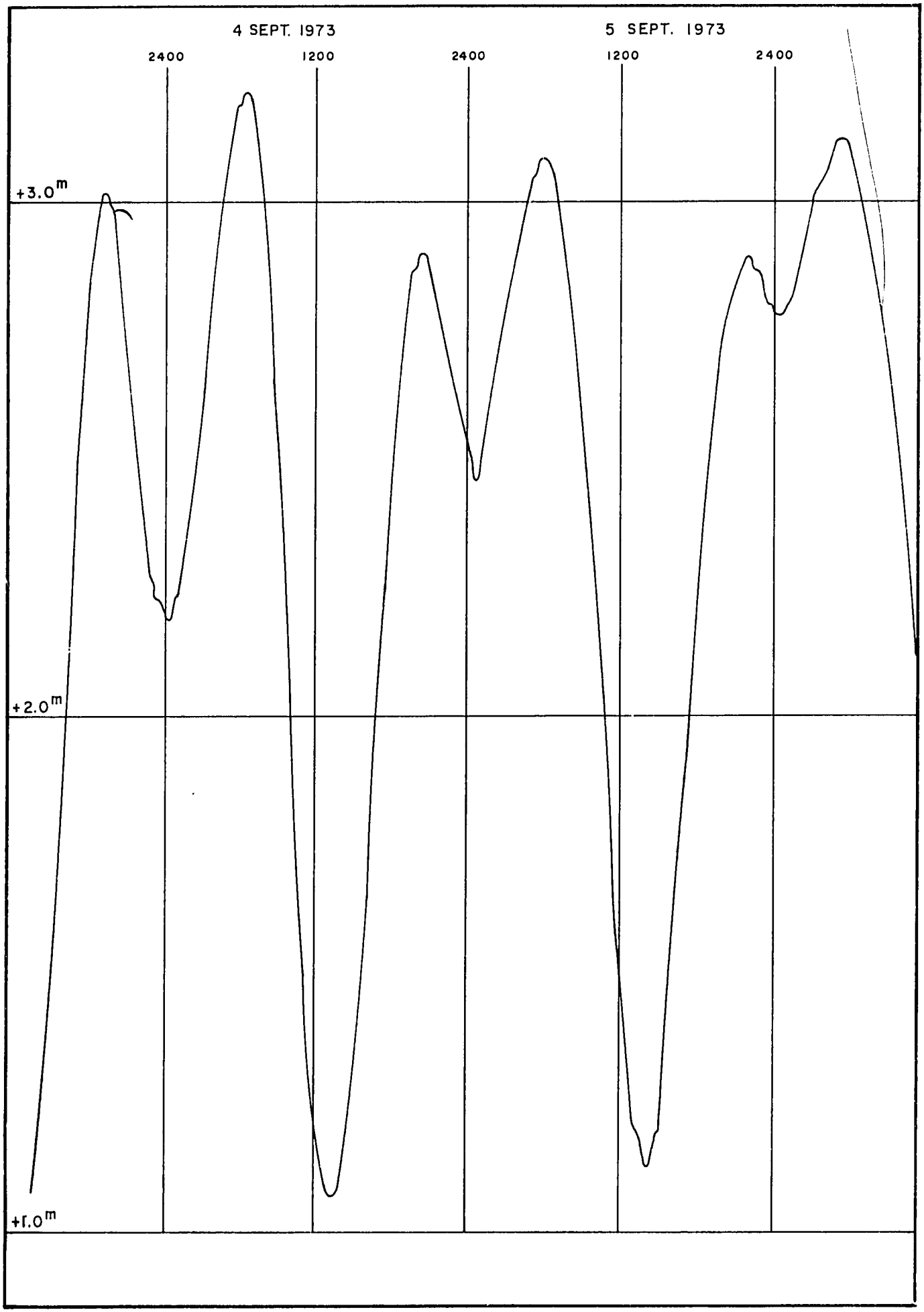


Figure 4 Typical Tidal Curve, Cap St. Jacques
Hình 4 Biểu đồ thủy triều điển hình, Vũng Tàu

NOTES:

1. Approximate Lowest Low Water Hydrographic Datum has been set 0.4 m above Lowest Possible Low Water by the RVN Hydrographic Office.

2. Mean Tide Level is defined as a plane midway between Mean Low Water and Mean High Water and is not the same as Mean Sea Level as determined by the RVN Geodetic Survey.

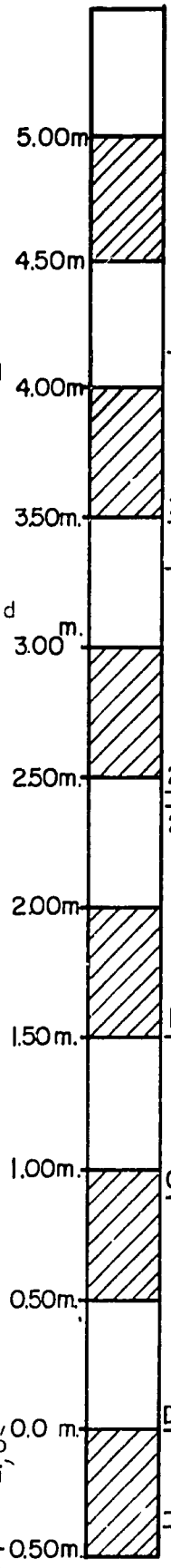
3. Highest High Water is based on 5 years of tide table predictions, not actual records. It is therefore only due to astronomical tides, and there is no meteorological component.

GHI CHÚ:

1. Thủy tính của mực nước thấp nhứt phổng độ được, đặt là 0m,4 trên mức nước thấp nhứt có thể của Sở Thủy-Vận, VNCH.

2. Mức thủy triều trung bình được chỉ rõ như một đường bình diện ở giữa mực nước thấp trung bình và cao trung bình và không giống như mực nước biển trung bình được xác nhận bởi sự trắc lượng địa dư của Việt-Nam.

3. Mực nước cao nhứt được căn cứ vào bảng tiên đoán thủy triều cho 5 năm và không có hồ sơ thật sự hiện tại. Vì thế chỉ nhờ vào thủy triều theo thiên văn học mà thôi và không có phần khí tượng.



4.15m Highest High Water
Mực Nước Cao Nhứt

3.48m. Mean Higher High Water (US Navy Pub # 93)

3.31m Mean High Water (USC + GS Tide Tables)
Mực Nước Cao Hơn Trung Bình
Mực Nước Cao Trung Bình

2.46m. Mean Sea Level (RVN Geodetic Survey)

2.41m. Mean Tide Level (USC + GS Tide Tables)
Mực Nước Biển Trung Bình
Mực Thủy Triều Trung Bình

1.51m. Mean Low Water (USC + GS Tide Tables)
Mực Nước Thấp Trung Bình

0.89m. Mean Lower Low Water (US Navy Pub 93.)
Mực Nước Thấp Trung Bình

DATUM - Approx. Lowest Low Water (RVN Hydro Office)
Dữ Kiện Phổng Chưng - Mực Nước Thấp Nhứt
(Sở Thủy Vận)

-0.40m. Lowest Low Water
Mực Nước Thấp Nhứt

Figure 5 Tide Levels, Cap. St. Jacques, South Vietnam
Hình 5 Mực nước thủy triều, Vũng Tàu, Nam Việt-Nam

b. Design Still Water Level

Still water level is defined as the water level in a no wave or perfect calm condition. The design still water level is the maximum level that the sea can reach. It is important to know the design still water level because this parameter is essential for the calculation of design or maximum waves at the site, it is also important because it will be a governing factor in the setting of the height of structures above datum or the sea bottom.

The maximum still water level is a combination of some selected high astronomical tide level above datum plus the maximum storm surge. Storm tides or surges are associated with major storms which cross the coastline and are caused by a rising of the water level in response to lowered barometric pressure and to wind setup or a forcing of waters up against a shoreline by the stress or drag of wind blowing over the water.

Maximum still water level as a function of probability of occurrence (expressed as return period) is given in Table 10. The astronomical tide height selected was Mean Higher High Water which has been set at 3.48 meters (rounded to 3.5 m) (See Figure 5.). Return periods given in Table 10 represent the combination of the probability of occurrence of storm surge and an astronomical tide level equal to or greater than Mean Higher High Water; that is, the probability that both events will occur at the same time on any given day. For storm surge the probabilities were based on the probabilities of occurrence of storms creating the surge. For astronomical tidal height tide tables over several years were analyzed

in order to determine frequencies of occurrence and durations of high tide levels over a typical year. This investigation involved a determination of coincidence of high tides during the year with seasons of maximum probability of occurrence of design storms. It was found that the greatest frequency of high tide coincided with the late fall and winter seasons. Inspection of Table 5 will reveal that October, November and December have the greatest frequency of typhoons in the project area, thus partially coinciding with a time of maximum frequency of occurrence of high astronomical tides.

TABLE 10

Maximum Still Water Level above Approx. L.L.W. Datum

Return period (Years)	Storm Surge (m)	Astronomical Tide (MHHW) (m)	Total SWL (m)
40	1.2	3.5	4.7
80	1.4	3.5	4.9
200	1.7	3.5	5.2

It should be noted, however, that strong winds associated with the Southwest Monsoon may also occur and this summer period is a time of relatively low astronomical tides. The probabilities shown in the table may therefore be considered to be on the conservative side because they represent conditions during the fall of a typical year which is the season of highest combined probability of occurrence of high astronomical tide and storm tide.

In general values having a return period of 50 years are usually recommended as this return period gives a reasonably low probability of

occurrence for design lives usually assigned to offshore structures. As can be seen from Table 10, there is little difference between still water levels having widely differing return periods. A level of 4.7 meters, having a return period of 40 years, was therefore considered to be adequate for this project and use of this level as a design criterion is therefore recommended.

As can be seen the maximum still water level was obtained by calculating storm surge and adding this to a high level of astronomical tide. It should be noted, however, that storm surge consists of two components: an increase in water height due to reduced barometric pressure and wind setup or the forcing of water up against a straight coastline. Thus because of the large fetch available over the open sea, the maximum still water level could be expected to be associated with winds blowing from the southerly directions at Vung Tau because the maximum wind setup could be realized. Winds blowing from northerly directions, however, could actually act to reduce the tide because they would be blowing offshore. In either case the barometric pressure component would be unaffected.

Reference to Plates 6 to 11 will indicate that in all port layout alternatives, the large vessel handling quays face in a northerly or north easterly direction. The height of water which could be expected against such a quay wall should therefore be analyzed on the basis of the maximum still water level without the wind setup component of the storm surge. The possibility that the offshore winds might actually lower the tide probably should not considered because of the difficulty in estimating

such an effect and to allow a safety margin in the analysis. The resulting still water height was as follows:

Astronomical Tide (MHHW):	3.5 m
Barometric Component of Storm Tide:	0.5 m
TOTAL	4.0 m

This level is below the level of the maximum astronomical tide (4.15 m) which could occur in a typical year so in order to allow for the possible coincidence of storm conditions with periods of high tide, a maximum still water level for winds blowing from the northern quadrants was taken as 4.15 m.

In addition to the above calculations an investigation of actual past observations of tidal and storm tidal heights was undertaken by questioning local residents in the Vung Tau area. It was found that although tide levels during storms were sometimes higher than normal, no serious flooding of the existing commercial port area, which ranges between + 4.0 and 5.0 meters in elevation, had occurred during the past 8 to 10 years, even during storms. This would indicate that the recommended 4.7 meter still water level is probably not unreasonable. It was also noted, however, that high astronomical tidal levels are observed frequently at Vung Tau and that therefore use in design of a maximum still water level less than the highest possible astronomical tide which could be expected in a typical year (i.e. +4.15 m - see Figure 5) is not recommended. This subject is dealt with in regard to specification of heights of structures in Section V. B. 3. of this report.

2. Waves

a. Typical Waves

The typical wave regime at the project site results chiefly from the monsoonal wind system characteristic of the area. Thus waves approach the site from the northeast during the winter months and from the southwest during the summer. During the spring and fall transition periods waves may approach from nearly any direction although calm conditions are most frequent during these periods.

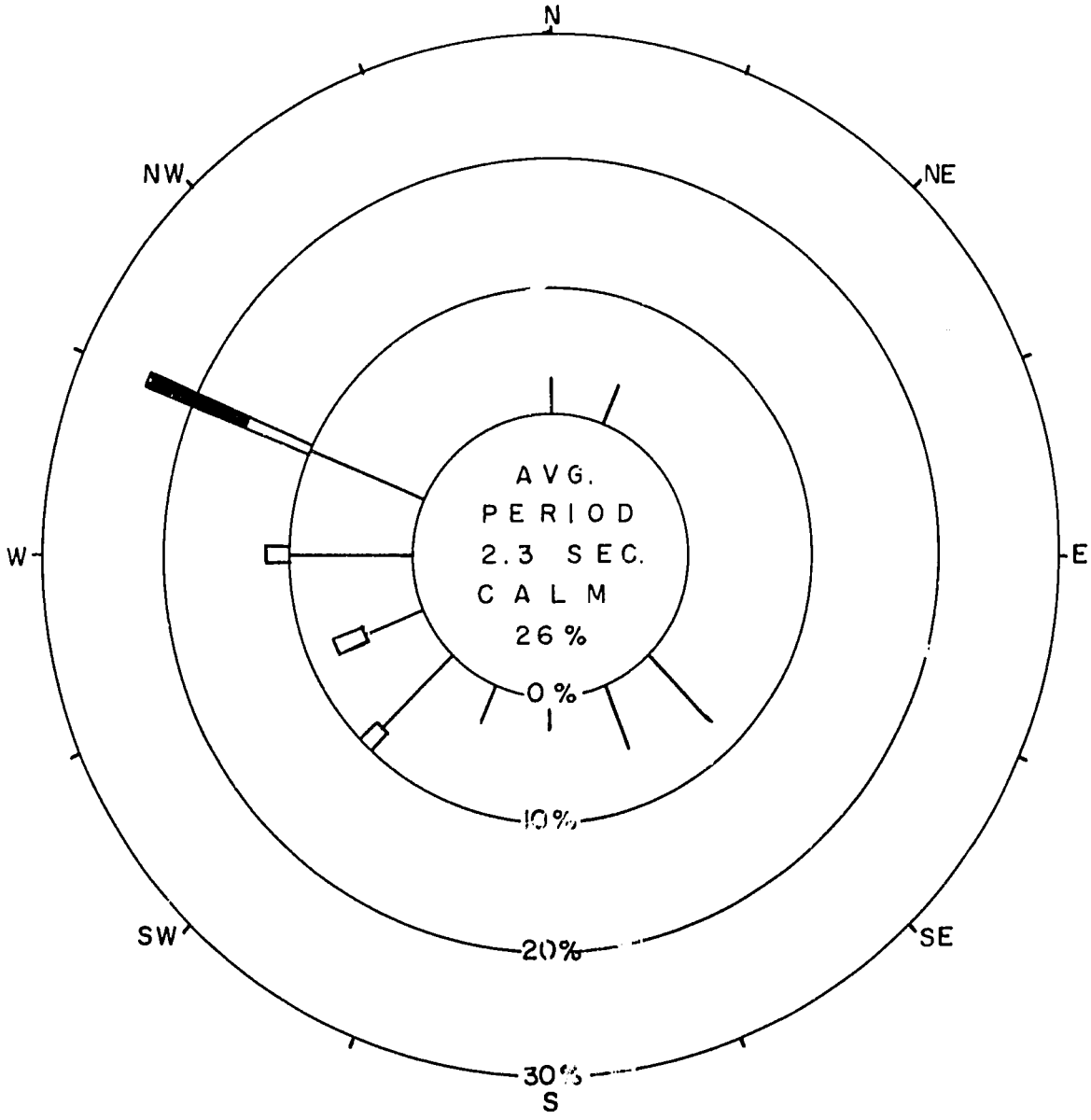
Table 11 summarizes wave conditions at the entrance to the Saigon River. Both sea and swell are given; sea being defined as waves being actively built by winds within the generating area and swell as waves which have been generated outside the area of interest and have left their generating area. As can be seen low sea and swell conditions predominate. The correlation with monsoonal winds is also evident.

Data shown in Table 11 represent several years of observations and are thus best suited to describing typical wave conditions for the project site on a yearly basis. However, the observations were made in an area more exposed to sea and swell action than the proposed port site and are therefore not precisely representative of conditions at the project site. In order to more accurately describe wave conditions at the site and to further understand the relationship between these conditions and those given in Table 11, actual field measurements of wave height were made using wave staffs placed at two locations in the area as shown in Figure 1. Table 12 and Figures 6 and 7 summarize the data taken at these two sites

TYPICAL WAVES
PERCENT FREQUENCY OF OCCURRENCE – HEIGHT AND DIRECTION
SIGNIFICANT WAVES
12 SEPTEMBER TO 14 OCTOBER 1973

PORT OF VUNG TAU, SOUTH VIETNAM

INNER WAVE STAFF (No.1)



NOTES: 1. Direction Frequency: Bars represent percentage frequency of waves observed from each direction.

2. Height Frequency: Length of height category represents percentage frequency of waves observed at that height from the direction indicated

Legend: —— 0 0.1 meters ▬ 0.0 - 0.6 meters
▭ 0.1 - 0.3 meters

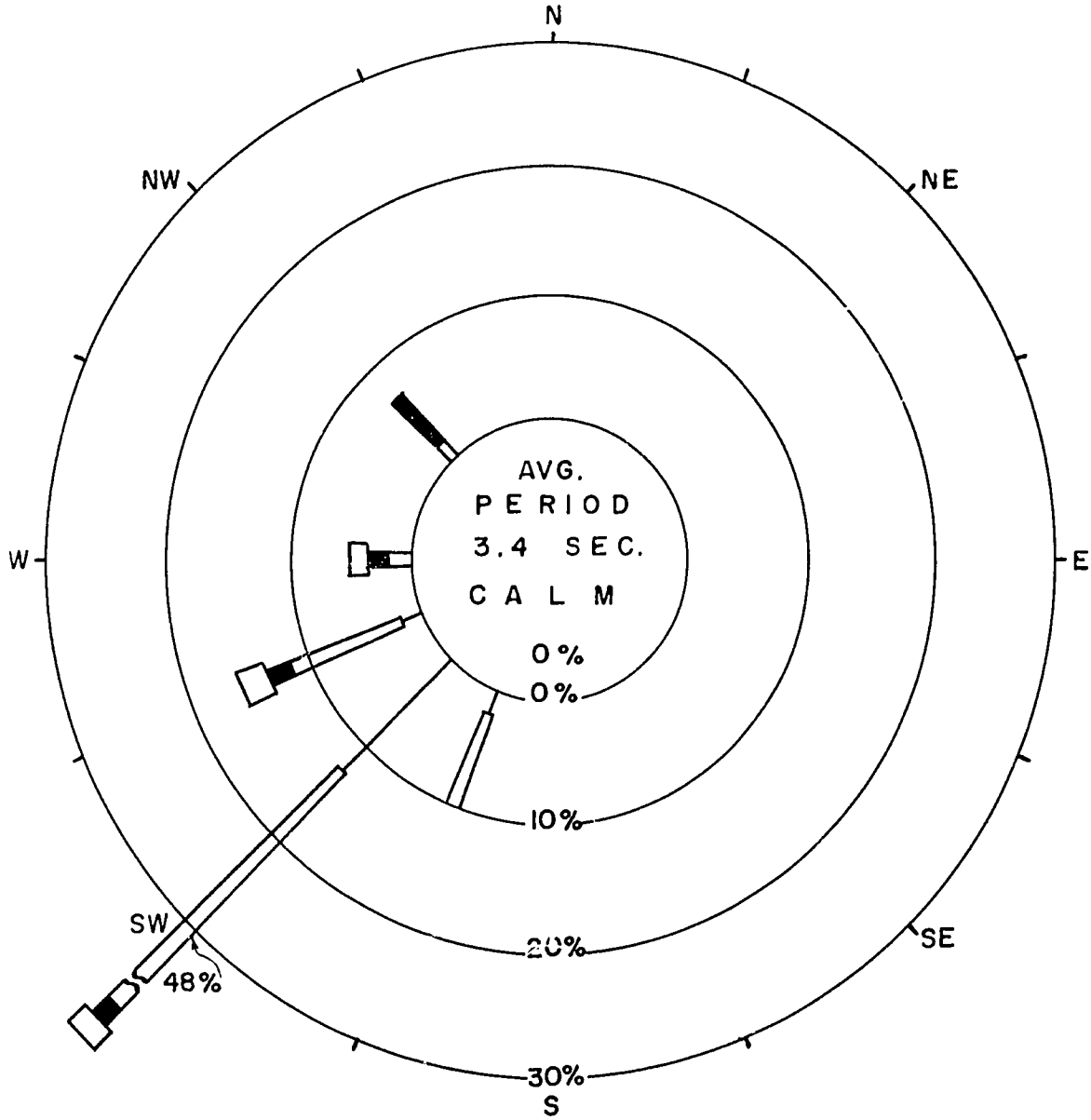
3. Scale: Each circle represents 10%

Figure 6, Typical waves, Inner Wave Staff, Vung Tau, 12 Sept. to 14 Oct. 1973

TYPICAL WAVES
PERCENT FREQUENCY OF OCCURRENCE - HEIGHT AND DIRECTION
SIGNIFICANT WAVES
12 SEPTEMBER TO 14 OCTOBER 1973

PORT OF VUNG TAU, SOUTH VIETNAM

OUTER WAVE STAFF. (No.2)



NOTES: 1. Direction Frequency: Bars represent percentage frequency of waves observed from each direction.

2. Height Frequency: Length of height category represents percentage frequency of waves observed at that height from the direction indicated.

Legend: 0 - 0.1 meter; 0.1 - 0.3 meter; 0.3 - 0.6 meter; Greater than 0.6 meter

3. Scale: Each circle represents 10%

Figure 7, Typical waves, Outer Wave Staff, Vung Tau, 12 Sept. to 14 Oct. 1973

during the 12 September to 14 October 1973 field measurement program. Inspection of Figures 6 and 7 will reveal that winds from the westerly and southwesterly directions predominated during the measurement period which is to be expected since during the period the Southwest Monsoon was in progress. Comparison of the two tables shows that wave heights at the project site were somewhat lower during the measurement period than would be indicated by data shown in Table 11. The reason for this is probably due to the fact that the data in Table 11 are indicative of more exposed waters in the Saigon River entrance area. Wave heights can be expected to be lower in the project area as a result of land sheltering and shallow water effects.

TABLE 11

Percent Frequency of Occurrence of Sea and Swell
Saigon River Entrance
(from H.O. Pub 93, "Sailing Directions, Western Shores of South China Sea")

Direction	Sea 0.3 - 0.9 m	Sea >0.9 m	Swell 0.3 -0.9 m	Swell >0.9 m
WINTER				
NE	9	8	4	29
E	5	1	1	2
SE	2	-	-	-
S	1	-	-	-
SW	-	-	-	-
	Calm (0-0.3M)	47%	Calm (0-0.3M)	64%
SUMMER				
NE	-	-	-	-
E	1	-	1	-
SE	1	-	1	-
S	15	5	5	14
SW	18	15	4	17
	Calm (0-0.3M)	45%	Calm (0-0.3M)	58%

TABLE 12

Percent Frequency of Measured Significant Wave Height
(12 Sept to 14 Oct 1973)

Location and Time	Calm	0-0.1m	0.1-0.3m	0.3-0.6m	>0.6m
Inner Wave Staff (No. 1)					
Morning	42%	42%	10%	6%	0
Afternoon	10%	68%	12%	10%	0
Day	26%	55%	11%	8%	0
Outer Wave Staff (No. 2)					
Morning	0	9%	65%	10%	6%
Afternoon	0	13%	72%	9%	6%
Day	0	16%	68%	10%	6%

In order to compare Northeast Monsoonal conditions with data given in Table 11, spot observations of waves were made at Vung Tau in December and these observations indicated a corresponding reduction of wave height at the project site during this period as a result of short fetches over which the wind could build waves. Furthermore, in applying the data shown in the table to the project site it should be noted that the swell percentages given in the winter section of the table are not accurate inasmuch as they show relatively high percentages of high swell coming from the northeast and east. In fact because the site is protected from open sea waves approaching from these directions, the occurrence of waves from these directions which could be classified as swell is essentially nonexistant.

The conclusion drawn from the analysis of typical wave conditions is that during a typical year wave heights greater than 1.0 meter will occur only a small percentage of the time, say 2 to 4%, at the project site and that in all likelihood these large waves will approach from a southerly to

a southwesterly direction. The 1.0 meter height is important because waves larger than this height generally cause difficulties in such port operations as cargo handling and ship maneuvering and berthing.

It should be noted, however, that if loading, unloading, and berthing of barges and small river and coastal craft is planned at the new port, waves exceeding 0.5 meter could cause difficulties in these operations. The analyses indicate that typical wave conditions generated by the Northeast Monsoon could exceed 0.5 meter as much as 15% of the time and by the Southwest Monsoon as much as 20% of the time at the outer end of the proposed quay area.

Within the harbor area in the vicinity of the proposed commercial fishing port wave heights above 0.5 meter could probably be expected no more than 1 to 3% of the time during the year and would most likely occur during the Southwest Monsoonal period.

b. Design Waves

The design waves for a planned port facility constitute one of the most important design criteria for shoreline structures because waves are capable of exerting tremendous forces on these structures. Design waves are generally considered to be extreme waves which would be generated by a major storm passing through the area of interest.

There are a number of methods for calculating wave heights associated with storm wind speeds. The heights of waves generated in the deep waters of the open ocean are functions of the speed and duration of the generating wind and the fetch or distance over which the wave is being built by

the wind. When a wave train is propagated into or generated over shoal waters, other factors must be taken into account in the calculation of wave height. Shoal waters in terms of waves are defined as those where water depths are approximately equal to 1/2 the wave length. At depths equal to 1/2 the wave length the wave begins to "feel" the bottom which effects certain changes in the characteristics of the wave. In general waves slow in speed, may decrease in height and will generally shorten in length. When a wave encounters bottom depths approximately equal to 1.3 times their height, they become unstable and break, dissipating most of their energy.

Shallow water effects include shoaling, or the peaking up or increase of wave height due to slowing of the wave velocity; refraction or the alteration of wave height in response to bending of the waves due to bottom and shoreline features; bottom friction, resulting in a reduction of wave height, and percolation, also resulting in a reduction of height. In the project area bottom friction, which is of relatively great importance because of the gentle slope and long distance the wave must travel in shoal waters, shoaling, and wave refraction were considered in calculating wave height. Percolation will be negligible as it is only important in relatively steep bottoms composed of coarse grained sediments.

Design wave characteristics are presented in Table 13 as a function of return period. These characteristics were calculated using extreme wind speeds given in Table 6 which were considered to be associated with storms having the height probability of producing extreme wave conditions

in the project area (i.e. tropical storms). Return periods shown in Table 13 correspond to the appropriate wind speeds of Table 6 used to calculate wave characteristics. Table 13 gives the heights of the significant wave (Hs) and the maximum wave (Hmax.). Waves which are generated by a wind are not all equal in height or period. The wave train generated may be thought of as a mixture of waves of many different heights and periods known as the wave spectrum. In order to simplify the design of shoreline structures one or more representative waves are selected from the total wave specturm for use in design analysis. The waves selected depend upon the design technique and the type of structure being designed but the most commonly used wave is the significant wave which, by definition, has a height equal to the average of the highest one-third of the waves of the spectrum. It has been statistically shown that the significant wave is the one most likely to be reported in the logs of shipboard observers as representative of wave conditions in which the ship is sailing, a fact which probably accounts for its wide use. Assuming that the shape of the spectrum is known, all other heights of interest can be calculated from the significant wave. Thus the height of the maximum wave (Hmax.) was calculated using the formula Hmax. = 1.86 Hs which is a simplification of the formula Hmax. $=0.707\ Hs\ \sqrt{Log_e N}$ where N is the number of waves sufficient to define the full spectrum. The simplification is a general one based on the average ocean wave spectrum and is usually a close enough approximation for coastal engineering purposes.

In order to utilize design wave data presented, the location of the structure or facility to be designed must be known so that shallow water

effects adjacent to the structure may be evaluated. Figures 8 and 9 are refraction diagrams for approach directions considered for design waves which show the effect of shoaling water on wave direction. The height of waves arriving at the end points of the wave rays or tracks shown are those given under the heading "Design Wave Hs" in Table 13. The coefficient "K" in the table is a combination of all the shallow water effects described (refraction, shoaling, etc.).

It is interesting to note from Table 13 that the heights of design waves are similar regardless of the direction of approach even though waves generated in the open sea can be expected to be much larger than those generated in the enclosed waters adjacent to the proposed port site. It is obvious from inspection of "K" values given that the shallow water effects imposed upon waves generated at sea come very near to balancing the limitation imposed by the shorter fetch on waves generated within the protected water areas (i.e. from the northern quadrants) adjacent to the port site.

As with maximum still water level, it is usually recommended that storm waves having a return period of 50 years be used. In this case, however, the difference between wave heights of different return periods is small to the point where it is questionable that predictive techniques are accurate enough to insure the validity of the small differences shown. A design significant wave having a height of 1.7 meters and a maximum wave of 3.2 meters are therefore recommended irrespective of approach direction and return period. Selection of design wave period will depend

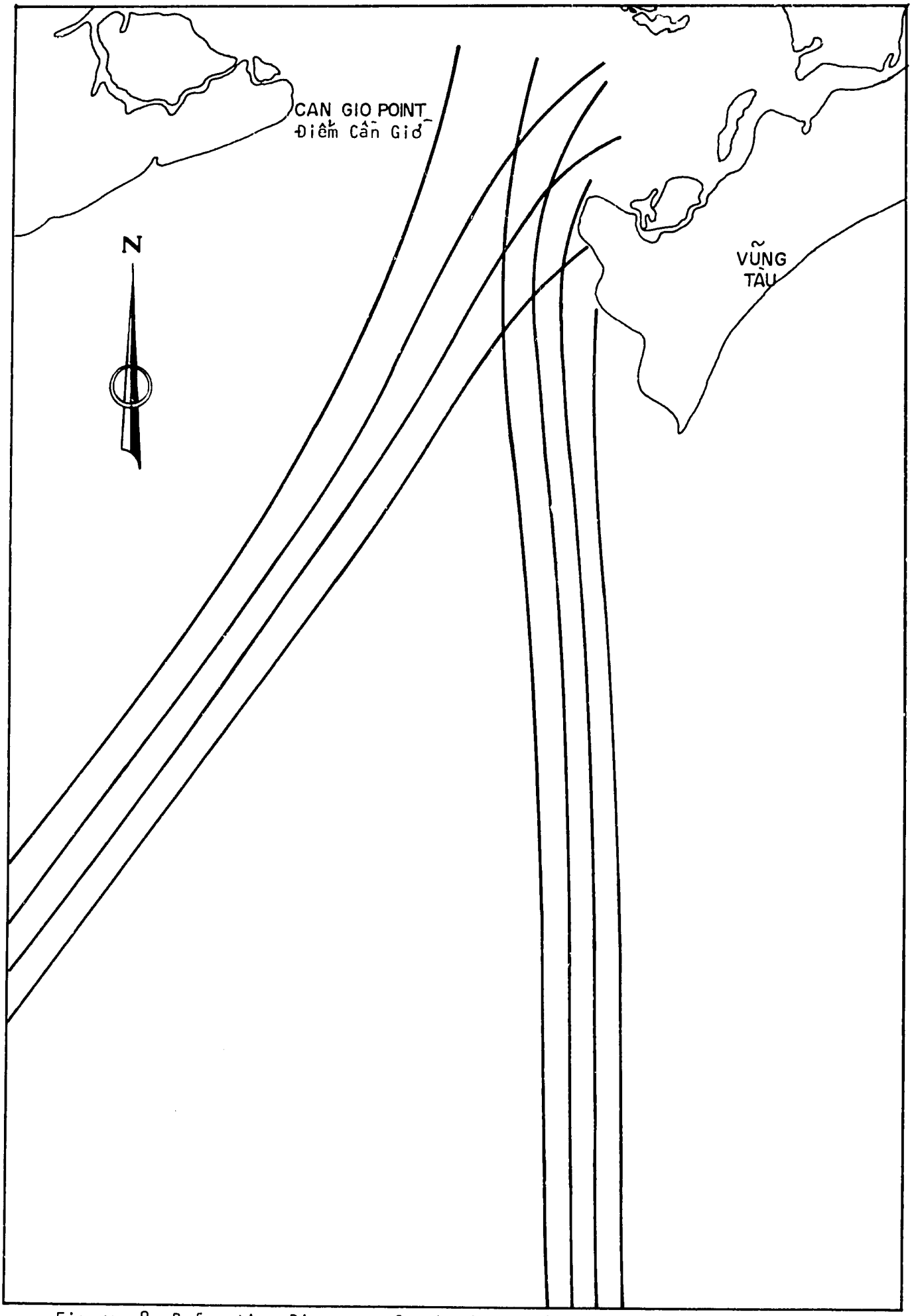


Figure 8 Refraction Diagrams, Southerly and Southwesterly Design Waves.
Hình 8 Lược đồ khúc xạ, các gợn sóng trù tính khoảng từ hướng Nam và Tây Nam.

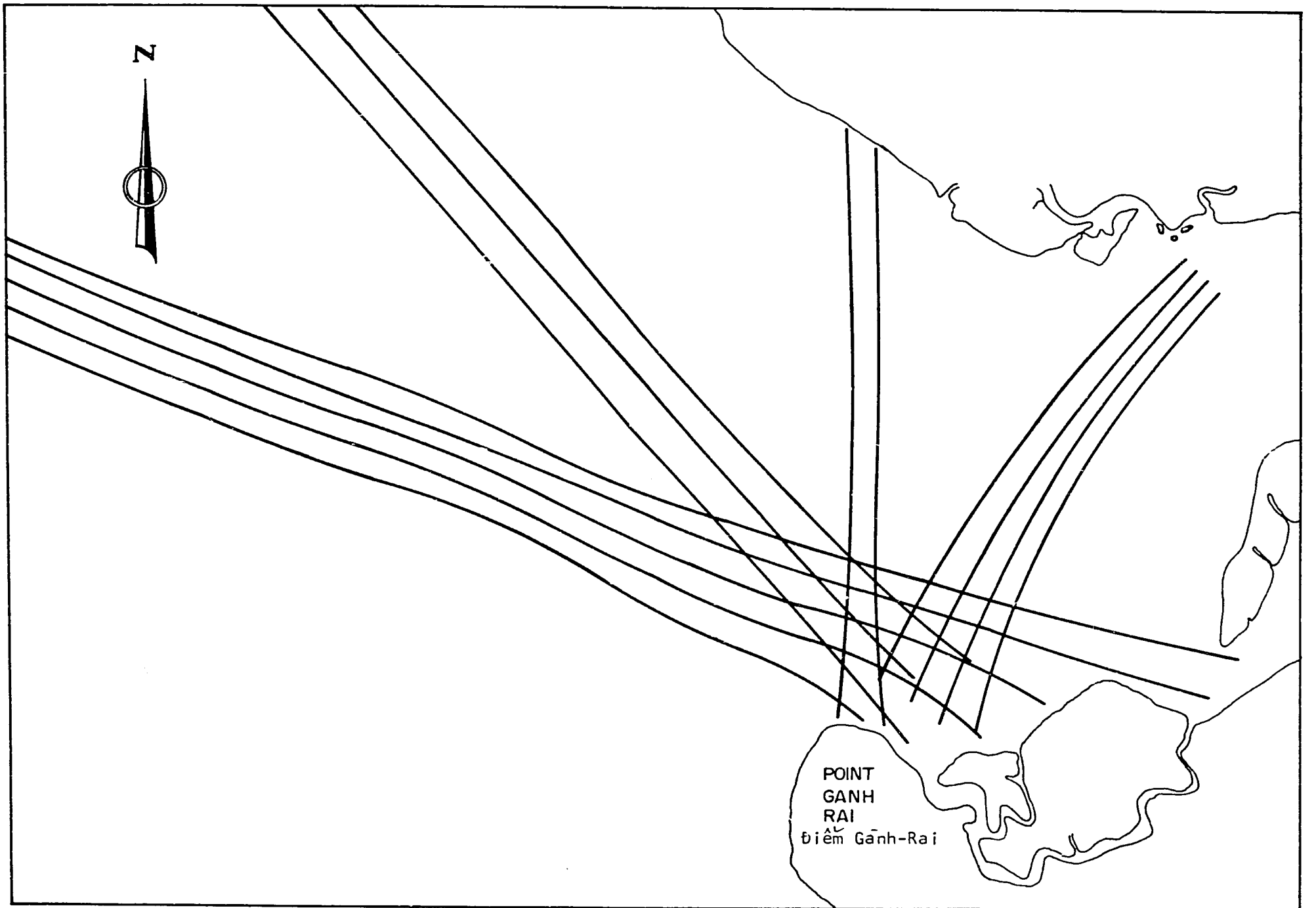


Figure 9 Refraction Diagrams, Northeasterly, Easterly, Northwesterly and West Northwesterly Design Waves.
Hình 9 Lược đồ khúc xạ, các gợn sóng trù tính khoảng từ hướng Đông Bắc, Đông, Tây Bắc và Tây Tây Bắc.

upon the orientation of the structure designed which will determine the direction from which waves impinging on the structure will come. It should be remembered, however, that longer period waves characteristically have higher runup values on sloping structures so if waves from different directions having similar heights but different periods could strike a structure, the longer period wave (Ts = 10.0 seconds) should be selected as design wave.

The design waves calculated for the proposed commercial fishing port are also given in Table 13. Due to protection afforded by surrounding land masses, design waves could only approach from the west northwest and could be generated by storm winds blowing from the northwestern quadrant. A design significant wave height (H_s) of 1.0 meter having a period (Ts) of 4.6 seconds and an associated maximum wave height (Hmax.) of 1.9 meters is recommended.

As previously stated the oceanographic study team was fortunate enough to obtain measurements of wave conditions resulting from storm winds which blew in Vung Tau during the 12 September to 14 October field program. Table 14 gives a summary of maximum wave heights recorded during this period. It was gratifying to note that, after correcting for the lesser wind speeds involved, these maximum conditions coincided well with the conditions which would be predicted by the techniques utilized to arrive at the design wave criteria given in Table 13, thus providing a good check on the methods used.

TABLE 13

Design Wave Data, Vung Tau Port

Return Period (Years)	Deep Water Significant Wave (meters)	Shallow Water Coefficient-K	Design Wave-Hs (m)	Hmax (m)	Wave Period-Ts (sec)
		VUNG TAU COMMERCIAL PORT			
		Southwest Approach Direction			
10	4.9	0.29	1.4	2.6	9.2
25	5.5	0.27	1.5	2.7	9.7
50	6.9	0.25	1.7	3.2	10.5
100	7.6	0.24	1.8	3.3	11.0
		South Approach Direction			
10	4.9	0.27	1.3	2.4	9.2
25	5.5	0.25	1.4	2.6	9.7
50	6.9	0.23	1.6	3.1	10.5
100	7.6	0.22	1.7	3.2	11.0
		Northeast Approach Direction			
10	1.4	0.93	1.3	2.3	3.1
25	1.5	0.93	1.4	2.6	3.3
50	1.8	0.91	1.6	3.1	3.8
100	1.9	0.90	1.7	3.1	4.3
		North Approach Direction			
10	1.6	0.94	1.5	2.7	3.3
25	1.8	0.91	1.6	2.9	3.9
50	2.1	0.86	1.8	3.2	4.5
100	2.2	0.82	1.8	3.4	4.8
		Northwest Approach Direction			
10	1.9	0.53	1.0	1.9	4.3
25	2.2	0.50	1.1	2.0	4.8
50	2.6	0.50	1.3	2.4	5.3
100	2.8	0.49	1.4	2.6	5.6
		VUNG TAU COMMERCIAL FISHING PORT			
		West Northwest Approach Direction			
10	1.9	0.47	0.9	1.7	4.1
25	2.1	0.46	1.0	1.9	4.6
50	2.6	0.44	1.1	2.0	5.0
100	2.9	0.43	1.2	2.2	5.3

TABLE 14

Maximum Wave Heights Measured
12 September - 14 October 1973

Location	Date	Time	Wave Ht (Hmax)m	Period (sec.)	Approach Direction(°)	Wind Speed (m/sec)	Wind Direction (°)
Inner Staff	9 Oct	Morning	0.5	6.0	298	7	270
(No. 1)	9 Oct	Afternoon	0.6	6.0	292	7	310
Outer Staff	7 Oct	Morning	0.9	7.0	230	12	260
(No. 2)	9 Oct	Afternoon	0.9	9.0	274	9	270

c. Seiche

If the surface of an enclosed body of water such as a harbor is disturbed, standing waves may be set up which will oscillate rhythmically with a period which depends on the size and depth of the basin. These standing waves are called seiches and they are a fairly common phenomenon, but, because of their characteristically low height, they are often overlooked.

Seiches can be troublesome in two respects. First, long period bay seiches may tend to cause strong reversing currents in harbor basins which can be dangerous to ships underway while entering or leaving the port or to moored vessels. Secondly, the shorter period seiching can adversely affect moored shipping by inducing motion of ships as oscillators under the nonlinear elastic restraint of their mooring lines.

Seiches may be caused by single impulses, which set the waters of a basin oscillating, or by a periodic phenomenon, such as waves or astronomical tide. The latter are of far greater importance than the former in the design of ports because of the possibility of resonance of the

periodic phenomenon with one of the natural periods of oscillation of the water body. Should such resonance occur, seiches of large magnitude in height and current velocity may result which could severely interfere with harbor operations. Most adverse effects due to seiches occur in the period band between 20 seconds and two minutes because basins with natural periods within this band are highly susceptible to resonant seiching.

It has been reported by an earlier study that seiching was present in the port area being considered by this project, the seiching having been noted on tide gauge records made in the Vung Tau area. A study of seiching was therefore made of the port area. A study of tide gauge records revealed that evidence of seiching is inconclusive at best. Given the fact that harbor seiching is fairly common, however, it can be said that if seiching exists, it is almost certainly caused by a single impulse forcing mechanism, such as a storm, rather than a periodic one, such as the tide or waves. Due to this factor and to the fact that the geometry of the basin with its energy absorbing boundaries does not favor seiching, it was concluded that the chance of resonant seiching is extremely remote. It is unlikely, in fact, that detection of seiching by the casual observer would be possible.

In addition to overall harbor seiching consideration of seiching within the breakwater enclosed barge and coastal vessel basin of the Alternative Port Layout Concept No. 3 (see Plates 10+11) was also undertaken. Such an analysis was carried out by first calculating the natural

period of oscillation of the basin and comparing this with periodic forcing mechanisms, such as waves and tide, which might produce a resonant condition within the basin.

Calculated natural periods are as follows:

Basin Length -	High Tide:	8.8 minutes
	Low Tide:	11.5 minutes
Basin Width -	High Tide:	26 seconds
	Low Tide:	33 seconds

As can be seen the natural period of the basin length is such that even in the higher harmonics, resonance from waves or tide would be unlikely. The basin width, however, has a period low enough to be within the danger zone. However, it is felt that because of the highly energy absorptive surface presented by the rubble mound breakwater and the general orientation of the basin with respect to incident waves, seiching in either direction would be unlikely.

It should be noted that the above analysis assumes closed type construction for the quay. If open construction is used, there would be no enclosure of the basin and seiching need not be considered.

d. Reflected Waves

The reflection of sea wave energy from vertical walls in the harbor is an important consideration because of the exposure of quay walls in the proposed alternative port plans to wave energy at certain times of the year. When waves encounter a vertical wall they are reflected

in such a way that standing waves in which incident waves are combined with reflected waves may be formed. In such a case the wave peaks of the two wave trains would be additive and the troughs subtractive with the result that the resulting standing wave would be twice the height of the incident wave. In most cases such a condition would probably not seriously hamper the handling or loading and unloading of large ships. However, small vessels, lighters, and barges might encounter difficulties.

This consideration was one of the major ones in the laying out of the third alternative port scheme as the enclosed barge basin would provide good protection for small craft. Incident waves entering this basin would encounter only the rubble mound breakwater which would absorb vertually all the wave energy. Wave reflection in this basin will be minimal.

3. Currents

a. General Circulation - South China Sea

The general current circulation of the South China Sea is affected to a small degree by the great current systems of the Pacific a and Indian oceans but it consists mainly of flows generated by the monsoonal winds characteristic of the area. The general current regime, then, is seasonal in nature and it responds quite closely to the changes in the monsoonal wind pattern during the year.

As might be expected currents are generally strongest and steadiest in winter under the influence of the Northeast Monsoon and weakest and

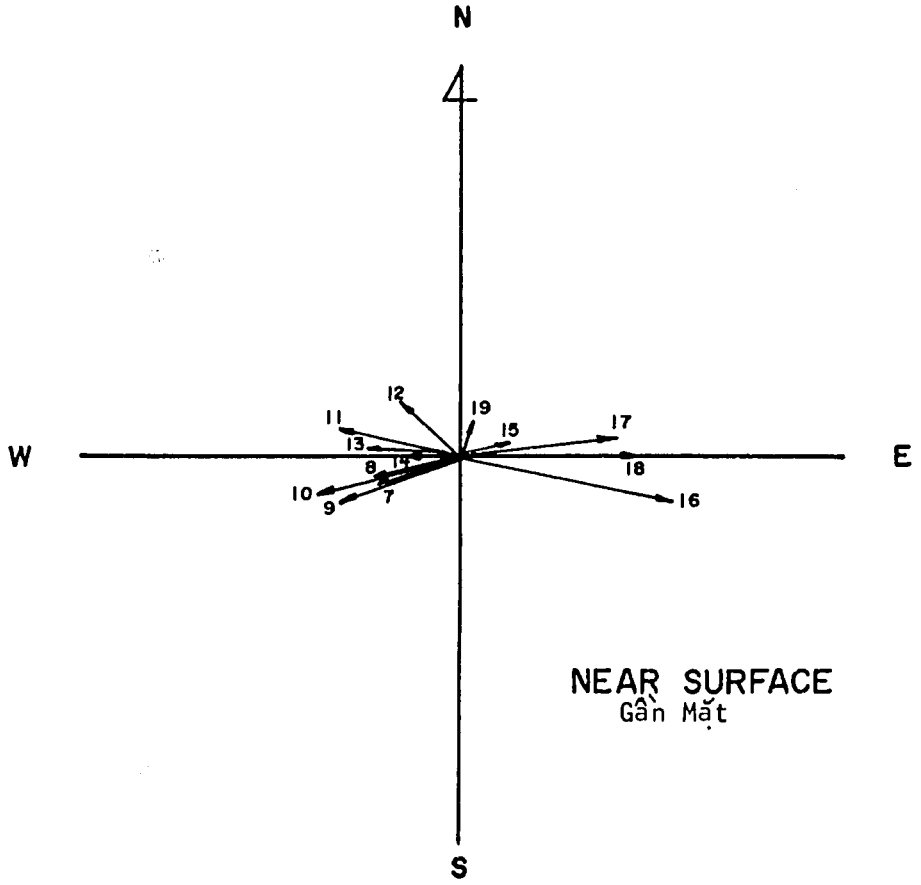
most variable during the spring and fall transition periods. The currents flowing during the Southwest Monsoon are steadier and stronger than those of the transition periods but are not as strong as those of the Northeast Monsoon. In general these currents tend to parallel the coast within a few miles of shore.

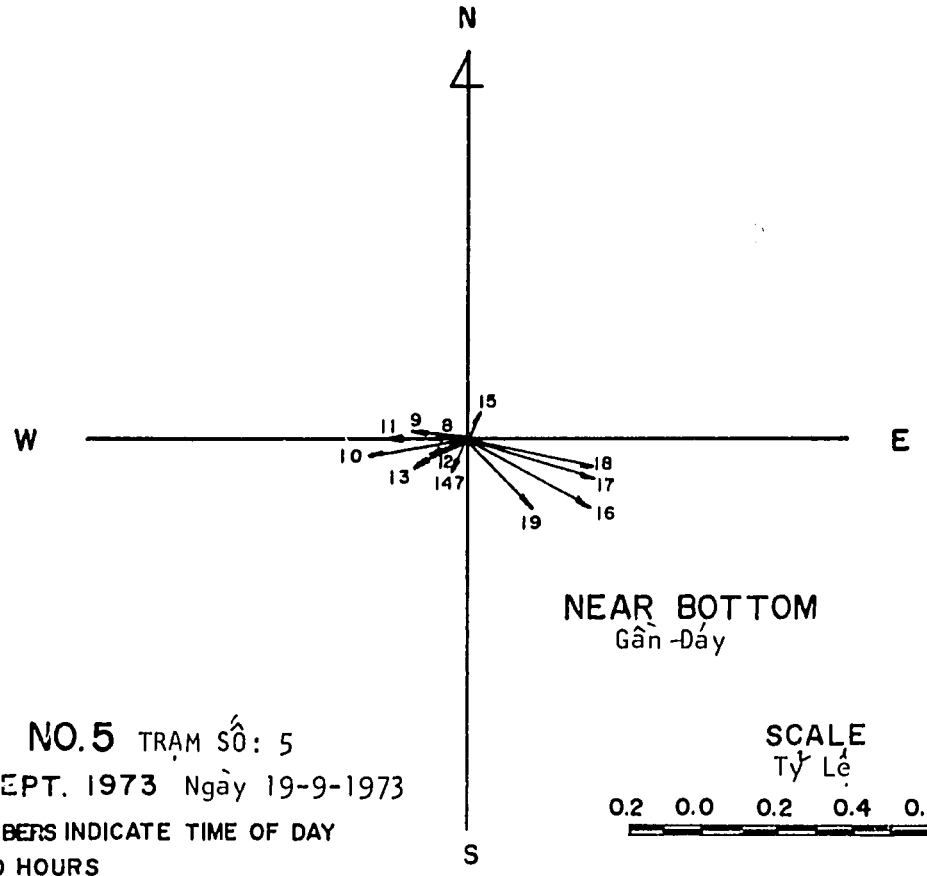
b. Currents in the Project Area

The current regime in the project area results chiefly from tidal forces with contributions from the outflow of rivers emptying into the area. In order to better understand the hydrodynamics of the region a field study of currents was made. The study consisted of occupying each of a number of stations over a 12 to 13 hours period, the period of a tidal cycle, and taking hourly measurements of current direction and speed at two vertical positions; i.e. near the water surface and near the bottom. At the same time measurements of salinity (chlorinity) of the water near surface and near bottom were made and samples of bottom sediment were obtained.

Vector plots were made showing hourly current speed and direction at near surface and near bottom position at each station. Figures 10 and 11 show examples of typical vector plots at Stations 5 and 10. Figures 12 and 13 show simplified versions of these plots for all stations in which only maximum velocities are shown. These figures serve to show the general characteristics of the current flow in the area.

It will be noted that in general current velocities are greater at the surface than near the bottom in the area. This is to be expected in





STATION NO.5 TRẠM SỐ: 5

DATE 19 SEPT. 1973 Ngày 19-9-1973

VECTOR NUMBERS INDICATE TIME OF DAY

IE. 12 = 1200 HOURS

Số Vec-tơ chỉ thời gian của ngày

Thí-dụ 12 = 12 giờ

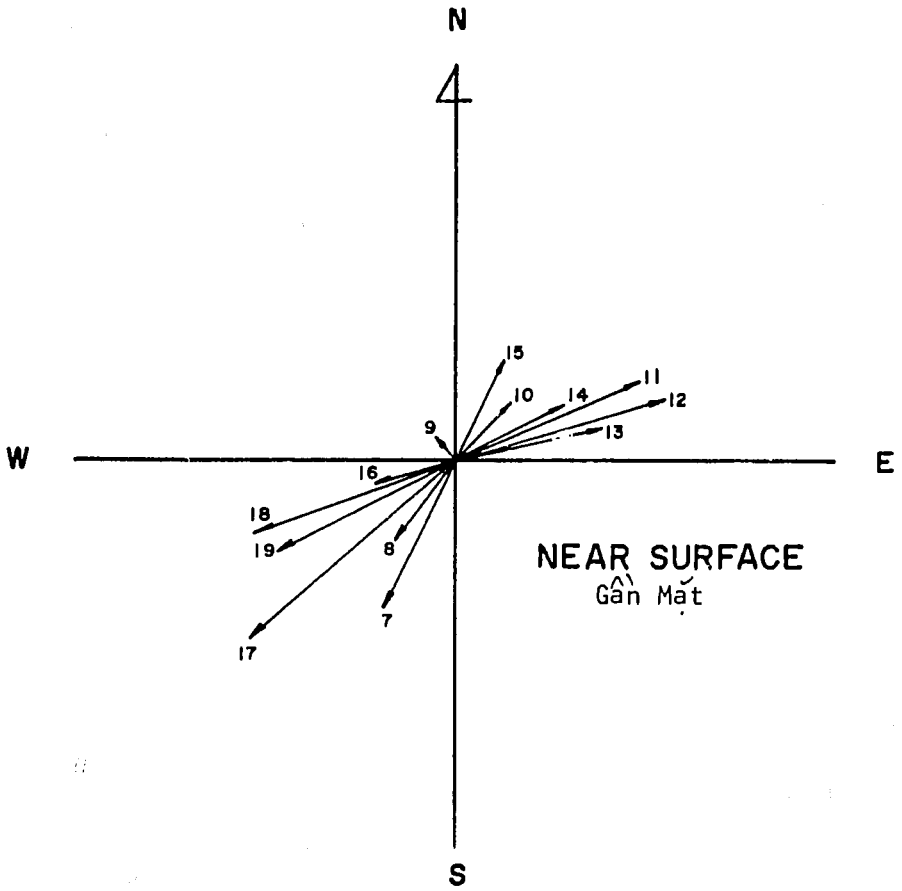
SCALE

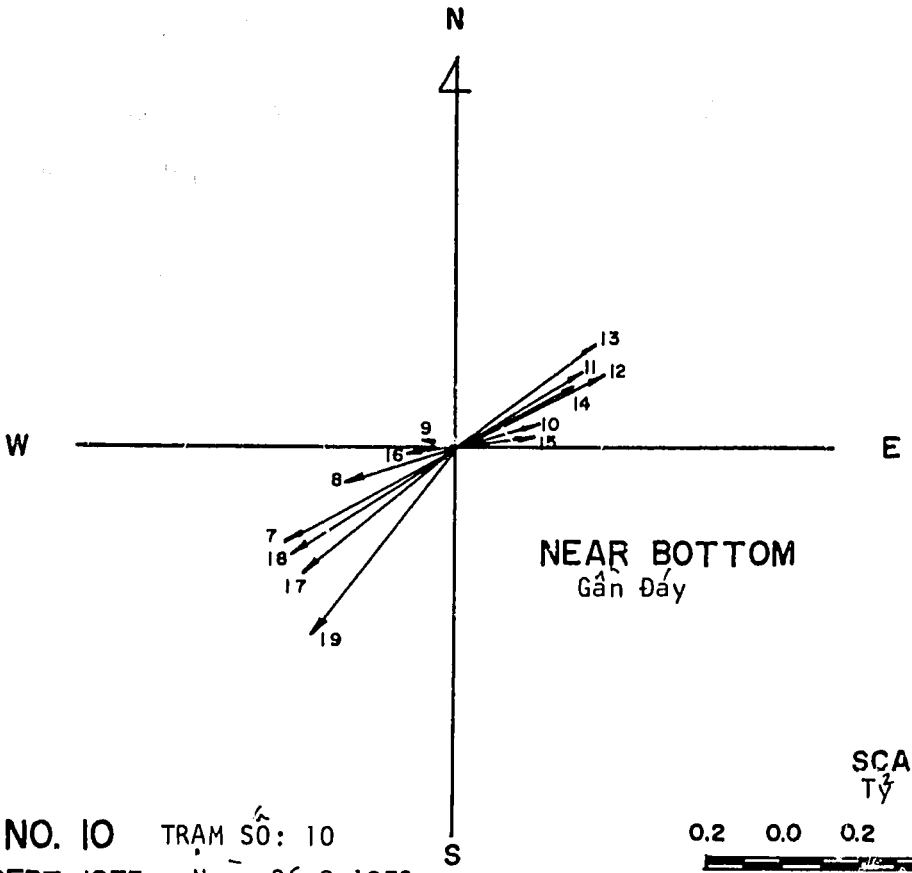
Tỷ Lệ

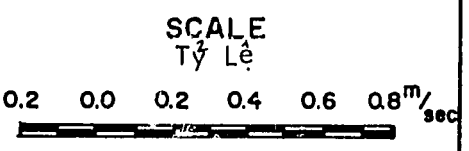
0.2 0.0 0.2 0.4 0.6 0.8 m/sec

Figure 10 Typical Current Velocity Vector Plot, Station No. 5, Vung Tau Port

Hình 10 Phát hoạ Vec-tơ của Tốc-độ dòng nước điển hình, Trạm số 5, Hải Cảng Vũng Tàu







STATION NO. 10 TRẠM SỐ: 10

DATE 26 SEPT. 1973 Ngày 26-9-1973

VECTOR NUMBERS INDICATE TIME OF DAY Số Vec-tơ chỉ thời gian của ngày

IE. 12 = 1200 HOURS Thí dụ 12 = 12 giờ

Figure 11 Typical Current Velocity Vector Plot, Station No. 10, Vung Tau Port
Hình 11 Phát họa Vec-tơ của tốc-độ dòng nước điển hình, Trạm Số 10, Hải Cảng V. Tàu

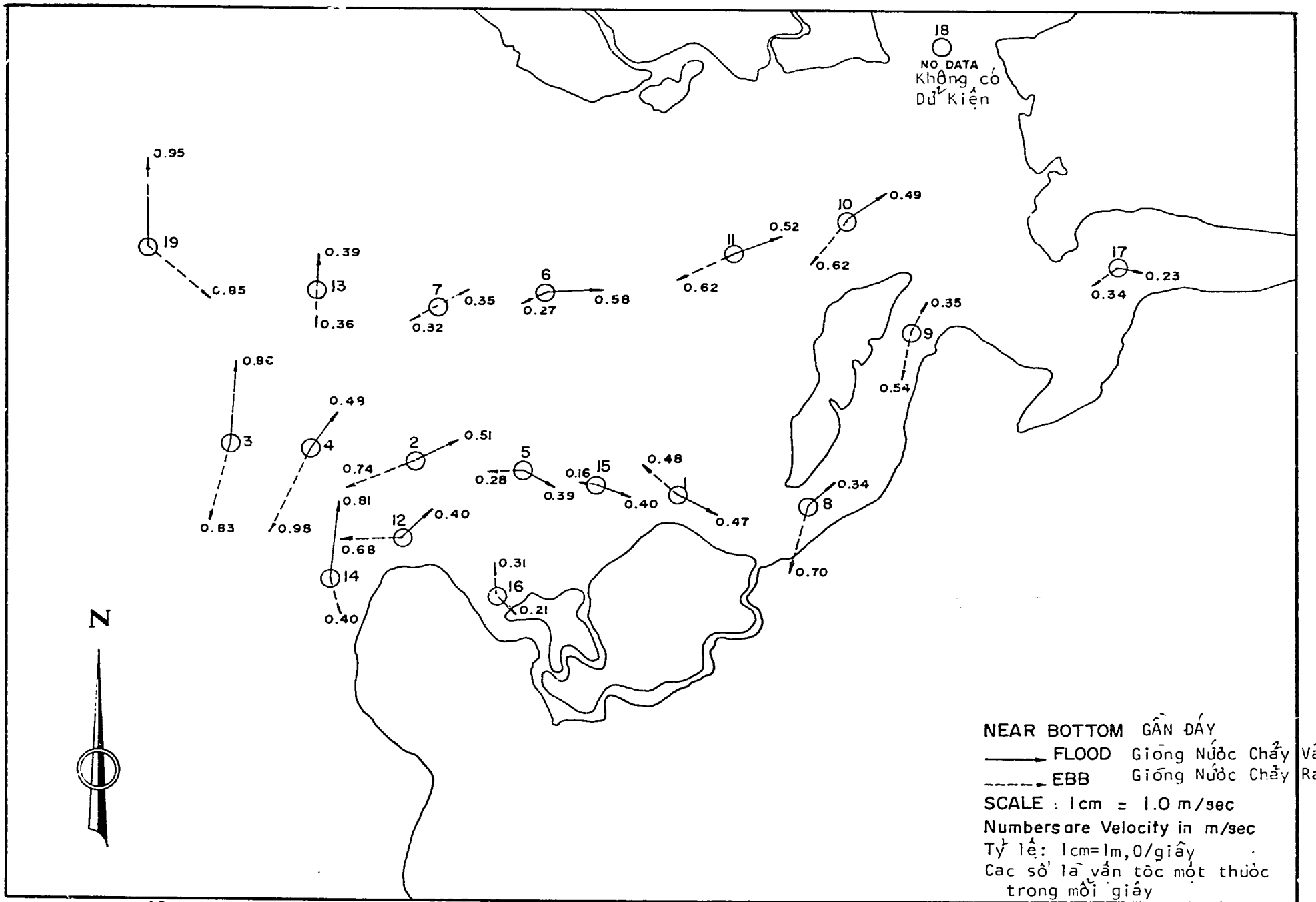


Figure 12 Maximum Sustained Current Direction and Speed, VUNG TAU PORT, 13 Sept. - 14 Oct. 1973
Hình 12 Tốc-độ và chiều nước chảy tối đa được duy-trì, Hải Cảng Vũng Tàu, thời gian từ 13 thang 9 đến 14 thang 10, 1973

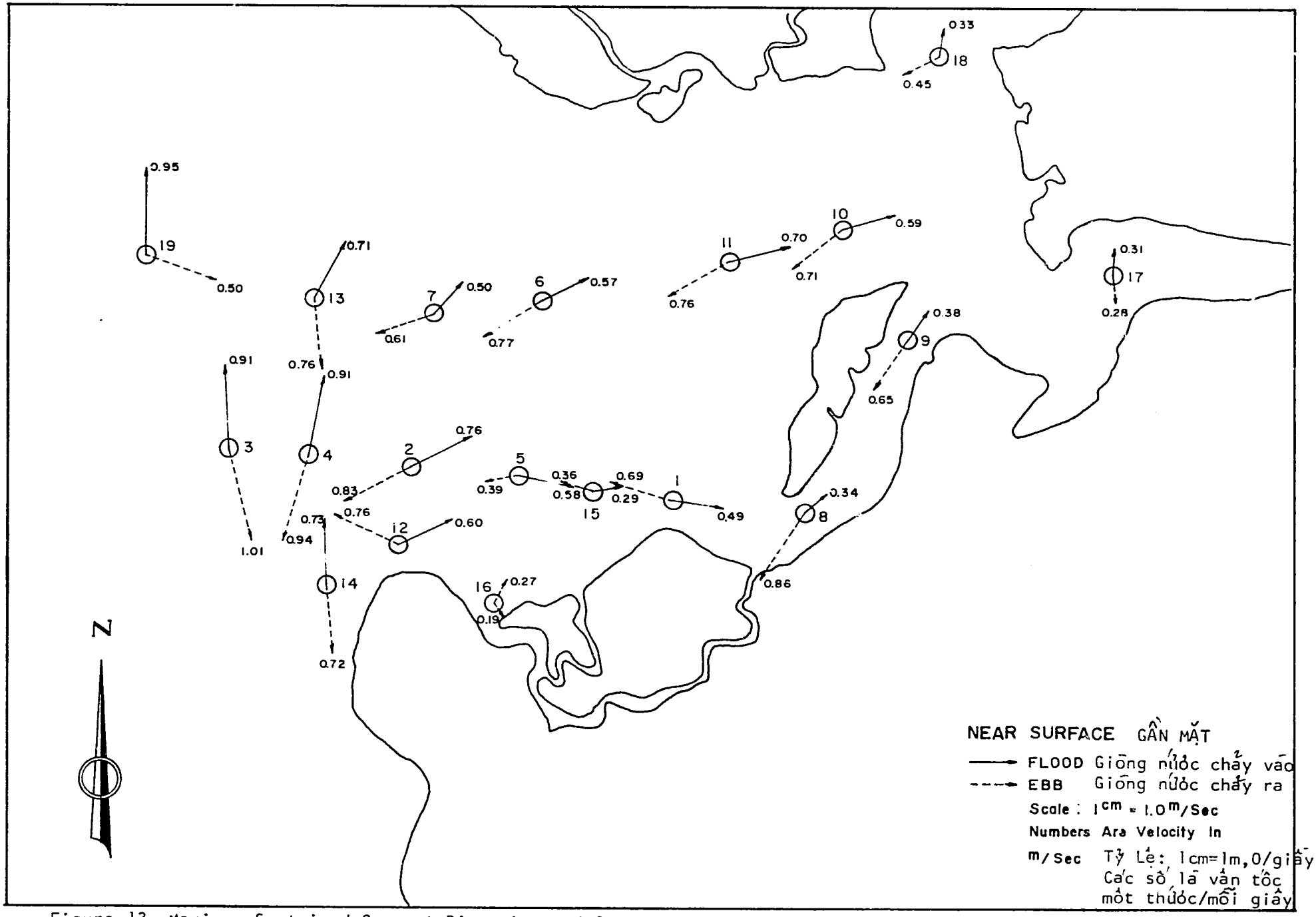


Figure 13 Maximum Sustained Current Direction and Speed, VUNG TAU PORT, 13 Sept. - 14 Oct. 1973

Hình 13 Tốc-độ và chiều nước chảy tối đa được duy-trì, Hải Cảng Vũng Tàu, thời gian từ 13 tháng 9 đến 14 thg. 10, 1973

view of the effect of bottom friction on water flow. It is also evident that near the water surface ebb flows are stronger than floods because of river freshwater runoff. This runoff is particularly strong at the time of the year that measurements were taken because of the generally large amounts of precipitation characteristic of the time. The time of maximum river flow will conform fairly closely to the seasons of maximum precipitation because the river systems drain lowlands on which the precipitation falls. During dry seasons flows will be considerably reduced and tidal forces will dominate the flow patterns in the area. Because the lower density fresh water will tend to remain near the surface, the dominance of ebb over flood flows near the bottom is not nearly so prevalent and at many stations the opposite is true with flood flow being greater than ebb. The reasons for this particular condition will be dealt with in more detail in the sedimentation and hydrodynamics section of this report. In general, however, it can be said that where turbulent mixing within the water column is strong, ebb flow at both surface and bottom will be greater than flood flow. Where salt wedging occurs there will be a net movement of saline bottom water upstream in certain areas and flood velocities might therefore be expected to be greater than ebb velocities. This condition appears to prevail in the vicinity of Station 1 and at Stations 6 and 7 (see Figure 1). This fact has important significance in harbor sedimentation and will be discussed at length in Section C. 5.

The figures also show two rather distinct flow regimes in the harbor area; a general east-west flow in and out of the proposed harbor area and

north-south flow in the fairway to the west in Ganh Rai Bay. Currents in the north-south direction are quite strong and a strong cross current where north-south and east-west currents meet has been reported near the entrance to the existing channel serving the Vung Tau Port area. The strongest currents measured during the field program were of the order of 1 meter per second or about 2 knots. Although such currents are not expected to adversely affect shipping entering or leaving the proposed port area or berthing therein, ship captains and pilots should exercise caution during periods of high current speed.

c. Design Maximum Currents

The maximum current conditions will occur when tidal and river currents are at a maximum and at a time when storm winds may generate an additional current. The worst case will be if all three currents coincide in direction which would probably mean in a southerly or westerly (ebb current) direction. The most probable time of the year for highest current velocities would be the fall inasmuch as maximum tidal ranges occur in late fall and winter, river flows are at a maximum during the October rains, and the probability of occurrence of tropical storms is highest at that time. Assuming approximately 0.5 m/sec (about 1 knot) storm wind generated current, a maximum current of about 2 m/sec could occur in the project area assuming all forces coincided in direction.

4. Salinity and Temperature

The vertical salinity and temperature profile in a harbor area into which fresh water flow enters can be an extremely useful tool in understanding the dynamics of the area. Measurements of chlorinity of

the water were made at each station near the bottom and near the surface of the water at two hour intervals. Measurement of water temperature was similarly made at some stations. Determination of salinity was made by the old fashioned but effective titration of water samples which actually gives determination of chlorinity, rather than salinity. Chlorinity is related to salinity by a constant value in the ocean and because relative concentrations in the vertical water column were of interest rather than absolute values of salinity, conversion to salinity was not made in the plots of salinity versus depth which were prepared for each station. Figures 14 and 15 are examples of typical plots of chlorinity as related to depth of sample, time and tidal phase at two stations.

At all stations salinity (chlorinity) was found to be higher in bottom waters than in surface waters over the full tidal cycle measured. This situation is not unusual in that less dense fresh water tends to remain near the surface. It indicates that turbulent mixing of the waters is not complete, a factor which will be given greater attention later in this report. It was also noted that in some stations the rate of change of chlorinity of bottom waters was greater than the rate of change for surface waters during the flood tide. This factor was particularly noticeable at Stations 1, 15 and 5 (see Figure 1) and Stations 6 and 7. This situation may be indicative of a net upstream movement of bottom waters in these regions during the tidal cycle, a factor of importance in the prediction of harbor sedimentation characteristics. This problem will be dealt with more fully in the following section.

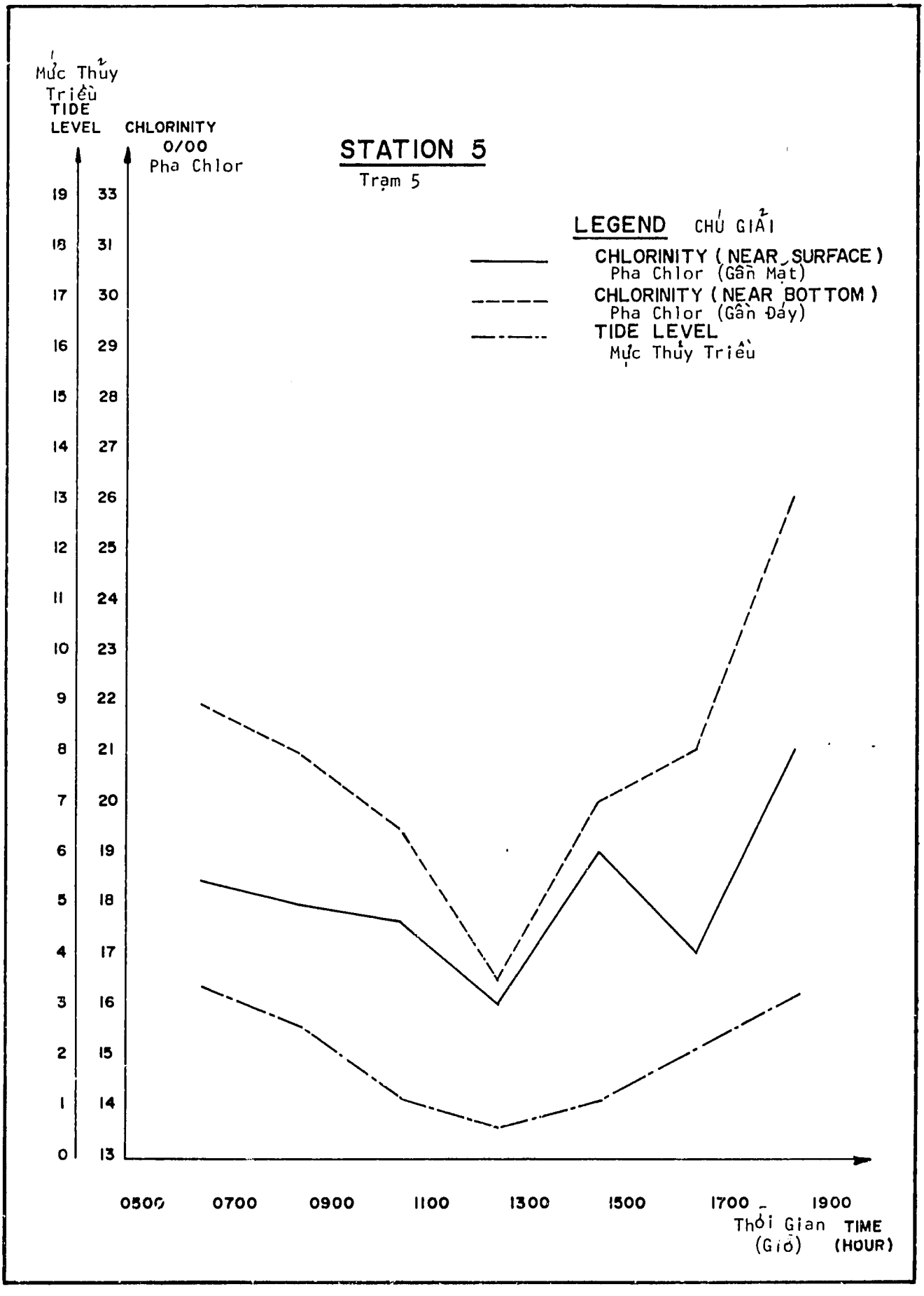
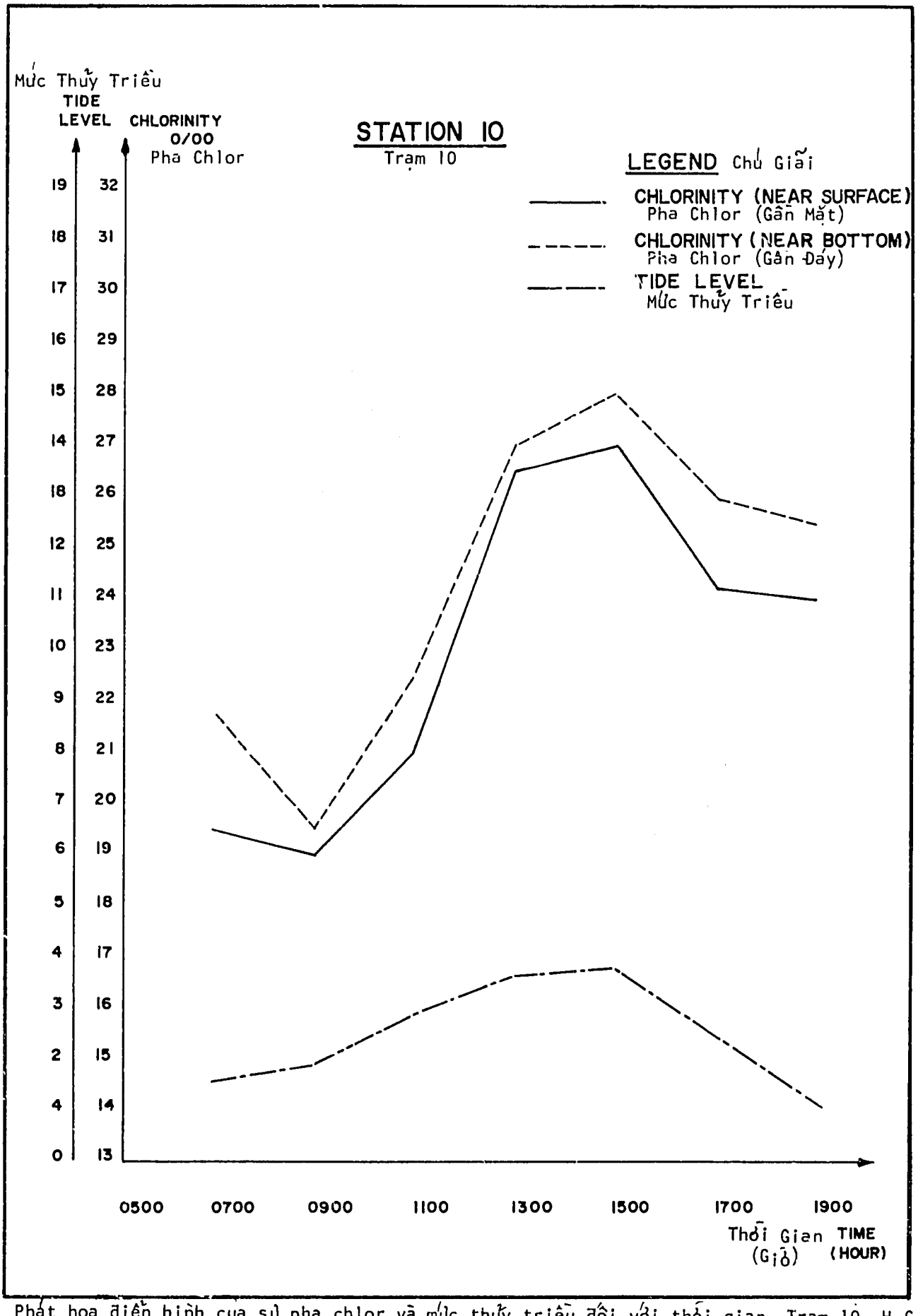


Figure 14 Typical Plot of Chlorinity and Tide Level Vs. Time, Station 5, Vung Tau Port
Hình 14, Phát họa điển hình của sự pha chlor và nước thủy triều đối với thời gian, Trạm #5, H.C.V.Ta



Hình 15, Phát họa điển hình của sự pha chlor và mức thủy triều đối với thời gian, Trạm 10, H.C.V.T

Figure 15, Typical Plot of Chlorinity and Tide Level Vs. Time, Station 10, Vung Tau Port

5. Sedimentation and Regional Hydrodynamics

a. Hydrodynamic Considerations

Recent research in the hydrodynamics of estuaries has shown that sedimentation in estuarine harbors, channels and other waterways is closely related to both fresh water and tidal flow and to salinity patterns within the estuary. Because the proposed port facilities at Vung Tau are located within an estuarine system, it was thought that a study of the hydrodynamics of the port area might give insight into the characteristics of sedimentation in the area and enable a more valid prediction of sedimentation to be made for the proposed channel and turning basin. The study consisted of a field program, previously described, which features measurement of currents and salinity near the water surface and near the bottom over a full twelve hour tidal cycle at 19 sites in the proposed port region (see Figure 1, Index Map). The field data were analyzed to outline the flow pattern of waters in the area.

The primary components of water flow in an estuary are tidal flow and fresh water river flow. These two flows combine to form the characteristic dynamical pattern ofthe estuary. Basically three types of flow patterns can occur. The first is stratified flow in which the relatively dense saline ocean water flows in with the tide near the bottom and fresh water flows out of the estuary on top of this saline water. In a highly stratified estuary a definite boundary exists between the lower saline waters and the upper fresh waters and little mixing between the two layers occurs. This situation gives rise to the so called "salt wedge" which

moves into and out of an estuary or river with the tide. This particular pattern is found in estuaries in which the tidal range and strength of tidal flow is relatively small and fresh water runoff is high.

The second type of estuarine pattern is the well mixed flow type in which turbulence is high resulting in a mixture of tidal saline waters with the outflowing fresh water. In this type no boundary between fresh and saline waters exists in the vertical profile and salinity is uniform from surface to bottom. This type of pattern is characteristic of estuaries in which fresh water runoff is low and tidal range and flow is high, thus causing high turbulence.

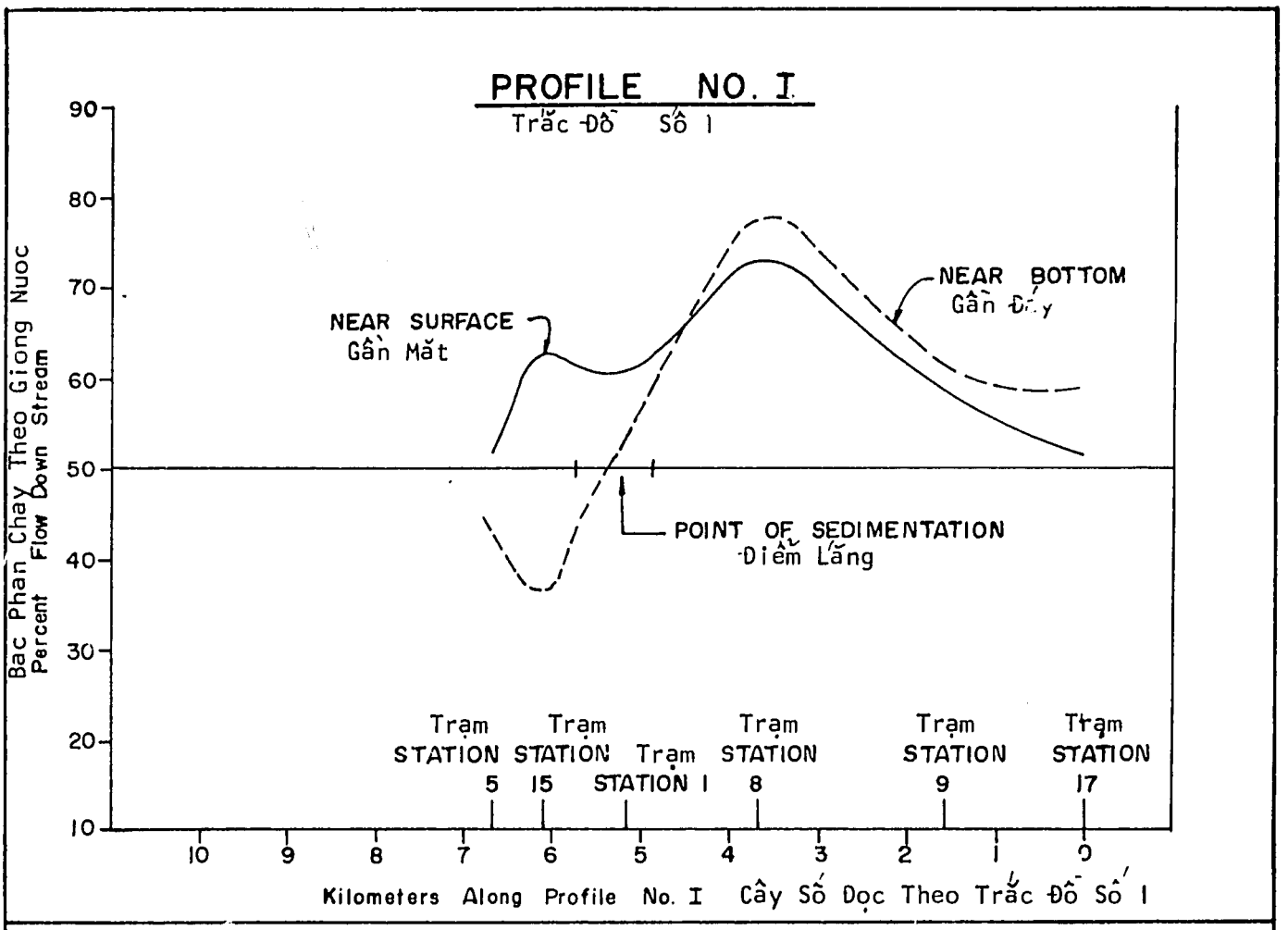
The third type of estuary is a partially mixed type which exhibits conditions characteristic of both of the types described above. In a partially mixed estuary a boundary between fresh and salt waters exists but it is a weak boundary which can better be described as a fairly sharp gradient in the vertical profile between lower salt water and upper fresh water.

In general all types of estuary are characterized by a net inflow of waters near the bottom and a net outflow of water near the surface. In order to satisfy equilibrium conditions there must be a vertical movement of bottom waters toward the surface along the estuary. Thus the net upstream flow of bottom waters decreases gradually in an upstream direction so that at some point the net upstream movement is zero and the same amount of bottom water moves upstream as moves downstream with the oscillation of the tide. Intuitively it is evident that sediment suspended

in the waters near the bottom of the estuary or transported as a bedload in the region of no net movement upstream or downstream will eventually settle in this region. The region would therefore be one of relatively heavy sedimentation. Research in various estuaries has revealed that this relationship does in fact exist in nature.

The field program was thus designed to determine whether the above described conditions exist in the region of the proposed port at Vung Tau and, if so, to indicate areas of heavy sedimentation. Figure 16 shows plots of flow movement in both surface and bottom waters along two flow profiles shown in Figure 17. The profiles were selected on the basis of flow characteristics of the region as indicated by current and salinity patterns.

It became evident with study that two separate flow regimes exist in the region: one in the far western part having north-south flow which is associated with the large Saigon River system and a more localized east-west flow associated with the Dinh and Cha Va River systems. Characteristics of the bottom sediment also reflect the differences between the two systems as indicated in Figure 17. It will be noted that sediments at the far western stations (i.e. 14, 4, 3, and 13) are generally relatively coarse grained and well sorted while those in the remaining stations to the east are much finer grained and poorly sorted. (Station 19, although located in the western of north-south current system, had sediments exhibiting characteristics similar to the eastern stations. No explanation was found for this apparent anomaly.) The sediment



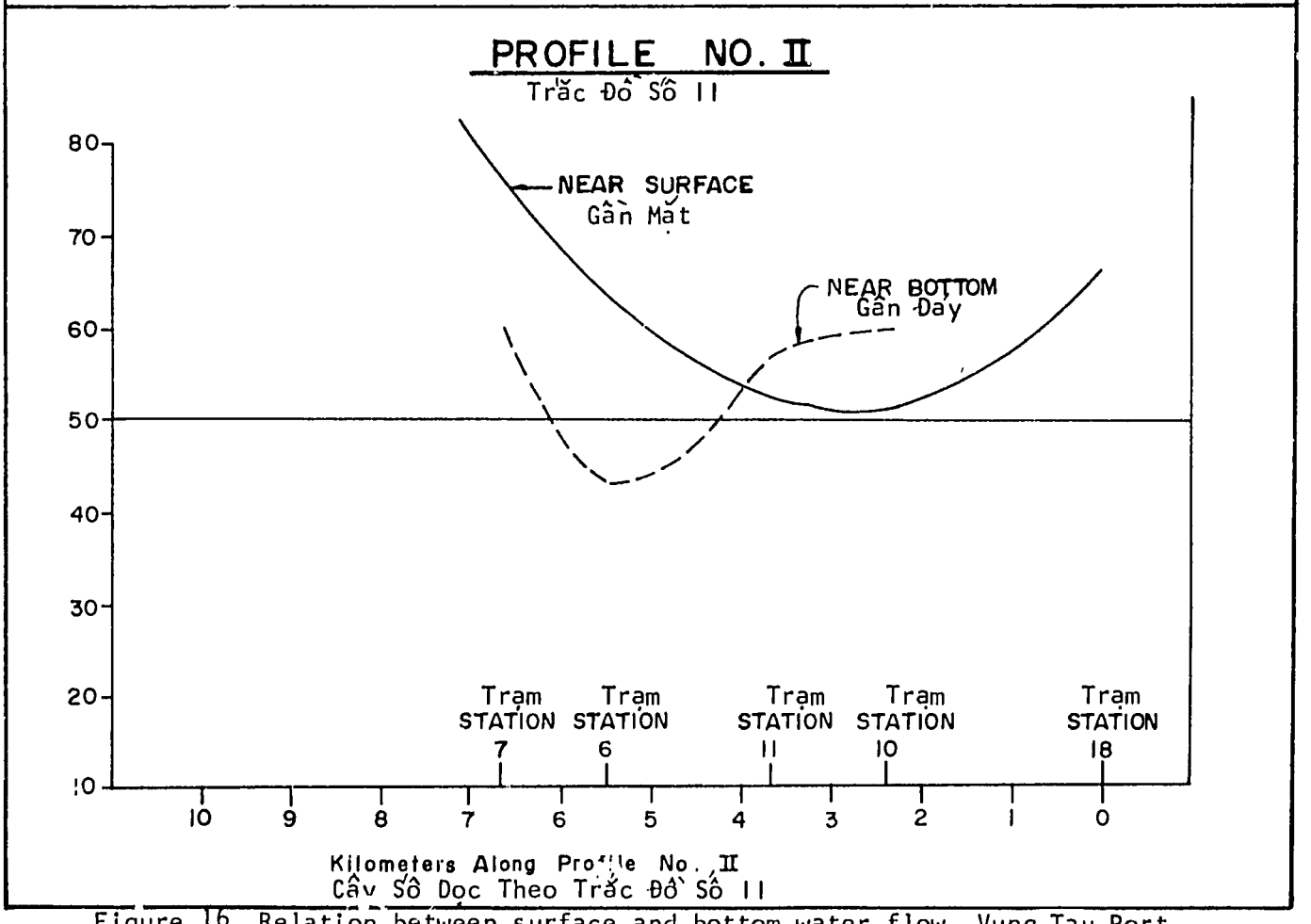
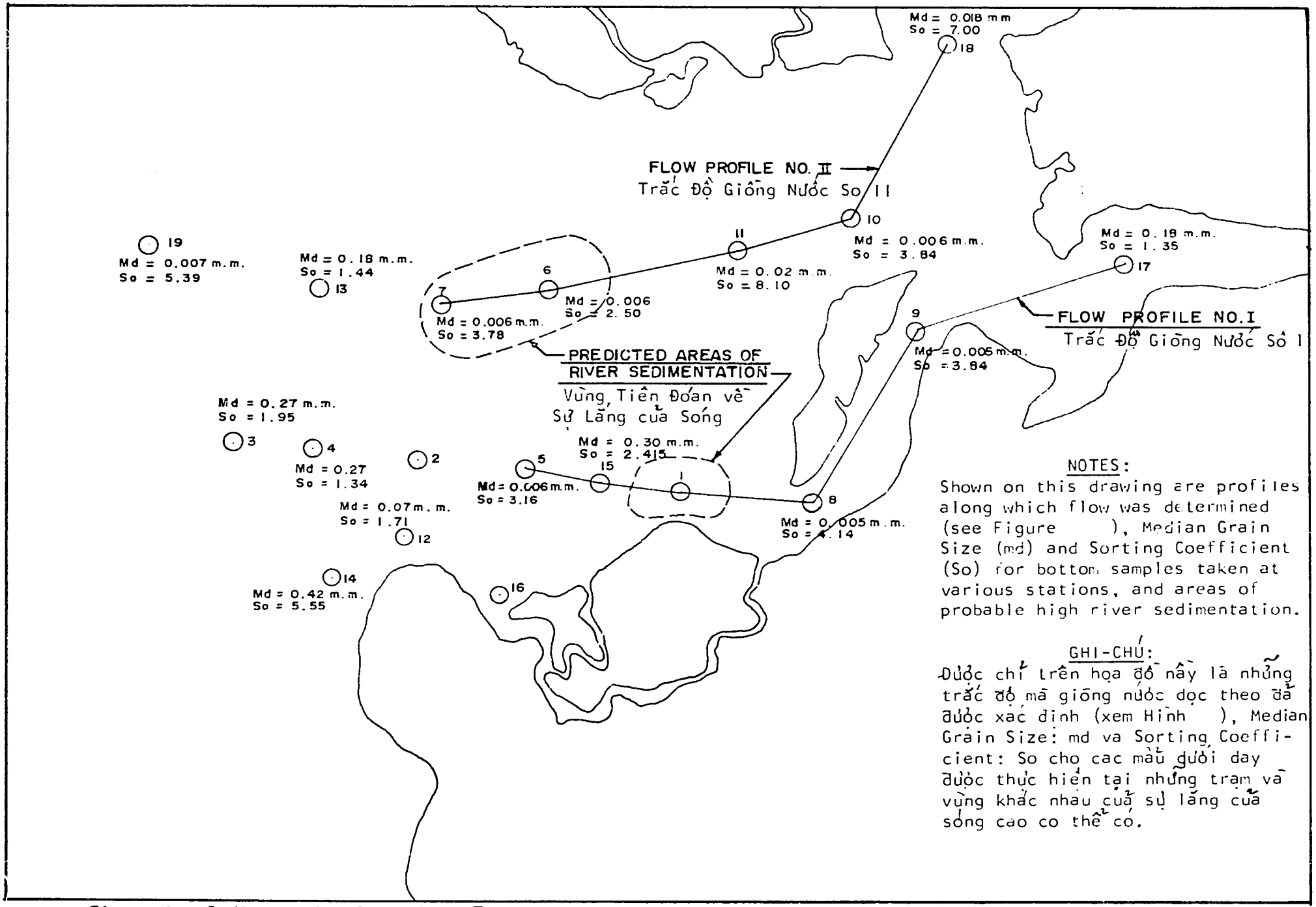


Figure 16, Relation between surface and bottom water flow, Vung Tau Port
Hình 16, Sự liên quan giữa giòng nước chảy trên mặt và dưới đáy, Hải Cảng Vũng Tàu



NOTES:
Shown on this drawing are profiles along which flow was determined (see Figure), Median Grain Size (md) and Sorting Coefficient (So) for bottom samples taken at various stations, and areas of probable high river sedimentation.

GHI-CHÚ:
Được chỉ trên họa đồ nầy là những trắc độ mà giông nước dọc theo đã được xác định (xem Hình), Median Grain Size: md va Sorting Coefficient: So cho cac mẫu dưới day được thực hiện tại những trạm và vùng khác nhau của sự lắng của sông cao co thể có.

Figure 17, Sedimentation Data, Vung Tau Port
Hinh 17, Dữ kiện lắng cặn, Hải Cảng Vũng Tầu

characteristics indicate that fine grained sediments are essentially continuously flushed from the western estuarine area and that current patterns are fairly steady as indicated by the good sorting of sediments. In the eastern area fine sediments are not so readily removed from the region and current patterns are relatively confused resulting in poorly sorted sediments. This characteristic is important and will be addressed again later.

Inspection of Figure 16 will indicate that flow patterns characteristic of the Dinh River system are those of a typical estuary; that is, net downstream flow of surface waters all along both profiles and net upstream flow of bottom waters in the seaward end of the profiles and net downstream flow of these waters in the landward end. Profile I shows better flow definition than Profile II because of its location along a dredged channel and its relationship to the better defined Dinh River flow. The flow patterns predict relatively heavy river sedimentation in the vicinity of Station 1 and of Stations 6 and 7 (see Figure 17). The prediction for Station 1 is corroborated in that this is an area known to be one of relatively heavy channel sedimentation.

It should be noted that the conditions shown in Figure 16 are characteristic of the period during which field measurements were taken. Measurements of salinity and currents indicated that at the time the Dinh River system could probably be classified as a partially mixed estuary. However, the measurement program took place during the rainy season with relatively heavy fresh water runoff which favors stratified

flow. Considering the large tide range at Vung Tau it is probable that during dryer periods the estuary will revert to a well mixed type and river sedimentation would probably be more evenly distributed along the flow paths.

b. Quantitative Sedimentation Analysis

The above described study is extremely useful in predicting areas of relatively high sedimentation but cannot be used to predict quantities. In fact further studies into sedimentation characteristics in the region revealed that direct sedimentation from inflowing river waters will probably constitute only a minor part of the total sedimentation which could be expected in the proposed channel and turning basin. A study conducted by Daniel, Mann, Johnson and Mendenhall (DMJM) for the U.S. Navy OICC in 1966 indicated that total annual sedimentation in the then planned but presently existing channel would be over 1 million cubic meters but that only 56,000 m^3 would be contributed yearly by the Dinh River. The bulk of the sedimentation would come as a result of shifting sediments within the area under the influence of currents and wave action. The relative importance of sediment shifting in the area is indicated by the amount of suspended sediment found in the waters as shown in Table 15. Water samples analyzed were taken during conditions of relatively high wave action indicating that sediments are readily placed in suspension by wave forces. As previously stated bottom sediments are fine grained and poorly sorted attesting to their inefficient removal from the area and to the fact that they are continually being moved around by waves and currents. It is a known fact that shoals shift frequently in the region.

It is likely, therefore, that shifting sediments will be far more important in harbor sedimentation than direct river sedimentation. The DMJM study made an estimate of the quantity which could enter the present channel but it was handicapped in that no known method exists in quantifying this type of sedimentation other than by means of successive hydrographic surveys of an already existing channel or turning basin. This type of information was not available to DMJM.

However, the results of successive surveys are now available and were analyzed in an attempt to quantify sedimentation. Analysis of the surveys indicated that sedimentation in the channel would be of the order of 370,000 m^3 per year, considerably below the estimate predicted by DMJM but still very high. It is difficult to extrapolate sedimentation in a narrow channel to the large turning basin and channel proposed for Vung Tau Port. Two approachs were taken. The first was to assume that the 370,000 m^3 of the existing channel would be spread over the full turning turning basin and recommended channel area. The second was to assume a sediment thickness in the turning basin and channel equal to that of the existing channel. This second approach would produce on annual sedimentation of 1.0 to 1.2 million cubic meters or a thickness averaging about 1.0 to 1.2 meters for first construction phase facilities and nearly double this amount for full size facilities resulting from second phase construction and dredging.

In actual fact neither of these figures is probably correct. The lower figure of 370,000 m^3 cannot be considered to be realistic as there

is no reason to suppose that the same amount of sedimentation would take' place in the large turning basin and channel that occurs in the existing channel. On the other hand the higher amount tends to be discredited by the fact that the proposed turning basin is partially sheltered from sediments being shifted from southerly directions and the fact that some sedimentation in the existing channel may result from a caving in of its sides, a problem which would be minimized in a larger basin. A compromise estimate amounting to approximately 0.6 million cubic meters per year has therefore been made for the first construction phase of all alternative concepts and about 1.2 million cubic meters per year for the full extent of port facilities shown.

The DMJM report concluded that because currents were effective in flushing the narrow region between the existing commercial port and the adjacent island, sedimentation in this area would be minimal. Studies of successive hydrographic surveys verify this observation. It is therefore concluded that annual sedimentation of the basin adjacent to the proposed commercial fishing port will not be a problem. As previously stated the existing entrance channel accumulates sediment at a rate of about 370,000 m^3 per year. In view of the fact that the draft of fishing vessels expected to use the proposed fishing port is only 3.7 meters and that the average depth of nondredged areas over which the vessels would pass is about 2.0 meters below Approx. LLW datum, it can be seen that fishing boats could utilize the port during high tides without recourse to a dredged channel. Should access to the port over a full or more substantial part of the tidal cycle be required, a channel will be needed

which can be expected to accumulate sediment at a rate similar to the existing channel. If the proposed commercial cargo port is built, the extent of this channel could be reduced as fishing boats could traverse the channel and turning basin of the cargo port until such time as traffic becomes so heavy that congestion of the cargo port results. In this event a special arrangement would be needed.

The relatively light sedimentation adjacent to the existing commercial port raises the question of whether location of the proposed commercial general cargo port in this area would result in a reduction of the annual sedimentation of its turning basin and channel. In considering this question it must be realized that sedimentation is only light in the narrow, restricted area between the mainland and the island located offshore from the existing port site by virtue of the relatively efficient flushing by tidal and river currents through the restricted opening. Should a port of the scope anticipated for the general cargo port be built here, the turning basin would certainly require that dredging of a large area, possibly including all or part of the offshore island, be carried out. With the removal of the narrow flow channel, sedimentation in the region could be expected to be high, possibly higher than at the location proposed in this report due to direct deposition of riverine deposits in addition to shifting sediments. Furthermore, the total volume of sedimentation in the long entrance channel can be expected to be high, of the order of 370,000 m^3 per year as is presently experienced in the existing channel.

c. Conclusions

It is evident from the above discussions that annual sedimentation in the channel and turning basin of the proposed commercial port may be extremely heavy. Due to the fact that most of this material will be the result of shifting sediments rather than river inflow, it is unlikely that a change in location of the port will help matters if the port remains within the area north of Point Ganh Rai. The alternative to relocation is the construction or establishment of some device for keeping sediments out of the harbor. The most obvious methods are to redirect the flow of the Dinh River by damming flow presently passing through the channel between the existing port area and the adjacent offshore island, to construct a long breakwater along the northern perimeter of the turning basin, or to realign the channel and turning basin to maximize flushing. The first alternative is not recommended on the grounds that most sedimentation is not a result of direct river inflow and that redirection will alter the flow adjacent to the proposed commercial fishing port in such a way that sedimentation in this area might be increased. The third alternative is also rejected because realignment would probably have little effect inasmuch as sediment could be moved into the area from nearly any direction at the whim of wind, wave, and current forces.

The construction of a breakwater designed to block the flow of sediment shifting in the area from entering the turning basin and channel would be an expensive proposition; the cost of construction amounting to approximately 3 to 5 million U.S. dollars. In view of the fact that of the order of 600,000 cubic meters of sedimentation per year might be expected in

first construction phase channel and turning basin and about double this amount in the channel and turning basin enlarged as part of second phase construction, with the cost of dredging and disposal of this material of the order of US$1.70 per cubic meter it can be seen that the cost of maintenance dredging could amount to as much as 1 to 2 million US dollars per year. It is evident that this magnitude of expenditure could pay for a screening breakwater in a very few years. In spite of this fact the construction of such a breakwater at the time port facilities are constructed is not recommended. The reason for this lies in the gross inaccuracies and low confidence attendent with the prediction of quantitative harbor sedimentation. It is believed that the best course of action would be to build the port first and then assess, through frequent hydrographic surveys, the rate and pattern of sedimentation which actually occurs. If the amounts are large enough in the first years of port operation so that a breakwater might appear advisable on the basis of the cost of maintenance dredging, its installation could then be seriously considered. In this event a moveable bed hydraulic model study might be worth considering. Such a study could show patterns or sediment flow around the ends of such a breakwater and might indicate changes in current, wave, and sedimentation regimes which might occur. It is even possible that quantitative estimates of sedimentation might be made.

As to specific areas within the turning basin and channel where sediment might concentrate, in view of the estuarine dynamical analysis described above, it seems likely that sedimentation will be relatively heavy at the extreme eastern end of the turning basin. The outer channel

will probably receive the least sediment as this area is most likely to be flushed by tidal currents.

A useful piece of information would be to determine whether sedimentation would be greater at certain times of the year than at other times in order to aid in the planning of maintenance dredging. It is likely that periods of highest sedimentation would coincide with stormy periods inasmuch as the primary source of sedimentation in the harbor area will be material placed in suspension by waves and moved by wind and tidal currents. Thus periods of relatively heavy sedimentation might be expected in fall and winter, the seasons of more frequent storms. Also, of course, river sedimentation can be expected to be greater during and shortly following the summer and early fall rainy seasons. Although this sedimentation will probably be less important than that caused by sediment shifting, it is likely to be localized in the extreme eastward part of the turning basin as explained in Section III. 5. a. above.

In any case it would be highly advisable to conduct frequent hydrographic surveys in order to monitor the extent and location of sediment buildup. These surveys could be run at six month intervals using an electronic echosounder mounted in a small boat.

TABLE 15

Suspended Sediment Content of Water Samples

Station (see Fig 1)	Sediment Content Grams/Liter Near Surface	Near Bottom
1	0.932	0.419
2	0.291	0.427
3	0.530	1.151
4	0.345	0.551
5	-	-
6	0.300	0.450
7	0.375	0.345
8	-	0.671
9	0.328	0.305
10	0.334	0.707
11	0.527	0.895
12	1.058	0.893
13	0.912	0.987
14	0.891	0.966
15	0.788	0.947
16	0.608	0.940
17	0.621	0.434
18	0.499	0.600
19	0.428	0.782

D. ENVIRONMENTAL IMPACT OF PROPOSED PORT DEVELOPMENT

The growing awareness of the possible damaging effect of large scale development projects on resources of potential use to man has made consideration of the environmental impact of such projects of great importance in the evaluation of their overall feasibility. In the case of the proposed port development, environmental effects will be generated by both the construction and the use of port facilities.

The most important effect resulting from construction will result from dredge and fill activities. This effect will be twofold. On the short term, dredging may increase the turbidity of surrounding waters while dredging operations are going on. The effect of this turbidity, however, is expected to be minimal, particularly if the silt curtain method is used to retain hydraulically placed sediment as proposed. It is unlikely that sea life will be adversely affected.

It is possible that dredging operations may actually be temporarily beneficial to sea life in that a stirring up of bottom sediments which are rich in organic material should increase concentrations of nutrients in surrounding water. This effect could eventually cause an increase in populations of species at all levels of the food chain in the region. The only adverse effect which might result is an increase in numbers of planktonic organisms. These organisms presently contribute substantially to the turbidity of waters currently used for bathing at the local beaches.

A far more important consequence of dredging activity will be the covering of Ben Dinh Island located near the proposed port site with hydraulic fill for port structures and an adjacent industrial area. Experiments recently conducted by marine biologists have shown that this island is extremely rich in nutrients and that it is an important maturing ground for a number of species of marine life, notably the white and pink shrimp, which constitute a potentially valuable living resource both for local consumption and for export. The life cycle of these shrimp begins with their hatching at sea. The newly hatched larvae then swim into estuarine waters where they grow to maturity living off the rich nutrients present in these areas. The mature shrimp then swim back to sea where they spawn, starting a new cycle. The shrimp are marketable in the adult stages and in the larval and young adult stages and they are presently caught both at sea by large trawlers and in estuarine waters by small boats and by fisherman using push nets. The destruction of this mangrove island could be a disastrous blow to the ecology because there is some evidence, admittedly as yet inconclusive, that certain species utilize this island exclusively for their maturation. These species would probably be oceanic species which would tend to utilize protected estuarine areas which are nearest to the sea, a condition idealy fulfilled by Ben Dinh Island. It is therefore possible that destruction of this island may have a long term adverse effect on the ecology of the region in the selective destruction of an important living resource. Furthermore the richness of the mangrove island makes its consideration for use as a center for the aquaculture of certain indigenous species

highly desireable. It should be stated, however, that species presently utilizing the island may be able to adapt to other mangrove areas in the region. It should also be understood that the above discussion is based upon incomplete research as to the habits of the marine species in question and that their maturing grounds may be more widespread than presently is believed.

Although land fill operations associated with the proposed commercial port and industrial area would necessarily destroy a part of this mangrove island, design and layout of the land fill areas might be accomplished in such a way that a portion of the island would be left undamaged. Designs would have to allow not only for leaving certain areas uncovered but for a continuation of unobstructed flow of sea water in and out with the tide. The port plans proposed by this study would not interfere with such a decision and the port facilities could be designed so that the mangrove island could in large measure continue its functions as part of the local ecosystem.

Effects of construction of fishing port facilities will be minimal in both the long and short term as dredge and fill activities are relatively minor.

The effects on the environment of the use of the port consist chiefly of the introduction into the environment of pollutant wastes by ships and other port users and by industries which become established as a consequence of port development. The most important of these would be introduction of a large quantity of oil or other petroleum products

or of some other toxic chemical into the water. Of secondary importance is a minor but continuous introduction of such wastes on a daily basis.

The large tidal and fresh water flows characteristic of the region are favorable from the point of view of waste dispersion and removal from spill areas. The location of the port as shown in the three alternative port development schemes is favorable from this point of view because spills in this area will quickly be carried away. It cannot be denied, however, that a major spill would be a catastrophe both to the local marine ecology and to human habitation in the area. This is particularly true if an incoming tide were to spread the pollutant into the many estuarine waterways which wind through the region.

It is difficult to assess the losses which would occur in the event of a major spill but they could be substantial. The effect of every day pollution probably will not be great, however, again largely because of the efficiency of flushing of the harbor area and waterways. Furthermore, although there is evidence at the present time that oil pollutants are sometimes retained by sediments, mangrove and other vegetation, the pollutants do not appear to have much effect on the local ecology in terms of outright mortality, a reduction of the efficiency of vital processes of organisms or a disruption of the local food chain.

It is known, however that some marine species present in the Vung Tau area sequester or store such poisonous materials as lead within edible portions of their bodies. It may well be that exhaust and petroleum pollutants containing such poisonous materials may pose the most serious

threat in terms of environmental pollution. This threat directly affects humans in that while the poisons do not affect the sequestering organism, they do poison eaters of the organism.

It must be noted that research in the possible effects of pollutants in the Vung Tau area is incomplete and the above conclusions are therefore somewhat tenuous. It is recommended that such research be carried out. It is further recommended that should port development be undertaken at Vung Tau care should be taken in the elimination of wastes into waterways Precautions should be taken to avoid massive spills, and a program of continuous testing of edible marine species should be carried on to determine whether they are sequestering poisonous materials in dangerous concentrations.

In summary it is concluded that the major detrimental environmental effect of port construction is the destruction of the mangrove island adjacent to the proposed port site. The major detrimental effect of port use is the possibility of an oil toxic chemical spill. In the former case steps should be taken in the design and layout of reclaimed areas to leave some portion of the mangrove island untouched and its tidal flow unbroken to the greatest extent possible. For the latter effect care in avoiding the occurrence of spills should be exercised.

Provided that the above steps are successful, the port should have little impact on the environment of the region. Recreational facilities and tourism should be essentially unaffected because the beach areas which constitute the major attraction of Vung Tau as a resort are located

on the opposite side of the Cap St. Jacques peninsula well away from the port and port activities. The effect of ships and ship traffic using the port should be no worse than that presently experienced.

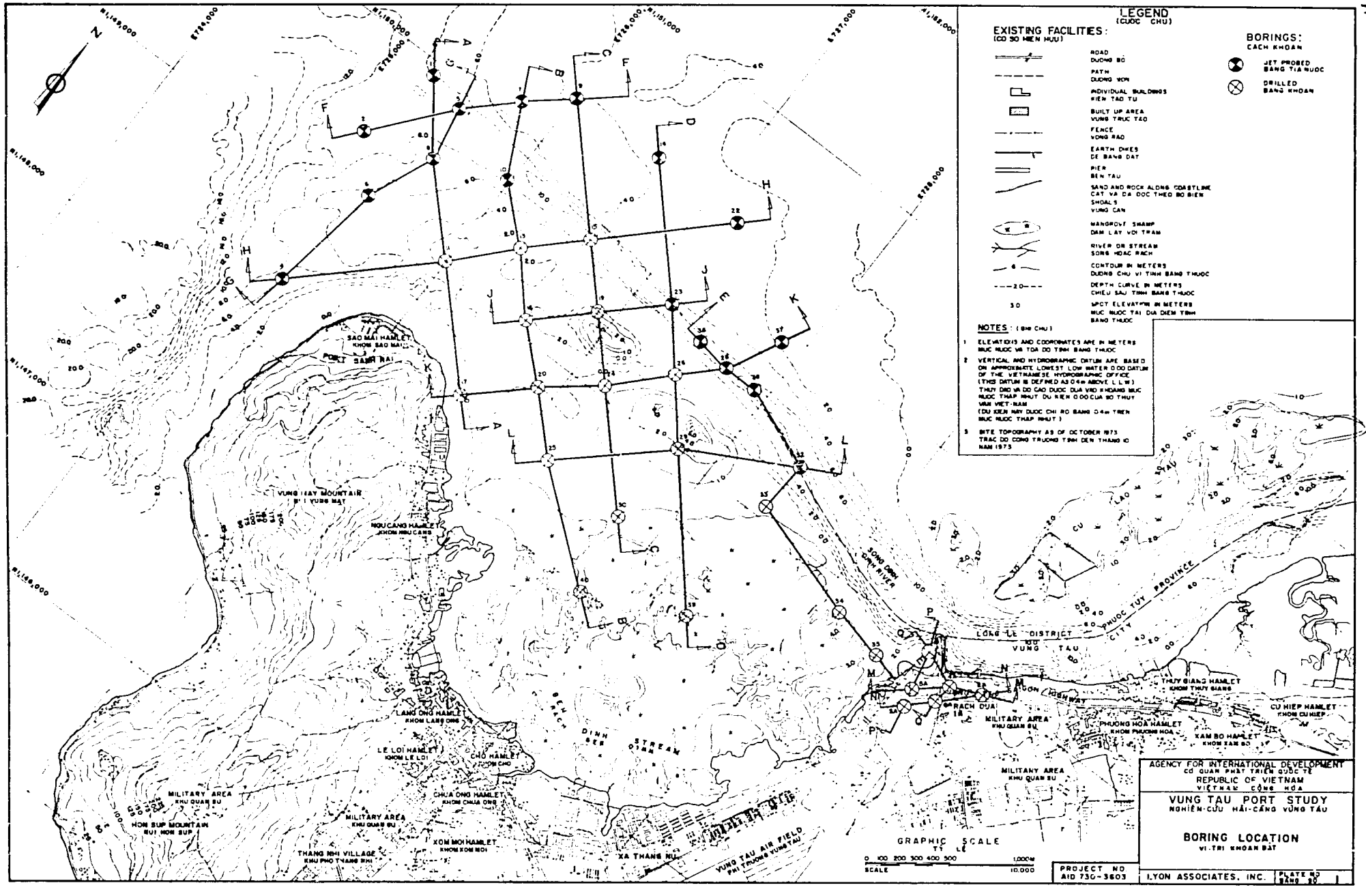
SECTION IV

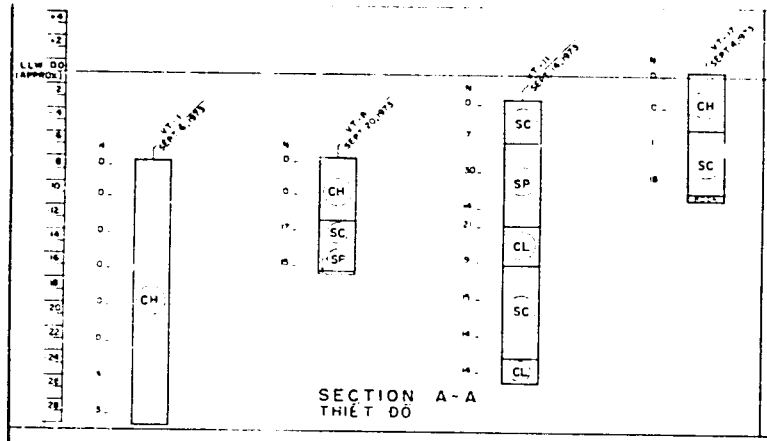
SUBSURFACE CONDITIONS

A. INTRODUCTION

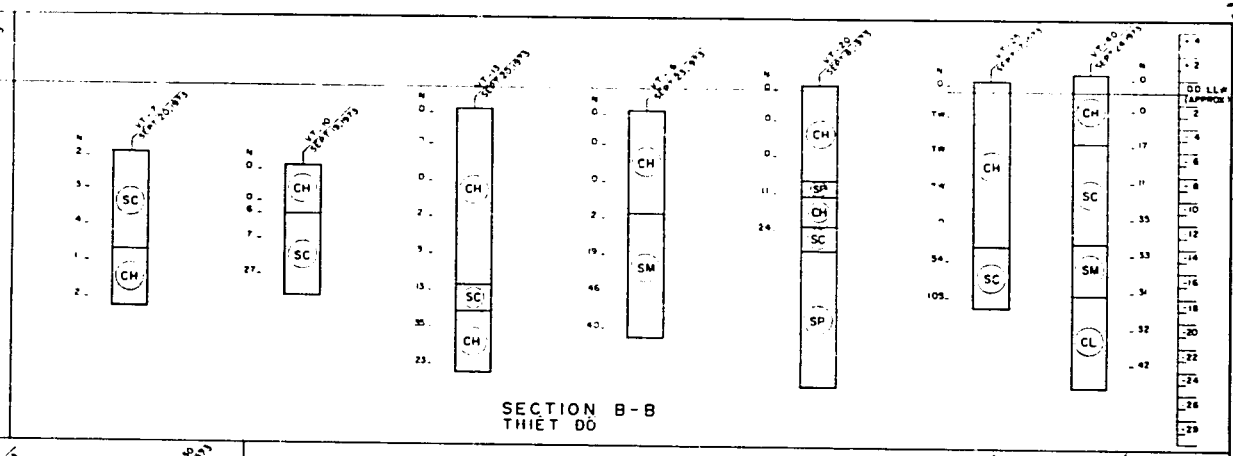
In order to engage in preliminary design work for port structures and to assess soils types for dredging and hydraulic fill purposes, a soils and subsurface investigation was conducted for the region near Vung Tau in which it is proposed that the new commercial general cargo port and commercial fishing port would be located. This investigation commenced with the collection and study of existing soils data. Inasmuch as these data were known to be insufficient for the purposes intended, a field program was carried out early in the study period.
This program consisted of a total of 34 holes of which 18 were probes, for a total of 222 meters depth, and 16 were drilled holes, for a total of 367 meters depth. The primary purpose of the probes was to determine soil type for assessment of dredge and fill operations and the purpose of the drilled holes was, in addition to soil type information, determination of subsurface soil strengths and bearing capacities to provide criteria for structural design. The locations of these borings are shown on Plate No. 1. Profiles of borings taken showing graphic representations of soils conditions can be seen on Plate Nos. 2 and 3. All borings were made using an Acker "TH" rotary drill rig mounted on a floating platform which was positioned by small boats and anchored over each site. The location of the boring sites was accomplished by shore based surveyors

In addition to the information obtained in the field investigation, a valuable source of data, particulary for the proposed commercial fishing port area, was a series of six borings carried out in 1966-1967 by Pacific Architects and Engineers, Inc. (P.A. & E.). The locations of all borings are shown on Plate No. 1 and Plate No.4 gives boring profile information.


LEGEND
(CUOC CHU)
EXISTING FACILITIES:
(CO SO HIEN HUU)
ROAD
DUONG BO
PATH
DUONG MON
INDIVIDUAL BUILDINGS
KIEN TAO TU
BUILT UP AREA
VUNG TRUC TAO
FENCE
VONG RAO
EARTH DIKES
DE BANG DAT
PIER
BEN TAU
SAND AND ROCK ALONG COASTLINE
CAT VA DA DOC THEO BO BIEN
SHOALS
VUNG CAN
MANGROVE SWAMP
DAM LAY VOI TRAM
RIVER OR STREAM
SONG HOAC RACH
CONTOUR IN METERS
DUONG CHU VI TINH BANG THUOC
DEPTH CURVE IN METERS
CHIEU SAU TINH BANG THUOC
SPOT ELEVATION IN METERS
MUC NUOC TAI DIA DIEM TINH
BANG THUOC
BORINGS:
CACH KHOAN
JET PROBED
BANG TIA NUOC
DRILLED
BANG KHOAN
NOTES: (BIN CHU)
1 ELEVATIONS AND COORDINATES ARE IN METERS
MUC NUOC VA TOA DO TINH BANG THUOC
2 VERTICAL AND HYDROGRAPHIC DATUM ARE BASED ON APPROXIMATE LOWEST LOW WATER O.DO DATUM OF THE VIETNAMESE HYDROGRAPHIC OFFICE
(THIS DATUM IS DEFINED AS 0.4m ABOVE L.L.W.)
THUY DIO VA DO CAO DUOC DUA VAO KHOANG MUC NUOC THAP NHUT DU KIEN O.DO CUA SO THUY VAN VIET-NAM
(DU KIEN NAY DUOC CHI RO BANG 0.4m TREN MUC NUOC THAP NHUT)
3 SITE TOPOGRAPHY AS OF OCTOBER 1973
TRAC DO CONG TRUONG TINH DEN THANG 10 NAM 1973
SAO MAI HAMLET
KHOM SAO MAI
VUNG TAY MOUNTAIN
NGU CANG HAMLET
KHOM NGU CANG
LANG ONG HAMLET
KHOM LANG ONG
LE LOI HAMLET
KHOM LE LOI
CHO HAMLET
KHOM CHO
CHUA ONG HAMLET
KHOM CHUA ONG
MILITARY AREA
KHU QUAN SU
HON SUP MOUNTAIN
NUI HON SUP
THANG NHI VILLAGE
KHU PHO THANG NHI
XOM MOI HAMLET
KHOM XOM MOI
XA THANG NHI
VUNG TAU AIR FIELD
PHI TRUONG VUNG TAU
BEN RACH DINH STREAM
SONG DINH RIVER
LONG LE DISTRICT
PHUOC TUY PROVINCE
VUNG TAU CITY
RACH DUA
THUY GIANG HAMLET
KHOM THUY GIANG
PHUONG HOA HAMLET
KHOM PHUONG HOA
CU HIEP HAMLET
KHOM CU HIEP
KAM BO HAMLET
KHOM KAM BO
GRAPHIC SCALE
TỶ LỆ
SCALE
0 100 200 300 400 500 1,000M
10,000
PROJECT NO.
AID 730-3603
AGENCY FOR INTERNATIONAL DEVELOPMENT
CO QUAN PHAT TRIEN QUOC TE
REPUBLIC OF VIETNAM
VIETNAM CONG HOA
VUNG TAU PORT STUDY
NGHIEN-CUU HAI-CANG VUNG TAU
BORING LOCATION
VI-TRI KHOAN DAT
LYON ASSOCIATES, INC.
PLATE NO
BANG SO
1



SECTION A-A
THIẾT ĐỒ



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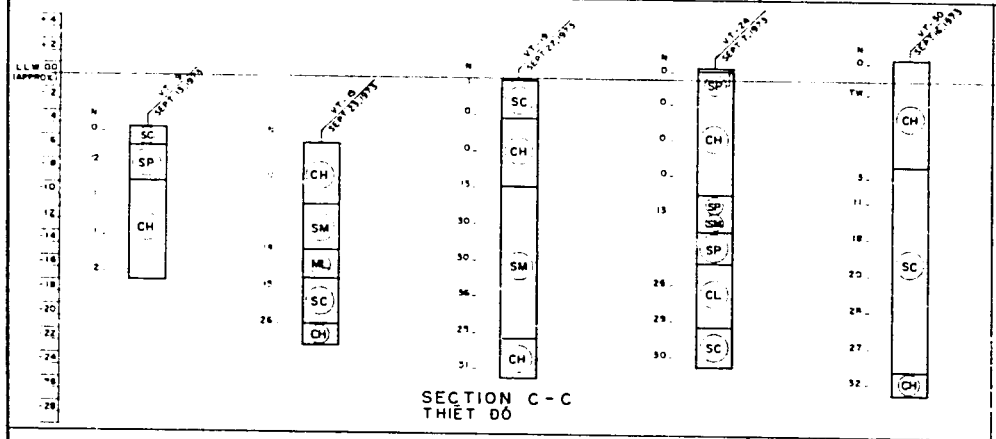

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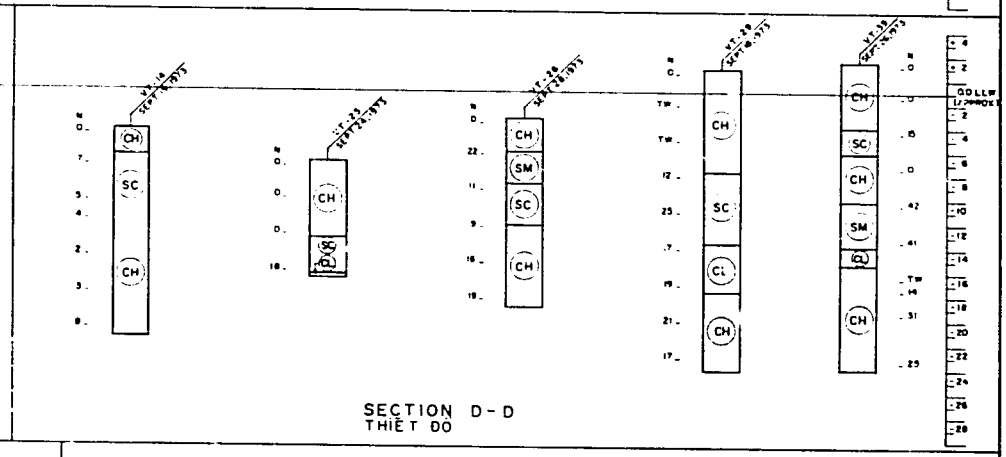

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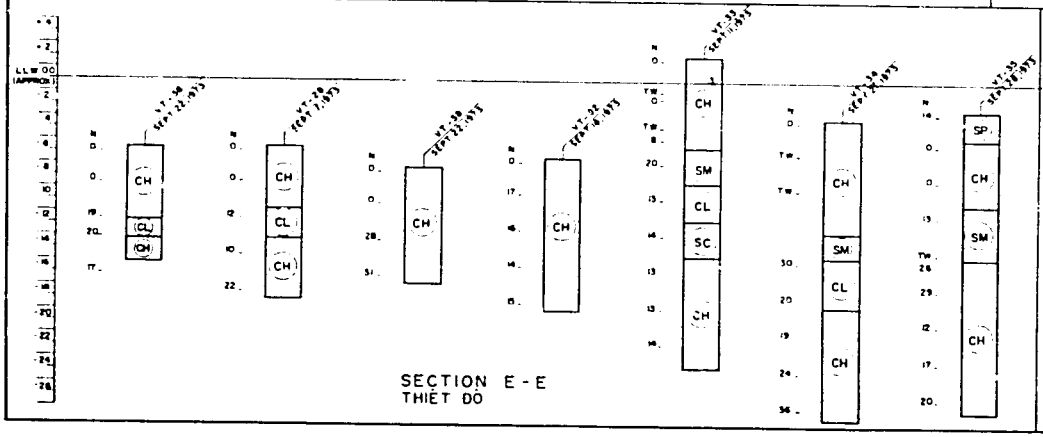

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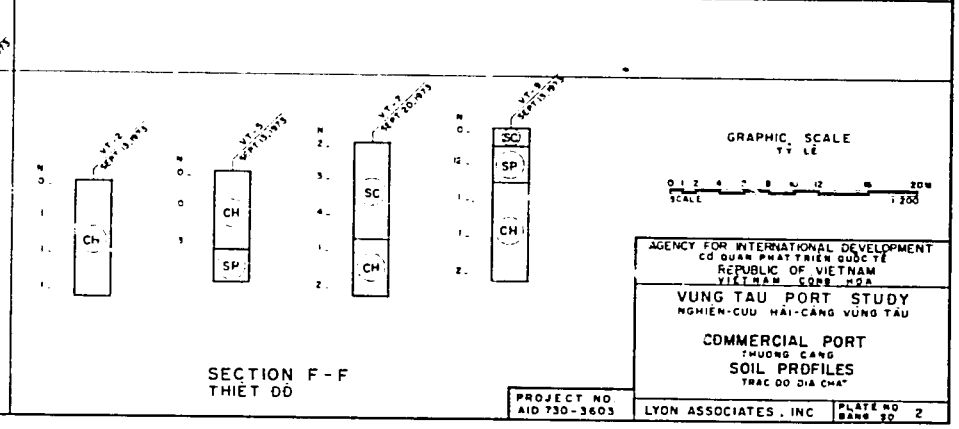

SECTION F-F
THIẾT ĐỒ

GRAPHIC SCALE
TỶ LỆ

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AGENCY FOR INTERNATIONAL DEVELOPMENT
CƠ QUAN PHÁT TRIỂN QUỐC TẾ
REPUBLIC OF VIETNAM
VIỆT NAM CỘNG HÒA

VUNG TAU PORT STUDY
NGHIÊN-CỨU HẢI-CẢNG VŨNG TÀU

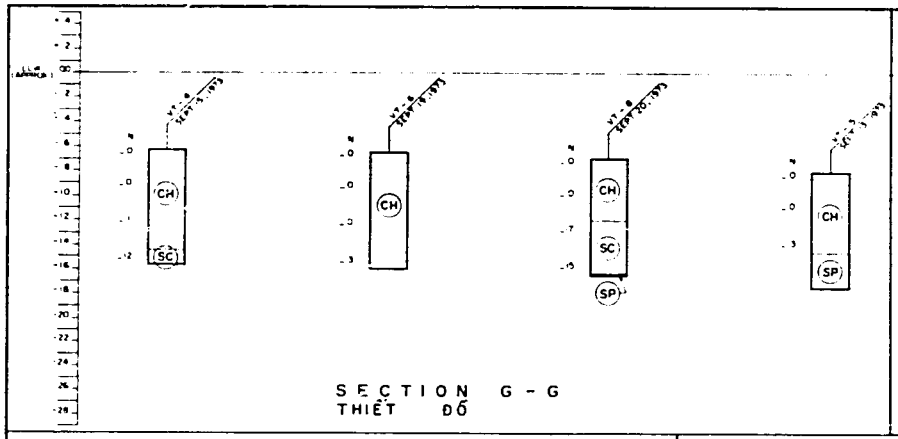
COMMERCIAL PORT
THƯƠNG CẢNG

SOIL PROFILES
TRẮC ĐỒ ĐỊA CHẤT

PROJECT NO
AID 730-3603

LYON ASSOCIATES, INC

PLATE NO
BẢNG SỐ 2



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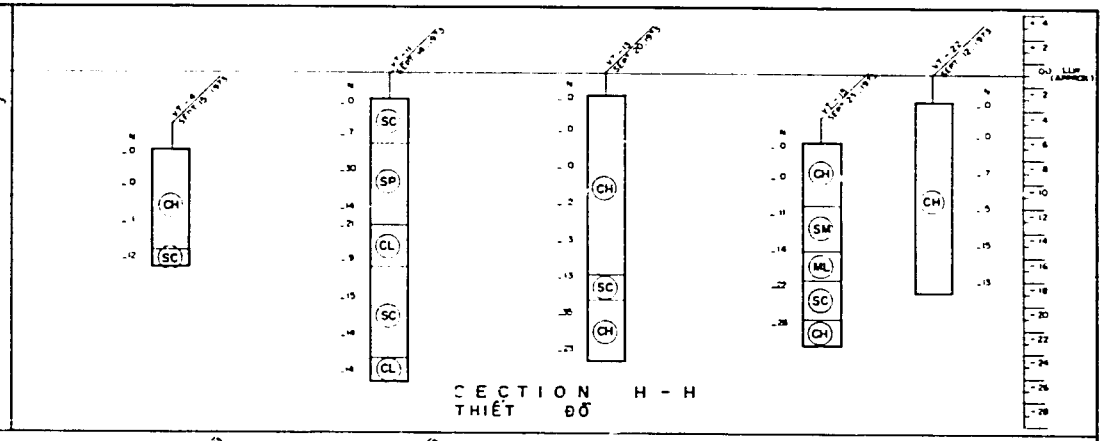

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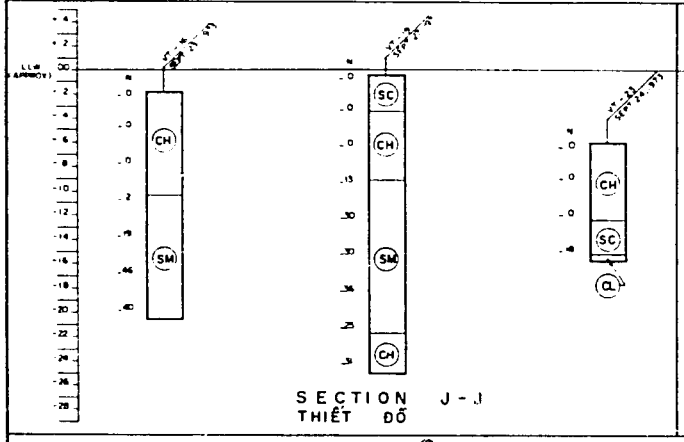

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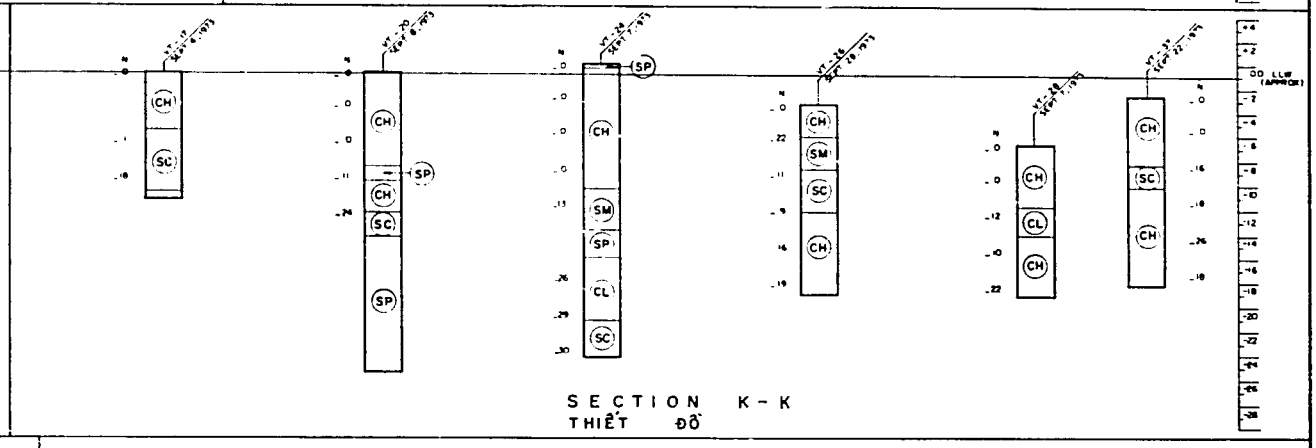

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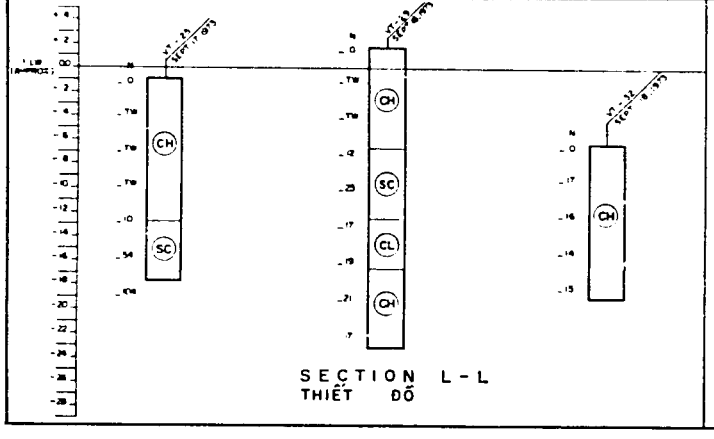

SECTION L - L
THIẾT ĐỒ

LEGEND:
CƯỚC CHÚ

N – BLOW COUNT
ĐỘ NÉN

CH – GRAY MARINE CLAYS, WET & SOFT, HIGH PLASTICITY
ĐẤT SÉT BIỂN XÁM, ƯỚT & MỀM CÓ ĐỘ DẺO CAO

CL – GRAY SANDY CLAYS, MOIST & STIFF, MEDIUM PLASTICITY
ĐẤT SÉT LẪN CÁT MÀU XÁM, ẨM & CỨNG CÓ ĐỘ DẺO TRUNG BÌNH

SC – LIGHT GRAY CLAYEY SANDS, WET & LOOSE, LOW PLASTICITY
CÁT LẪN ĐẤT SÉT XÁM LỎT, ƯỚT & RỜI CÓ ĐỘ DẺO THẤP

SM – WHITISH GRAY SILTY FINE SAND, MOIST & MEDIUM COMPACT
CÁT NHUYỄN LẪN BỤN XÁM HỚI TRẮNG, ẨM & HƠI CỨNG

ML – GRAY MOTTLED BROWN WITH STREAK OF RUST COLOR SANDY - SILT MEDIUM PLASTICITY, MOIST & MEDIUM COMPACT
ĐẤT BỤN & CÁT CÓ SỌC MÀU BỤ NÂU LẪN VẰN XÁM CÓ ĐỘ DẺO TRUNG BÌNH VÀ HƠI CỨNG

TW – THIN WALL
ỐNG LẤY ĐẤT

GRAPHIC SCALE
TỶ LỆ

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PROJECT NO
AID 730-3603

AGENCY FOR INTERNATIONAL DEVELOPMENT
CƠ QUAN PHÁT TRIỂN QUỐC TẾ
REPUBLIC OF VIETNAM
VIỆT NAM CỘNG HÒA

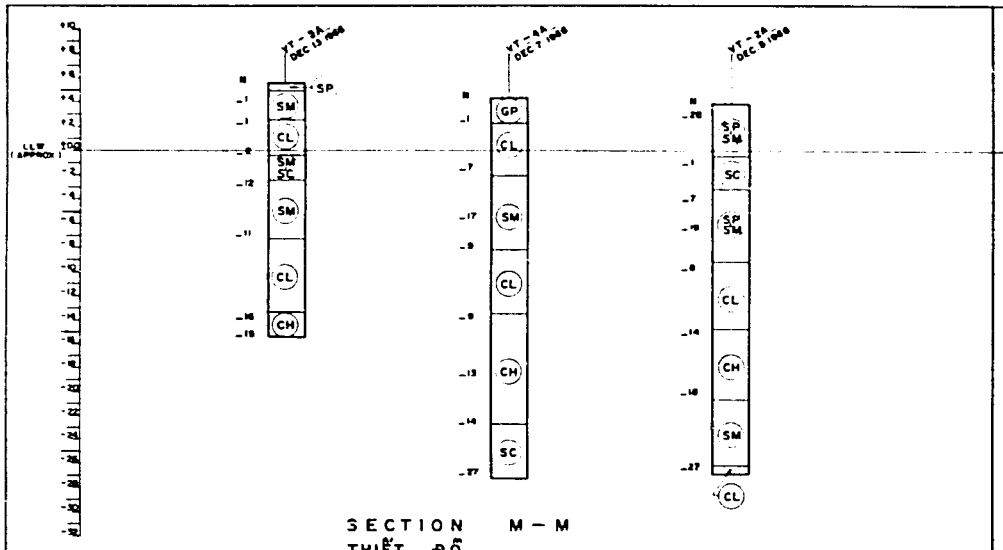
VUNG TAU PORT STUDY
NGHIÊN-CỨU HẢI-CẢNG VŨNG TÀU

COMMERCIAL PORT
THƯƠNG CẢNG

SOIL PROFILES
TRẮC ĐỒ ĐỊA CHẤT

LYON ASSOCIATES, INC.

PLATE NO.
BẢNG SỐ 3



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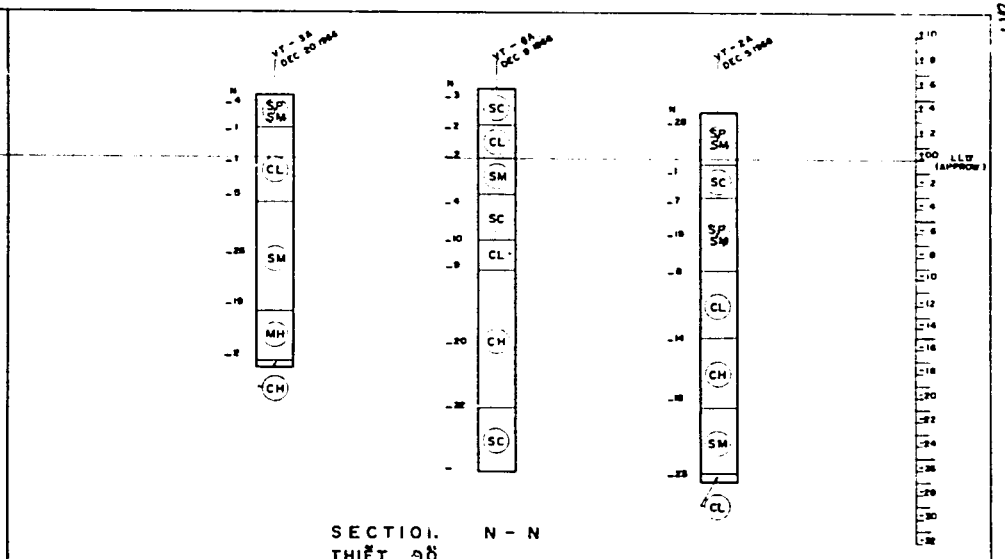

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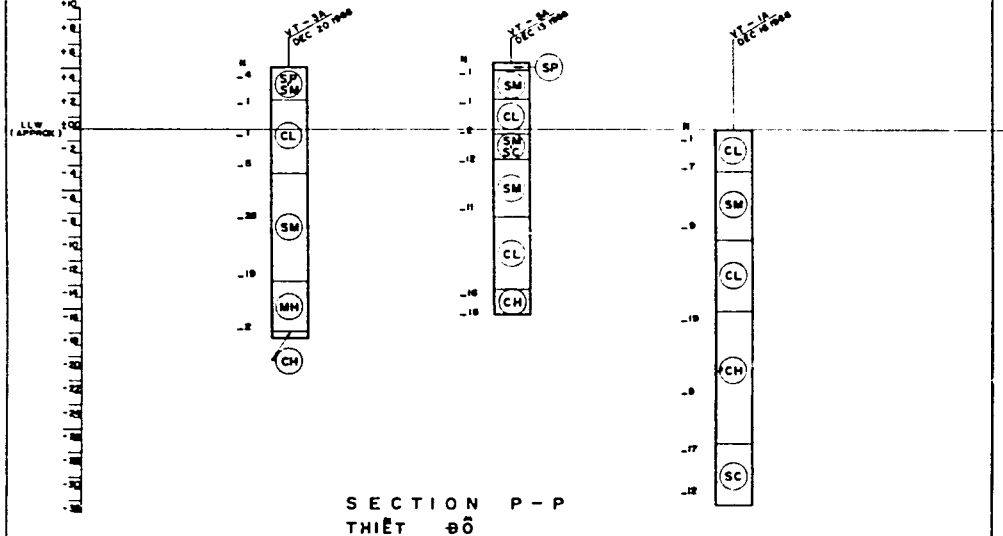
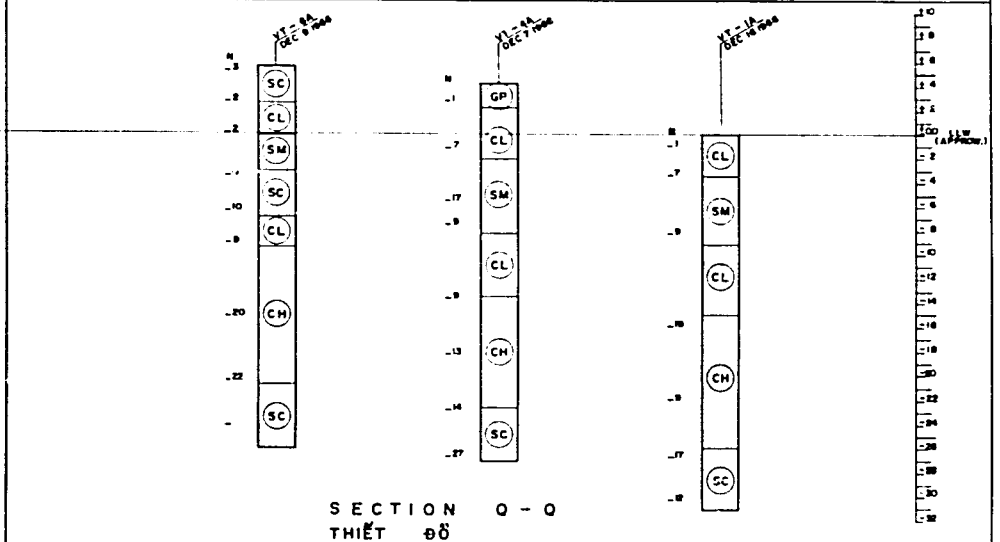


SECTION P – P
THIẾT ĐỒ



SECTION Q – Q
THIẾT ĐỒ

LEGEND :
CUỐC CHU

N – BLOW COUNT
ĐỘ NẶN

GP – GRAVEL SAND MIXTURE, LITTLE OR NO FINES
CAT SOI LAN LON, MOI NHUYEN HOAC TO

SP – POORLY GRADED SAND, LITTLE OR NO FINES
CAT PHAM CHAT XAU, MOI NHUYEN HOAC THO

SM – SILTY SAND AND SAND-SILT MIXTURE, SOME POORLY GRADED
CAT CO BUN VA CAT LAN LON, MOT IT PHAM CHAT XAU

SC – CLAYEY SAND AND SAND-CLAY MIXTURE, SOME POORLY GRADED
CAT CU DAT THO VA DAT SET CAT LAN LON, MOT IT PHAM CHAT XAU

CL – INORGANIC CLAY OF LOW MEDIUM PLASTICITY ; SILTY, SANDY CLAY
DAT SET VO CO IT DEO, CO BUN, DAT SET CO CAT

CH – INORGANIC CLAY OF HIGH PLASTICITY, FAT CLAY
DAT SET VO CO RAT DEO, DAT SET TOT

MH – FINE SANDY SOIL
DAT CO CAT NHUYEN

GRAPHIC SCALE
TỶ LỆ

0 1 2 4 6 8 10 12 16 20 M
SCALE 1 : 200

PROJECT NO
AID 730-3603

AGENCY FOR INTERNATIONAL DEVELOPMENT
CƠ QUAN PHÁT TRIỂN QUỐC TẾ
REPUBLIC OF VIETNAM
VIETNAM CỘNG HÒA

VUNG TAU PORT STUDY
NGHIÊN CỨU HẢI CẢNG VŨNG TÀU

COMMERCIAL FISHING PORT
NGƯ CẢNG

SOIL PROFILES
TRẮC ĐỒ ĐỊA CHẤT

LYON ASSOCIATES, INC

PLATE NO
BẢNG SỐ 4

B. COMMERCIAL PORT AREA

1. General Stratigraphy

Subsurface conditions may be generally considered to be a two layer system: an upper layer of very soft gray marine clays (CH)* varying in depth from 2 meters to 16 meters which shall be referred to as the Younger Sediments. This layer is underlain by a layer of heterogeneous and lenticular deposits of medium stiff to hard clays (CL, CH), poorly graded fine sands (SP), sandy clays (SC) and silty sands (SM). This layer will be referred to as Older Sediments. Rock was encountered in only one boring (VT-17) at an elevation of-10m (Approx. LLW).

The Younger Sediments consist of very soft to soft gray marine clays with basic index properties as follows:

Moisture Content (%):	89-129
Liquid Limit (%):	75-107
Plasticity Index (%):	43- 70
Liquidity Index (%):	$\geq$ 1.0

Based on the laboratory testing it appears that the Younger Sediments can be further divided into two units: an upper layer of higher moisture content clay (89-129%) and a lower clay layer having a lesser moisture content (55-75%). Both materials have Standard Penetration

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* All abreviations of soil type are in accordance with the Unified Soils Classification designation.

"N-values" of zero; however, the high moisture content clays appear, from the limited amount of data, to be more compressible and to have a lower shear strength than the lower moisture content clays. The presence of this lower moisture content clay was evidenced in the majority of borings. It is not clear whether this lower stratum of soft clay is a geologically different deposition from the upper layer of soil or merely the result of the collapse of the flocculated structure of the marine clay due to over burden pressure.

Shear strengths (Unconfined Compression Tests) of the Younger Sediments varied between 7.35 kg/cm^2 to 19.6 kg/cm^2. An average value of 9.8 kg/cm^2 was used for design purposes.

Four consolidation tests were performed on undisturbed samples of the soft clays and four consolidation tests on samples remolded to high moisture contents to determine compression characteristics of the hydraulic fill. The results of the tests show the marine clays to be normally consolidated with compression index (C_c) in the range 0.83-1.05 for the undisturbed samples and 0.65-0.75 for the remolded samples.

The Older Sediments are marine deposits of considerably greater age than the Younger Sediments and consist of heterogeneous and lenticular deposits of medium stiff to hard clays (CL, CH), poorly graded fine sands (SP), sandy clays (SC) and silty sands (SM).

For this project, laboratory testing was limited due to budgetary constraints. Also, since there are wide variations in the stratification

of the Older Sediments and strength properties appear to vary within wide limits, little emphasis was placed on laboratory testing for this material for this preliminary engineering study. Some data were obtainable for engineering purposes from the laboratory and boring program conducted in the area of the proposed fishing port by P.A. & E. for another project. This previous program consisted of six deep borings and a fairly extensive laboratory testing program. The borings penetrated into the Older Sediments and show stratification and basic properties similar to those found in the proposed commercial cargo port area.

For design purposes on this project, the following soils parameters were determined as appropriate for preliminary calculations.

Classification (Unified Soils System)	Range of N-Values (Blows/30cm)	γnat kg/m^3	C kg/m^2	ϕ (degrees)
SP	7- 30	177-209	0	32-38
SM	13- 30	177-209	0	32-38
SC	18-105	177-217	1340-2680	29-36
CL	14- 25	177-201	2680-5360	0
CH	9- 41	164-193	3580-8940	0

2. Dredging

Extensive dredging will be required in the areas of the entrance channel and turning basin. Final dredge elevations are - 13.0m or -11.5m depending on the choice of proposed port alternative concepts.

Subsurface probes with Standard Penetration Tests performed in these areas indicate an upper layer of very soft marine clays ("N" values of zero) underlain by loose to medium compact silty sands, clays sands and

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medium stiff to stiff clays ("N" Values 5-28). Rock was not encountered in any of the probes performed within the limits of dredging. It is expected that most of the dredge material encountered will be the soft clays with occasional ridges of the more compact soils.

Recommended dredge slopes (based on the properties of the soft clays which predominate) are IV to 6H for long-term stability requirements. For short-term stability considerations, such as for temporary construction, slopes as steep as IV to 3H may be used, subject to stability limitations imposed by depth of cut and distance to hard bottom.

The soft clays can be adequately removed by simple suction dredging; however, the stiff clays and compact silty sands will require the use of a suitable cutterhead on the suction line.

3. Hydraulic Fill

Material for the filling operation of the site will be obtained from the areas to be dredged for the deepening of the entrance channel and turning basin. The soils consist, to a large extent, of very soft clays with lesser amounts of stiff clays, sandy clays and silty sands. It was assumed for this study that the hydraulic fill material will consist only of the soft clays which predominate and which can be satisfactorily analyzed using standard consolidation theory and laboratory testing whereas the properties of hydraulic fills derived from stiff clays can only be predicted from full-scale test sections (Whitman, 1969).

The resulting fill has a very high water content and generally

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remains very soft for a long time. In cases where the fill builds up slowly, the fill generally is highly stratified in regard to permeability. Fills of this type are highly compressible and the compressibility can be estimated satisfactorily from laboratory tests on representative samples; however, the rate of consolidation will generally be much greater than indicated by laboratory tests owing to the stratified nature of the fill (Whitman, 1968). Since the fill remains very soft for a considerable time, a granular fill blanket will be required on top of the soft clay to serve as a construction surface for heavy equipment and for proper drainage afterwards. The minimum thickness of the sand blanket for these requirements is estimated to be 2 meters.

The dredge fill will be initially underconsolidated at the time of placement and eventually will be normally consolidated under its own weight. In an attempt to determine the compression properties of the soft clay dredge material, a special series of laboratory tests was performed. Undisturbed samples of the soft clay were remolded to a high moisture content using sea water to create a slurry-like consistency. The slurry was then placed in a flat pan and allowed to consolidate under its own weight while occasionally drawing off some of the water accumulating on the surface of the clay. A thin surface layer of water was allowed to remain on the clay to prevent drying of the soil. After a period of one week, all remaining surface water was removed, the clay was remolded and placed in the consolidometer, and a light seating load was applied. When consolidation under the seating load had stopped, normal consolidation test methods were utilized. Four series of tests were performed in

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this manner and the results compared with those obtained for the undisturbed samples as shown in Table 16.

Table 16

Comparison of Consolidation Properties
Remolded and Undisturbed Marine Clays

	Remolded				Undisturbed			
Sample	W(%)	Cc	Cv m^2/day	Co	W(%)	Cc	Cv m^2/day	Co
34-2	105.3	0.696	1.9×10^{-3}	2.865	106.0	1.042	1.9×10^{-3}	3.016
34-3	96.0	0.743	2.3×10^{-3}	2.624	95.6	0.970	2.8×10^{-3}	2.582
30-2	139.3	0.656	2.8×10^{-3}	3.873	97.8	0.825	2.8×10^{-3}	2.710
30-3	78.8	0.363	2.8×10^{-3}	2.127	54.2	0.370	4.6×10^{-2}	1.495

The above tabulated data indicate that the hydraulic fill will reconsolidate at higher void ratios and moisture contents, which would be expected of a resedimented clay in a marine environment. The Compression Indices (Cc) of the resedimented soils, however, were lower than those measured for the undisturbed soils whereas it would normally be expected that higher or equal Compression Indices would be obtained for the resedimented clay. The reason for the difference is not clear. However, it would seem that the resedimentation technique used in the laboratory is not compatible with that existing during the actual process expected in the field anomaly; i.e., a dispersed soil structure is produced rather than the flocculated structure expected. Further study of this and a more careful and elaborate testing program would be required during design if it were decided to construct the port.

Although data available are limited, settlement estimates can be made. The average elevation of the area to be filled is at present +2m

above Approx. LLW. The final grade of the area has been set at + 6 m (Approx. LLW) after consolidation of the clays and placement of a 2.0 m sand fill on the surface. The borings indicate between 5.0 and 11.0 m of in-situ soft clay underlying the area. Settlement calculations are as tabulated below for varying amounts of soft clay fill.

Table 17
Total Settlement Calculations

Depth of soft clay fill (m)*	Settlement of soft clay fill (m)*	Settlement of in-situ clay 5 m depth (m)	11 m depth (m)
2.5	0.17	0.95	2.09
3.0	0.21	1.00	2.20
3.5	0.24	1.05	2.31
4.0	0.27	1.09	2.40
4.5	0.34	1.14	2.51
5.0	0.41	1.18	2.60
6.0	0.47	1.23	2.71

* Plus 2.0 m sand fill.

Consolidation of the soft foundation soils and hydraulic fill will occur over a considerable time period. Assuming an average coefficient of consolidation (Cv) of $2.8 \times 10^{-3} m^2/day$ and various drainage paths and layer thicknesses, time settlement estimates can be made as shown in Table 18.

Table 18
Time Settlement Relations using Various Assumptions

Degree of Consolidation(%)	1-Way Drainage Thickness of Foundation Clay* 5 m	11 m	2-Way Drainage Thickness of Foundation Clay* 5 m	11 m
20	1.6	3.9	0.3	1.2
40	7.0	11.0	1.5	4.9
60	11.0	18.0	2.9	10.1
80	15.0	-	5.6	17.0
90	-	-	8.0	-

* Plus 3.0 m hydraulic clay fill.

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The minimal information available from the few borings and limited testing program does not supply sufficient data for determining which choices of drainage conditions and layer thicknesses should be used. However, even using the best combination of conditions, large settlements are to be expected after construction is completed.

4. Sand Drains and Wick Drains

When deep deposits of soft marine clays are surcharged by fill, large settlements are to be expected. Since these clays have extremely low permeabilities, these settlements will occur over a long period of time, far exceeding the actual construction period. As a result, structures built on this consolidating soil mass will be subjected to such extremely detrimental conditions as differential settlements, low bearing capacity for shallow foundations, and negative skin friction forces on deep foundations. It is therefore important that these settlements be completed during or shortly after the construction period of the fill. To speed up the consolidation period, techniques such as vertical drains (sometimes in conjunction with preloading) are often used to provide a shorter drainage path for the consolidating layers. Two common types of vertical drains are sand drains and cardboard wick drains.

Cardboard wick drains have been used extensively in Japan to consolidate reclaimed land (Kawamoto, 1965; Kjellman, 1948; Neukirchner, 1968).

Wick drains speed the consolidation of soft soil layers in the same manner as sand drains; i.e., by accelerating the drainage of pore water.

Methods of design of either type of drain are similar. Sand drain design methods are discussed by Johnson (1970) and Younger (1968). Design methods for cardboard wick drains are given by Kjellman (1948) and Kawamoto (1965). By varying the applied surcharge load and drain spacing, suitable rates of consolidation and total settlement can be achieved for most projects by either technique.

Because of the similarity between the two systems, it is natural to seek comparisons between them. The following points of comparison are based on published data taken from Kato Works Co., Ltd. of Japan;

(1) Approximately 2-1/2 times as many cardboard wicks as 40 cm sand drains are required.

(2) Field installations showed no appreciable difference between the two in regard to:

- Total settlements
- Rate of settlement
- Soil strength increase

(3) Cost of the wick drain system was about 60% of the cost of the sand drain system.

(4) Installation time for the cardboard wicks was less than for sand drains.

Factors which would favor the use of sand drains are as follows:

(1) Cardboard drains can only be inserted to a depth of 20 meters due to present equipment limitations.

(2) Drain driving machines for wick drains are manufactured only in Japan.

(3) The wick drain process is patented and royalties must be paid for its use.

(4) For the use of cardboard wick drains, soil permeabilities must be less than 10^{-5}cm/sec.

Wick and Sand Drain Design

Data

Existing ground surface elevation:		+ 2m (Approx. LLW)
Height of hydraulic fill:		3.0 m
Height of sand fill:		2.0 m
Made-ground elevation (end of const.):		+ 7 m (Approx. LLW)
Foundation settlement expected for:	5m soft clay:	1.00 m
	11m soft clay:	2.20 m
Hydraulic fill settlement expected:		0.21 m
Total settlement expected:		1.2 - 2.4 m

Assuming that 5 m of in-situ soft clay cover most of the site, final elevation after completion of primary settlement would be approximately + 6.0m(after including allowances for settlements occurring during placement).

Assuming = 2 x Cv and use of 40 cm diameter sand drains spaced 2.4 m on center in a triangular pattern with no preloading, the time-settlement data are as follows:

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$\bar{U}$ (%)	Time (Months)	Settlement (m)
30	2	0.36
40	3.5	0.48
50	5	0.60
70	9	0.84
90	16	1.08

One cardboard wick drain is generally assumed to be equivalent to a 5 cm sand drain for design purposes. To achieve the same results as for the 40 cm sand drain, the cardboard wicks would have to be installed on a 1.3 m spacing.

Based on the above analysis, it appears that sand or wick drains could be successfully utilized to speed the consolidation process. Further, it appears that the addition of surcharging loads to the vertical drains will not be necessary. However, the determination regarding the desirability of preloading cannot be properly made until further soils data and construction time requirements are obtained. Furthermore it is to be expected that a rather extensive field testing program will be required for the design of the drain system.

The choice of which drain system, sand or wick, in the optimum scheme will depend on more exact performance information developed from field tests. However, from an engineering viewpoint, certain comparisons should be brought out:

(1) Cardboard wick drains are relatively untested as compared to the much more extensively used sand drain method. The use of wick drains has essentially been restricted to Japan.

(2) During placement the drains of the sand type are prone to discontinuities due to intermixing with the very soft clay. Shear stresses will also cause discontinuities in the sand columns. To prevent this problem it may prove necessary to encase the sand in a pervious membrane to help maintain continuity of the column.

(3) Sand drains require a highly pervious, well-graded material. The local Vung Tau sand is a uniform, poorly graded sand and does not meet the gradation requirements for a properly designed sand drain material. Therefore, without a special study of the effects of using the Vung Tau sand in the drains, it will be necessary to use Bien Hoa sand which has a better gradation for use in the drains.

In view of the above, the use of sand drains has been assumed in the design of the reclaimed areas for this study. Due to the unsuitability of Vung Tau sand for these drains, Bien Hoa sand was also assumed in preparing the preliminary construction cost estimates.

5. Breakwater Design for Barge Basin of Alternative Concept No. 3

Four different typical heights of embankment will be required for construction of the full length of the rubble mound breakwater (see Section V. b. 1. f. and Plates 10 and 11). In all cases the foundation soils are deposits of very soft marine clays underlain by the stiff clays and compact sands of the Older Sediments. Typical thickness of the soft clays are shown in Table 19.

Table 19

Variation in Depths of Soft Clay

Breakwater Section	Average Breakwater Height (m)	Depth of Soft Clay(m)
I	13.0	4.0 - 4.5
II	11.0	4.0 - 4.5
III	9.0	4.0 - 4.5
IV	7.0	3.5 - 8.0*

For the most part, the soft marine sediments are highly plastic gray clays (CH) with average undrained shear strengths of 9.8 kg/cm^2. Stability analysis of each section indicates factors of safety considerably less than 1.0. To provide a satisfactory safety factor ($\geq$1.25), three options were considered:

(1) Addition of stabilizing berms at the toe of the breakwater.

(2) Partial removal of the soft clay by dredging and back filling with the locally available Vung Tau sand followed by construction of the breakwater.

(3) Displacement techniques, whereby the placement of the quarry run core of the breakwater is performed in such a manner that the soft clay is pushed out from beneath the embankment in the form of a mud wave until the embankment reaches the proper height and a sufficient amount of the soft clay has been displaced. Blasting to aid in displacement of the clay has been used in conjunction with normal displacement techniques on some similar projects.

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* Boring 13, located approximately 300 m east of the proposed breakwater location, indicated 15 m depth of soft clay.

These three construction options are now considered in more detail herein:

- Stabilizing Berms

For the design of stabilizing berms for embankments two criteria must be satisfied (DM-7):

(a) The berm must provide a sufficient counterbalancing weight to the embankment forces to increase the factor of safety of the critical failure surface to 1.25 (overall factor of safety).

(b) The bearing stress under the berm must not exceed 5.5 x undrained shear strength divided by a factor of safety (Berm failure criteria).

Of the four sections studied only the lowest embankment height satisfied criterion (b) however, a berm 70 meters long and 2.4 meters high is required to satisfy criterion (a) using the method of analysis given by DM-7, Figure 7-7. Such a berm is less satisfactory than methods 2 and 3.

- Partial Removal of Soft Clay

By replacement of the soft clay with a higher strength soil, foundation conditions can be improved to safely carry the weight of the breakwater. Similar techniques with construction examples are described by Feld (1968).

Using the locally available Vung Tau fine sand (ϕ = 30°) as backfill after dredging, 6 meters of clay must be dredged for Section IV while

Sections I, II and III require 4 meters of dredging to reach competent bearing soils. Suitably dredged side slopes in the soft clay are 3H:IV for the short-term stability analysis using undrained strengths. A typical section is shown on Figure 22. Since the Vung Tau fine sand will tend to be highly erodable, a small berm of filter blanket material must be placed on top of the fine sand to prevent undermining of the toe of the breakwater.

- Displacement Technique

By means of suitable and careful construction techniques a considerable quantity of the soft clay may be displaced ahead of the front of the embankment in the form of a mud wave and a reasonably stable structure can result. A wedge-shaped construction front is required at all times to insure the movement of the mud wave is in the direction of the longitudinal axis of the embankment. Additionally, due to the length of the breakwater, accumulations of soft clay built up in front of the embankment will have to be periodically removed to insure a uniform displacement depth (Stamatopolos et al, 1972). Inherent difficulties with this method are:

(1) Extreme care must be taken during the construction operation to maintain a uniform displacement of soft clay. This is best monitored by determination of the embankment volume ratio; i.e., actual volume placed divided by theoretical volume of unfailed section. Large changes in this ratio over short distances would indicate areas where pockets of soft clay have been trapped due to improper construction methods. Base failures associated with an embankment volume ratio of up to 2.5 generally

are not accompanied by pronounced heaving and long periods of initial instability. Such base failures can be termed mild. In cases where the ratio is higher than 4, heaving is pronounced and the period of initial instability is longer.

(2) Heaved areas along the side of the breakwater, while aiding stability initially, will eventually be eroded away thereby jeopardizing the stability after construction is completed or resulting in cracking of the embankment due to differential settlements and creep movements.

(3) Due to the high probability of uneven displacement of the soft clay and disturbance of soil structure, large consolidation and plastic creep settlements would be expected with associated differential settlements resulting in serious maintenance problems of the armor stone units.

Fill material used for the displacement of the clay could conceivably be the Vung Tau fine sand or quarry-run rock. The quarry-run rock is to be preferred for this operation since:

(a) The rock has a higher density and average grain size than the sand and therefore would produce a greater and more uniform depth of displacement.

(b) Since the Vung Tau sand is a uniformly graded fine sand and will be placed at a low density, the soil will be subject to liquefaction and flow movement due to shocks. If blasting is required to aid in the displacement of the soft clay, the loose, saturated sand will have a large potential to liquefy and flow at flat slopes considerably increasing the volume of fill required and creating additional construction difficulties.

(c) The Vung Tau fine sand is highly susceptible to erosion and must therefore be well protected from the effects of scour and wave action by means of filter blankets and armor units. Since large differential settlements would be expected using a displacement technique, deformations of the embankment would result in openings in the armor units and filter layers and the rapid erosion of the fine sand core by wave and current action.

In view of the above discussion, the most appropriate design method for the foundation conditions characteristic of the proposed breakwater site would appear to be the technique involving removal of the soft clay by dredging and back filling with Vung Tau sand. The features of the breakwater are presented in Section V. B. 1. f. A stability analysis carried for the proposed breakwater has indicated that it will be stable using this design technique. In addition the berm slope underlying the open wharf structures utilized in the alternative concepts, which are essentially the same design as that of the breakwater, were found to be stable.

6. Retaining Dikes

To prevent the hydraulic fill material from running back into the sea during the dredging operations, it will be necessary to construct earth retaining dikes around the periphery of the site. The retaining dikes would be built to elevation + 6m (Approx. LLW); thus approximately 4 m high earth structures would be required. Stability analysis of the embankment sections indicate that the maximum height of fill that can be

placed without failure occurring is 2.2 m. It will therefore be necessary to utilize displacement techniques to provide for a relatively stable dike before the start of placement of the hydraulic fill. Displacement techniques have not been recommended for use in the breakwater construction due to large differential settlements and the resulting maintenance problems. However, the retaining dike construction represents lighter loading conditions as well as being a less critical section and therefore lends itself more readily to displacement methods assuming use of careful and proper construction techniques.

It is economically advantageous to utilize the locally available Vung Tau fine sand for the core of the retaining dikes. However, the use of blasting to aid in the displacement of the soft clay is a highly suspect construction aid due to the probable tendency of the Vung Tau sand to liquefy from blast shock effects which will result in increased volumes of sand required as well as increased construction problems.

Additional problems are presented as the hydraulic fill is placed on the site and more load is imposed on the area along the retaining dikes. As the fill builds up behind the dikes instability forces are introduced. To prevent these stability problems, hydraulic fill placed behind the dikes should be limited in height. By restricting the location of the dredge pipe outlets to the interior parts of the site, deposition of significant amounts of material directly behind the dikes can be prevented. Thus the function of the dikes will be to prevent erosion of the soft clay fill by wave and tidal action as well as to prevent the return of excess

fines to the sea. Build-up of hydraulic fill behind the dikes should be accomplished at a slow rate to allow for dissipation of excess pore pressures in the soft foundation clays and heights should be held to a minimum to prevent stability problems with the dikes.

C. COMMERCIAL FISHING PORT

1. General

Borings were not performed in the existing commercial port area as part of this project due to the availability of sufficient boring data for this study from the exploration program performed in 1966-1967. Available test data consist of basic index properties, unconfined compression tests, direct shear and triaxial (UU) tests.

2. Subsurface Stratigraphy

Stratification in the upper 9 to 14 meters is not well correlated between borings. Clayey sands, silty sands, lean clays and plastic silts are interwoven in a heterogeneous and lenticular manner. These soils are believed to be river levee and flood plain deposits and therefore represent a different deposition process from that found in the commercial cargo port area where soft marine clays are found. "N-values" in these upper layers were low, in the range of 1 to 7 blows per foot.

Beneath the upper, weak soil complex, medium compact to compact silty sand overlies a very stiff to hard highly plastic clay. These lower layers appear to be part of the older sediment continuum found in the proposed commercial cargo port area as previously described.

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D. CONSTRUCTION MATERIALS

1. Quarry Rock and Coarse Aggregate

Immediately adjacent to the project site is Vung May Mountain. Investigation of the area disclosed two operating quarries under the control of VECCO, a semi-governmental organization. Inspection of the quarry faces indicates the rock to be a moderate to closely jointed rhyolite with some basalt flow surfaces. Blasting has been required for the production of rock for construction.

The maximum size armor stone required for this project will be one ton stone which can be produced in more than sufficient quantity. Rock suitable for underlayers and core material would also be available.

Concrete coarse aggregate has been obtained from the quarry and it is expected that sufficient quantities will be available for this project.

2. Fine Aggregate

Vung Tau Sand

Locally available fine aggregate is limited to the Vung Tau beach sand which is a uniformly graded fine sand unsuitable for use as a concrete fine aggregate. Use of the Vung Tau fine sand would be considered for use as a general site fill material only.

Bien Hoa Sand

Concrete sand in the Vung Tau area is commonly obtained from river dredged sand deposits in the Bien Hoa area, approximately 20 kilometers

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northeast of Saigon. Large quantities of this material are available and have been successfully utilized in concrete mixes on other projects. It is also expected that the Bien Hoa sand would be required in the sand drain construction described in this section.

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SECTION V

CONCEPTS FOR DEVELOPMENT PLANNING

A. EXISTING CONDITIONS

1. Port Facilities

Vung Tau, located at the entrance of the Saigon ship channel, is a seaside resort city and a small commercial cargo port and fishing port which supplies the Saigon market with fish and shrimp. Existing port facilities are limited and in poor condition and waters in the region are generally shallow. There are several small fishing villages along the coast west of Point Ganh Rai and in the Dinh River. One of the most important of these is the Nhu Cang Hamlet which has a relatively new pier, an unfinished fish market building (see Figure 18) and a second pier in general disrepair. Still farther upstream at Cho Hamlet is another pier which was first used by the French army then later by the ARVN. All these facilities are accessible only to small fishing boats and some offer fueling and icing services.

To the west on the Dinh River is the existing commercial cargo port which at one time was used by ocean going ships bringing war material into the area but is now used only by small cargo vessels. Facilities at the port include the approach causeway to a Delong pier which has been removed leaving only some of the support pilings. Extending from the east side of the causeway are two wooden finger piers, one of which

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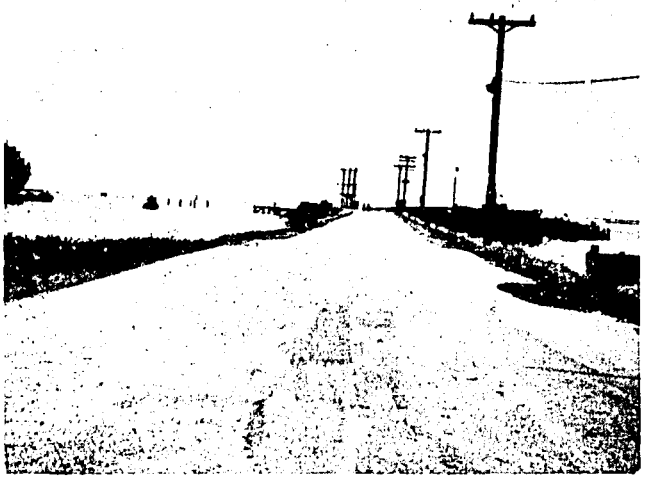
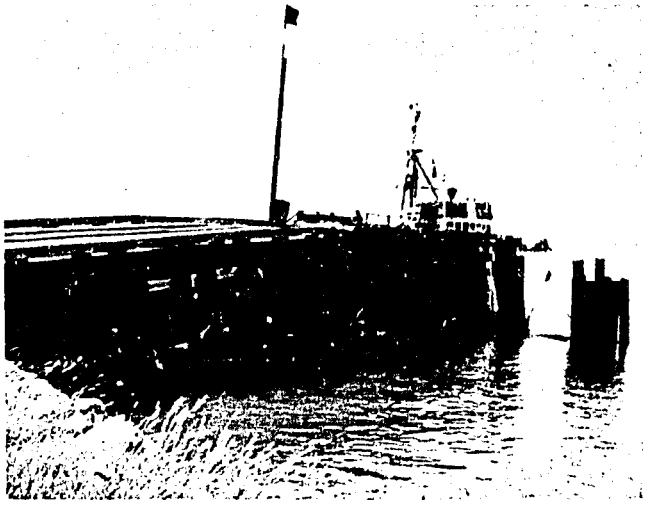
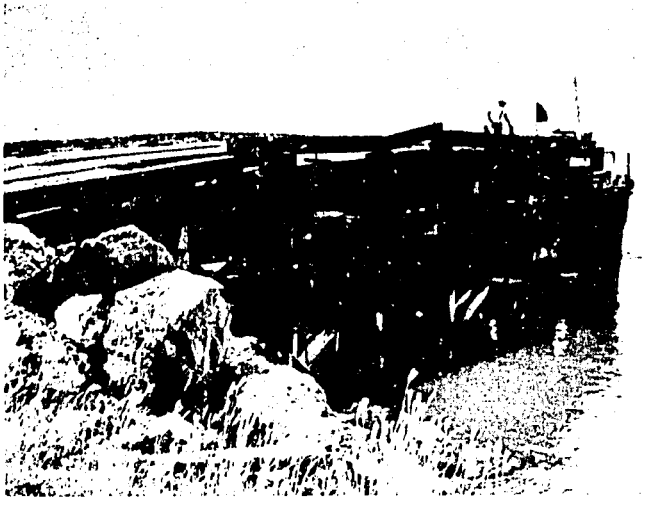
Commercial Port Area
Vùng Thương Cảng



Delong Pier Causeway ,
Thuộc Đường Trải Đá của Bến Tàu



First Pier, Delong Pier Causeway
Cầu Tàu Thứ Nhứt, Thuộc Đường Trải Đá của Bến Tàu



Second Pier, Delong Pier Causeway
Cầu Tàu thứ Hai, Thuộc Đường Trải Đá của Bến Tàu

Fish Market - Ngu Cang

Figure 18 - View of Existing Commercial Port and Fishing Port, Vung Tau
Hình 18 Hình Ảnh Thương Cảng Hiện Hữu và Ngư Cảng, Vũng Tàu

is in general disrepair while the other is in relatively good condition (see Figure 18). To the east of the causeway is a concrete topped barge on piles which is used for mooring by small cargo vessels. Further upstream on the Dinh River is a petroleum berth in poor condition. At Cat Lo on the river are the relatively new ARVN naval port facilities.

2. Waterways

The approach fairway to the proposed port passes through a bank of shoals and has a minimum depth of 9.7 meters at Approximate Lowest Low Water. At Mean High Water (+3.3 meters Approx. LLW) the minimum depth is 13.0 meters.

Farther inland the Dinh River estuary gives access to the existing commercial port and to the ARVN and other installations on the Dinh River. The existing dredged channel traversing the estuary is approximately 76 m wide and has a depth of 8 to 10 meters. It must be dredged regularly in order for ships to have access to the Dinh River installations.

The Ben Dinh stream giving access to the fishing hamlets is very shallow. Depths are shallow allowing passage of small fishing boats only. At low tide most of the fishing port facilities do not have sufficient water depth even for these small vessels so that instead of unloading at the berth, the boats are anchored in midstream and the catch is transferred to the beaches by lighters.

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3. Inland Transportation

Land communication from Saigon to Vung Tau is by road only. The road may be divided into sections according to the existing width:

- Saigon-Thu Duc section: Four lane highway, 18.2 m wide, currently being widened, good surface, used by heavy traffic.

- Thu Duc-Gien Hoa (Long Ginh Turnoff) section:

  Four lane highway, 15.4 m wide being widened in certain parts, good surface, being used by heavy traffic.

- Long Binh-Phuoc Le (Baria) section:

  Two lane road, surface poor to very poor, patched and narrow in spots, Width varies from 12.6 m to 6.7 m close.to the turn-off from the Saigon - Bien Hoa highway. Used by military type traffic.

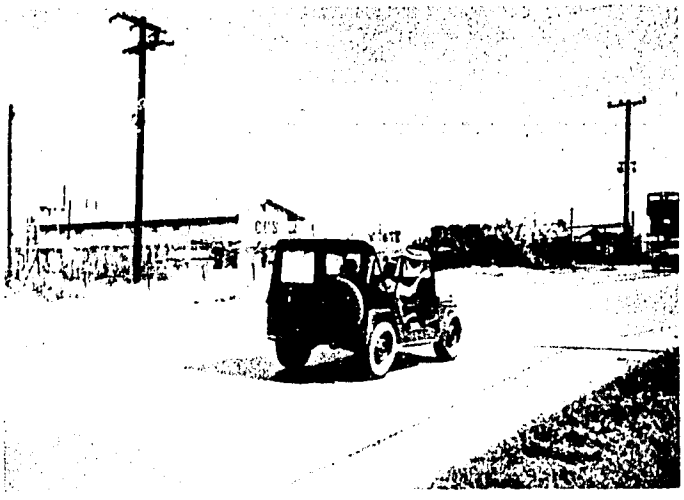
- Phuoc Le (Baria) - Vung Tau (Rach Dua) section:

  Two lane road, 12.4 m wide, good surface, used by military type traffic.

- Vung Tau from Rach Dua to Point Ganh Rai:

  Two lane road with very poor surfacing becomes very narrow in spots, width varies from 6.6 m to 4.3 m, obstructed by markets, pedestrian and vehicular traffic.

According to the Saigon Directorate of Engineering (Subdivision of Roads and Bridges) the Long Binh - Vung Tau portion of the road is 12.3 m wide and consists of a 17 to 25 cm granular subbase and base on fill with a 9 cm asphaltic concrete base topped by a 5 cm asphaltic concrete surfacing.



Road Opposite Existing Commercial Port
Đường Lộ Đối Diện Thương Cảng Hiện Hữu

Intersection, Port and Pt. Ganh Rai Roads
Điểm Tiếp Giáp, Hải Cảng và Các Đường Lộ
tại Điểm Gành Rai

Road to Point Ganh Rai - Đường Lộ Dẫn đến
Điểm Gành Rai

Figure 19, Existing Roads, Vung Tau Port
Hình 19, Đường Lộ Hiện Hữu, Hải Cảng Vũng-Tau

The road is designed for a simple axle load of 8.2 tons. The bridges were designed for the AASHO HS20-44 load or a 10 ton single axle load.

4. Utilities

a. Water

The existing water supply of Vung Tau is taken from wells and the total yearly supply is 170,000 m^3. This volume is the maximum that can be obtained with the existing installation. The total yearly demand o, Vung Tau and vicinity is 200,000 m^3, the balance being supplied by truck. The town and hamlet consume 142,000 m^3 and the military facilities 58,000 m^3. The available volume barely meets the demand and will not be sufficient for the city of Vung Tau itself in the near future in consideration of the estimated growth of the Vung Tau area excluding any commercial port or industrial growth. The Ralph M. Parsons Company and the Snowy Mountain Engineering Corporation have both made studies of the water supply in Vung Tau and have made recommendations which will be reviewed later in this report.

b. Electric Power

The electric power plant is located on Phan Hung Tai Street in the city of Vung Tau. Electricity from this power plant is distributed via three feeders to the municipality of Vung Tau, to Truong Cong Dinh and to the entire Province of Phuoc Tuy.

The power plant consists of five diesel generators as follows:

Units 1. 2 and 3 are identical and were installed in 1969:
General Motors, 2100 KW, 2625 KVA, 4160 Volt Wye,
0.8 P.F., 50 Hz.

Units 4 and 5 are identical and were installed in 1972:
SACM (French), 1200 KW, 1500 KVA, 5500 Volt, o.8 P.F., 50 Hz.

The total installed power at this facility is 8,700 KW.

The power plant is in good physical condition and the operating and maintenance personnel appear knowledgeable in their duties. A planned maintenance program allows for one unit to be off the line for maintenance at all times with the maintenance procedure being extensive and thorough, extending for a period of three to four weeks per unit. All five generators are systematically rotated through this maintenance procedure.

Two power ships which previously supplied power to the Air Base are no longer in operation although they remain in location offshore. Transmission lines have been dismantled and it is understood that the ships may soon be removed from the area.

Power is distributed at three phase, 15,000 volts and is utilized at three phase 380 volt, single phase 220 volts, and single phase 120 volts. The single phase 120 volt installation is a carry over from the old system and all new installations are being installed as single phase 220 volt.

The primary lines are supported on wooden poles similar to REA installations in the U.S.A. The secondary distribution system is installed on wooden and concrete poles. The concrete poles are the remains of the original distribution system and are generally located in the older, more congested areas. Transformers are all single phase and are installed singularly or in banks of three as required.

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The maximum demand occurs during a three hour period between 1900 and 2200 hours. The maximum demand during the weekdays averages 4,500 KW but increases during the weekend to 5,200 KW. The increase in power consumption during the weekend is a result of the influx of tourists from Saigon and vicinity.

There appears to be very little growth in power consumption as confirmed by the following figures:

Maximum Monthly KW/Hr. Usage

1971	:	1,400,000
1972	:	1,450,000
1973	:	1,600,000

The increase in 1973 was caused primarily by the transfer of military facilities at the air base from the two power ships to the Vietnam Power Company. The present maximum demand is well within the capabilities of the existing power plant even when one of the largest generators is down for maintenance. Although little growth in electrical demand is evidenced to date, future industrial and population growth at Vung Tau and the surrounding region may cause this situation to change. In the event this happens existing plans to expand the power availability in this area will probably be sufficient to handle the increased demand. The nature of these plans is described later in this report.

B. DESIGN CRITERIA

1. Commercial General Cargo Port

a. General

A commercial port is the interface between ocean and land and/or inland waterway transportation systems. Thus the primary function of a commercial port is the transfer of cargo between ocean carrier and inland carrier. Since the transfer of cargo within the port area is frequently the most costly element between origin and destination of cargo, despite the fact that it does not contribute to the movement of it between these points, careful consideration must be given to the layout and requirements of facilities in order to minimize costs.

The availability of a network of required roads, rails and waterways to inland cites is essential if a port is to flourish. Particular attention must be given to access from the port area to these main arteries of communication. For example the port road traffic should be routed so as to avoid as much as possible city traffic and built up congested areas.

The assessment of land requirements for a port must take into consideration the area necessary for the channel, turning basin, anchorage, berths and the on-shore facilities for cargo handling, storage and other port related functions. The width, length, depth and size of the navigation facilities should be based upon economic factors resulting in optimum design without jeopardizing the safe maneuvering of vessels. Of particular concern in this study is the cost for the initial dredging

and for maintenance dredging. In addition the onshore area must be such that it allows the free flow of traffic generated within the port by the cargo handling equipment and the various inland transport modes.

Due to the awareness of man for stewardship of environmental resources, an analysis of the environmental effects a proposed port facility will have on the local area has become a component part of many port development studies. This aspect has been considered in the preparation of alternative port development concepts presented in this report.

b. Ship Characteristecs

The Scope of Work for this study states that the commercial port should be developed to accommodate ships having drafts up to 14.6 meters (48 feet). However, nautical charts of the region show that the depth of water in the approach fairway to Vung Tau is only 9.7 meters at Approximate Lowest Low Water. Assuming a high tide level (Mean High Water) of 3.3 meters, it can be seen that the available depth for ships using the fairway in this tide condition is only 13.0 meters. Subtracting from this depth a surge allowance of 1.5 meter (this value is the allowance for waves in the fairway; a 3.0 meter wave was used which represents maximum conditions which might occur during a typical year in the exposed fairway region), an out of trim or squat allowance of 0.3 m plus a safety margin 0.5 m, it can be seen that the maximum draft of ships that could be calling at the port of Vung Tau on essentially an every day basis at average high tide levels amounts to only about 10.7 meters (35 feet). Thus in order to fulfill the requirement set forth in the Scope, massive

dredging of a channel in the approach fairway would be necessary. This dredging would require a large ocean going dredge which would have to move many millions of cubic meters of material and the cost of this capital dredging would be prohibitively high. Moreover, in its exposed location, sedimentation of a dredged fairway channel could be expected to be substantial thus requiring considerable annual maintenance dredging. For these reasons it was decided that the draft of ship for which the port of Vung Tau would be developed should be limited to the maximum which could make use of the fairway without dredging, or about 10.7 meters.

Given the above described limitation, two alternative ship drafts were considered in the formulation of alternative port development concepts. These are 10.7 meters and 9.1 meters. The former draft was set by the limiting depth of the fairway as explained above. The latter is a common draft characteristic of a large number of ships which could be calling at Vung Tau if it were developed as a commercial cargo port. The following table gives the characteristics of typical ship types having these drafts.

TABLE 20

Ship Characteristics
10.7 Meter Maximum Draft Ships

Draft (m)	Type of Vessel	Dead Weight DWT (T)	Length of Ship (m)	Width (Beam) (m)
9.8	Freighter	20,000	170	21
10.7	Tanker	35,000	208	24
10.7	Ore Carrier	30,000	205	26.5
10.7	Container vessel	26,700 (1,300) (1)	230	30.5

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TABLE 20 - Cont'd

Ship Characteristics
9.1 Meter Maximum Draft Ships

Draft (m)	Type of Vessel	Dead Weight DWT (T)	Lc Length of Ship (m)	Width (Beam) (m)
9.1	Freighter	15,000	160	20.5
9.1	Tanker	17,000	170	21
9.1	Ore Carrier	15,000	163	20.7
9.1	Container vessel	16,600 (589) (1)	180	24

c. Navigation Facilities

General

As seen from the preliminary cost estimates (see Section V. c.) and the oceanographic studies (Section III) the capital and maintenance/ dredging costs would constitute a large portion of the required expenditures for the proposed port developments. Therefore the length, depth and width of the approach channel and turning basin were kept to a minimum consistant with safety.

The optimum depth of the approach channel and inner harbor should be sufficient, at Approximately Lowest Low Water, to permit navigation when vessels are fully loaded. This depth must include, in addition to the draft of the vessel, allowances for surge, out of trim or squat when the vessel is in motion, and an empirical factor which depends on whether the sea bottom is soft or hard, and for siltation.

---

(1) Number of 20 foot equivalent containers the ship can carry.

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The maximum size of ship used to determine the optimum depth of the approach channel and inner harbor depends upon an analysis of certain cost factors within the total transport system. However, due to the limited scope of this study, the size, depth, and shape of the navigation facilities for the various alternative development plans were determined for the two drafts (10.7 and 9.1 meters) discussed in the previous section.

Depth of Approach Channel and Inner Harbor

As a rule the depth of the approach channel is greater than that of the inner harbor because the entrance is usually exposed to larger waves. Consequently the surge, which is 1/2 the wave height, would ordinarily be greater in the approach channel than in the inner harbor. However, as stated in the oceanographic section (Section III) the maximum seasonal wave, having a height of about 1.0 meter, likely to occur in the entrance channel is the same as that expected in the inner harbor because of the geographical location of the port. Thus the depth of these two navigational facilities has been set at the same level in port alternative concepts.

The required depths for the two assumed drafts, which are based upon the Panama Canal tests and the Permanent International Association of Navigational Congresses recommendation are as follows:

- Surge = 1/2 Wave Height = 1/2 x 1.0 m = 0.5 meter
- Squat = 0.3 meter
- Empirical factors = 1.6 meters

  (Additional clearance under the keel = 0.6 meter (soft bottom)

plus 1.0 meter overdredging for siltation. Due to the tenuous nature of predicting quantities of siltation, only 1.0 meter of overdredging has been allowed for siltation.)

Adding these factors to the drafts of the vessels, the required depths are as follows:

- 9.1 meter draft vessels = 9.1+0.5+0.3+1.6 = 11.5 meters
- 10.7 meter draft vessel =10.7+0.5+0.3+1.6 = 13.1 meters; say 13.0 m

Width of Approach Channel

Depending on the number of ships expected to use the facility, the width of the approach channel could be set to accommodate one way or two way traffic. Thus, based upon the criteria resulting from the Panama Canal studies, the following criteria for widths of channels were used:

One-way traffic:

Width of maneuvering lane = 2 B (B = Beam of the vessel)

Bank clearance 2 x B = 2 B

4 B

Two-way traffic:

Width of maneuvering lane = 2 x 2 B = 4B

Clearance between maneuvering lanes = B but not less than 30.5 meters

Bank clearance 2 x B = 2B

6B + B or 30.5 meters, whichever is greater.

Therefore the width of the channels for ships used in the study are as follows:

One-way traffic:

9.1 m draft vessel = 4 x 24 m = 96 meters; say 100 meters

10.7 m draft vessel = 4 x 30.5 m = 122 m; say 125 meters

Two-way traffic:

9.1 m draft vessels = 6 x 24 m + 30.5 m = 144 + 30.5

= 174.5 m; say 175 meters

10.7 m draft vessel = 6 x 30.5 + 30.5 m = 213.5 m; say 215 meters

Size of Turning Basin

The radius of the turning basin without tug assistance should be equal to two times the length of the largest ship. However, with tug assistance this radius could be reduced although in no case should the radius be less than one ship's length. In order to keep capital dredging to a minimum yet provide maximum safety in the face of strong currents and a rather exposed harbor, a radius of 1.5 times the maximum length of ships described above was taken for the turning basins in alternative concepts. It must be realized, however, that tugs will be required to aid some vessels in maneuvering and docking and undocking.

d. Height of Quay Structures

The height of the quays shown in the three alternative port layouts must be set so that overtopping by waves, even during major storm conditions, is kept to a minimum. In general therefore, heights were set to insure dryness during design storm conditions; that is, minimal overtopping of quays or backup areas even by the maximum wave of the storm wave spectrum.

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As stated in Section III. c. of this report, a maximum still water level of + 4.15 meters is recommended for northward facing structures which include deep water wharfage in all port alternatives considered. In calculating the height of these structures, therefore, 4.15 meters was added to the height to which the water level would be brought as a result of the design maximum wave (Hmax. = 3.2 m). Two wave produced levels were calculated which depend on the type of construction, closed or open, which could be used in construction of the wharfage. For closed construction, in which waves will encounter a solid quay wall, the Sainflou method for calculating the height of a standing wave against a vertical wall was used (see Section III. C. 2. d., Reflected Waves). This height was determined to be 3.8 meters above maximum still water level. The total wave plus still water level is 7.95 meters and the height of the deck was therefore set at + 8.0 meters.

In the selected open type wharf structure the height that the maximum wave would reach on the structure is not governed by standing wave phenomena against a vertical wall but by the characteristics of waves travelling through shoal waters. Waves in deep waters reach to a height equal to their amplitudes (i.e. 1/2 their height) above still water level. In shallow waters, however, waves tend to flatten in their troughs and to "peak up" or increase in height in their crests. In water depths proposed for the quays, the height of the wave crest above still water level will be about 0.6 times the wave height. Again using Hmax. = 3.2m the total height on an open pier structure to which water could reach during extreme storm conditions would be

$$4.15 \text{ m} + 0.6 \times 3.2 \text{ m} = 6.05 \text{ m; say } 6.0 \text{ m.}$$

Taking into consideration the fact that the seasonal wave crests would be much lower than those generated by maximum storm conditions and the large tidal range which makes it mandatory to set the top of deck as low as possible, the height of deck was set at elevation +6.0 meters and designed to withstand the uplift forces caused by storm waves which might come in contact with the bottom of the deck.

In addition to exposure to winds and waves from the north, the quay areas will also be exposed to southerly winds. Careful consideration of this eventuality was necessary because of the fact that the full effect of storm surge can be expected associated with winds from this direction. A maximum still water level of 4.7 meters was therefore used in this analysis.

In port layout Alternative Schemes 1 and 2 the back, or southern, boundary of the port backup area will consist of a protected slope having armor protection and stone underlayers in a section similar to that used for the breakwater shown in Alternative 3 (see Section V.B.1.d.). The maximum height to which water will reach on this structure is the maximum still water level plus the runup of the maximum design wave on the structure. The design criteria are therefore:

Maximum Still Water Level:	4.7 m
Design Maximum Wave Height (Hmax.)	3.2 m
Runup factor on rubble structure	0.7

The maximum water height will be:

4.7 m + 3.2 m x 0.7 = 6.9 m; say 7.0 m

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The height of the wall should therefore be at least 7.0 m high to insure dryness of the port area during a storm in which winds blow from the southerly quadrants.

In port layout Alternative No. 3 the southward facing quay is protected by a breakwater. However, as stated in Section V.B.1.d. significant overtopping of this structure by waves is expected during a major storm and in this event a significant wave height of about 0.6 m and a maximum wave of 1.1 m can be expected in the barge basin. For a vertical closed quay wall in the barge basin the Sainflou method for determining the height to which standing waves created by a 1.1 m incident wave can reach was used.

The total water height on the wall would be:

Maximum Still Water Level	4.7 m
Height of wave on wall	1.2 m
Total:	5.9 m; say 6.0 m

For an open quay with no vertical wall, the height would be:

Maximum Still Water Level:	4.7 m
Height of Wave on wall: 0.6x1.1=	0.7 m
	5.4 m; say 5.5m

Based on the criteria the quay wall should therefore have at least + 6.0 m elevation for a closed structure with vertical quay wall and +5.5 m for an open structure without quay wall.

Since northerly approaching waves can encounter the pier on the north side and since these criteria will result in a higher pier structure, the pier height should be set in accordance with the northerly wave, namely +8.0 m for closed and +6.0 m for open type construction.

e. Type of Construction

The types of construction for wharfs and piers generally fall into two broad classifications: Open and closed.

The open type construction consists of a deck supported on piles. The deck, constructed of steel, reinforced or prestressed concrete, or wood, can be a high-level or relieving platform type. In the relieving type the main structural slab is below the finished deck and the space between is filled, generally with sand, to provide additional weight for stability. The piles, arranged in rows or bents, can be driven wooden, steel, or reinforced or prestressed concrete or can be cast in place reinforced concrete caissons.

The closed or solid type of construction can be subdivided as follows:

- Gravity type quay walls which are constructed of either concrete blocks or open well concrete caissons filled with rock or a granular material.

- Sheet pile bulkhead which may be constructed of steel or concrete sheet piling and, depending on the fill retained, can be supported by tie rods anchored to piles or by a wall located a safe distance behind the bulkhead. Also this type of bulkhead can be anchored by batter piles

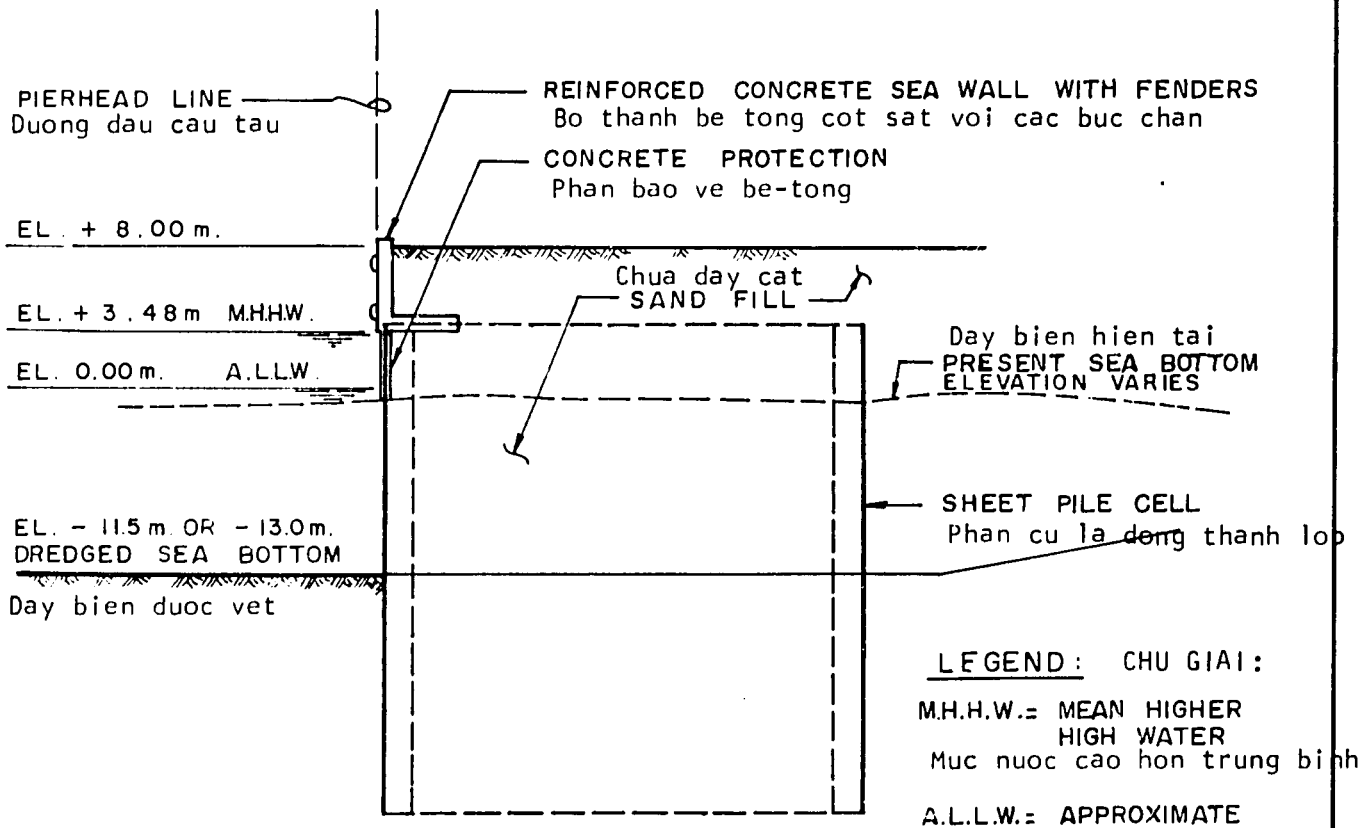
along the back of the piling. In addition, this type of construction can be built as a series of sheet pile arcs abutting a king pile which may be anchored as described above for the sheet pile bulkhead.

- Cellular sheet-pile bulkhead which consists of a series of cells either fully circular or having circular ends and straight walls constructed of flat web-steel piling filled with a granular material. The circular type is generally preferred because each cell can be filled independently without jeopardizing the structural integrity of that cell; thus each cell is stable in itself.

Due to the required depth in front of the docking facilities and the foundation conditions at the site, only the open high deck and the closed cellular sheet pile types of construction could be considered for the wharfs and piers at the commercial general cargo port. Since each of these two types of construction would fulfil the main function of the required docking facilities, the choice between the two types was made on the basis of relative unit costs which are as follows:

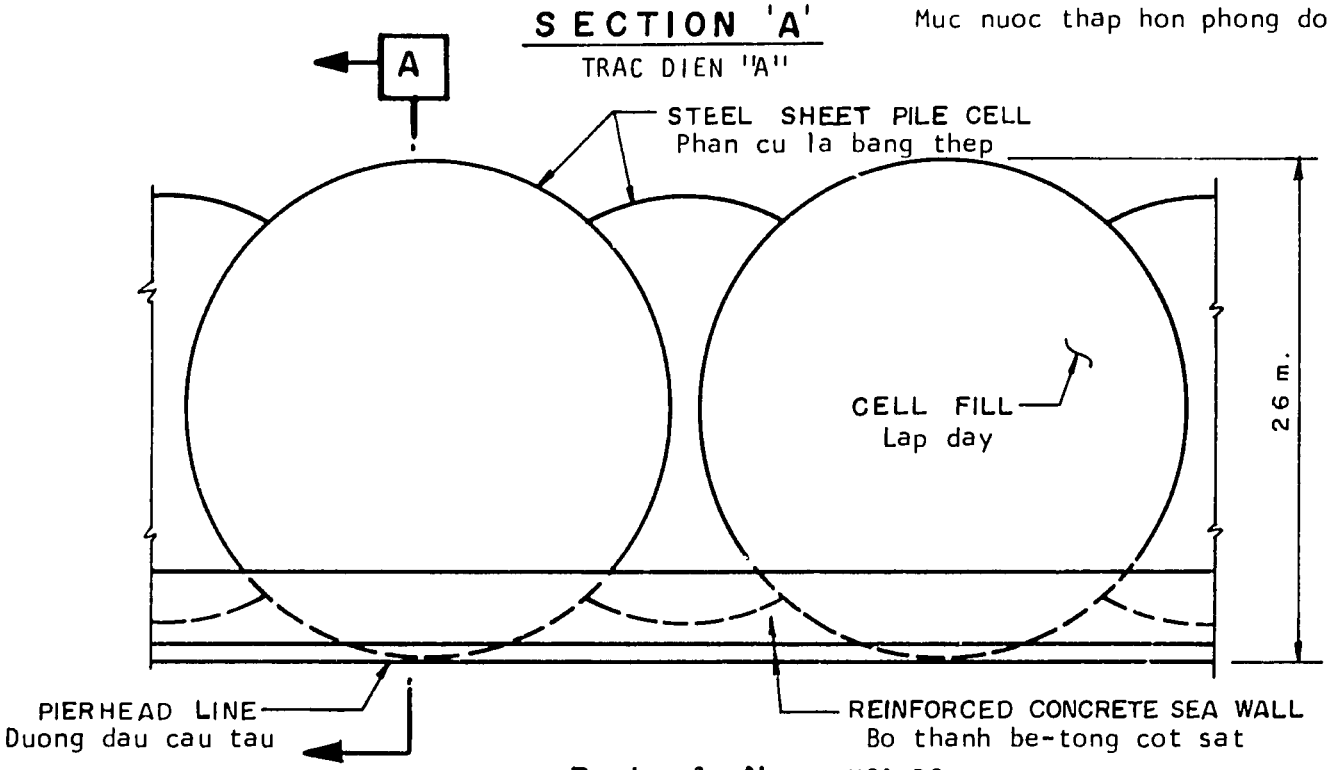
Open construction - high level deck on piles:	approx. US$7,600.00/m
Closed construction - cellular sheet pile	approx. US$8,500.00/m

The closed construction is depicted on Figure 20 and Figure 21 shows the open type. As seen from the above, the open type is the least expensive type of construction. Therefore, its cost was used as an input to determining the preliminary estimated cost for each alternative development concept.



SECTION 'A'

TRAC DIEN "A"



PLAN - HOA DO

COMMERCIAL GENERAL CARGO PORT - THUONG CANG HANG HOA TONG QUAT

CLOSED CONSTRUCTION

STEEL SHEET PILE CELLULAR COFFERDAM

PHAN KIEN TRUC KIN

ONG CU THEP CELLULAR

FIGURE 20 - HINH 20

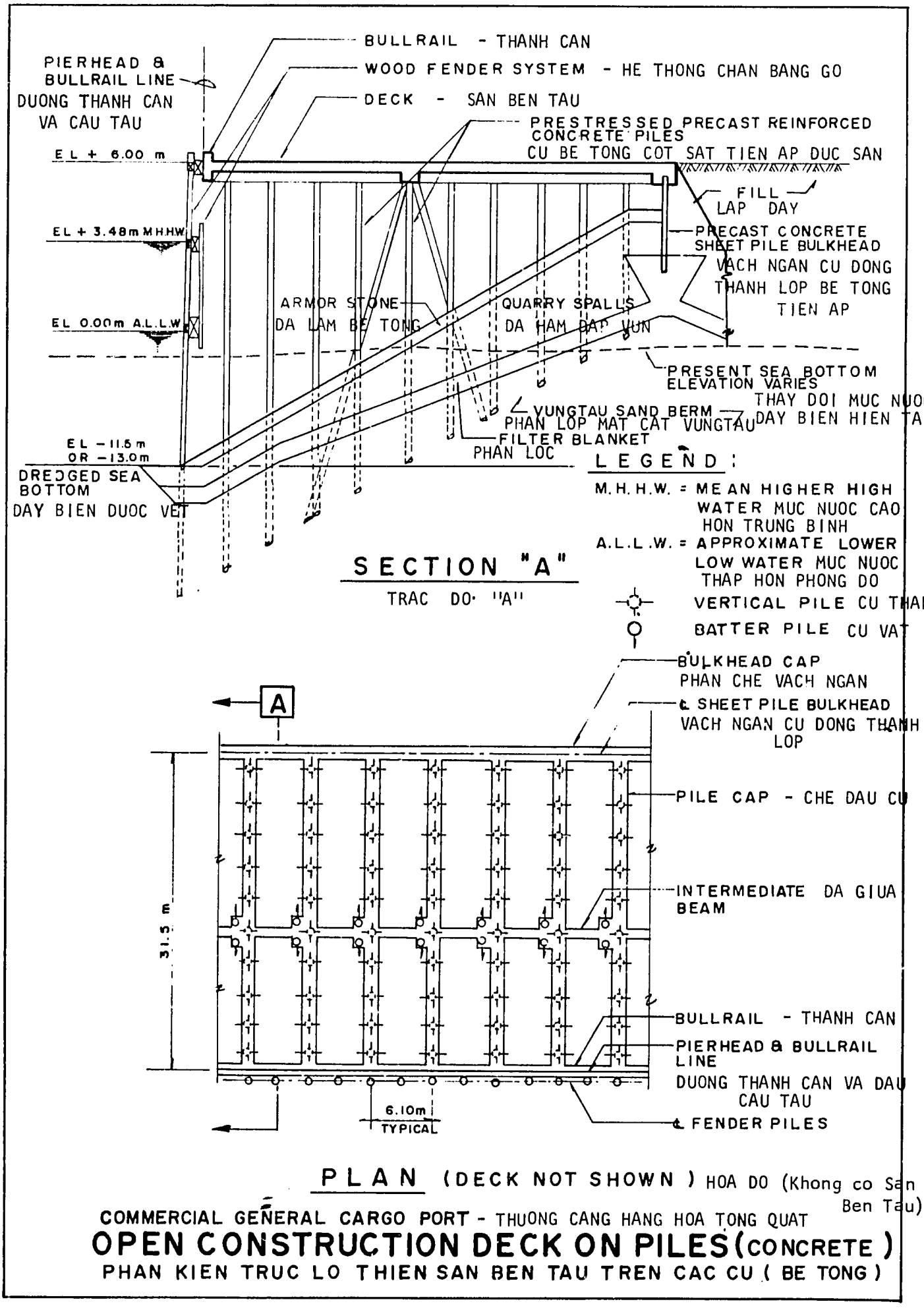


FIGURE 21 - HINH 21

f. Breakwater

The breakwater protecting the barge and small vessel handling area of Alternative No. 3 was designed using standard methods which call for the use of the significant wave (Hs) modified by shoaling, refraction, and other shallow water effects in the determination of armor unit and underlayer stone size, runup factors, and breakwater dimensions. Because of the location of the breakwater in water depths ranging from 2.0 to 8.0 meters below datum, the availability in Vung Tau of sufficient stone suitable in size and durability for use as armor stone, and wave reflection and absorption considerations, a rubble mound type structure is proposed. Figure 22 shows a typical cross section for this breakwater.

Prior to the selection of the rubble mound type construction for the breakwater, an alternative design consisting of a steel sheet pile bulkhead type wave barrier braced by batter piles was considered. It was found, however, that such a structure would be more costly than the rubble mound type and so this possibility was rejected.

In setting the crest elevation of the breakwater, a major consideration was the decision that the primary purpose for the breakwater would be to protect small craft and barge cargo handling operations taking place during typical seasonal wave conditions rather than to provide a safe harbor during a major storm. This decision was influenced by the assumption that all port operations would probably cease in the event of a major storm. Thus the selected crest elevation of +5.0 meters was based on a maximum astronomical tidal height of 4.15 meters (see Fig. 5)

coinciding with the maximum typical or seasonal wave of 1.0 meter expected at the site. Runup of this wave was determined to be 0.7 times the wave height and from this information it is evident that a +5.0 meter crest height will be sufficient to insure quiet conditions for cargo handling operations inside the basin during typical wave conditions.

In determining the size of stone for the construction of the breakwater however, design storm criteria must be used to insure the survival of the breakwater during a major storm. Design criteria used were as follows (see Section III of this report):

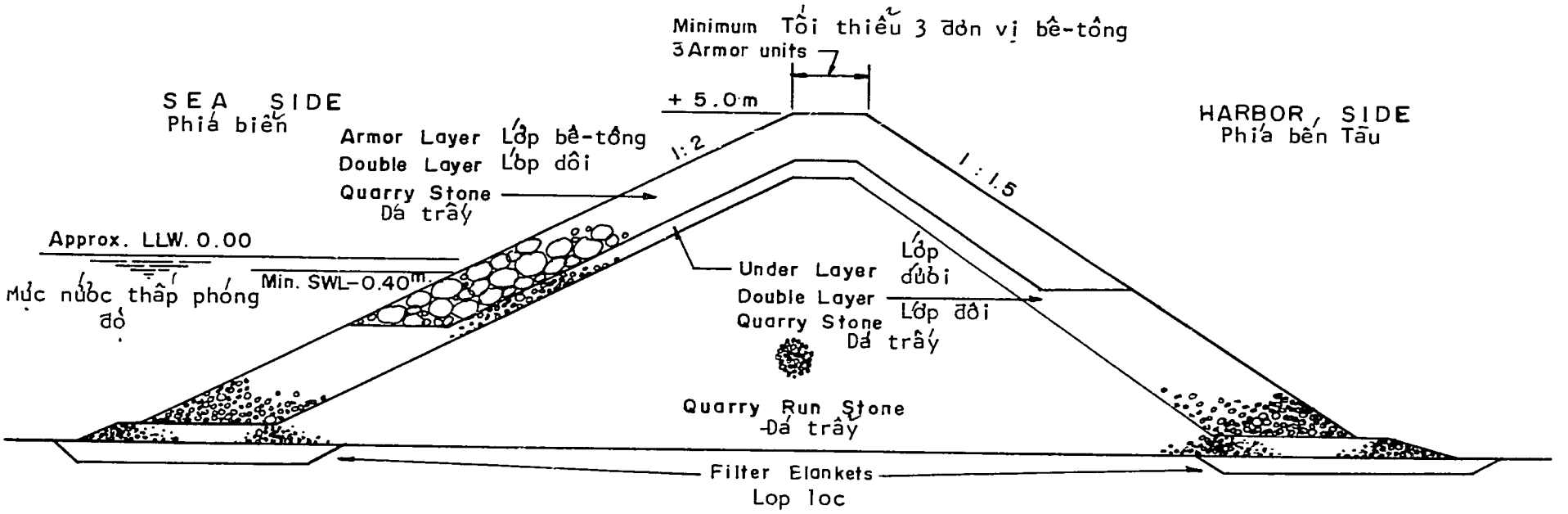
Wave Height (Hs) = 1.7 m

Wave Period (Ts) = 10.0 sec.

Still Water Level (SWL) = 4.7 m

Runup Factor = 0.7

Stone sizes were determined in accordance with methods given in U.S. Army Corps of Engineers Technical Report No. 4 "Shore Protection, Planning, and Design". Using the above criteria, a stone size of 1.0 ton was selected for the armor layers and this stone size was determined to be adequate for both trunk and head sections of the breakwater. As can be seen from Figure 22, armor units are placed not only on the seaward side of the breakwater but also on the harbor side. The reason for this is that significant overtopping is expected to occur during major storm conditions; thus the reverse side of the breakwater must be constructed with sufficient strength to withstand the forces exerted by overtopping waves.



BARGE BASIN BREAKWATER

ĐÊ NGĂN SÓNG CHỐ ĐẬU XÀ-LAN

(Port Layout Alternative No. 3)
(Phần lực chọn để phát hoạ Hai Cảng Số 3)
Typical Section
Thiết diện điển hình

Figure 22 - Typical Section, Barge Basin Breakwater
Hình 22 - Thiết diện điển hình, đê ngăn sóng chỗ đậu của xà-lan

In order to determine the effectiveness of the breakwater in reducing wave energy in the harbor during design storm conditions, a study of wave energy transmission over the breakwater was made. Recent experiments have shown that even though considerable overtopping may occur for a particular protective structure, considerable energy is expended in turbulence over the breakwater resulting in a reduction of wave height on the harbor side of the breakwater. Calculations using the above criteria revealed that during design storm conditions, wave heights of the order of 0.6 meter could be expected in the basin as a result of a major storm. Waves of this height would almost certainly preclude cargo handling operations for barges and small craft in the basin. However, barges and small craft might be safely moored in such conditions.

2. Commercial Fishing Port

a. General

In general the overall factors governing the location and characteristics of the fishing port are similar to those applicable to a commercial cargo port. Efficient land access as free as possible from city traffic and congestion is essential. Sufficient backup area must be made available for catch storage and handling as well as for any fish processing functions that may be required. The size and characteristics of the channel and turning basin and of mooring and unloading wharfage and quays must be set in accordance with the characteristics of vessels expected to utilize the port. However, since the general design and main operational characteristics differ greatly from those of a general purpose port, the best interest of both are better served by keeping

them completely separated. On the other hand their proximity should be such that the transfer cost for seafood export products between these two ports would be kept to a minimum.

b. Vessel Characteristics

The Scope of Work for this project states that the port should be designed to accommodate 50 ocean going fishing vessels. The characteristics of these vessels are summarized as follows:

Draft	3.65 m
Length	30 m
Beam	6.5 - 7.5 m
Dead Weight Tonnage (DWT)	40-50 tons

c. Navigation Facilities

As with the commercial general cargo port the depth and dimensions of the entrance channel and turning basin should be set so that fully loaded vessels can maneuver with safety at all levels of the tide. The criteria are summarized as follows:

Depth of Channel and of Inner Harbor

Channel

- Wave height = 1.0 m
- Surge = 1/2 wave height = 1/2 x 1.0 m = 0.5 meter
- Squat = 0.15 meter
- Empirical factors = 1.45 meters (clearance under keel for a a soft bottom, plus overdredging)

Adding these factors to the draft of the vessel the required channel depth would be 3.65m + 0.5m + 0.15m = 5.75 m; say 6.0 m

Inner Harbor

- Wave height = 0.5 m
- Surge = 1/2 wave height = 1/2 x 0.5 m = 0.25 m
- Squat = 0.15 meter
- Empirical factors = 0.45 meter (clearance under keel for a soft seabottom, no allowance has been made for overdredging).

Adding these factors to the draft of the vessel the required bottom depth would be 3.65 m + 0.25m + 0.15m + 0.45m = 4.60 m.

The difference between channel and inner harbor criteria in wave height and in overdredging allowance is explained by the choice of location of the commercial fishing port. The inner harbor is more sheltered than the channel area accounting for the lower wave height used. Also, as stated in Section III. c. 5., sedimentation in the inner harbor is expected to be minimal.

Width of Approach Channel

Criteria for the commercial fishing port will be similar to those selected for the commercial general cargo port. However due to the number of vessels expected to utilize the port (50), only a channel width capable of allowing two way traffic was considered. This width (6B + 15 meters where B equals the beam of the vessel) would be:

6 x 7.5m + 15.0m = 60 meters

It should be noted, however, that a channel of sufficient depth and width to accommodate expected fishing vessels already exists. It is therefore anticipated that this channel would be used until it is filled by sedimentation, a process which should take several years. In this

event two possibilities would be presented. The first would be to allow fishing vessels to enter and leave the port at high tides only without benefit of a channel. The second would be to dredge a channel for the vessels in accordance with the above criteria. In either case it is possible that the fishing vessels could utilize the commercial general cargo port channel, if constructed, as part of the access route until such time that congestion in the commercial port may force an end to this practice.

Size of Turning Basin

As with the cargo port the radius of the turning basin should be equal to twice the length of the vessel for maximum safe maneuverability. At the site proposed for the fishing port a protected area presently exists for a basin of this size without recourse to dredging.

d. Height of Quay Structures

As explained in Section III. C. 2, because of surrounding shoals and land areas, design storm wave conditions can only occur with winds blowing from approximately west northwest or a few degrees either side of this direction. Because the wind would be blowing in such a way that wind setup of water would be minimal, a design still water level of +4.15 meters can be used. In calculating the height of water on a closed type quay, the same approach may be taken as that used for closed quays of the proposed commercial general cargo port. Thus the height of water would be:

Maximum Still Water Level	4.15 m
Maximum Height of Wave	1.90 m
Total:	6.05 m; say 6.0 m

For closed type construction, deck heights should be set at at least +6.0 meters.

For open type structures, again the same procedure can be used as that used for the open commercial cargo port quays. For water depths anticipated for the fishing port quay, the factor to determine height of the maximum wave at the structure is about 0.6, the same as that used for cargo port quays. Thus the height of water for open structures would be:

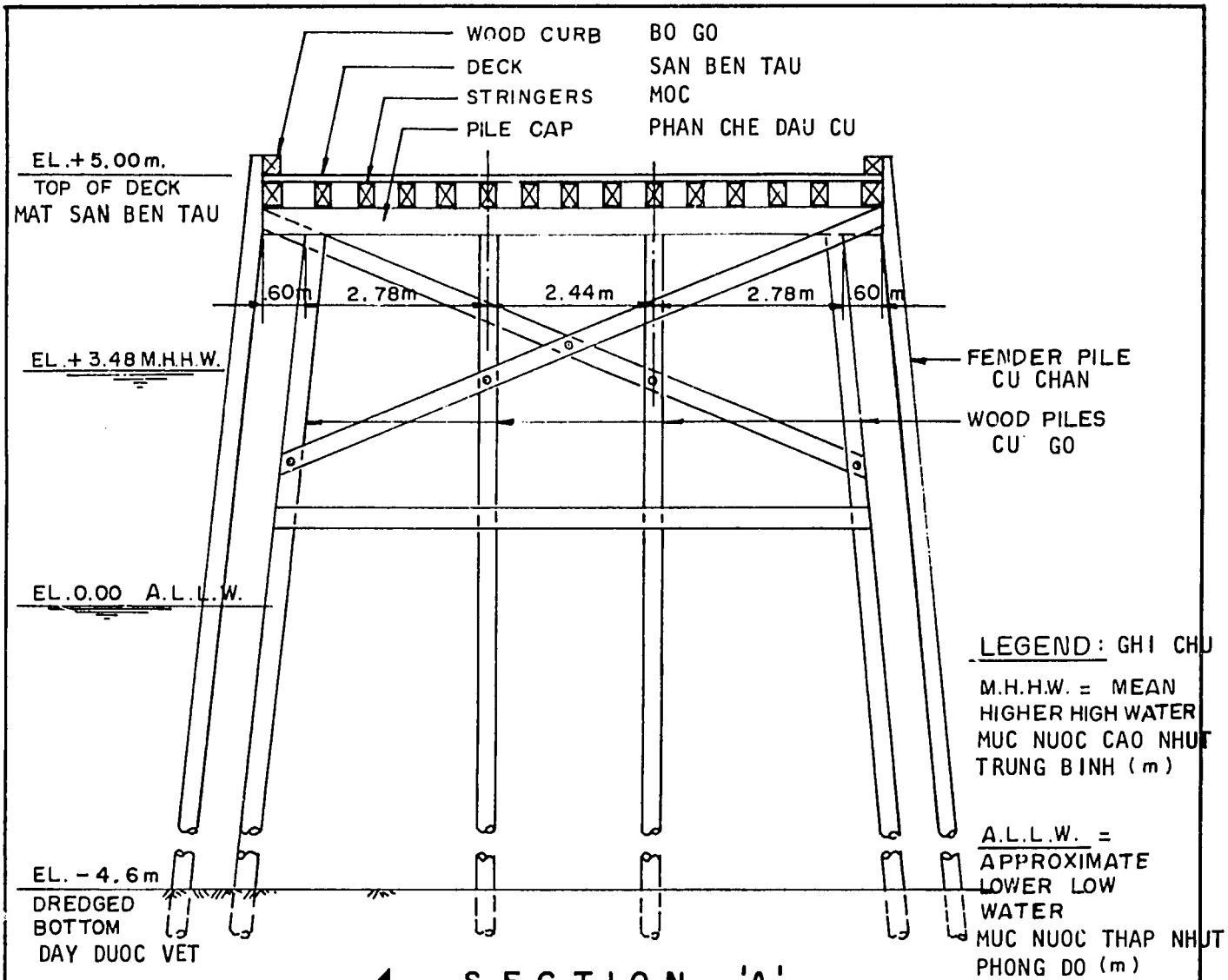
$$4.15 \text{ m} + 0.6 \times 1.9 \text{ m} = 5.29 \text{ m}$$

Thus for dry conditions in all circumstances the open structures should be set at about 5.3 m. However, in view of the difficulty in unloading and servicing the relatively small fishing vessels at high piers and wharves, a +5.0 m elevation for the top of deck was utilized in the open structure design and the risk of a small amount overtopping by maximum storm waves and the uplift forces caused by these waves were accepted.

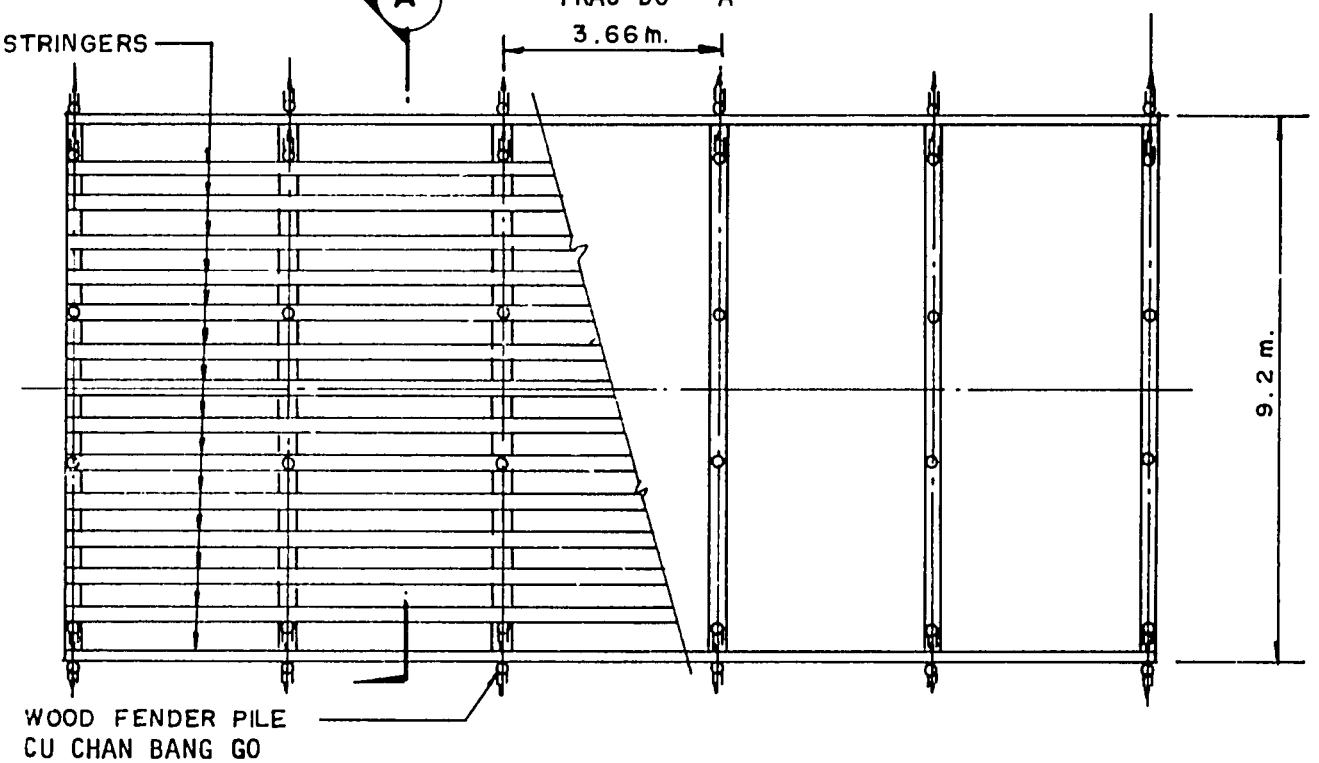
e. Type of Construction

Types of construction have been described previously in the commercial general cargo port section (V. B. 1.). As stated the open type structure consisting of a deck supported by piles was found to be least expensive and was selected for the fish cargo unloading wharfage and for the mooring wharves.

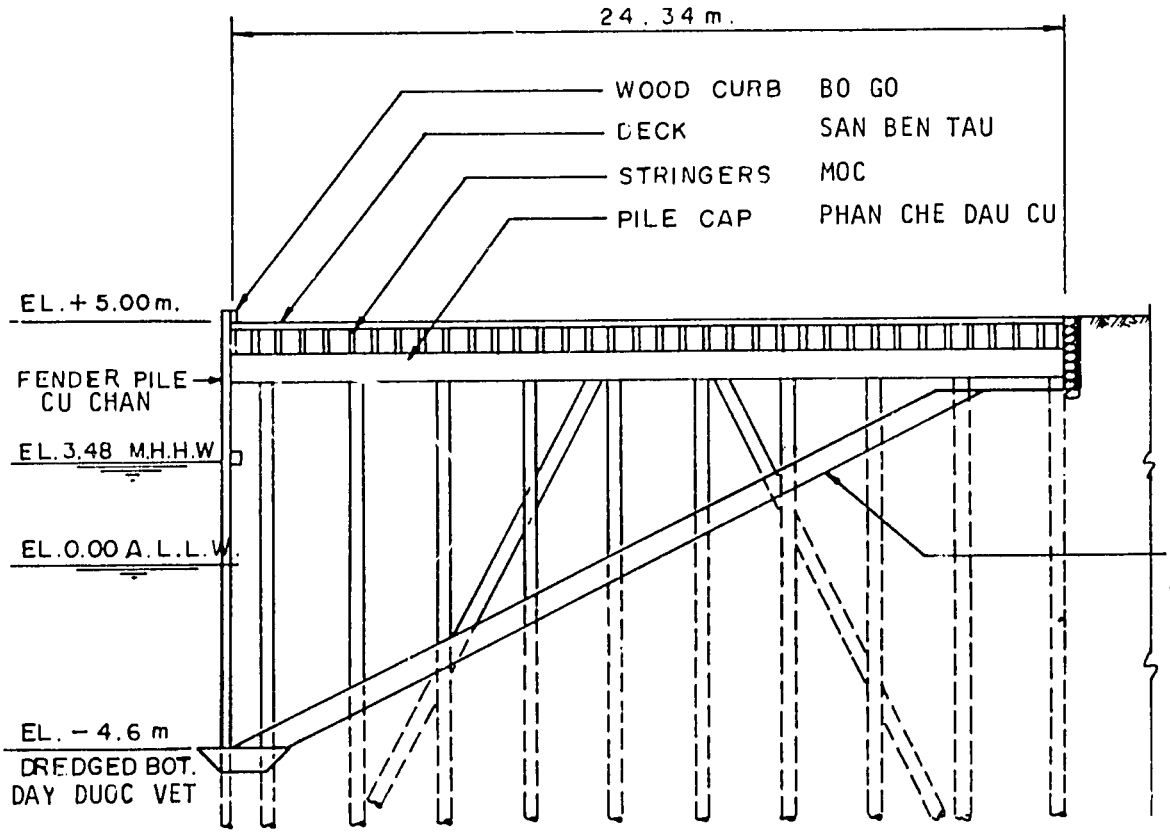
A third type of construction for the mooring wharves involving floating piers connected to the existing Delong pier causeway by ramps was also considered. As stated in Section III. waves up to 0.5 meter



SECTION 'A'
TRAC DO "A"



COMMERCIAL FISHING PORT. NGU CANG
OPEN CONSTRUCTION PIER PHAN KIEN TRUC LO THIEN CUA CU
FIGURE 23 - HINH 23



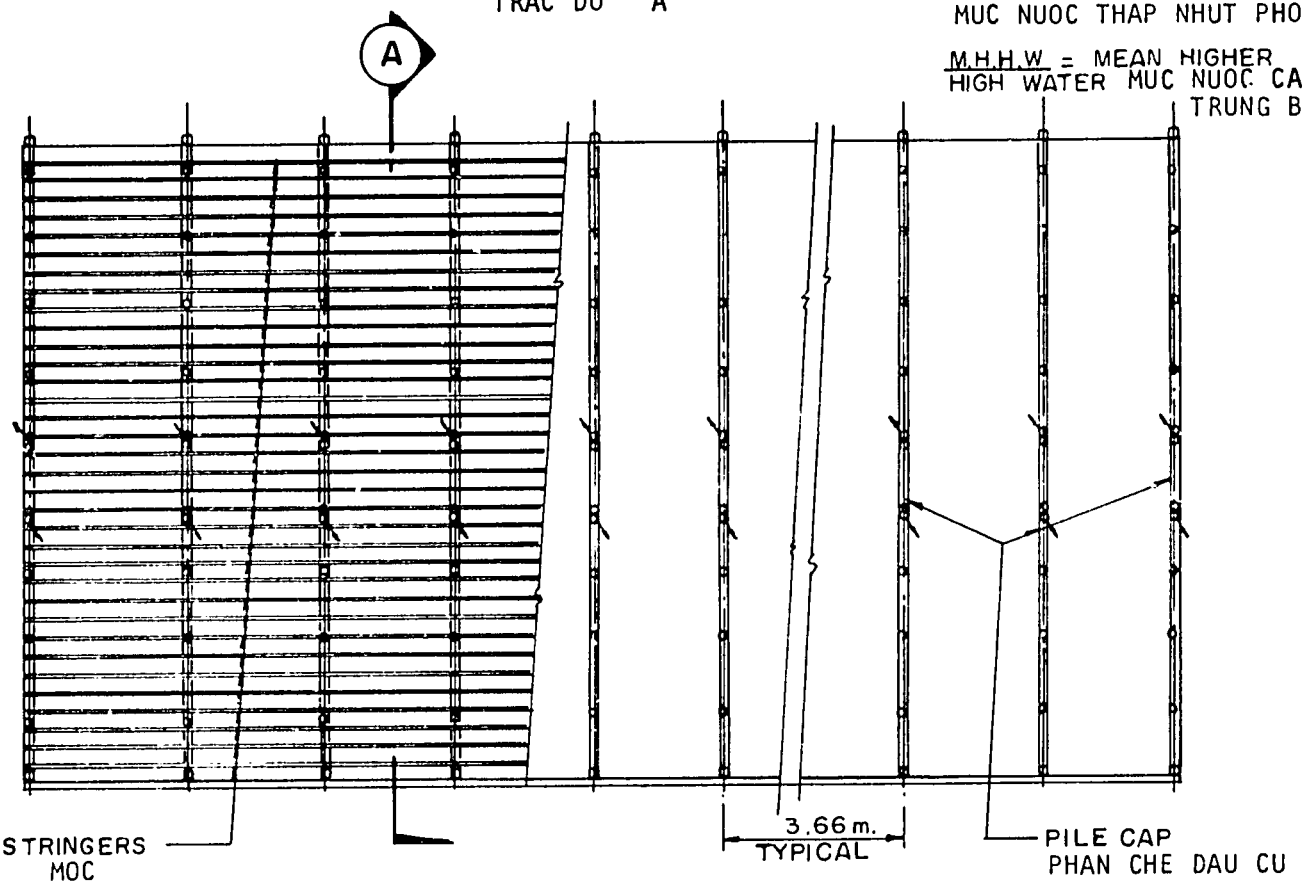
SECTION 'A'

TRAC DO "A"

LEGEND: GHI CHU

A.L.L.W = APPROXIMATE LOWER LOW WATER (m)
MUC NUOC THAP NHUT PHONG DO

M.H.H.W = MEAN HIGHER HIGH WATER MUC NUOC CAO NHAT TRUNG BINH (m)



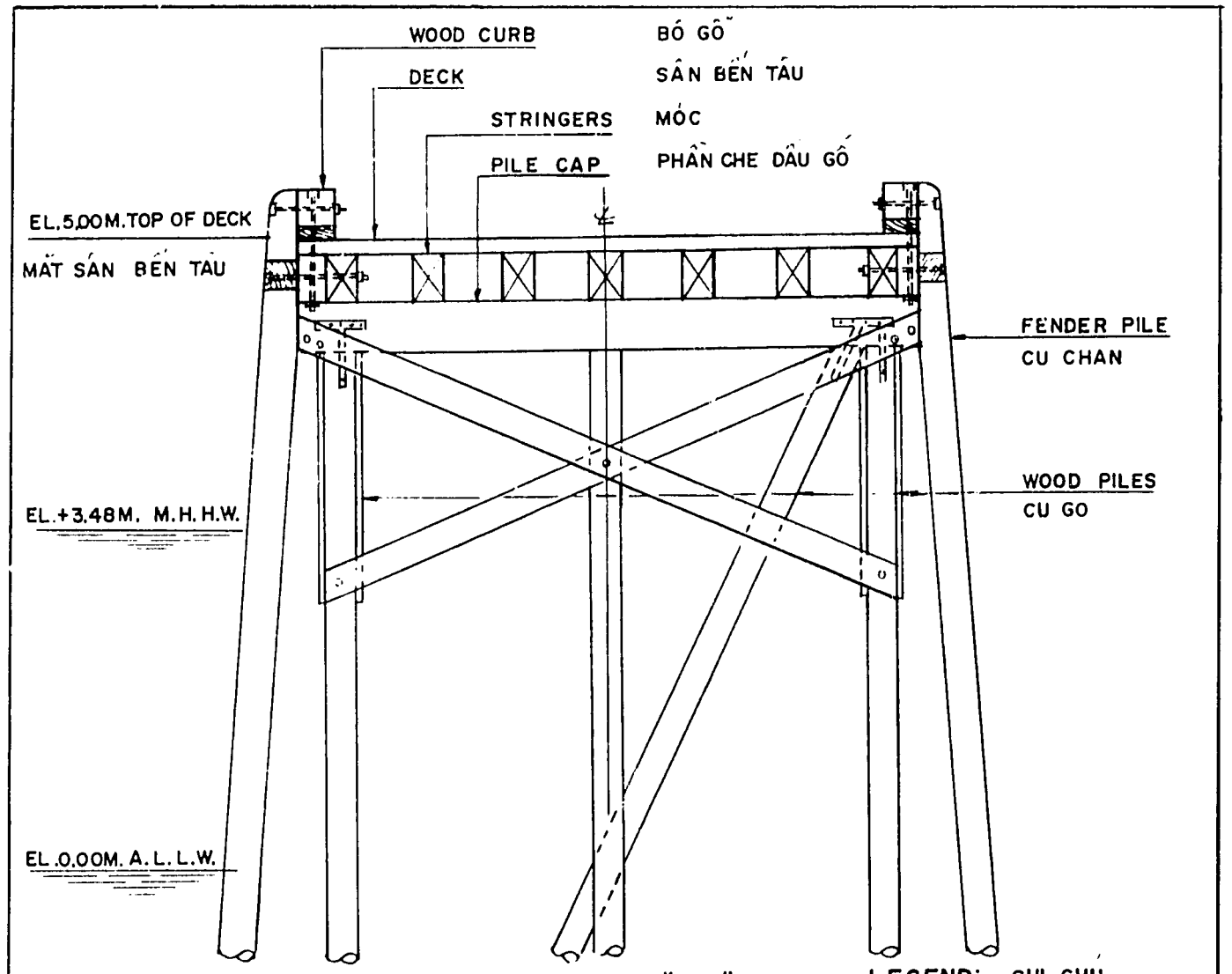
COMMERCIAL FISHING PORT

NGU CANG

OPEN CONSTRUCTION MARGINAL WHARF

PHAN KIEN TRUC LO THIEN
BO CAU TAU

FIGURE 24 - HINH 24



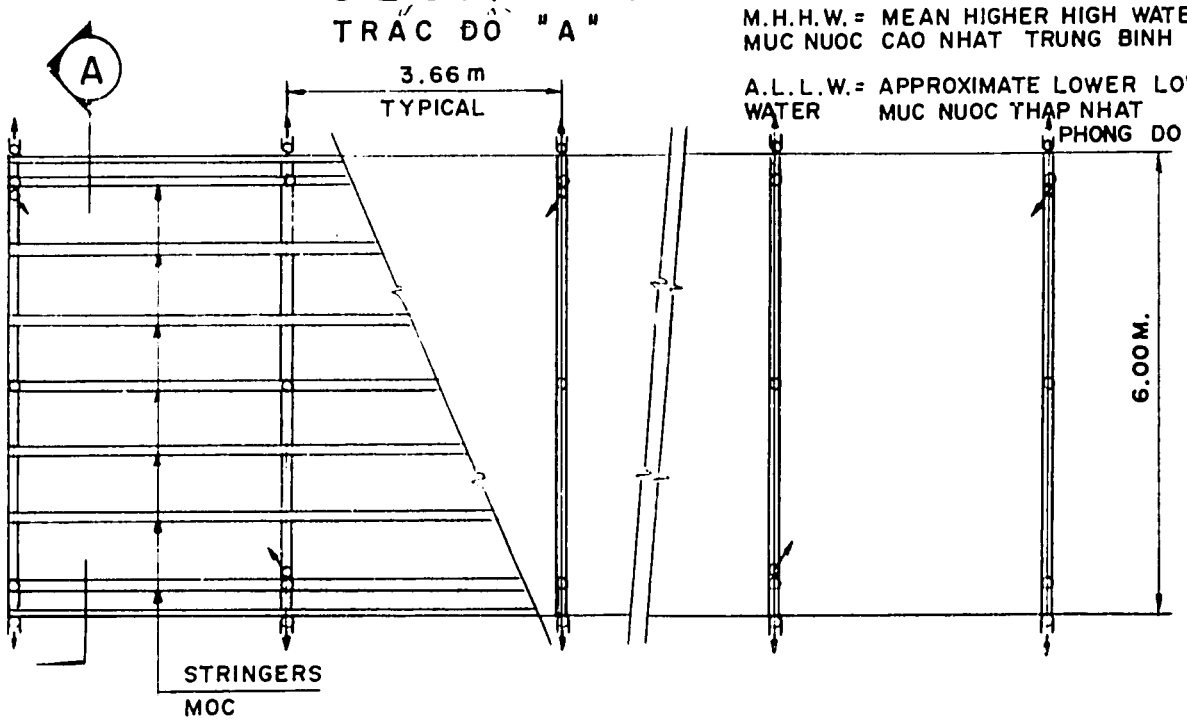
SECTION "A"

TRẮC ĐỒ "A"

LEGEND: GHI CHÚ

M.H.H.W. = MEAN HIGHER HIGH WATER
MUC NUOC CAO NHAT TRUNG BINH

A.L.L.W. = APPROXIMATE LOWER LOW WATER
MUC NUOC THAP NHAT PHONG DO



COMMERCIAL FISHING PORT NGU CANG

OPEN CONSTRUCTION – MOORING PIER

PHAN KIEN TRUC LO THIEN CHO NEO TAU

FIGURE 25 HINH 25

in height could be expected in the proposed fishing port harbor and it is felt that wave action of this magnitude would cause difficulties in the utilization of such piers and would result in excessive maintenance costs. This approach to construction was therefore abandoned.

C. CONCEPTS FOR DEVELOPMENT

1. Commercial General Cargo Port

a. General

The general approach in analyzing the technical considerations in establishing a commercial cargo port at Vung Tau consisted of the formulation and evaluation of three alternative layout concepts. These three layout concepts, each developed to accommodate ships having drafts of 9.1 and 10.7 meters, are shown on Plates 6 through 11. Proposed construction phasing is also shown.

In general the port alternatives shown reflect two possibilities in overall port operation. In the first case the port would function as a transfer medium both between ocean going vessels and land transport and between ocean vessels and barges and small coastal craft. In the second case the function of transfer between ocean ships and small craft and barges would be of minimal importance. Alternatives 2 and 3 are designed for maximum efficiency in the former case; that is, they make provision for extensive cargo transfer operations between ocean ships and smaller craft. Alternative No. 1, on the other hand, was designed to accommodate deep water shipping with no specialized mooring and handling areas for small craft and barges. Thus the alternatives were chosen in such a way that several foreseeable possibilities for the evolution of port development requirements would be provided for.

The location chosen for the port is essentially the same for all

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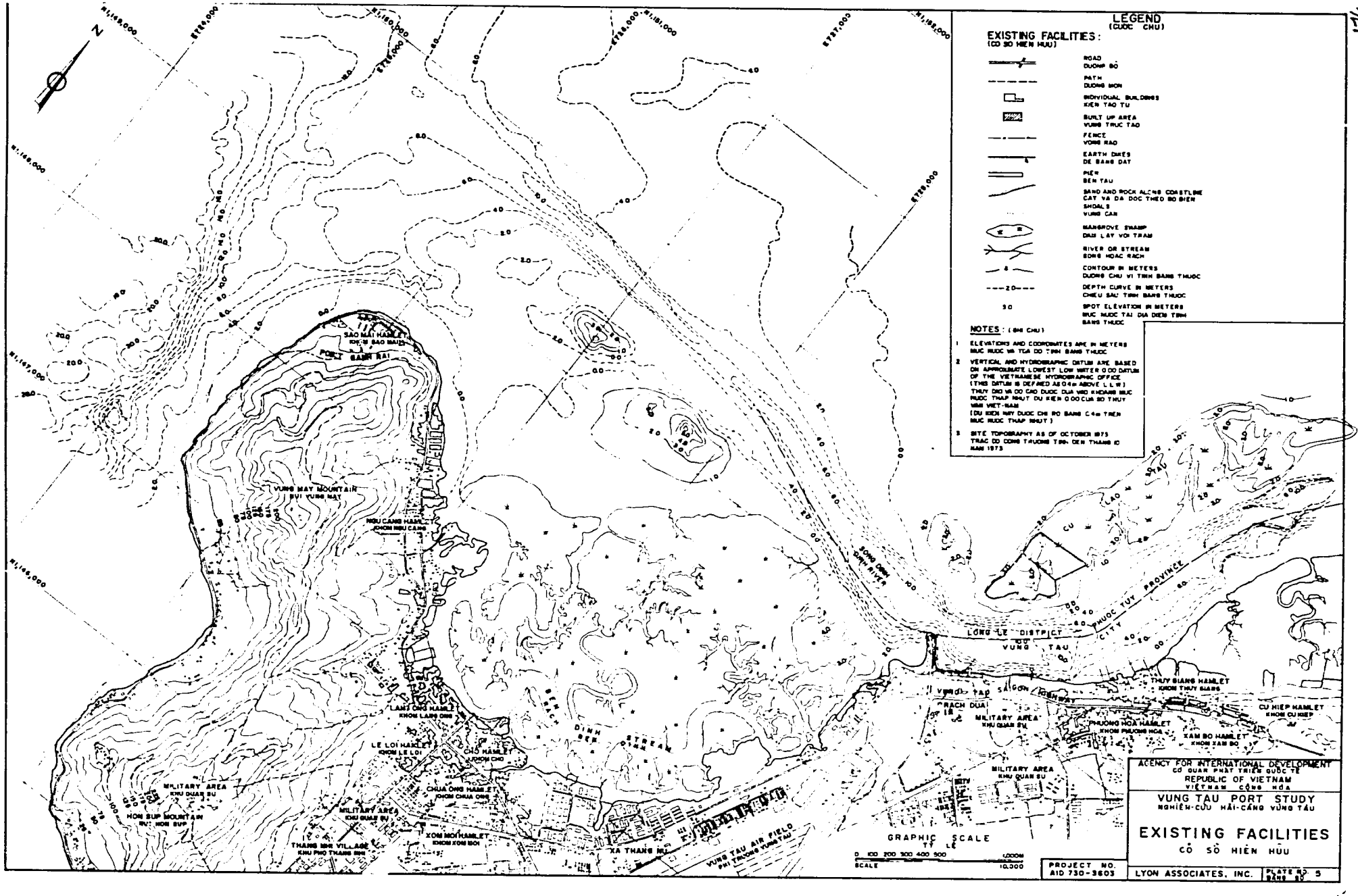
LEGEND
(CUOC CHU)
EXISTING FACILITIES:
(CO SO HIEN HUU)
ROAD
DUONG BO
PATH
DUONG MON
INDIVIDUAL BUILDINGS
XIEN TAO TU
BUILT UP AREA
VUNG TRUC TAO
FENCE
VONG RAO
EARTH DIKES
DE BANG DAT
PIER
BEN TAU
SAND AND ROCK ALONG COASTLINE
CAT VA DA DOC THEO BO BIEN
SHOALS
VUNG CAN
MANGROVE SWAMP
DAM LAY VOI TRAM
RIVER OR STREAM
SONG HOAC RACH
CONTOUR IN METERS
DUONG CHU VI TRIM BANG THUOC
DEPTH CURVE IN METERS
CHIEU SAU TRIM BANG THUOC
SPOT ELEVATION IN METERS
MUC NUOC TAI DIA DIEM TRIM BANG THUOC
NOTES: (GHI CHU)
1 ELEVATIONS AND COORDINATES ARE IN METERS
MUC NUOC VA TOA DO TRIM BANG THUOC
2 VERTICAL AND HYDROGRAPHIC DATUM ARE BASED ON APPROXIMATE LOWEST LOW WATER 0.00 DATUM OF THE VIETNAMESE HYDROGRAPHIC OFFICE
(THIS DATUM IS DEFINED AS 0.4m ABOVE L.L.W.)
THUY DO VA DO CAO DUOC DUA VAO KHOANG MUC NUOC THAP NHUT DU KIEN 0.00 CUA SO THUY VAN VIET-NAM
(DU KIEN NAY DUOC CHO BO BANG 0.4m TREN MUC NUOC THAP NHUT)
3 SITE TOPOGRAPHY AS OF OCTOBER 1973
TRAC DO CONG TRUONG TRIM DEN THANG 10 NAM 1973
SAO MAI HAMLET
KHOM SAO MAI
PORT
BAIN BAI
VUNG MAY MOUNTAIN
DUI VUNG MAY
NGU CANG HAMLET
KHOM NGU CANG
LANG ONG HAMLET
KHOM LANG ONG
LE LOI HAMLET
KHOM LE LOI
CHO HAMLET
KHOM CHO
CHUA ONG HAMLET
KHOM CHUA ONG
MILITARY AREA
KHU QUAN SU
HON SUP MOUNTAIN
DUI HON SUP
THANG NHI VILLAGE
KHU PHO THANG NHI
XOM MOI HAMLET
KHOM XOM MOI
XA THANG NHI
VUNG TAU AIR FIELD
PHI TRUONG VUNG TAU
DONG CONG
CONG RIVER
LONG LE DISTRICT
VUNG TAU
CITY
PHUOC TUY PROVINCE
THUY GIANG HAMLET
KHOM THUY GIANG
CU HIEP HAMLET
KHOM CU HIEP
PHUONG HOA HAMLET
KHOM PHUONG HOA
XAM BO HAMLET
KHOM XAM BO
RACH DUA
GRAPHIC SCALE
TỶ LỆ
SCALE
1:10,000
PROJECT NO.
AID 730-3603
AGENCY FOR INTERNATIONAL DEVELOPMENT
CO QUAN PHAT TRIEN QUOC TE
REPUBLIC OF VIETNAM
VIETNAM CONG HOA
VUNG TAU PORT STUDY
NGHIEN-CUU HAI-CANG VUNG TAU
EXISTING FACILITIES
CO SO HIEN HUU
LYON ASSOCIATES, INC.
PLATE NO. 5
BANG SO

three alternatives. As can be seen from the Plates, the port has been located in the protected area inside Point Ganh Rai to the northwest of the large mangrove island. The reasons for selecting this location are that it is relatively well protected from both storm and seasonal waves, the location is favorable for future expansion in that it is essentially unrestricted by geographical features and human habitation, sufficient backup area can be developed through reclaiming by dredge fill and, most importantly, the location allows a short entrance channel and is characterized by relatively deep water which will minimize capital and maintenance dredging costs.

In selecting the proposed locations, due regard was given to placing the port at the existing general cargo port site. However, if the new port were to be so located, a large portion of the existing island northwest of the site would have to be removed in order to obtain sufficient water area to safely maneuver the vessels. In addition this site would require a longer entrance channel than the proposed site. It is evident, therefore, that the capital and maintenance dredging costs for a port developed in this area would greatly exceed those of the selected site. As stated in Section III.C. 5. partial removal of the aforesaid island would, in all probability, decrease the currents in the area to such an extent as to nullify the flushing action which presently keeps the area relatively free of sedimentation.

A further disadvantage of the existing site is that the backup area for a major, multi-purpose cargo handling port will not be sufficient without relocation of the existing Saigon-Vung Tau highway presently

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flanking the site and without acquisition of extensive tracts of land already being used for commercial and residential purposes. Future expansion of the port will also be hampered due to the insufficiency of land. The availability of land is one of the most important factors in the consideration of sites for future port development as illustrated by the fact that in modern port development, worldwide standards advise that approximately 200 meters of backup area be available in back of docking facilities associated with a general cargo berth and that six to ten hectares, depending on the type of operation engaged in, be made available for each container berth planned.

Referring again to the Plates it will be noted that in all three concepts the port area has been set apart from the adjacent land. The primary reason for this is to insure that disruption of the local fishing industry in this area, with its established port facilities, businesses, and homes, is minimized, a decision that is in keeping with the consultant's opinion that the existing local fishing ports should be allowed to continue to function (see Section V.C.2.). If the port were to be placed adjacent to the land, a new entrance channel to the fishing villages would therefore have to be provided around or through the cargo port area. This new channel would interfere with the future expansion of the port.

A second reason for locating the port away from adjacent land is to keep the Ben Dinh tidal stream which flows through the mangrove island behind the port from being blocked, thus cutting off circulation of water into portions of this island not covered by land fill.

Blocking of water circulation could detrimentally affect the ecosystem of the stream which could interrupt the life cycle of commercially valuable species of sea life and could preclude exploitation of the region by aquaculture (see Section III. D. for a discussion of this consideration).

Another major disadvantage in placing the commercial cargo port adjacent to the land would be the cost of gaining access to the site. The existing road, which is narrow and would clearly be inadequate to handle large cargo vehicles and which traverses a highly congested area, would have to be widened and improved. The expenditure which would be needed to acquire the necessary land and to construct this road as well as rail access is considered to be unreasonably high.

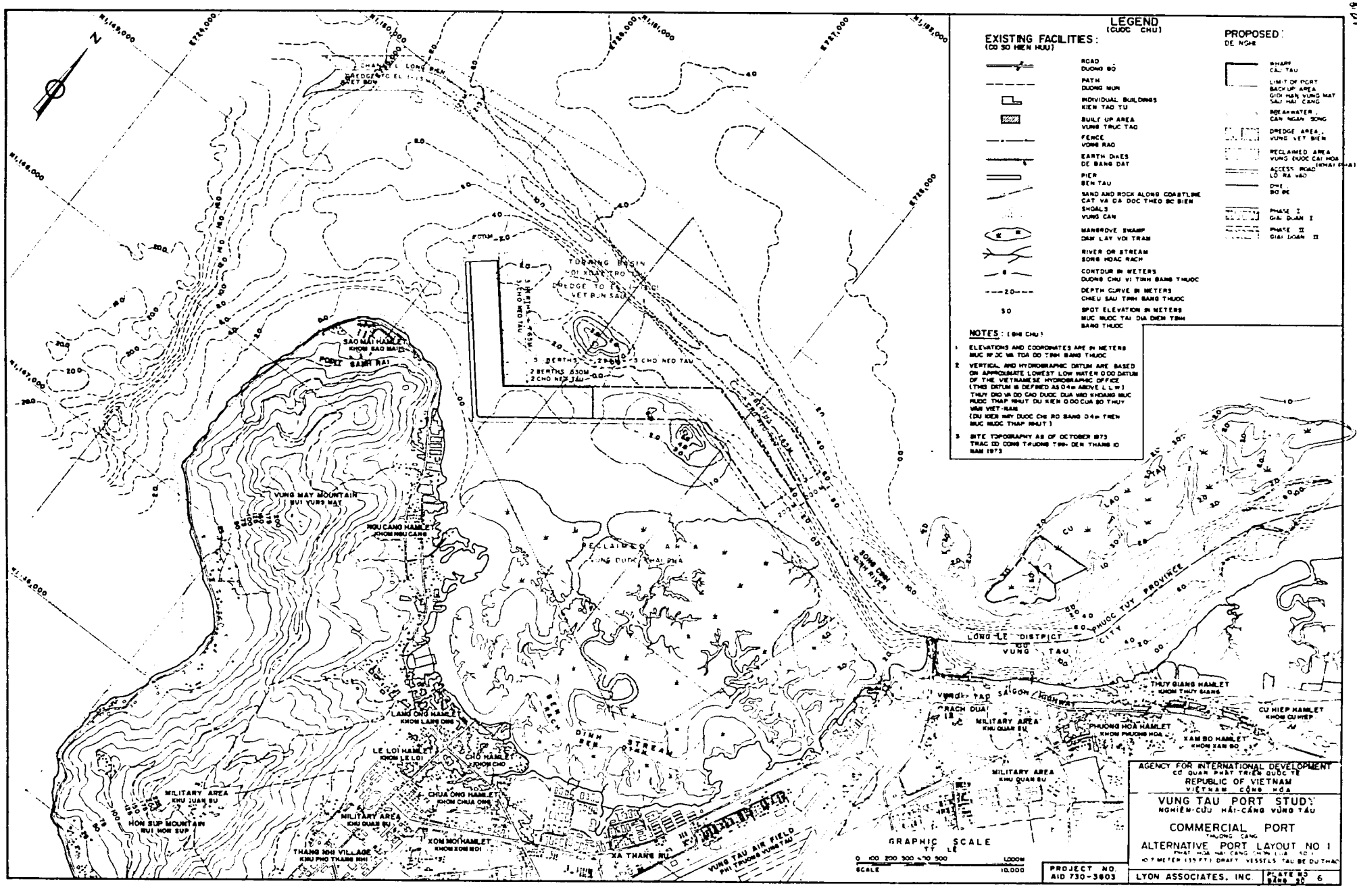
Road and rail access are provided for all alternative layouts by means of a dike located at the eastern end of the new port area. By developing the road access in this manner it would traverse only the port area and could thus be restricted to port traffic only. Also it intersects the Saigon-Vung Tau highway at a point where hinterland port traffic would pass through a relatively uncongested area. In addition, during early phases of construction, this dike would act as a retaining structure for the dredged fill along one side of the reclaimed area which would lower the construction cost. Following is a brief description of each alternative plan. In addition approximate construction costs were calculated for each alternative and are presented herein.

b. Alternative Concept No. 1

Plates 6 and 7 show proposed layouts for Alternative Concept No. 1. As previously stated this concept was conceived to accommodate primarily relatively large ocean going cargo vessels in the event that future demands for port services involve only minimal use by coastal vessels, lighters, and barges. No special provision for accommodating these small vessels has been made.

The dimensions of port facilities shown on Plates 6 and 7 correspond to the characteristics of vessels having maximum drafts of 10.7 meters and 9.1 meters respectively as shown in Table 20, Section V. B. 1. b. and facilities have been designed in accordance with criteria presented in Section V. B. 1. The plates also show proposed phasing of construction and two phases are depicted. The extent of each phase and of the port as a whole were arbitrarily determined on the basis of what might be considered to be reasonable from a total space available point of view and in accordance with budgetary constraints which might be imposed.

The first phase of construction was designed to accommodate approximately five vessels of the types shown in Table 20. Total wharf length was set at 1,020 meters and 1,295 meters for 9.1 meter draft vessels and 10.7 meter draft vessels respectively. These lengths were determined by assuming an arbitrary mix of vessels having the characteristics given in Table 20 plus standard allowances for mooring and for the accommodation of such auxiliary port vessels as tugs. Although the size and configuration of port backup area depends upon the type of ship and type of


LEGEND
(CUOC CHU)
EXISTING FACILITIES:
(CO SO HIEN HUU)
ROAD
DUONG BO
PATH
DUONG MUN
INDIVIDUAL BUILDINGS
KIEN TAO TU
BUILT UP AREA
VUNG TRUC TAO
FENCE
VONG RAO
EARTH DIKES
DE BANG DAT
PIER
BEN TAU
SAND AND ROCK ALONG COASTLINE
CAT VA CA DOC THEO BO BIEN
SHOALS
VUNG CAN
MANGROVE SWAMP
DAM LAY VOI TRAM
RIVER OR STREAM
SONG HOAC RACH
CONTOUR IN METERS
DUONG CHU VI TINH BANG THUOC
DEPTH CURVE IN METERS
CHIEU SAU TINH BANG THUOC
SPOT ELEVATION IN METERS
MUC NUOC TAI DIA DIEM TINH BANG THUOC
PROPOSED:
DE NGHI
WHARF
CAU TAU
LIMIT OF PORT BACK UP AREA
GIOI HAN VUNG MAT SAU HAI CANG
BREAKWATER
CAN NGAN SONG
DREDGE AREA
VUNG VET BIEN
RECLAIMED AREA
VUNG DUOC CAI HOA
ACCESS ROAD (KHAI PHA)
LO RA VAO
DIKE
BO BE
PHASE I
GIAI DOAN I
PHASE II
GIAI DOAN II
NOTES: (GHI CHU)
1 ELEVATIONS AND COORDINATES ARE IN METERS
MUC NUOC VA TOA DO TINH BANG THUOC
2 VERTICAL AND HYDROGRAPHIC DATUM ARE BASED ON APPROXIMATE LOWEST LOW WATER O.DO DATUM OF THE VIETNAMESE HYDROGRAPHIC OFFICE
(THIS DATUM IS DEFINED AS 0.4m ABOVE L.L.W.)
THUY DO VA DO CAO DUOC DUA VAO KHOANG MUC NUOC THAP NHUT DU KIEN O.DO CUA SO THUY VAN VIET-NAM
(DU KIEN NAY DUOC CHO RO BANG 0.4m TREN MUC NUOC THAP NHUT)
3 SITE TOPOGRAPHY AS OF OCTOBER 1973
TRAC DO CONG TRUONG THAN DEN THANG 10 NAM 1973
TURNING BASIN
DREDGE TO
VET RUN SAU
3 BERTHS 230M
2 BERTHS 330M
2 CHO NEO TAU
3 CHO NEO TAU
SAO MAI HAMLET
KHOM SAO MAI
POST
BAIN MAI
VUNG MAY MOUNTAIN
NUI VUNG MAT
NGU CANG HAMLET
KHOM NGU CANG
RECLAIMED AREA
VUNG DUOC KHAI PHA
SONG DINH
DINH RIVER
PHUOC TUY PROVINCE
LONG LE DISTRICT
VUNG TAU
CITY
THUY GIANG HAMLET
KHOM THUY GIANG
CU HIEP HAMLET
KHOM CU HIEP
RACH DUA
MILITARY AREA
KHU QUAN SU
PHUONG HOA HAMLET
KHOM PHUONG HOA
XAM BO HAMLET
KHOM XAM BO
LAM ONG HAMLET
KHOM LAM ONG
LE LOI HAMLET
KHOM LE LOI
CHO HAMLET
KHOM CHO
CHUA ONG HAMLET
KHOM CHUA ONG
MILITARY AREA
KHU QUAN SU
HON SUP MOUNTAIN
NUI HON SUP
THANG NHI VILLAGE
KHU PHO THANG NHI
XOM MOI HAMLET
KHOM XOM MOI
XA THANG NHI
VUNG TAU AIR FIELD
PHI TRUONG VUNG TAU
GRAPHIC SCALE
THANG TY LE
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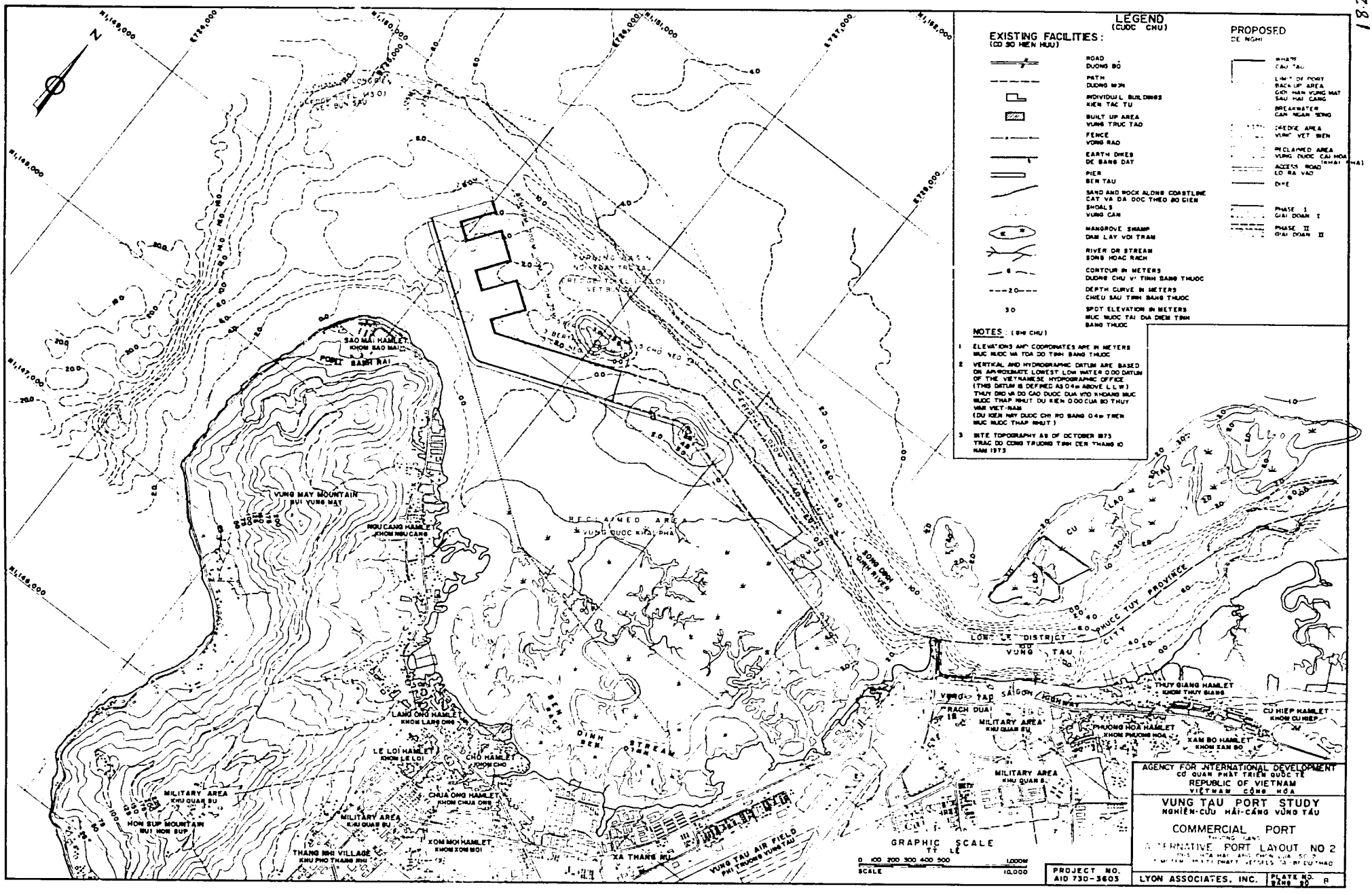
SCALE
1,000M
10,000
PROJECT NO.
AID 730-3803
AGENCY FOR INTERNATIONAL DEVELOPMENT
CO QUAN PHAT TRIEN QUOC TE
REPUBLIC OF VIETNAM
VIETNAM CONG HOA
VUNG TAU PORT STUDY
NGHIEN-CUU HAI-CANG VUNG TAU
COMMERCIAL PORT
THUONG CANG
ALTERNATIVE PORT LAYOUT NO 1
10.7 METER (35 FT) DRAFT VESSELS TAU BE DU THAC
LYON ASSOCIATES, INC
PLATE NO
BANG SO
6


LEGEND
(CUOC CHU)
EXISTING FACILITIES:
(CO SO HIEN HUU)
ROAD
DUONG BO
PATH
DUONG MON
INDIVIDUAL BUILDINGS
KIEN TAC TU
BUILT UP AREA
VUNG TRUC TAO
FENCE
VONG RAO
EARTH DIKES
DE BANG DAT
PIER
BEN TAU
SAND AND ROCK ALONG COASTLINE
CAT VA DA DOC THEO BO GIEN
SHOALS
VUNG CAN
MANGROVE SWAMP
DAM LAY VOI TRAM
RIVER OR STREAM
SONG HOAC RACH
CONTOUR IN METERS
DUONG CHU VI TINH BANG THUOC
DEPTH CURVE IN METERS
CHIEU SAU TINH BANG THUOC
SPOT ELEVATION IN METERS
MUC NUOC TAI DIA DIEM TINH BANG THUOC
PROPOSED
DE NGHI
WHARF
CAU TAU
LIMIT OF PORT BACK UP AREA
GIOI HAN VUNG MAT SAU HAI CANG
BREAKWATER
CAN NGAN SONG
DREDGE AREA
VUNG VET BIEN
RECLAIMED AREA
VUNG DUOC CAI HOA
ACCESS ROAD
LO RA VAO
DIKE
PHASE I
GIAI DOAN I
PHASE II
GIAI DOAN II
NOTES: (GHI CHU)
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2 VERTICAL AND HYDROGRAPHIC DATUM ARE BASED ON APPROXIMATE LOWEST LOW WATER 0.00 DATUM OF THE VIETNAMESE HYDROGRAPHIC OFFICE (THIS DATUM IS DEFINED AS 0.4m ABOVE L.L.W.)
THUY DO VA DO CAO DUOC DUA VAO KHOANG MUC NUOC THAP NHUT DU KIEN 0.00 CUA SO THUY VAN VIET-NAM
(DU KIEN NAY DUOC CHI RO BANG 0.4m TREN MUC NUOC THAP NHUT)
3 SITE TOPOGRAPHY AS OF OCTOBER 1973
TRAC DO CONG TRUONG TINH DEN THANG 10 NAM 1973
VUNG MAY MOUNTAIN
BUI VUNG MAT
NGU CANG HAMLET
KHOM NGU CANG
SAO MAI HAMLET
KHOM SAO MAI
RECLAIMED AREA
VUNG DUOC KHAI PHA
SONG DONG NAI RIVER
LONG LE DISTRICT
VUNG TAU CITY
PHUOC TUY PROVINCE
VUNG TAU
SAIGON HIGHWAY
THUY GIANG HAMLET
KHOM THUY GIANG
CU HIEP HAMLET
KHOM CU HIEP
XAM BO HAMLET
KHOM XAM BO
PHUONG HOA HAMLET
KHOM PHUONG HOA
MILITARY AREA
KHU QUAN SU
LANG CHO HAMLET
KHOM LANG CHO
LE LOI HAMLET
KHOM LE LOI
CHO HAMLET
KHOM CHO
CHUA ONG HAMLET
KHOM CHUA ONG
XOM MOI HAMLET
KHOM XOM MOI
THANG NHI VILLAGE
KHU PHO THANH NHI
HON SUP MOUNTAIN
BUI HON SUP
DINH BEN STREAM
BEN BACH
XA THANH MY
VUNG TAU AIR FIELD
PHI TRUONG VUNG TAU
GRAPHIC SCALE
TỶ LỆ
SCALE
0 100 200 300 400 500 1,000M
10,000
PROJECT NO.
AID 730-3603
AGENCY FOR INTERNATIONAL DEVELOPMENT
CƠ QUAN PHÁT TRIỂN QUỐC TẾ
REPUBLIC OF VIETNAM
VIỆT NAM CỘNG HÒA
VUNG TAU PORT STUDY
NGHIÊN-CỨU HẢI-CẢNG VŨNG TÀU
COMMERCIAL PORT
ALTERNATIVE PORT LAYOUT NO 2
LYON ASSOCIATES, INC.
PLATE NO.
BẢNG SỐ
8

cargo handling operation anticipated, due to the lack of such information, a standard area having a width of 200 meters behind the quay was selected, that width being the recommended one for general cargo handling type operations.

In accordance with the determination that a wharf having an open type construction would be the least expensive design approach (see Section V. B. 1. e.), the quays shown are of open type design.

The depths of the turning basin and entrance channel (-11.5 m for 9.1 m draft vessels and -13.0 m for 10.7 m vessels, Approx. LLW datum) were set in accordance with criteria given in Section V. B. 1. c. Due to the low volume of traffic expected initially and in order to keep initial and maintenance dredging costs to a minimum, the width of the entrance channel for the first phase of construction was set to allow only one way traffic and the turning basin radius was set at 1.5 times the length of the maximum ship expected to use the port for each alternative draft. As previously stated, this size of turning basin would require the larger vessels to be tug assisted in their maneuvering and docking operations.

As can be seen from the Plates, the location of the first phase of construction has been placed at the outer, or western, end of the port complex. The primary reason for this is to minimize the cost of initial and maintenance dredging. This location will result in an entrance channel of minimum length, thus minimizing initial dredging.

Also, as pointed out in Section III. C. 5. annual sedimentation may be somewhat less in this area than in adjacent regions nearer to shore because of the more efficient flushing which is apparently afforded by currents.

In recommending the location of first phase development serious consideration was given to placing it at the extreme inner, or eastern, end of the port complex. The advantages of such a location are that it was believed that quays would be subjected to somewhat lower wave conditions on the average and the length of land access roads and rail lines would be shortened. This alternative phasing is not favored, however, on the grounds of dredging cost. The location would require a much longer entrance channel and more dredging would be required for the turning basin due to its location in shallower water. Also, as stated in Section III. C. 5., annual sedimentation can be expected to be significantly higher in this area, possibly as much as 20 to 30% higher, due to river borne sedimentation in response to the hydrodynamic characteristics of the region and because flushing of fine sediment from dredged areas is expected to be less efficient. Furthermore protection from wave action, particularly during the Northeast Monsoon, will probably not be significantly greater at this site than at the recommended outer location.

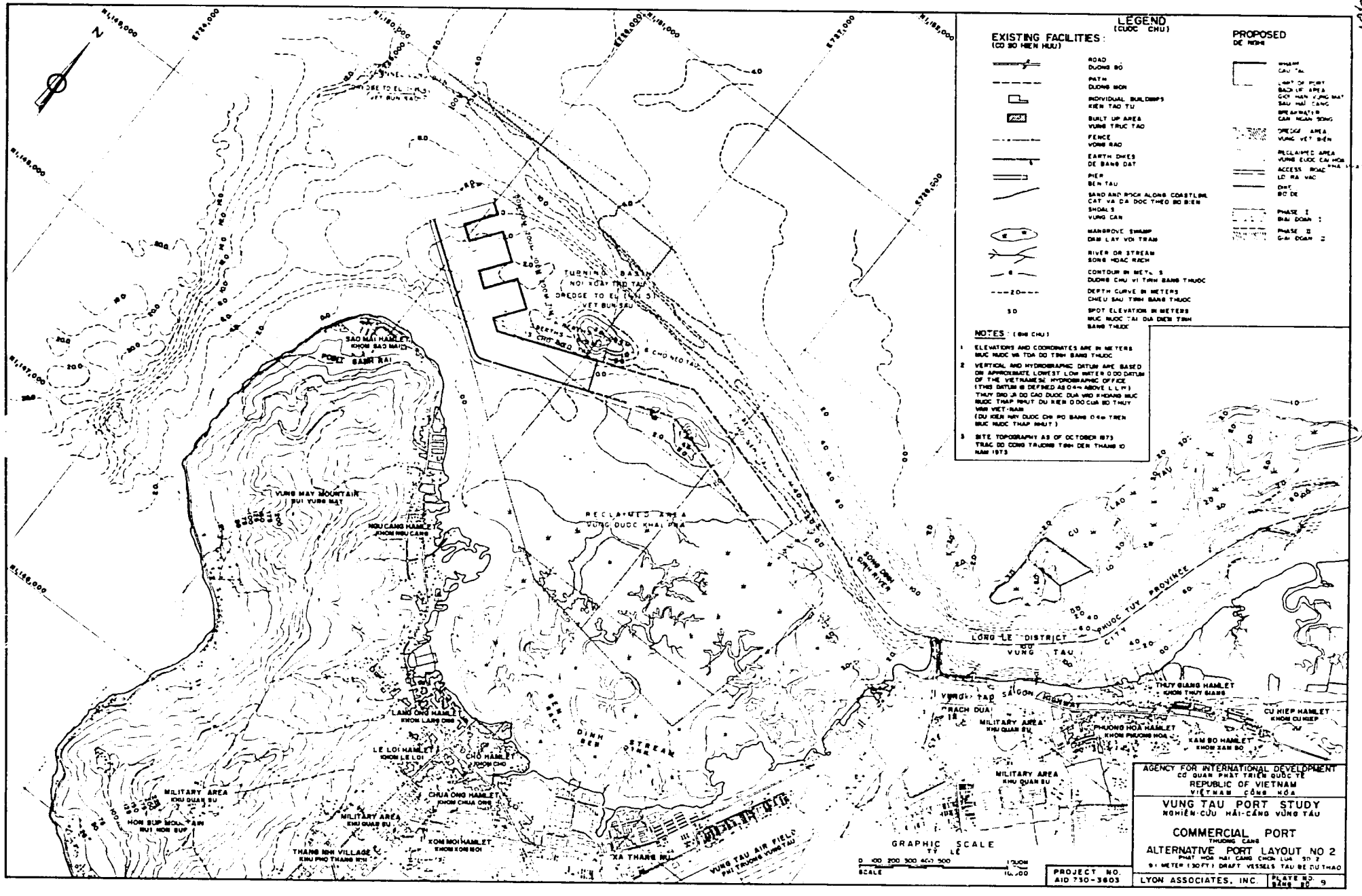
Due to the lack of specific criteria, the total remainder of proposed port development has been included in the second construction phase. A total of 2,820 m of quay, including first phase construction,

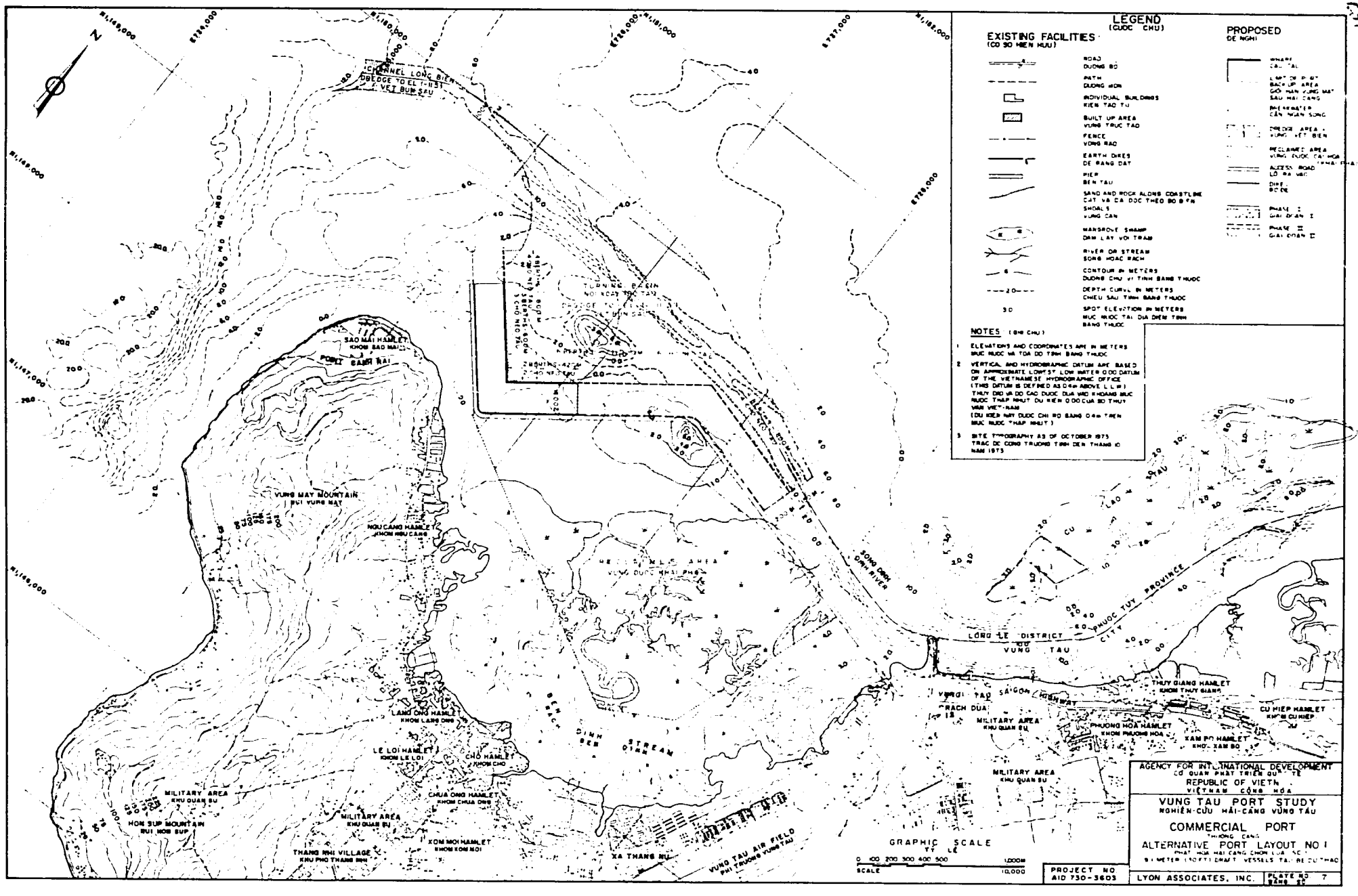
will be available for 9.1 m draft ships and 2,825 m will be available for 10.7 m draft ships. These lengths will provide approximately 14 berths for 9.1 m draft ships and 11 berths for 10.7 m draft ships. Once again a mixture of different type ships was assumed.

In view of the increased number of berths and increased port traffic expected, the size of the entrance channel has been increased to allow two way vessel traffic and the turning basin has been enlarged sufficiently so that tug assistance would probably not be necessary for most ships using the port except possibly those using the four berths located at the extreme inner, or eastern, end of the port.

c. Alternative Concept No. 2

The layouts for this alternative corresponding to the two ship drafts considered are shown on Plates 8 and 9. As can be seen the primary feature of this concept is the use of three wide finger pier type structures. This concept was designed to provide for cargo transfer between ocean going vessels and small coastal vessels and barges in the event that port requirements take this course. The chief feature of the finger piers is that they would allow direct transfer of cargo between ocean going ships moored to one side of a particular pier and coastal vessels moored to the other side, a more efficient operation than cargo transfer lengthwise along a marginal wharf between such vessels.


LEGEND
(CUOC CHU)
EXISTING FACILITIES:
(CO SO HIEN HUU)
ROAD
DUONG BO
PATH
DUONG MON
INDIVIDUAL BUILDINGS
KIEN TAO TU
BUILT UP AREA
VUNG TRUC TAO
FENCE
VONG RAO
EARTH DIKES
DE BANG DAT
PIER
BEN TAU
SAND AND ROCK ALONG COASTLINE
CAT VA DA DOC THEO BO BIEN
SHOALS
VUNG CAN
MANGROVE SWAMP
DAM LAY VOI TRAM
RIVER OR STREAM
SONG HOAC RACH
CONTOUR IN METERS
DUONG CHU VI TRIM BANG THUOC
DEPTH CURVE IN METERS
CHIEU SAU TRIM BANG THUOC
SPOT ELEVATION IN METERS
MUC NUOC TAI DIA DIEM TRIM BANG THUOC
PROPOSED
DE NGHI
WHARF
CAU TAU
LIMIT OF PORT
RANH GIOI HAN VUNG MAT
SAU HAI CANG
BREAKWATER
CAN NGAN SONG
DREDGE AREA
VUNG VET BIEN
RECLAIMED AREA
VUNG DUOC CAI HOA
ACCESS ROAD
LO RA VAO
DIKE
BO DE
PHASE I
GIAI DOAN I
PHASE II
GIAI DOAN II
NOTES: (GHI CHU)
1 ELEVATIONS AND COORDINATES ARE IN METERS
MUC NUOC VA TOA DO TRIM BANG THUOC
2 VERTICAL AND HYDROGRAPHIC DATUM ARE BASED ON APPROXIMATE LOWEST LOW WATER (LLW) DATUM OF THE VIETNAMESE HYDROGRAPHIC OFFICE
(THIS DATUM IS DEFINED AS 0.4m ABOVE LLW)
THUY DO JA DO CAO DUOC DUA VAO KHOANG MUC NUOC THAP NHUT DU KIEN (0.0) CUA SO THUY VAN VIET-NAM
(DU KIEN NAY DUOC CHI PO BANG 0.4m TREN MUC NUOC THAP NHUT)
3 SITE TOPOGRAPHY AS OF OCTOBER 1973
TRAC DO CONG TRUONG TRIM DEN THANG 10 NAM 1973
TURNING BASIN
NOI QUAY TRO TAU
DREDGE TO EL (-) 5
VET BUN SAU
SAO MAI HAMLET
KHOM SAO MAI
PORT BANG BAI
VUNG MAY MOUNTAIN
DUI VUNG MAY
NGU CANG HAMLET
KHOM NGU CANG
RECLAIMED AREA
VUNG DUOC KHAI PHA
SONG DINH RIVER
LONG LE DISTRICT
VUNG TAU CITY
PHUOC TUY PROVINCE
THUY GIANG HAMLET
KHOM THUY GIANG
CU HIEP HAMLET
KHOM CU HIEP
PHUONG HOA HAMLET
KHOM PHUONG HOA
KAM BO HAMLET
KHOM KAM BO
MILITARY AREA
KHU QUAN SU
LANG CHO HAMLET
KHOM LANG CHO
LE LOI HAMLET
KHOM LE LOI
CHO HAMLET
KHOM CHO
CHUA ONG HAMLET
KHOM CHUA ONG
KOM MOI HAMLET
KHOM KOM MOI
THANG NHI VILLAGE
KHU PHO THANG NHI
HON SUP MOUNTAIN
DUI HON SUP
XA THANG NHI
VUNG TAU AIR FIELD
PHI TRUONG VUNG TAU
GRAPHIC SCALE
TY LE
SCALE
PROJECT NO.
AID 730-3603
AGENCY FOR INTERNATIONAL DEVELOPMENT
CO QUAN PHAT TRIEN QUOC TE
REPUBLIC OF VIETNAM
VIETNAM CONG HOA
VUNG TAU PORT STUDY
NGHIEN-CUU HAI-CANG VUNG TAU
COMMERCIAL PORT
THUONG CANG
ALTERNATIVE PORT LAYOUT NO 2
PHAT HOA HAI CANG CHON LUA SO 2
9.1 METER (30FT) DRAFT VESSELS TAU BE DU THAO
LYON ASSOCIATES, INC.
PLATE NO.
BANG SO 9


LEGEND
(CUOC CHU)
EXISTING FACILITIES
(CO SO HIEN HUU)
ROAD
DUONG BO
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DUONG MON
INDIVIDUAL BUILDINGS
KIEN TAO TU
BUILT UP AREA
VUNG TRUC TAO
FENCE
VONG RAO
EARTH DIKES
DE RANG DAT
PIER
BEN TAU
SAND AND ROCK ALONG COASTLINE
CAT VA CA DOC THEO BO BIEN
SHOALS
VUNG CAN
MANGROVE SWAMP
DAM LAY VOI TRAM
RIVER OR STREAM
SONG HOAC RACH
CONTOUR IN METERS
DUONG CHU VI TINH BANG THUOC
DEPTH CURVE IN METERS
CHIEU SAU TINH BANG THUOC
SPOT ELEVATION IN METERS
MUC NUOC TAI DIA DIEM TINH BANG THUOC
PROPOSED
DE NGHI
WHARF
CAU TAU
LAYOUT PLOT
BACK UP AREA
GIO HAN VUNG MAT
SAU HAI CANG
BREAKWATER
CAN NGAN SONG
DREDGE AREA
VUNG NEO BIEN
RECLAIMED AREA
VUNG DUOC CAI HOA
ACCESS ROAD
LO RA VAO
DIKE
DE DIE
PHASE I
GIAI DOAN I
PHASE II
GIAI DOAN II
NOTES (GHI CHU)
1 ELEVATIONS AND COORDINATES ARE IN METERS
MUC NUOC VA TOA DO TINH BANG THUOC
2 VERTICAL AND HYDROGRAPHIC DATUM ARE BASED ON APPROXIMATE LOWEST LOW WATER 0.00 DATUM OF THE VIETNAMESE HYDROGRAPHIC OFFICE
(THIS DATUM IS DEFINED AS 0.4m ABOVE L.L.W.)
THUY DIO VA DO CAO DUOC DUA VAO KHOANG MUC NUOC THAP NHUT DU KIEN 0.00 CUA SO THUY VAN VIET-NAM
(DU KIEN NAY DUOC CHI RO BANG 0.4m TREN MUC NUOC THAP NHUT)
3 SITE TOPOGRAPHY AS OF OCTOBER 1973
TRAC DC CONG TRUONG TINH DEN THANG 10 NAM 1973
CHANNEL LONG BIEN
DREDGE TO EL. -11.5
VET BUN SAU
TURNING BASIN
NOI RONG DOC TAU
DREDGE TO EL. -11.5
SAO MAI HAMLET
KHOM SAO MAI
PORT SAIGON
VUNG MAY MOUNTAIN
DOI VUNG MAY
NGU CANG HAMLET
KHOM NGU CANG
RECLAIMED AREA
VUNG DUOC KHAI PHA
SONG DONG NAI RIVER
PHUOC TUY PROVINCE
LONG LE DISTRICT
VUNG TAU
CITY
VUNG TAU
SAIGON
THUY GIANG HAMLET
KHOM THUY GIANG
CU HIEP HAMLET
KHOM CU HIEP
PHUONG HOA HAMLET
KHOM PHUONG HOA
XAM BO HAMLET
KHOM XAM BO
RACH DUA
MILITARY AREA
KHU QUAN SU
LANG ONG HAMLET
KHOM LANG ONG
LE LOI HAMLET
KHOM LE LOI
CHO HAMLET
KHOM CHO
CHUA ONG HAMLET
KHOM CHUA ONG
BEN DINH STREAM
MILITARY AREA
KHU QUAN SU
HON SUP MOUNTAIN
DOI HON SUP
MILITARY AREA
KHU QUAN SU
THANG NHI VILLAGE
KHU PHO THANG NHI
KOM MOI HAMLET
KHOM KOM MOI
XA THANG NHI
VUNG TAU AIR FIELD
PHI TRUONG VUNG TAU
GRAPHIC SCALE
0 100 200 300 400 500 1,000M
SCALE 1:10,000
PROJECT NO
AID 730-3603
AGENCY FOR INTERNATIONAL DEVELOPMENT
CO QUAN PHAT TRIEN QUOC TE
REPUBLIC OF VIETNAM
VIETNAM CONG HOA
VUNG TAU PORT STUDY
NGHIEN-CUU HAI-CANG VUNG TAU
COMMERCIAL PORT
THUONG CANG
ALTERNATIVE PORT LAYOUT NO I
PHAT HOA HAI CANG CHON LUA SO I
9.1 METER (30 FT) DRAFT VESSELS TAI BE CU THAO
LYON ASSOCIATES, INC.
PLATE NO
BANG SO
7

As with Alternative No. 1 the first phase of construction was designed with five ocean going vessel berths for each ship draft class considered. Three of these berths would be located on marginal wharfage adjacent to the finger piers and two berths would be provided by two of the five sides of the finger piers. The other three sides of the finger piers would be usable by small craft although due to design constraints, they could also be utilized by deep draft vessels if necessary. Thus for 9.1 m draft vessels 620 meters of marginal wharf plus two 206 meter finger pier sides are assumed. For 10.7 m draft vessels 785 meters of marginal wharf plus two 216 meter finger pier sides are assumed.

The widths of the two primary finger piers, of the backup area behind the marginal wharf and of the slips between the finger piers were set in accordance with standard criteria for general cargo vessels and cargo handling. An exception is the 80 meter wide finger pier at the far outer, or western, end of the port. This pier does not have sufficient backup area to function efficiently as a deep water berth but could accommodate small craft or harbor craft such as tugs or lighters. It also provides protection from waves approaching from the south or west inasmuch as the outer boundary of the pier has been designed as a sloping seawall.

The dimensions of the turning basin and entrance channel are similar to these given for Alternative No.1 having been designed in accordance with the same criteria. Also, open type construction for wharves was assumed.

As with Alternative No.1 the first phase of construction was placed at the outer, or western, end of the port complex. The same reasons apply for this alternative as with Alternative No.1. In addition, because of space constraints and configuration of the sea bottom topography, the outer location is far more suitable for the location of the finger pier configuration than any other location, notably the far eastern end. Maneuvering of vessels would be most easily accomplished in the outer location due to the sea room afforded.

Again the second phase of construction includes all of the remaining port development anticipated. Only additional deep water marginal type wharfage is provided, a total of 2,220 m for 9.1 m draft ships (including first phase construction) and 2,315 m for 10.7 m draft ships. Thus approximately 13 deep water berths plus finger pier sides for small craft would be provided for the 9.1 m draft vessel configuration and 11 deep water berths and three finger pier sides for small craft would be provided for the 10.7 m draft vessel configuration. Also a channel capable of handling two way vessel traffic and a larger turning basin were provided as previously described.

d. Alternative Concept No. 3

Similarly to Alternative No. 2 a primary feature of Alternative No.3, shown on Plates 10 and 11, is provision for transfer of cargo between deep water ocean going vessels and small coastal craft and barges. This configuration, however, provides a separate basin protected from wave action by a breakwater having the specific purpose

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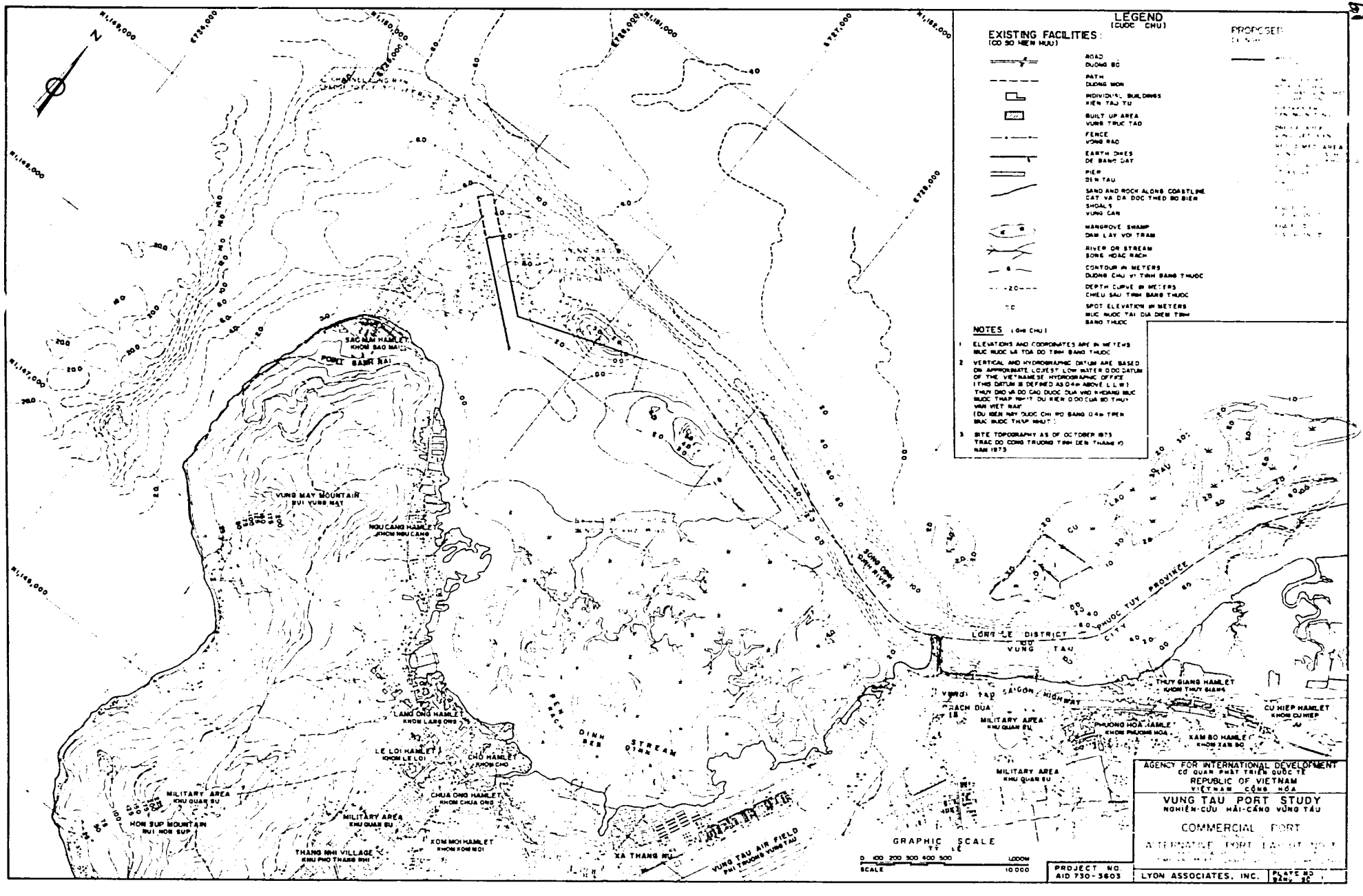
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EXISTING FACILITIES
(CO SO HIEN HUU)
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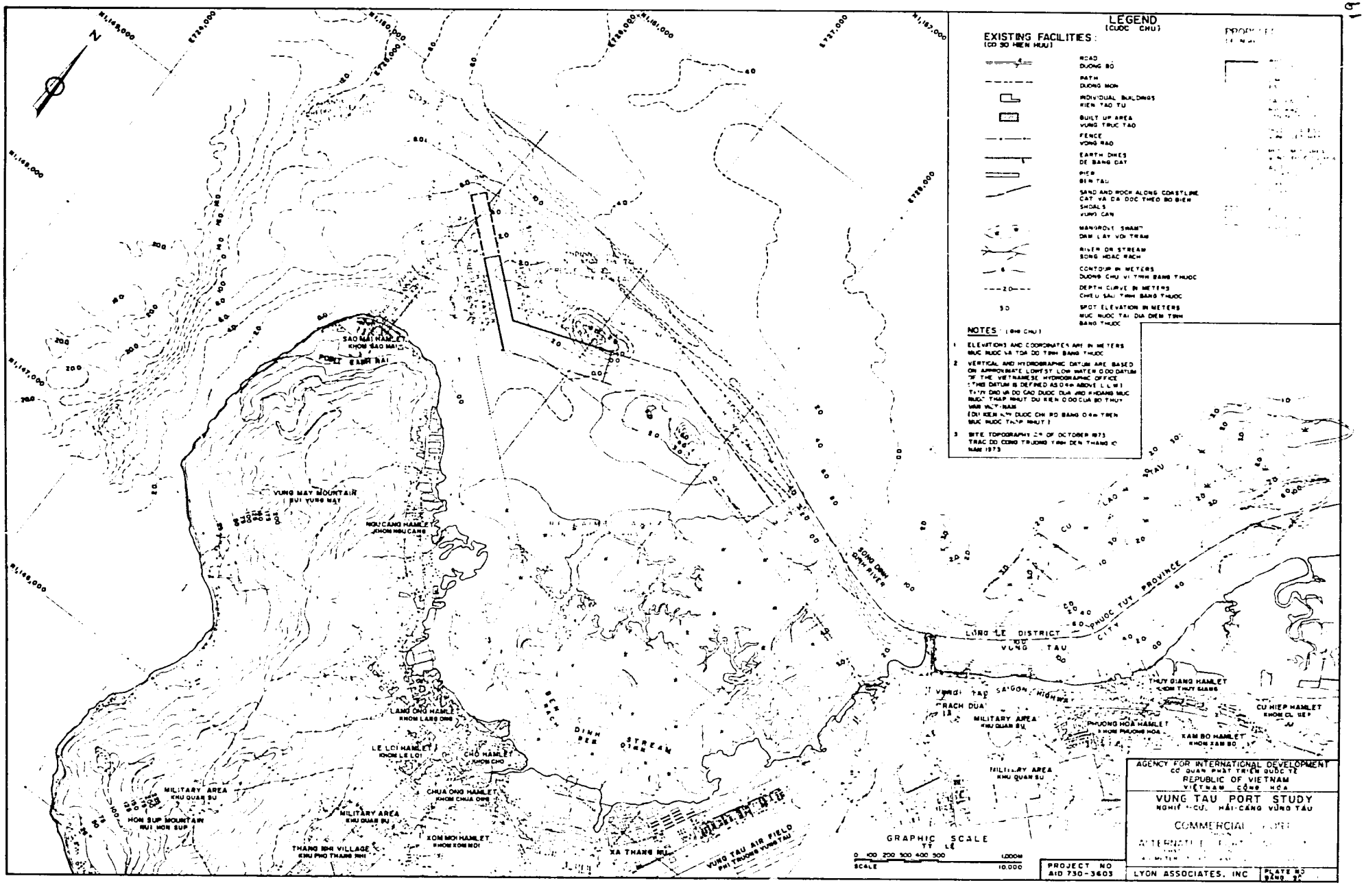
DUONG MON
INDIVIDUAL BUILDINGS
KIEN TAU TU
BUILT UP AREA
VUNG TRUC TAO
FENCE
VONG RAO
EARTH DIKES
DE BANG DAT
PIER
BEN TAU
SAND AND ROCK ALONG COASTLINE
CAT VA DA DOC THEO BO BIEN
SHOALS
VUNG CAN
MANGROVE SWAMP
DAM LAY VOI TRAM
RIVER OR STREAM
SONG HOAC RACH
CONTOUR IN METERS
DUONG CHU VI TRINH BANG THUOC
DEPTH CURVE IN METERS
CHIEU SAU TRINH BANG THUOC
SPOT ELEVATION IN METERS
MUC NUOC TAI DIA DIEM TRINH
BANG THUOC
NOTES (GHI CHU)
1 ELEVATIONS AND COORDINATES ARE IN METERS
MUC NUOC LA TOA DO TRINH BANG THUOC
2 VERTICAL AND HYDROGRAPHIC DATUM ARE BASED ON APPROXIMATE LOWEST LOW WATER 0.00 DATUM OF THE VIETNAMESE HYDROGRAPHIC OFFICE
(THIS DATUM IS DEFINED AS 0.4m ABOVE L.L.W.)
THUY DIO VA DO CAO DUOC DUA VAO KHOANG MUC NUOC THAP NHIT DU KIEN 0.00 CUA BO THUY VAN VIET NAM
(DU KIEN NAY DUOC CHI RO BANG 0.4m TREN MUC NUOC THAP NHUT)
3 SITE TOPOGRAPHY AS OF OCTOBER 1973
TRAC DO CONG TRUONG TINH DEN THANG 10 NAM 1973
SAO MAI HAMLET
KHOM SAO MAI
PORT BAIE NAI
VUNG MAY MOUNTAIN
NUI VUNG MAY
NGU CANG HAMLET
KHOM NGU CANG
LANG ONG HAMLET
KHOM LANG ONG
LE LOI HAMLET
KHOM LE LOI
CHO HAMLET
KHOM CHO
CHUA ONG HAMLET
KHOM CHUA ONG
XOM MOI HAMLET
KHOM XOM MOI
MILITARY AREA
KHU QUAN SU
HON SUP MOUNTAIN
NUI HON SUP
THANG NHI VILLAGE
KHU PHO THANG NHI
XA THANG NHI
VUNG TAU AIR FIELD
PHI TRUONG VUNG TAU
DINH RIVER
SONG DINH
LONG LE DISTRICT
HUYEN LONG LE
VUNG TAU CITY
PHUOC TUY PROVINCE
VUNG TAU SAIGON HIGHWAY
RACH DUA
THUY GIANG HAMLET
KHOM THUY GIANG
CU HIEP HAMLET
KHOM CU HIEP
PHUONG HOA HAMLET
KHOM PHUONG HOA
XAM BO HAMLET
KHOM XAM BO
GRAPHIC SCALE
0 100 200 300 400 500 1000M
SCALE 1:10 000
AGENCY FOR INTERNATIONAL DEVELOPMENT
CO QUAN PHAT TRIEN QUOC TE
REPUBLIC OF VIETNAM
VIETNAM CONG HOA
VUNG TAU PORT STUDY
NGHIEN-CUU HAI-CANG VUNG TAU
COMMERCIAL PORT
ALTERNATIVE PORT LAYOUT NO. 1
PROJECT NO.
AID 730-3603
LYON ASSOCIATES, INC.
PLATE NO.


LEGEND
(CUOC CHU)
EXISTING FACILITIES:
(CO SO HIEN HUU)
ROAD
DUONG BO
PATH
DUONG MON
INDIVIDUAL BUILDINGS
KIEN TRUC TU
BUILT UP AREA
VUNG TRUC TAO
FENCE
VONG RAO
EARTH DIKES
DE BANG DAT
PIER
BEN TAU
SAND AND ROCK ALONG COASTLINE
CAT VA DA DOC THEO BO BIEN
SHOALS
VUNG CAN
MANGROVE SWAMP
DAM LAY VOI TRAM
RIVER OR STREAM
SONG HOAC RACH
CONTOUR IN METERS
DUONG CHU VI TRIH BANG THUOC
DEPTH CURVE IN METERS
CHIEU SAU TRIH BANG THUOC
SPOT ELEVATION IN METERS
MUC NUOC TAI DIA DIEM TRIH BANG THUOC
NOTES (GHI CHU)
1 ELEVATIONS AND COORDINATES ARE IN METERS
MUC NUOC VA TOA DO TRIH BANG THUOC
2 VERTICAL AND HYDROGRAPHIC DATUM ARE BASED ON APPROXIMATE LOWEST LOW WATER O.DO DATUM OF THE VIETNAMESE HYDROGRAPHIC OFFICE
(THIS DATUM IS DEFINED AS 0.4m ABOVE L.L.W.)
TRIN DIO VA DO CAO DUOC DUA TRO KHOANG MUC NUOC THAP NHUT DU KIEN O.DO CUA BO THUY VAN VIET NAM
(DI KIEN NAY DUOC CHI BO BANG 0.4m TREN MUC NUOC THAP NHUT)
3 SITE TOPOGRAPHY 24 OF OCTOBER 1973
TRAC DO CONG TRUONG TRIH DEN THANG 10 NAM 1973
SAO MAI HAMLET
KHOM SAO MAI
PORT BAIE NAI
VUNG MAY MOUNTAIN
NUI VUNG MAY
NGU CANG HAMLET
KHOM NGU CANG
LANG ONG HAMLET
KHOM LANG ONG
LE LOI HAMLET
KHOM LE LOI
CHO HAMLET
KHOM CHO
CHUA ONG HAMLET
KHOM CHUA ONG
MILITARY AREA
KHU QUAN SU
HON SUP MOUNTAIN
NUI HON SUP
THANG NHI VILLAGE
KHU PHO THANG NHI
XOM MOI HAMLET
KHOM XOM MOI
XA THANG NHI
VUNG TAU AIR FIELD
PHI TRUONG VUNG TAU
BEN RACH DINH STREAM
SONG DINH RIVER
LONG LE DISTRICT
VUNG TAU CITY
PHUOC TUY PROVINCE
VUNG TAU SAIGON HIGHWAY
RACH DUA
THUY GIANG HAMLET
KHOM THUY GIANG
CU HIEP HAMLET
KHOM CU HIEP
PHUONG HOA HAMLET
KHOM PHUONG HOA
KAM BO HAMLET
KHOM KAM BO
GRAPHIC SCALE
TỶ LỆ
SCALE
0 100 200 300 400 500 1,000M
10,000
AGENCY FOR INTERNATIONAL DEVELOPMENT
CƠ QUAN PHÁT TRIỂN QUỐC TẾ
REPUBLIC OF VIETNAM
VIỆT NAM CỘNG HÒA
VUNG TAU PORT STUDY
NGHIÊN CỨU HẢI CẢNG VŨNG TÀU
COMMERCIAL PORT
PROJECT NO
AID 730-3603
LYON ASSOCIATES, INC
PLATE NO
BẢNG SỐ

of providing a separate cargo handling wharf and waiting area for the small coastal craft. In this alternative the small craft would moor to the basin side of the wharf and the ocean going ships to the other side so that efficient cargo transfer between them could take place.

As with Alternatives 1 and 2 the first phase of construction provides five deep water berths of various lengths for each ship draft considered. Also about 870 meters of the barge basin breakwater and 600 meters of small craft wharf are provided for the 9.1 m draft ship configuration and 960 m of breakwater and about 700 m of small craft wharf for the 10.7 m draft configuration. Three of the deep water berths are located at marginal wharfage adjacent to the basin and the standard 200 meters of backup area are provided for these berths. Two of the berths are located at a 100 meter wide pier across from the basin. The 100 meter width was based on the assumption that, unlike the finger piers of Alternative No.2, deep water berthing would only be located on one side of the pier shown in the Alternative No.3 layouts.

Once again open type wharf construction was assumed. While the marginal wharf sections are backed by land fill, the small craft cargo transfer pier will be open giving access to the barge basin for waves approaching from northerly directions. In order to provide protection for small craft in the basin, a wave barrier attached to the piling under the pier has been provided and is included in the cost estimate.

The depth and dimensions of the turning basin and entrance channel for this alternative are similar to previous alternatives. The depth of the barge basin has been set at - 5.5 m below Approx. LLW datum.

The location of the first phase of construction was dictated by criteria similar to those already discussed; notably that the water depths and channel lengths are more favorable at the outer end of the port than at the inner end. Also these features make the construction of a barge basin in this area more favorable than at the eastern end of the port.

During the second and final construction phase the deep water wharfage at the small craft cargo transfer pier would be lengthened 800 m for 9.1 m draft vessels and to 765 m for 10.7 m vessels. This addition would provide approximately 1,000 m and 965 m of small craft wharfage for the 9.1 m and 10.7 m draft alternatives respectively. In order to provide protection of the longer basin the breakwater would have to be lengthened. It is assumed that the angled end section of the first phase breakwater would be relocated to form a part of the second phase breakwater.

Additional marginal wharfage would also be provided. Thus the 9.1 m draft vessel port would have a total of 14 deep water berths and the 10.7 m draft vessel port would have a total of 11 berths. As discussed previously the entrance channel would be widened to allow two way traffic flow and the turning basin would be enlarged during the second construction phase.

e. Disposal of Excess Dredged Material and Land Reclamation

In general two alternative methods exist for disposal of material dredged from the entrance channel and turning basin of the proposed commercial general cargo port. These are spoiling on adjacent land or in water areas, and use of the material for land reclamation. Of the two simple spoiling is less desirable because past experience worldwide has indicated that spoiling either on land or in water areas can hasten the process of resedimentation of dredged areas due to erosion and redistribution of dredged material unless the material is spoiled at points far removed from the site. Use of the material for a reclamation project often is the most favorable alternative because the dual purpose of permanent removal of material from dredged areas and provision of usable land area is served.

As can be seen on Plates 6 - 11, a large reclaimed area is shown located behind the port quays and backup area. This area is shown in consideration of the consultant's recommendation that the excess dredged material taken from the turning basin and entrance channel for the commercial general cargo port be disposed of in this manner. If the dredged material is disposed of in this way, it could, with certain preparation techniques described in Section IV of this report, be made suitable for use as an industrial area in which factories of various types could be located. This location could be highly favorable to industry because of its close proximity to the port.

The area shown is that which would result from the dredging associated with the first phase of construction and is essentially the same in all port concept alternatives. It will be noted that the area has been laid out so that part of the mangrove island is left uncovered and the Ben Dinh stream has been left open. This was done in response to environmental aspects discussed in Section III.D. and in order to provide access to fishing vessels mooring at the various hamlets along the stream.

In order to evaluate the possibility of engaging in an expensive reclamation project of the type proposed, an investigation of land values in Vung Tau and vicinity was made. It was found that most of the land is government owned and is leased to users in the community or used for military purposes. That land which was not government owned would sell for of the order of US$10 (VN$5,000) per square meter in the outskirts of the city and US$24 (VN$12,000) per square meter near the city center. The size of the area shown is about 2,400,000 square meters. Thus, if the area is sold at the rates quoted above, it would be worth between US$24,000,000, at US$10 per square meter, and US$57,600,000, at US$24 per square meter. The estimated cost of the reclamation project, including filling operations, retaining dikes, and consolidation, is about US$5,000,000. It can be seen that the total value which could be realized in excess of the cost of the reclamation would be between US$19,000,000 and US$52,000,000, assuming the land prices given are valid. Thus it is possible that the sale of the reclaimed area would not only cover the cost of the reclamation project but could also substantially contribute to the cost of building a port at Vung Tau.

At some point, in view of the considerable maintenance dredging needed, area suitable for reclamation will be exhausted. In this event it is recommended that dredge fill be disposed of at sea well outside the port area.

f. Sequence of Construction

Sequence of construction is essentially the same for all the alternative concepts shown on Plates 6 through 11. All alternatives include reclamation of the large mangrove island area adjacent to the proposed port in the first phase of construction. Thus the first activity undertaken in the first construction phase would be the construction of peripheral dikes to contain the dredged fill for the large reclaimed area and the construction of the port access dike which would act as a part of this retention structure. At the same time structural dredging at the wharf site would commence. In order to insure retention of dredged material in the designated area prior to completion of retaining dikes, it is expected that a fabric silt curtain suspended from buoys and anchored around the initial fill site would be used where appropriate. This method has been used successfully in many reclamation projects, notably in Japan.

Placing of selected fill in the structure dredged trench would follow directly behind the dredging operation. This fill would be kept in place by the placement of quarry run core material on the fill slope. Next would come the driving of the piles for the wharf in front of and through the quarry run protected berm. The final steps in the sequence

would be the placement of the armor stone on the fill slope followed by the installation of the concrete deck.

Upon completion of structural dredging the dredge could commence dredging in the turning basin and entrance channel. It is unlikely that the retaining dikes surrounding the reclaimed area would be completed and silt curtains continually moved to keep pace with dike construction would be used. Thus at this stage wharf construction, construction of retaining dikes around the reclaimed area and dredging of turning basin and entrance channel would proceed simultaneously.

During second phase construction, the sequence would commence with the dredging for the trench in which the wharf berm would be placed. Inasmuch as the reclaimed area shown on the Plates would be essentially completely filled by dredged material from the first phase works, material from second phase works would have to be placed in another reclamation project or dumped at sea. Again it is expected that dredging and wharf construction would proceed concurrently.

Normally a bar chart showing sequence and time frame for construction of facilities would be given. Due to the fact that no one specific port development plan is being recommended and the port concepts do not include all the facilities which would make up a complete port complex, such a chart has not been included in this report. However, it is estimated that the total time to construct port facilities shown would be between thirty and forty months, depending on which plan or combination of plans is ultimately chosen.

g. Cost Estimate

The following preliminary construction cost estimates for the alternative port concepts only include those facilities shown on Plates 6 through 11. They do not include buildings, surfacing, cargo handling equipment, navigation aids, utilities and other related facilities needed to make the port totally functional. Therefore, the costs presented herein should not be construed as being the total capital expenditure required for a fully operational port of the size depicted on the various plates.

The cost of the various items of work that have been included in the estimates were based upon 1973 prices. Although the estimates have been expressed in U.S. dollars, the local currency cost component of each item of work were computed, where appropriate, and converted into U.S. dollars at a rate of VN$500 to one U.S. dollar.

h. Discussion of Alternative Layout Concepts

The recommendation of an alternative development plan will depend upon the type of shipping traffic which can be expected to utilize the port and on the type of cargo handling operations which will take place at the port. In view of the fact that this information is not known at this time, no specific recommendation can be made. However, general observations can be noted in the light of alternative assumptions in regard to these criteria.

As previously stated Alternative Concept Nos. 2 and 3 were designed specifically to provide cargo transfer both between ocean going vessels and land transport and between ocean going vessels and small coastal

COMMERCIAL GENERAL CARGO PORT
ALTERNATIVE I

Item of Construction	10.7m DRAFT						9.1m DRAFT					
	Phase I			Phase II			Phase I			Phase II		
	Q'ty	Unit Price $	Cost $(000)	Q'ty	Unit Price $	Cost $(000)	Q'ty	Unit Price $	Cost $(000)	Q'ty	Unit Price $	Cost $(000)
(1) Port												
(a) Dredging												
- channel	1.2Mm3	1.00	1,200.0	0.78Mm3	1.00	780.0	0.48Mm3	1.00	480.0	0.72Mm3	1.00	720.0
- basin	10.5Mm3	1.00	10,500.0	7.2Mm3	1.00	7,200.0	7.0Mm3	1.00	7,000.0	8.3Mm3	1.00	8,300.0
- wharf	1.1Mm3	1.00	1,100.0	1.28Mm3	1.00	1,280.0	0.86Mm3	1.00	860.0	1.5Mm3	1.00	1,500.0
(b) Wharf												
- berm	1,295m	2,991.89	3,874.5	1,530m	2,141.18	3,276.0	1,020m	2,860.98	2,918.2	1,800m	2,342.48	4,216.46
- structure	1,295m	4,994.44	6,467.8	1,530m	5,015.69	7,674.0	1,020m	5,013.82	5,114.1	1,800m	4,999.50	8,999.1
(c) Fill	260,000m2	4,75	1,236.0	306,000m2	4.77	1,458.5	204,000m2	4.76	971.5	360,000m2	4.76	1,713.5
(d) Access road & railroad	2,750m	1,025.74	2,820.8	-	-	-	2,850m	1,022.31	2,913.5	-	-	-
Subtotal (1)			27,199.1			21,668.5			20,257.4			25,449.06
(2) Reclamation												
(a) Dikes	3,950m	624.40	2,466.4	-	-	-	3,850m	623.37	2,400.0	-	-	-
(b) Fill	10.86Mm3	0.15	1,629.0	6.96Mm3	0.15	1,044.0	6,820Mm3	0.15	1,023.0	7.82Mm3	0.15	1,173.0
Subtotal (2)			4,095.4			1,044.0			3,423.0			1,173.0
Subtotal (1) & (2)			31,294.5			22,712.5			23,680.4			26,622.06
Contractor's profit & overhead 25%			7,823.62			5,678.1			5,920.1			6,655.51
Construction contingency 15% appr.			4,681.88			3,409.4			3,499.5			4,022.43
Total			43,800.0			31,800.0			33,100.0			37,300.0
Total Phase I + II						75,600.0						70,400.0
Estimated annual maintenance dredging	0.6Mm3	1.70	1,020.0	1.2Mm3	1.70	2,040.0	0.6Mm3	1.70	1,020.0	1.2Mm3	1.70	2,040.0

* M = 1,000,000
Unit Prices are average rounded values

COMMERCIAL GENERAL CARGO PORT
ALTERNATIVE 2

Item of Construction	10.7 m DRAFT						9.1 m DRAFT					
	Phase I			Phase II			Phase I			Phase II		
	Q'ty	Unit Price $	Cost $(000)	Q'ty	Unit Price $	Cost $(000)	Q'ty	Unit Price $	Cost $(000)	Q'ty	Unit Price $	Cost $(000)
(1) Port												
(a) Dredging												
- channel	0.66Mm^3	1.00	660	0.48Mm^3	1.00	480.0	0.27Mm^3	1.00	270.0	0.32Mm^3	1.00	320.0
- basin	12.3Mm^3	1.00	12,300	9.8Mm^3	1.00	9,800.0	6.8Mm^3	1.00	6,800.0	6.6Mm^3	1.00	6,600.0
	2.25Mm^3	1.00	2,250	1.27Mm^3	1.00	1,270.0	2.04Mm^3	1.00	2,040.0	1.35Mm^3	1.00	1,350.0
(b) Wharf												
- berm	2,690m	2,592.60	6,974.1	1,530m	1,989.54	3,044.0	2,431m	2,645.86	6,432.1	1,600m	2,143.75	3,430.0
- structure	2,690m	4,879.37	13,125.5	1,530m	4,968.30	7,601.5	2,431m	5,017.69	12,198.0	1,600m	4,998.56	7,997.7
(c) Fill	377,000m^2	4,75	1,791.25	306,000m^2	4.77	1,458.5	332,000m^2	4.79	1,591.0	320,000m^2	4.77	1,526.5
(d) Access road & railroad	2,600m	1,023.38	2,660.8	-	-	-		1,022.94	2,710.8	-	-	-
Subtotal (1)			39,761.65			23,654			32,041.9			21,224.2
(2) Reclamation												
(a) Dikes	3,950m	558.78	2,207.2	-	-	-	3,900m	619.59	2,416.4	-	-	-
(b) Fill	12.4Mm^3	0.15	1,861.5	9.25Mm^3	0.15	1,387.5	6.61Mm^3	0.15	991.5	5.87Mm^3	0.15	880.5
Subtotal (2)			4,068.7			1,387.5			3,407.9			880.5
Subtotal (1) & (2)			43,830.35			25,041.5			35,449.8			22.104.7
Contractor's profit & overhead 25%			10,957.59			6,260.37			8,862.45			5,526.17
Construction contingency 15% appr.			6,612.12			3,698.13			5,287.75			3,269.13
Total			61,400.0			35,000.0			49,600.0			30,900.0
Total Phase I + II						96,400.0						80,500.0
Estimated annual maintenance dredging	0.6Mm^3	1.70	1,020.0	1.2Mm^3	1.70	2,040.0	0.6Mm^3	1.70	1,020.0	1.2Mm^3	1.70	2,040.0

* M = 1,000,000

Unit Prices are averaged rounded values

COMMERCIAL GENERAL CARGO PORT
ALTERNATIVE No. 3

Item of Construction	10.7 m DRAFT						9.1 m DRAFT					
	Phase I			Phase II			Phase I			Phase II		
	Q'ty	Unit Price $	Cost $(000)	Q'ty	Unit Price $	Cost $(000)	Q'ty	Unit Price $	Cost $(000)	Q'ty	Unit Price $	Cost $(000)
(1) Port												
(a) Dredging												
- channel	0.54Mm^3	1.00	540.0	0.4Mm^3	1.00	400.0	0.3Mm^3	1.00	300	0.38Mm^3	1.00	380
- basin	8.6Mm^3	1.00	8,600.0	7 Mm^3	1.00	7,000.0	5.6Mm^3	1.00	5,600	7.9Mm^3	1.00	7,900
- wharf	1.1Mm^3	1.00	1,100.0	1.28Mm^3	1.00	1,280.0	0.96Mm^3	1.00	960	1.09Mm^3	1.00	1,090
(b) Wharf												
- berm	1,805m	1,456.12	2,628.3	1,785m	1,984.14	3,541.7	1,580m	1,470.25	2,323.	2,000	1,792.23	3,942.9
- structure	1,805m	6,649.25	12,001.9	1,785m	5,828.23	10,403.4	1,580m	6,730.66	10,634.45	2,200	6,059.77	13,331.5
(c) Fill	157,000m^2	4.78	750.0	255,000m^2	4.76	1,213.5	124,000m^2	4.80	595.5	289,000m^2	4.77	1,336
(d) Access road & railroad	2,500m	1,024.32	2,560.8	-	-	-	2,600m	1,023.38	2,660.8	-	-	-
Subtotal (1)			28,181			23,838.6			23,073.75			27,980.4
(2) Reclamation												
(a) Dikes	3,800m	615.58	2,339.2	-	-	-	3,950m	624.41	2,466.4	-	-	-
(b) Fill	9.04Mm^3	0.15	1,356	6.78Mm^3	0.15	1,017	5.93Mm^3	0.15	889.5	7.27Mm^3	0.15	1,090.5
Subtotal (2)			3,695.2			1,017			3.355.9			1,090.5
Subtotal (1) & (2)			31,876.2			24,855.6			26,429.65			29,070.9
Contractor's profit & overhead 25%			7,969.05			6,213.9			6,607.41			7,267.72
Construction contingency 15% appr.			4,754.75			3,730.5			3,962.94			4,361.38
Total			44,600			34,800			37,000			40,700
Total Phase I + II						79,400						77,700
Estimated annual maintenance dredging	0.6Mm^3	1.70	1,020	1.2Mm^3	1.70	2,040	0.6Mm^3	1.70	1,020	1.2Mm^3	1.70	2,040

* M = 1,000,000
Unit prices are average rounded values

craft, barges, and lighters. Of these two alternatives, Alternative No. 3 is better suited to the port operation envisioned because only in this alternative has a specific area designed to accommodate a small craft operation been provided. In Alternative No. 2 small craft could moor opposite ocean going vessels at the finger piers shown so that direct cargo transfer could be accomplished. However, because of the configuration of the piers and the necessity of dredging the in situ soil to very flat slopes so that it would remain stable, it would not be possible to designate specific berths only for small craft traffic without resorting to costly slope protection. In effect, then, the finger pier solution provides deep water berths to accommodate small shallow water vessels. This operational configuration has generally been found to be uneconomical compared to configurations where more specialized accommodations were provided.

Specialized accommodation is provided in Alternative No. 3 in the form of a protected basin having shallower depth and a series of shallow water berths at a specialized wharf. On the other side of this wharf deep water berthing is provided. With the areas so designated each area could be specifically designed for the handling of the cargoes of the respective vessel sizes and direct transfer could easily be effected as could transit storage of goods awaiting transshipment.

Another characteristic which favors Alternative No. 3 is the year round protection from wave action afforded by the small craft basin. This feature is particularly important when it is realized that small craft queued or awaiting mooring space at wharfage of Alternative No. 2

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would have to wait in adjacent unprotected waters while those waiting in Alternative No. 3 could wait in the protected barge basin.

Finally, as seen from the cost figures given in the previous section, Alternative No. 3 is less expensive to build on a berth by berth basis than is Alternative No. 2.

Unlike Alternatives 2 and 3, Alternative No. 1 was designed to accommodate deep water shipping with only minimal small craft handling capability. Small craft and barges could, of course, be handled in this configuration either alongside the quay or outboard of moored deep water vessels. Direct transfer between small craft and ocean ships could also be effected although it would mean transfer along, rather than across, the wharf. Generally this arrangement is unsatisfactory because it could interfere with the normal movement of cargo to and from transit storage or land transport.

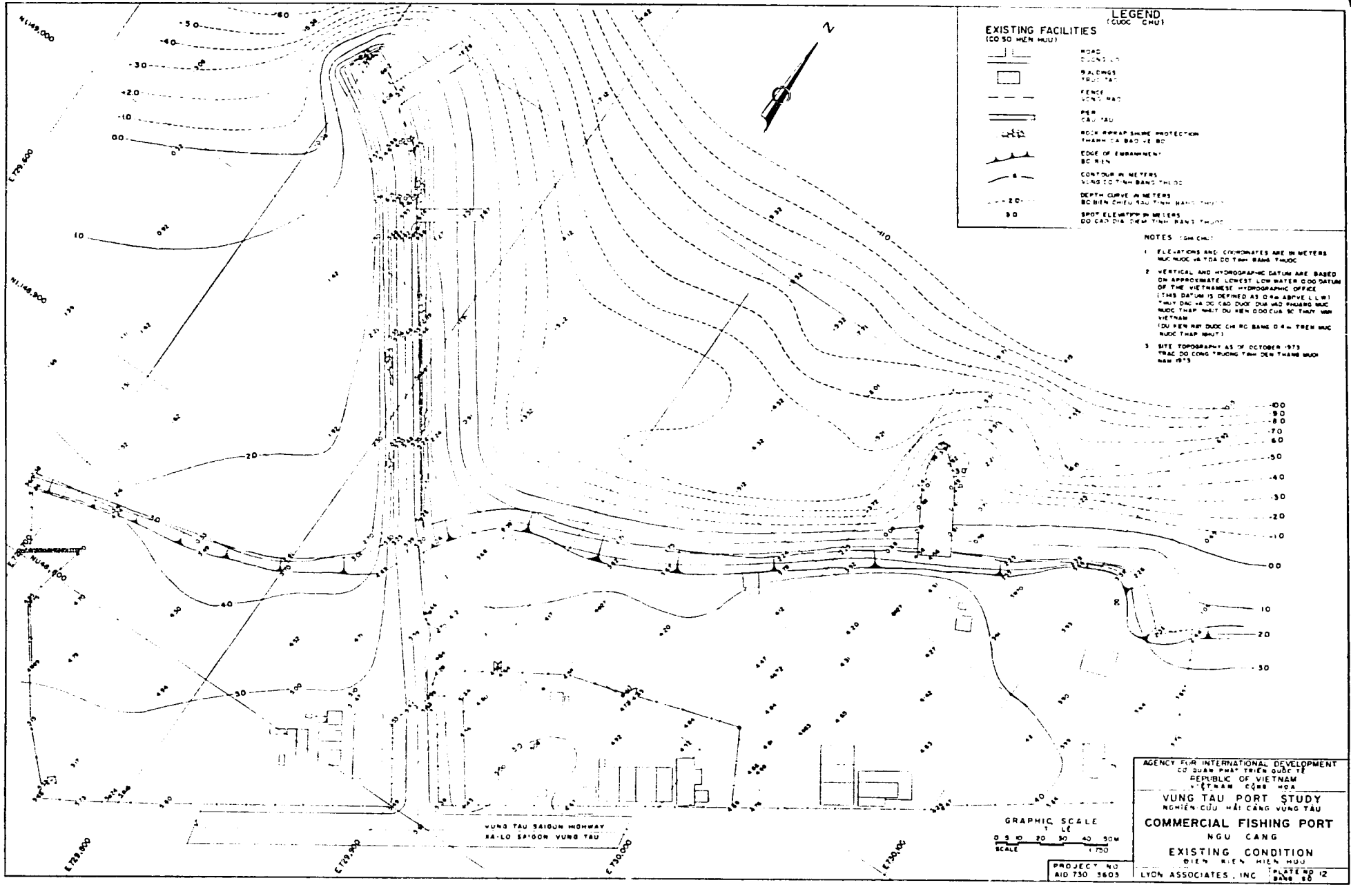
In conclusion, then, should significant small craft handling and water borne cargo transfer be indicated by future studies, a specialized port layout similar to Alternative No. 3 would be recommended. If studies indicate that small craft handling will be minimal, Alternative No. 1 is recommended because of its lower cost and higher efficiency in the accommodation and the handling of cargo carried by ocean going vessels.

2. Commercial Fishing Port

a. General

The primary purpose of the new commercial fishing port proposed herein will be to provide docking facilities and sufficient backup area to accommodate other related facilities and services for a fleet of relatively large ocean going fishing vessels. It has been assumed that most of their catch will be processed for export, not used for local consumption. Thus the fishing activities associated with this port would be essentially a new industry which would be additional to the small craft fishing activities which are currently being engaged in the Vung Tau.

The consultant feels that the two activities, i.e. the commercial fishing industry associated with the proposed new fishing port and the local fishing activity carried out by small boats on a daily basis, be kept separate. It is believed that the local small boat fishing activity represents an important industry and source of livelihood for the area and that it should be maintained with as little interference as possible. Separation of the commercial fishing from the local fishing activities would insure that neither interferes with the other in terms of port operation and expansion. It is assumed that the new commercial fishing enterprise would be engaged in fishing largely for export and that the existing fishing activities carried out from many fishing villages in the Vung Tau area would provide sea foods for local consumption and for markets in Vietnam.


LEGEND
(CUOC CHU)
EXISTING FACILITIES
(CO SO HIEN HUU)
ROAD
BUILDINGS
FENCE
PIER
CAU TAU
ROCK RIPRAP SHORE PROTECTION
EDGE OF EMBANKMENT
BO BIEN
CONTOUR IN METERS
DEPTH CURVE IN METERS
SPOT ELEVATION IN METERS
NOTES (GHI CHU)
1 ELEVATIONS AND COORDINATES ARE IN METERS
MUC NUOC VA TOA DO TINH BANG THUOC
2 VERTICAL AND HYDROGRAPHIC DATUM ARE BASED ON APPROXIMATE LOWEST LOW WATER GOO DATUM OF THE VIETNAMESE HYDROGRAPHIC OFFICE
(THIS DATUM IS DEFINED AS 0.4m ABOVE L.L.W.)
THUY DAC VA DO CAO DUOC DUA VAO PHAMG MUC NUOC THAP NHAT DU BIEN GOO CUA SC THUY VAN VIETNAM
(DU BIEN RIP DUOC CHI RO BANG 0.4m TREN MUC NUOC THAP NHAT)
3 SITE TOPOGRAPHY AS OF OCTOBER 1973
TRAC DO CONG TRUONG TINH DEN THANG MUOI NAM 1973
N.149,000
N.148,900
E.729,600
E.729,800
E.730,000
VUNG TAU SAIGON HIGHWAY
XA-LO SAIGON VUNG TAU
GRAPHIC SCALE
TỶ LỆ
0 5 10 20 30 40 50M
SCALE 1:750
AGENCY FOR INTERNATIONAL DEVELOPMENT
CƠ QUAN PHÁT TRIỂN QUỐC TẾ
REPUBLIC OF VIETNAM
VIỆT NAM CỘNG HÒA
VUNG TAU PORT STUDY
NGHIÊN CỨU HẢI CẢNG VUNG TAU
COMMERCIAL FISHING PORT
NGU CANG
EXISTING CONDITION
BIEN HIEN HIEN HUU
PROJECT NO
AID 730 3603
LYON ASSOCIATES, INC
PLATE NO 12
BANG SO

In choosing a location for the proposed commercial fishing port a number of possibilities were considered. Many of these sites were located on the coastline in the vicinity of existing fishing villages. However, these sites were rejected either because they interfered with existing local fishing activities or they were unsuitable in terms of channel depth, dredging requirements, backup area available, or land access.

After due consideration it has been recommended that the commercial fishing port be located in the area presently occupied by the existing commercial cargo port. Two alternatives are presented for development of this port and both are placed in this location. The location is favored because sufficient space exists for the establishment of a fishing port. This is true both in terms of land area for backup facilities and sea area for the maneuvering of vessels (see Section V. C. 1. a.). The adjacent turning basin and entrance channel are of sufficient size and depth to accommodate fishing vessels up to 30 meters in length, a size agreed as reasonable by various fisheries agencies consulted, with minimal dredging. The site is also favorable from the standpoint of land transport due to its proximity to the existing major road serving Vung Tau and to the most probable route of a rail line connecting Vung Tau with the Saigon line. Also the site is well protected from storm and seasonal wave activity, an important consideration in view of the relatively small size of vessels which will use the port. As already stated sedimentation is expected to be minimal in the port area and, because of the shallow draft of the fishing boats, entrance channel dredging requirements will also be relatively low.

Probably the most important advantage of the recommended location is the fact that the land area is immediately available and that a very good fishing port could be established easily and rapidly with relatively little cost because of the general overall suitability of the site. While years of preparation and construction would be needed to establish a major cargo handling port, a fishing port at this site could be built and operating in only a relatively short period of time.

At present a small volume of general cargo based on local activities is handled at a small pier in the existing commercial cargo port. In the event that if the proposed new commercial general cargo port is not built, the problem arises of where to relocate the existing general cargo handling area if the proposed commercial fishing port is placed as recommended above. For reasons previously discussed it would not be advisable to utilize existing wharf facilities at nearby fishing villages. It is therefore believed that the most suitable site for accommodating this cargo handling operation is the ARVN facility located up the Dinh River a small distance from the existing cargo port. The removal of the cargo activity to the ARVN site would, of course, require Government approval but it appears to be the most favorable solution considering the small cargo handling requirement involved.

b. Alternative Concept No. 1

This alternative concept, shown on Plate 13, is designed to accommodate up to 50 ocean going fishing vessels of lengths up to 30 m. The plan features the use of the existing Delong pier causeway to which

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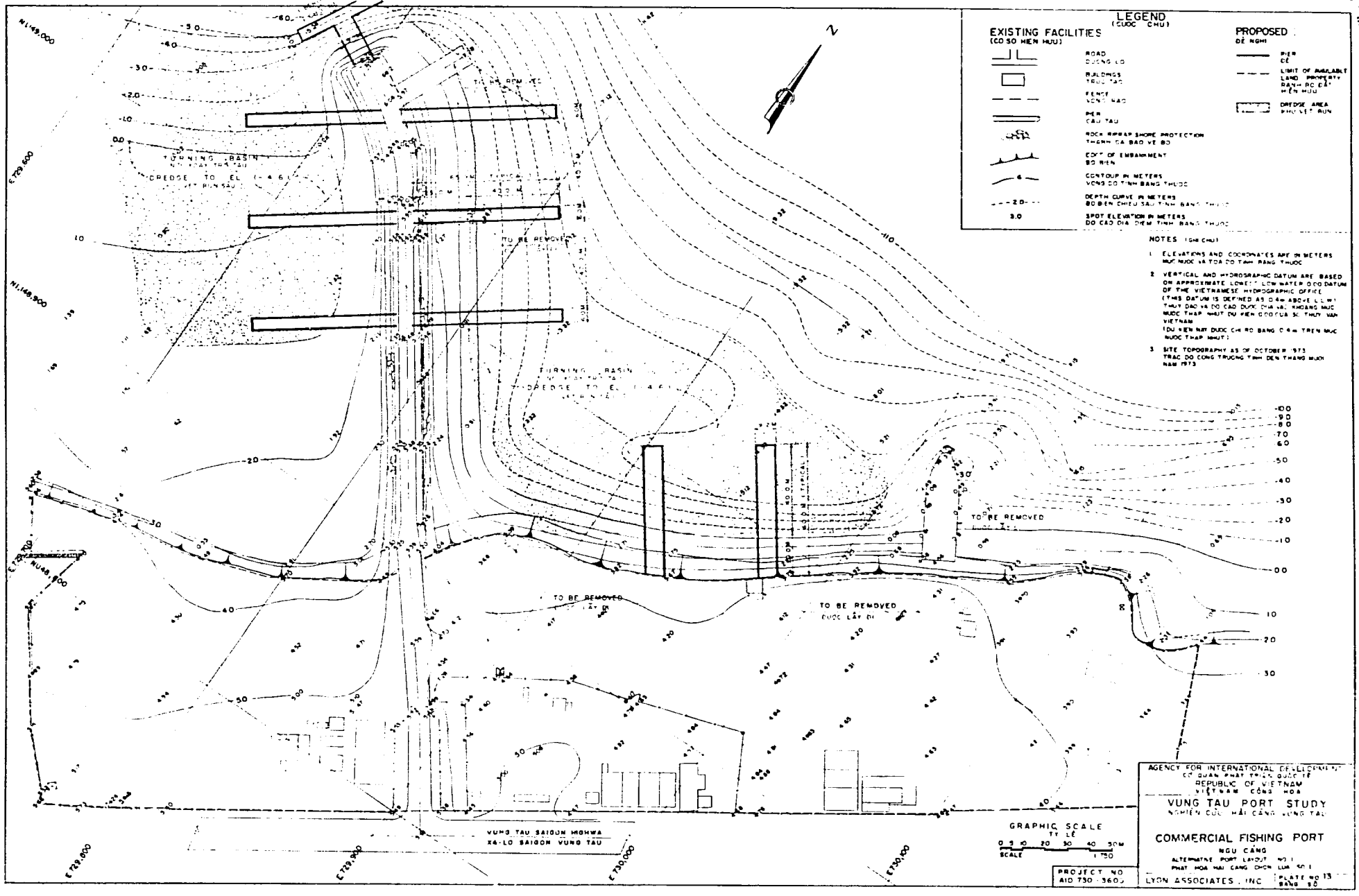
LEGEND
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EXISTING FACILITIES
(CO SO HIEN HUU)
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BUILDINGS
TRUU TAO
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PIER
CAU TAU
ROCK RIPRAP SHORE PROTECTION
THANH DA BAO VE BO
EDGE OF EMBANKMENT
BO RIEN
CONTOUR IN METERS
VONG DO TINH BANG THUOC
DEPTH CURVE IN METERS
BO BIEN CHIEU SAU TINH BANG THUOC
SPOT ELEVATION IN METERS
DO CAO DIA DIEM TINH BANG THUOC
PROPOSED
DE NGHI
PIER
CE
LIMIT OF AVAILABLE LAND PROPERTY
RANH RO DAT HIEN HUU
DREDGE AREA
PHU VET RUN
NOTES (GHI CHU)
1 ELEVATIONS AND COORDINATES ARE IN METERS
MUC NUOC VA TOA DO TINH BANG THUOC
2 VERTICAL AND HYDROGRAPHIC DATUM ARE BASED ON APPROXIMATE LOWEST LOW WATER 0.0 DATUM OF THE VIETNAMESE HYDROGRAPHIC OFFICE
(THIS DATUM IS DEFINED AS 0.4m ABOVE LOWEST THUY DAO VA DO CAO DUOC DINH NGHIA KHOANG MUC NUOC THAP NHAT DU HIEN 0.0 CUA SO THUY VAN VIETNAM
(DU HIEN NAY DUOC CHO RO BANG 0.4m TREN MUC NUOC THAP NHAT)
3 SITE TOPOGRAPHY AS OF OCTOBER 1973
TRAC DO CONG TRUONG TINH DEN THANG MUOI NAM 1973
TURNING BASIN
DREDGE TO EL (-4.6)
TO BE REMOVED
TO BE REMOVED
TO BE REMOVED
TO BE REMOVED
VUNG TAU SAIGON HIGHWAY
XA-LO SAIGON VUNG TAU
GRAPHIC SCALE
TY LE
SCALE 1:750
PROJECT NO
AID 750-3600
AGENCY FOR INTERNATIONAL DEVELOPMENT
CO QUAN PHAT TRIEN QUOC TE
REPUBLIC OF VIETNAM
VIETNAM CONG HOA
VUNG TAU PORT STUDY
NGHIEN CUU HAI CANG VUNG TAU
COMMERCIAL FISHING PORT
NGU CANG
ALTERNATIVE PORT LAYOUT NO 1
PHAT HOA HAI CANG CHON LUA SO 1
LYON ASSOCIATES, INC
PLATE NO 13
BANG SO

would be attached six piers at which vessels in port would moor for the purpose of resupply and minor repair. Since these facilities would only be used for mooring the fishing vessels during their resupply and minor repair period, finger piers six meters wide are recommended. Each pier is designed to accommodate up to four vessels, two moored abreast on each side. In addition to the mooring piers the causeway would also have a dock attached to its end at which vessels would take on ice and fuel.

Unloading of the catch would take place at two finger piers located adjacent to the major cargo handling and fish processing area of the port. These piers, 40 meters long with a 20 meter causeway, were designed so that four vessels, two to each pier, could be unloaded simultaneously. Thus, inasmuch as they would be used for cargo handling, their widths were set at 9.2 meters.

In determining the number of berths for unloading and for mooring it was assumed that 50 fishing vessels would utilize the port in accordance with a cycle period of approximately 25 days in length. This cycle period was based on the premise that the vessels would be at sea two to three weeks followed by about six days in port. Assuming a 4,000 pound per hour unloading rate, about two working days would be needed to unload a fully loaded 40 DWT vessel. Thus of the six days in port, two might be spent unloading and the other four moored to one of the finger piers. During a single six day period twelve vessels would occupy the port on any given day and therefore a minimum of twelve berths would be needed. However, as stated above, provision has been made for up to 28 vessels

to be berthed - 24 at the mooring finger piers and four at the unloading piers - a number considerably greater than the minimum. The purpose in providing the extra berthage lies in the realization that precise scheduling of arrival and departure of fishing vessels will not be practical and that there is a very good possibility that as much as one-half the total fleet could be in port at any given time. In fact in the event of a storm, a considerably higher percentage might be in port. Inasmuch as this probability is much lower, however, more extensive facilities are not deemed necessary and in this event vessels seeking shelter could anchor in the harbor basin or in nearby protected waters.

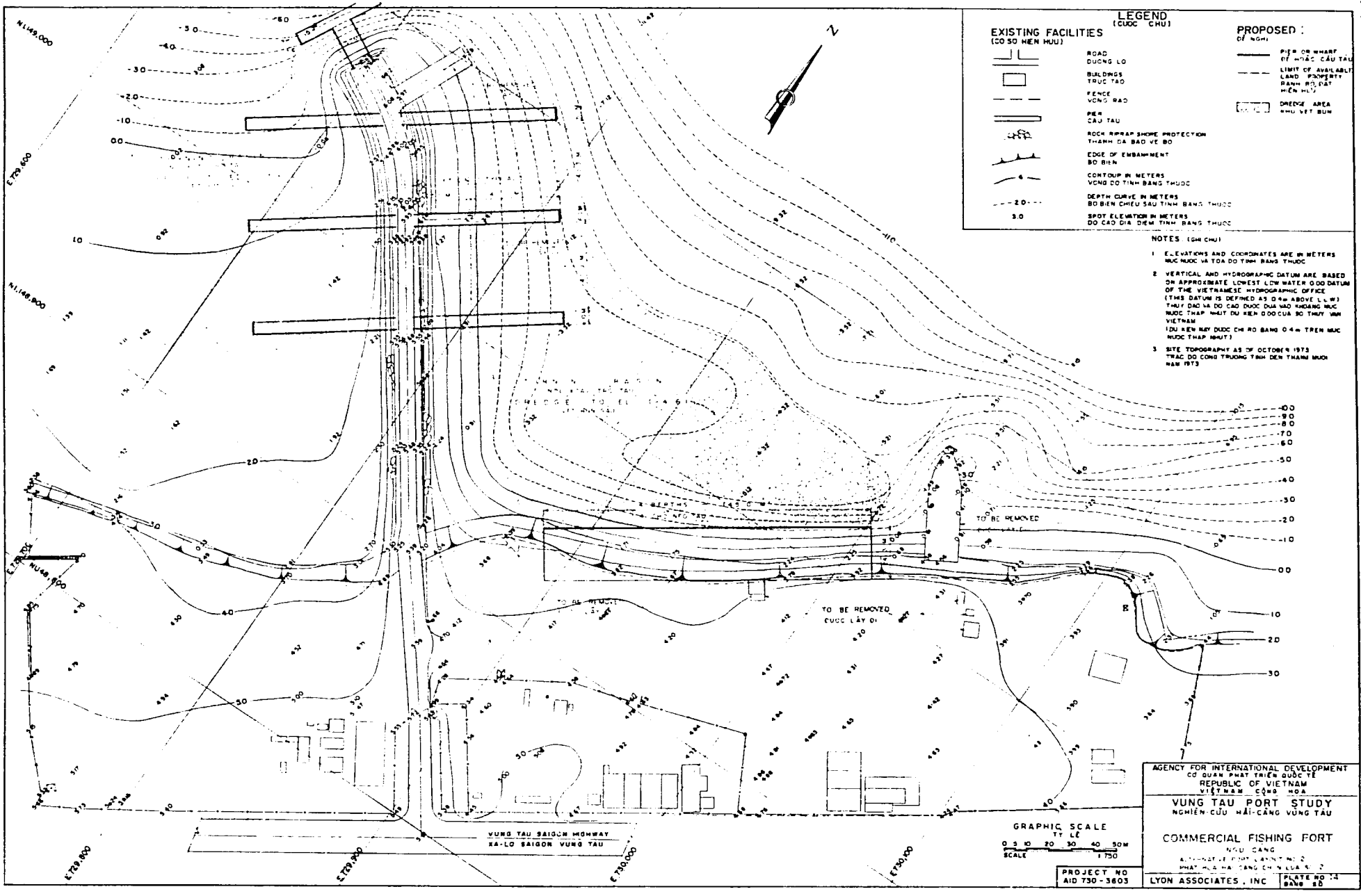
The backup area behind the unloading piers is ideally suited for establishment of such facilities as freezing plants, a cannery, a fish meal plant and a marine railway and repair yard as well as for the transfer of both processed and fresh fish to land transport.

Unlike the proposed commercial cargo port, only one phase of construction is envisioned. However, if the need arises, there is additional land area for future expansion.

c. Alternative Concept No. 2

Alternative No. 2 is similar in all respects to No. 1 except that, instead of finger piers for unloading fish, the plan shows a marginal wharf. The marginal wharf has a length of 145 meters and, like the finger piers, can accommodate four vessels unloading simultaneously (see Plate 14).

As with Alternative No. 1, no phasing of construction was anticipated.


LEGEND
(CUOC CHU)
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ROCK RIPRAP SHORE PROTECTION
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EDGE OF EMBANKMENT
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CONTOUR IN METERS
VONG DO TINH BANG THUOC
DEPTH CURVE IN METERS
BO BIEN CHIEU SAU TINH BANG THUOC
SPOT ELEVATION IN METERS
DO CAO DIA DIEM TINH BANG THUOC
PROPOSED :
DE NGHI
PIER OR WHARF
DE NGHI CAU TAU
LIMIT OF AVAILABLE LAND PROPERTY
RANH RO DAT HIEN HUU
DREDGE AREA
KHU VET BUN
NOTES (GHI CHU)
1 ELEVATIONS AND COORDINATES ARE IN METERS
MUC NUOC VA TOA DO TINH BANG THUOC
2 VERTICAL AND HYDROGRAPHIC DATUM ARE BASED ON APPROXIMATE LOWEST LOW WATER 0.00 DATUM OF THE VIETNAMESE HYDROGRAPHIC OFFICE
(THIS DATUM IS DEFINED AS 0.4m ABOVE L.L.W)
THUY DAC VA DO CAO DUOC DUA VAO KHOANG MUC NUOC THAP NHUT DU KIEN 0.00 CUA SO THUY VAN VIETNAM
(DU KIEN NAY DUOC CHI RO BANG 0.4m TREN MUC NUOC THAP NHUT)
3 SITE TOPOGRAPHY AS OF OCTOBER 1973
TRAC DO CONG TRUONG TINH DEN THANG MUOI NAM 1973
TO BE REMOVED
CUOC LAY DI
VUNG TAU SAIGON HIGHWAY
XA-LO SAIGON VUNG TAU
GRAPHIC SCALE
TY LE
SCALE 1:750
PROJECT NO
AID 730-3603
AGENCY FOR INTERNATIONAL DEVELOPMENT
CO QUAN PHAT TRIEN QUOC TE
REPUBLIC OF VIETNAM
VIETNAM CONG HOA
VUNG TAU PORT STUDY
NGHIEN CUU HAI-CANG VUNG TAU
COMMERCIAL FISHING PORT
NGU CANG
LYON ASSOCIATES, INC
PLATE NO 14
BANG SO

d. Sequence of Construction

Construction of the fishing port would commence with the dredging, demolition and land fill operations which could be carried out simultaneously. The dredged material could either be dumped in the reclaimed area adjacent to the general commercial cargo port, if this port is built, or can be disposed of at sea. Upon completion of dredge and fill operations at the unloading wharf site, construction of wharfage could proceed. Construction of berthing piers could commence as soon as the existing wooden piers on the Delong pier causeway are demolished.

e. Cost Estimate

Following is an estimated order of magnitude of costs to construct the proposed fishing port facilities. As with the Commercial General Cargo Port, these costs include only the dredging, wharfage, and backup area shown on the accompanying plates. No buildings, cargo handling equipment or other auxiliary facilities are included.

All costs are shown in U.S. dollars at 1973 prices. These costs were originally broken down into foreign and local expenditures where appropriate and piastre amounts were converted to U.S. dollars at the rate of VN$500 to one U.S. dollar.

f. Discussion of Alternative Layout Concepts

Unlike the commercial cargo port the type of cargo and the number and characteristics of vessels which the commercial fishing port will be expected to accommodate is essentially fixed. Specific recommendations of alternative plans can therefore be more easily made.

COMMERCIAL FISHING PORT

Item of Construction	ALTERNATIVE No. 1			ALTERNATIVE No. 2		
	Quantity	Unit Price $	Cost $	Quantity	Unit Price $	Cost $
(1) Demolition	L.S.	L.S.	25,000	L.S.	L.S.	25,000
(2) Dredging	145,000 m^3	1.20	174,000	145,000 m^3	1.20	174,000
(3) Mooring Piers	390 m	743.59	290,000	390 m	743.59	290,000
(4) Fueling Pier & Trestle	L.S.	L.S.	52,000	L.S.	L.S.	52,000
(5) Unloading Piers or Wharf	120 m	1,000	120,000	145 m	2,496.55	362,000
(6) Fill & Roadwork	L.S.	L.S.	70,000	L.S.	L.S.	70,000
Subtotal			731,000			973,000
Contractor's Profit and Overhead 25%			182,750			243,250
Construction Contingency 15%			109,250			145,750
Total Construction Cost			1,023,000			1,362,000

Unit prices are averaged rounded values
Note: Maintenance dredging will be minimal and no cost for this is presented.

The plan recommended for the commercial fishing port is Alternative No. 2 shown on Plate 14 featuring a marginal wharf for unloading the catches. The marginal wharf is favored even thought it is more expensive than the finger pier approach because of the greater efficiency with which cargo handling can be performed.

In view of the fact that the establishment of the commercial fishing port could precede that of a commercial cargo port at Vung Tau, the question was raised concerning loading of fish catches on ocean going vessels for export at Vung Tau. According to personnel associated with USAID fisheries as well as other sources, ships of the order of 4,000 DWT are used for this purpose. As an alternative to sending the product to Saigon for export it was thought that these ships could be accommodated at the proposed commercial fisheries port until such time as the cargo port becomes operational. It was found that, in addition to interfering with fishing port operations, the required expenditures to modify the proposed facilities to accommodate these vessels would be too high. A more practical solution would be to load these vessels at stream by lighter. This solution would require the construction of a lighter wharf to be used exclusively for handling export products at the fishing port. If the commercial general cargo port is constructed this lighter wharf could be used for barging fish products to Saigon or modified for unloading fish catches from the commercial fishing vessels.

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3. ACCESS

a. Roads

As can be seen from Plates 6 - 11 access from the Saigon-Vung Tau Highway to the proposed commercial general cargo port would be provided by a six lane road constructed on a dike. The full width of the crest of the dike and of the space adjacent to the port area is 35 meters although the width of the road would only be 30 meters. The excess space is provided for a single track rail spur.

In order to provide water circulation behind the mangrove island adjacent to the port area a culvert has been placed in the road dike and has been included in the cost estimate. This arrangement was provided in response to ecological considerations (see Section III. D.).

It is possible that an alternative route for the road and rail causeway and right of way may have to be considered in the event that the Vietnam Fertilizer Industry Company carries out plans revealed during the progression of this study. Respresentatives of the Fertilizer Company stated that serious consideration was being given to reclaiming land for establishment of plant facilities and a small port to handle plant cargo on the mangrove island in the vicinity of the existing commercial port. Should these plans be carried out and should the commercial cargo port discussed in this report subsequently be built, the port access road might cause mutual interference between fertilizer plant and port traffic. One possible solution is that the access road could be moved further to the south into the reclaimed land area although proper foundation for

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the road and rail spur would have to be provided. This method would mean added expense to the port project. A more suitable solution would therefore be to install conveyor machinery to transport the fertilizer materials to and from the plant in such a way that it bridges the proposed access road to insure noninterference with port traffic.

Access to the proposed commercial fishing port area poses no problem since it is directly adjacent to and parallels the existing Saigon-Vung Tau Highway.

Most truck traffic moving into and out of the proposed commercial general cargo port would use the Saigon-Vung Tau Highway. As stated in Section V. A. 3. a. large portion of this highway is of sufficiently good quality to handle port traffic. Bridges are designed in accordance with loads dictated by AASHO HS20-44 and should be adequate. An exception to the general adequacy of the road is the Long Binh - Phuoc Le (Baria) section which would need to be widened to a minimum of 7.5 m in some areas and is in need of general repair.

b. Railroad

As noted above, space for a rail spur to serve the port has been provided on the access dike and right of way behind the port area.

A preliminary engineering analysis of a railroad extension from the existing VNRS in the vicinity of Ben Hoa to the Vung Tau port area would indicate a capital outlay in the range of 20 million U.S. dollars would be required for this 93 km track segment. A considerable amount of this

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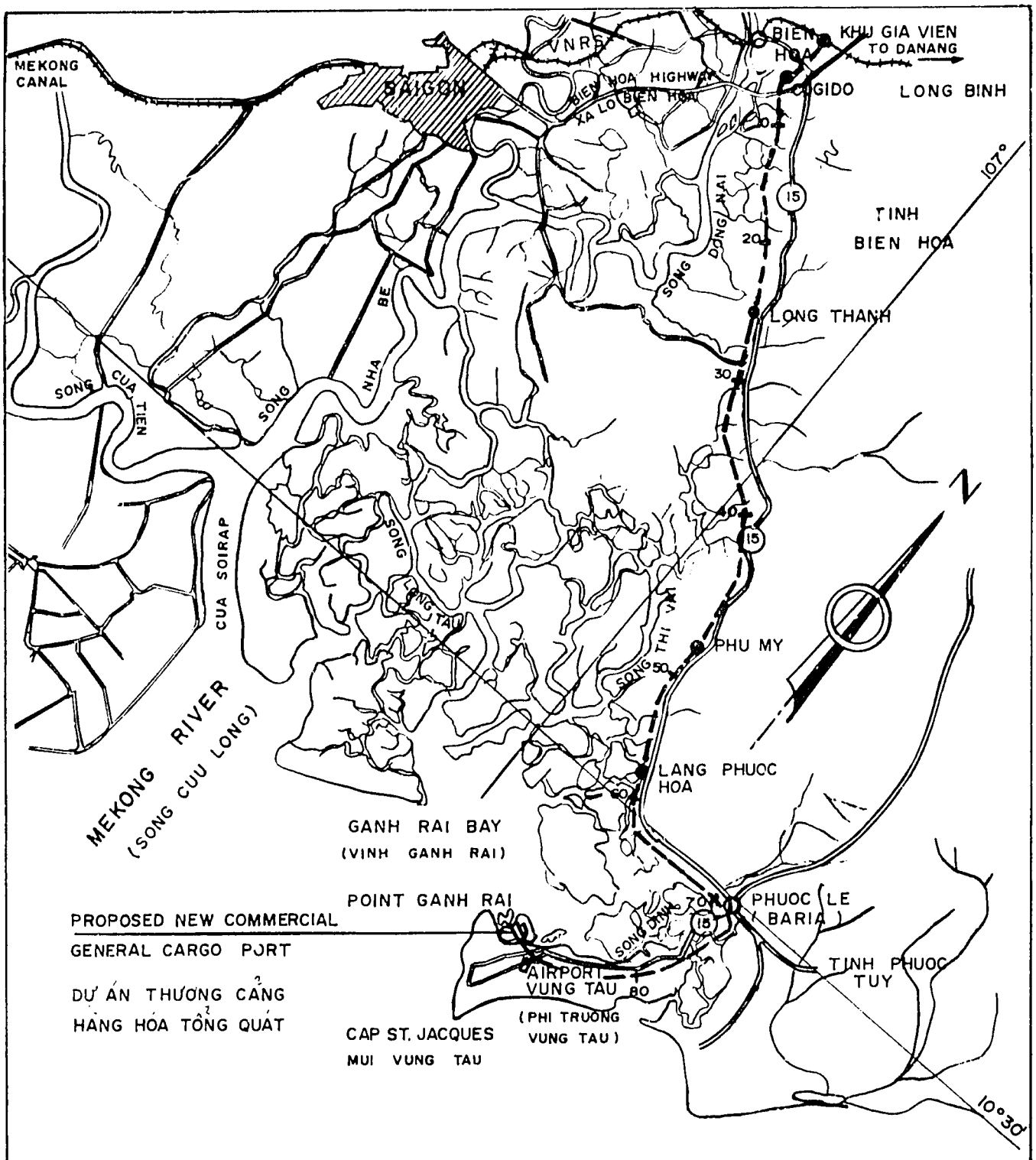

PRELIMINARY PROPOSED RAILWAY EXTENSION TO VUNG TAU
DỰ ÁN SƠ KHỞI DƯỜNG RÂY XE LỬA NỐI LIỀN TỚI VŨNG TÀU

FIGURE 26 (HINH 26)

expenditure would be in foreign exchange funds for the rail and track fastenings, steel for track bridges, and other miscellaneous material requirements. It is assumed all other material and labor would be furnished in Vietnam, including crossties fabricated with pre-stressed concrete.

The tentative alignment of the rail extension (shown on Figure 26) essentially parallels the existing Saigon-Vung Tau Highway. Thus, the rail access to the commercial fishery port area could be provided by a spur from this rail extension to the port area, if constructed.

4. Utilities

a. Water

As stated in Section V. A. 4. the present Vung Tau water supply is barely sufficient for the town itself. Two studies were ordered to investigate this problem. The first one was performed by the Ralph M. Parsons Company in July 1967 for USAID. This report recommended that inasmuch as ground water in the Vung Tau region has been tapped to its maximum output capacity, additional water should be obtained from the Dinh River at Phuoc Le and piped in to Vung Tau. The report also recommended construction of all necessary impounding reservoirs, pumping stations and treatment plants. The needs projected by the Parsons report included water for ships for a port facility projected to 1985 but this particular demand was for the existing ports only.

The latest study to date, performed by the Snowy Mountains Engineering Corporation (Department of Foreign Affairs, Commonwealth of Australia)

for the Republic of Viet Nam and dated November 1972, also indicates the inadequacy of the local ground water supply in Vung Tau and recommends using the Dinh River at Phuoc Le for a source of extra water. Methods recommended are different than the ones proposed by the Parsons Company report but the end result will be similar. The needs projected by the Snowy Mountains Engineering Corp. for 1985 included water for a major industrial development in Vung Tau but covered the existing ports only, not a major port installation.

Both reports project Vung Tau water demands up to 1985 including existing ports, but do not include consideration of a major commercial general cargo port such as the one proposed in this study though one includes an increase in industrial activity. Both reports assume the Dinh River can furnish more than the necessary amount of water needed for Vung Tau city. The major problem pointed out was the size and location of the impounding reservoir near Phuoc Le.

In conclusion it is not possible to determine whether use of the Dinh River as a water supply as proposed by the two studies will provide sufficient water for the ports discussed in this report. It is understood that construction of facilities to supply additional water is presently being undertaken by-an Australian firm. If the impoundment reservoir is large enough, sufficient water could probably be provided.

b. Electrical Power

There are no plans underway to expand the existing power plant. However, plans have been prepared and construction has been

authorized for a 66 KV tie line to connect the Thu Duc power plant to the Vung Tau distribution system. Construction will start upon request of the Vung Tau area office when they are assured of a need for additional power. Presently estimates based on the current rate of growth place the completion of the Vung Tau - Thu Duc tie line at the end of 1976. The transformers for the new tie line will be sized initially for 12 MW with the capability of upgrading the system to 20 MW when required.

Future expansion plans of the Viet Nam Power Company include additional generating facilities at Nha Be. The Nha Be power plant would augment the existing facilities at Thu Duc.

Presently the excess power generated by the existing power plant is as follows:

Total Installed Power	8,700 KW
Maximum Demand	5,200 KW
Spare Capacity	3,500
Assume Maint. of Large Gen.	2,100
Minimum power available for other uses	1,400 KW

This excess power coupled with the future expansion plans of the Vietnam Power Company should adequately meet the power needs for new port facilities as well as any satellite industrial estate generated by these developments.

SECTION VI

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