REPORT ON SURVEY FOR SONGKHLA PORT CONSTRUCTION PROJECT

(OUTLINED STAGE)

JUNE 1972

OVERSEAS TECHNICAL COOPERATION AGENCY

ERRATA

Page	Paragraph	Line	Error	Correct
1	1	10	worls.	world.
2	3	5	influence zone	hinterland
"	4	11	siol	soil
3	5	2	rebber	rubber
"	5	20	Sut-stage II	Sub-stage II
4	6	7	benefil-cost	benefit-cost
"	8	9	rabber	rubber
5	9	2	defferent	different
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"	"	6	cartage	charge
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6	11	1	bangkok	Bangkok
8	12	2	ablove	above
10	T.5	2	Bhat/Metric-Ton. Km	Bhat/Metric-Ton
"	T.5	4	Transpotation	Transportation
"	T.5	12	23]	231
12	14	4	As is clear in the figure, the	The
"	14	14	interland	hinterland
"	T.6		Transpotation	Transportation
14	15	3	mde	made
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17	18	1	hadling	handling
"	18	7	rebber	rubber
20	18	7	Petrolum: Imprted	Petroleum: Imported
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"	19	4,9	collecting and distributing	collection and distribution
"	21	11~12	therefore evident that there-fore evident that	therefore evident that
"	"	"	arise	be
23	23	4~5	pertoleum	petroleum
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27	29	7	to a water depth of	to a depth of
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29	30	2	futur	future
"	30	7	rebber	rubber
"	31	8	exibhit	exhibit
"	31	9	ecpital	capital
30	31	1	foom	room

Page	Paragraph	Line	Error	Correct
31	33	1,2	class	classes
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34	F.7		BURK HEAD	BULK HEAD
36	41	4	Atage	Stage
38	T.14	Item	xones	zones
39	43	1	1 st Stage	Sub-Stage I
"	43	5	2 nd Stage	Sub-Stage II
45	T.16		Burk head Suppervision	Bulk head Supervision
"	T.17		Remarko	Remarks
46	44	4	anlysis	analysis
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50	53	4	analyses	analysis
50	54	1~2	management	financial
"	54	6	wystem	system
52	1	5	appdendix	appendix
"	2	15	NE	NW
53	2	1	depermination	determination
"	2	9	the frequency	the cumulative frequency
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"	3	7	from NW direction provails	towards NW direction prevails
54	F.2-A		$H_{i/s}$ Cm	$H_{1/3}$ Cm
"	F.2-B		sec	$T_{1/3}$ sec
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"	4	5	Between -1.0m	Between +1.0m
59	5	7	of 100 is	of 100 μ is
"	5	10	$U_c^{*2} =$	$U_c^{*2} = \frac{\tau_c}{\rho}$
"	5	17	siol	soil
"	5	19	than 100 except	than 100 μ except
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"	5	21	$= 1.5$ dyne/cm^2	$\tau_c = 1.5$ dyne/cm^2
"	6	2	less than 5 times	larger than 10 times
"	6	3	$= 1.5$ dyne/cm^2	$\tau_c = 1.5$ dyne/cm^2
61	6	1	$= 10 \quad = 15$ dyne/cm^2	$\tau \geqq 10 \quad \tau c = 15$ dyne/cm^2
"	6	3	$= f.U.U$	$\tau = \rho . f./U/. U$
"	6	5	: Density of water	ρ : Density of water
"	6	17	$= 15$ dyne/cm^2	$\tau_c = 15$ dyne/cm^2

CONTENTS

I. SUMMARY

1. Thailand is known to have pursued a smooth course of economic development in Southeast Asia. Her socio-economic activities, however, are concentrically carried out in the central part around Bangkok, and the development of Southern Thailand still remains in the initial stage.

Southern Thailand abounds in primary products such as natural rubber and tin and offers a promising prospect for future development. Hat Yai and Songkhla are the centres of this district, and the port of Songkhla functions as the gateway of these two cities to the outside worls. At present, however, the port of Songkhla lacks the facilities for mooring large vessels, so that the hadling of natural rubber, the major commodity exported from this port, must necessarily rely on the lighter service. This means that the international competitive power of Thailand's natural rubber is made so much weaker and that the port is not capable of the functions it should perform for regional development.

2. At present, two Changwats, i.e., Songkhla and Phattalung, are the major areas embraced in the hinterland of the port's foreign trade. With the improvement and expansion of its facilities, however, the port of Songkhla will have a larger hinterland covering additional numbers of Changwat such as Nakon Si Thammarat, Trang, Pattani, Satun, Yara and Narathiwat. Further, it is likely that Changwat Surat Thani will join to the hinterland.

Besides the port of Songkhla, the port of Phuket is known as an important foreign trade port in Southern Thailand. These two are the representative ports in Southern Thailand and located on the east and west coast respectively. Viewed from their topographic conditions and port functions, the two ports are entirely independent of each other, and the improvement of the one can in no way give any effect on the improvement plan of the other. Improvement and expansion of both are indispensable for the balanced development of the entire Southern Thailand.

As for domestic trade, Songkhla and Phattalung will remain as the main Changwat embraced in the hinterland of the port of Songkhla because small vessels are the major means of domestic cargo traffic.

3. The volume of cargoes handled at the port of Songkhla in 1970 stood at 344 thousand tons. This naturally does not include the large volume of latent cargoes which were transported via other routes and by other transport means because of its poor facilities. Such latent cargoes exist in the port's own influence zone, and their volume is expected to increase more and more with the economic progress of Southern Thailand.

It is estimated that the volume of latent cargoes in the port's hinterland will reach 820 thousand tons in 1975, 1,060 thousand tons in 1980 and 1,850 thousand tons in 1990. An important fact to be noted here is that the improvement of wharves and other port facilities alone will not serve as an incentive for the consignors to ship this voluminous latent cargoes through the port of Songkhla.

To turn the latent cargoes actualized it is imperative that the improvement of transport facilities be coupled by that of the collecting and distributing mechanism of commodities. It will require quite a long period of time to materialize such functional improvements, but it is estimated that by executing such improvements, the cargo handling volume of the port of Songkhla will increase to 553 thousand tons in 1975 and further to 930 thousand tons in 1980. It is believed that the full coverage of all latent cargo volume of 1,847 thousand tons (estimate) will be attained in 1990.

4. Except in the vicinity of the lake outlet, the coastal area near the port of Songkhla is composed of fine sand, and the sea bottom slope ranges from 1/200 to 1/300. The area around the port presents the climatic features of Asian Monsoon Zone. No wave observation data are available, but the significant wave height and period for structural design estimated from the wind records are 2.2 m and 6-7 sec, respectively.

On the sea bottom, silty material carried from the lake and measuring less than 50 μ in grain size is widely distributed from the tip of the breakwater to Ko-Nu and its neighbourhood. Interposition of the soft silt layer is noticed in the siol, and this increases from beach towards the offing with the aggravating soil condition. For this geological reason, construction of port facilities in the open sea area will incur a large cost and is not therefore advisable.

The critical depth of sand movement, which bears upon the maintenance of the navigation channel, is estimated to range from 4.0 to 5.0 m. Therefore, intrusion of sand drift can be prevented almost entirely by constructing a breakwater to the said depth.

Further, if a training dike is constructed on the lake outlet, the flushing effect of stream be intensified and it is possible to maintain a depth sufficient for the navigation of large vessles.

5. The construction plan of the port of Songkhla must be mapped out for export expansion of primary products centering on natural rebber and for betterment of livelihood of local inhabitants. The plan should also be so formulated that the port facilities will exhibit their functions with the minimum cost and at the earliest date.

The inner harbour plan is most recommended as the construction site that meets these demends because of the above-mentioned technical conditions, possibility of making full use of the existing breakwater and navigation channel, and the small construction cost. Under this plan, it is envisaged that a quay wall with a water depth -5.5 m and having 4 berths, a 500 m long breakwater, a 1,770 m long training dike, etc. will be constructed till 1990.

Port construction will be carried out over two stages, with the First Stage divided into Sub-stage I and Sub-stage II.

Sub-stage I (1974-1977) will cover the construction of the training dike (1,000 m), quay wall with a water depth of -8.0 m and having 2 berths, another quay wall with a water depth of -5.5 m and having 2 berths, and other related facilitied. Capital input required for construction of these facilities is US$9,380 thousand.

Construction in Sut-stage II (1982-1985) will cover the training dike (770 m), breakwater (500 m), 2 berths (along quay wall with a water depth of -8.0 m), 1 berth (along quay wall with a water depth of -5.5 m), and other related facilities. Capital investment required in this stage is US$8,440 thousand.

In the 2nd Stage (1989-1990), 1 berth each along the quay wall with a water depth of -8.0 m and along the other quay wall with a water depth of -5.5 m will be constructed. Capital investment required in this stage is US$1,900 thousand.

6. Economic evaluation of the Songkhla port construction project which it calls for these investiments must be made from two different angles.

In other words, the project must be evaluated by the analysis of national econmy and port management. In the former approach, the analysis should be made to assess the net value to national economy that can be frought about by the port construction. In the latter apporach, on the other hand, the analysis is required to clarify if the plan ensres sound port management. In either case, the analysis must be based on the benefil-cost ratio method (discount rate: 10%) as well as on the method of internal rate of return.

7. The analysis of the net value to national economy shows that the benefit-cost ratio is 1.38 and the internal rate of return 14.9%, indicating that the project will serve for the development of national economy.

However, the project does not present a promising prospect when evaluated by the analysis of port management, financial rate of return at 5.5% with the present port tariff structure.

Government's subsidy, if granted to finance a part of the construction cost, will make this project economically sound for port management. If the Treasury covers the construction cost of outer facilities and harbour facilities (which is equivalent to 44% of total construction cost), the financial rate of return will rise to 12.8%.

Therefore, if the project is supported by such subsidiary measure of the government, construction of the port of Songkhla can be considered justifiable for sound port management.

8. It can be verified that the improvement of Songkhla port is not only technically feasible but also sound from the viewpoint of national economy and port management.

By investing about US$10 million during the four year period of Sub-stage I, the port of Songkhla will transform into a modern foreign trade port and will also to meet the transport demand expected in about eight years subsequent to 1974.

It is evident that the said 10 million dollar investment will foster the international competitive power of natural rabber and other primary export products and at the same time contribute largely to the improvement of international balance of payments of Thailand.

II. ECONOMIC FACTORS DETERMINING THE SCALE OF SONGKHLA PORT

A. Hinterland of Songkhla Port

9. A great diversity of factors must be taken into consideration in making selection between defferent transport means such as trucks, railways and vessels for shipment of cargoes generating in the hinterland of a port. In addition to speed, dafety and reliability, these factors include the type and volume of cargo, maximum payable rate of transport cost, freight and cartage, and route, and all these factors are put to rigid comprehansive review to determine which transport means is to be used.

10. In studying the hinterland of the port of Songkhla, the following preconditions must be assumed.

i) Origins and destinations of cargoes in Thailand are all to be represented by cities.

ii) Since the economic activities of Thailand are concentrically carried out in Bangkok and Thonburi, Bangkok is taken as an origin and a destination of the domestic cargo traffic.

iii) Rates of transportation charges have shown virtually no changes over the past seven years (See Table 1). This trend is considered to continue in future. If there arises any large fluctuation, the balance between the rates of respective transportation charges is condidered to be maintained.

iv) The system of roads and railways is taken to be in the state of 1970.

v) The amount of each cargo traffic demand, i.e., 1 lot, is 100 metric ton (values expressed in tons in the following pages are all in metric tons).

Table - 1 Consumer Price Index for Bangkok-Thon Buri by Group (October 1964-September 1965-100)

Period	All items	Food	Clothing	Housing	Personal and medical care	Transportation	Recreation reading and education	Tobacco and alcoholic beverages
Weights	100.0	49.0	9.4	17.8	7.2	6.1	5.6	4.9
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1964	99.4	99.5	100.9	98.8	99.0	99.6	99.4	100.0
1965	100.3	100.1	99.9	100.6	100.2	100.3	100.1	100.0
1966	104.1	106.6	100.4	102.2	104.0	99.9	101.5	99.9
1967	108.2	114.2	100.4	102.2	107.9	99.0	101.8	99.9
1968	110.5	118.1	100.7	103.0	107.9	102.8	101.9	99.9
1969	112.8	122.8	100.5	104.1	107.9	99.0	101.9	99.0
1970	113.7	123.1	102.4	106.7	108.1	100.1	101.7	100.4

*Financial Past. Sept. 2, 1971.

11. Since bangkok is one of the ends of domestic cargo traffic routes, the following four cargo traffic patterns are considered to exist between Bangkok and the cities in Southern Thailand. (See Table 2).

Table 2 Patterns of Domestic Trade Cargo Traffic

i) Truck Transportation

[Transit shed in Bangkok city] —Shipment from transit shed and (N_{1D})→ loading → (Truck) (L_T) —Unloading (N_{2D})→ [Transit shed at the place of destination]

ii) Railway Transportation

[Transit shed in Bangkok city] —Shipment from transit shed and (N_{1D})→ loading → (Truck) (L_T) —Transhipment ($N_{3(T-R)}$)→ (Railways) (L_R) —Transhipment ($N_{3(R-T)}$)→ (Truck) (L_T) —Unloading (N_{2D})→ [Transit shed at the place of destination]

iii) Transportation by Coastal Vessels (via Songkhla Port)

[Transit shed in Bangkok city] —Shipment from transit shed and (N_{1D})→ loading → (Truck) (L_T) —Transhipment ($N_{3(T-S)}$)→ [Bangkok port] (N_P) → (Coastal vessel) (L_S) → [Songkhla port] (N_P) —Transhipment ($N_{3(S-T)}$)→ (Truck) (L_T) —Unloading (N_{2D})→ [Transit shed at the place of destination]

iv) Transportation by Coastal Vessels (via Port Closest to Place of Destination)

[Transit shed in Bangkok city] —Shipment from transit shed and (N_{1D})→ loading → (Truck) (L_T) —Transhipment ($N_{3(T-R)}$)→ [Bangkok port] (N_P) --→ (Coastal vessel) (L_S) → [Port closest to the place of destination] (N_P) —Transhipment ($N_{3(S-T)}$)→ (Truck) (L_T) —Unloading (N_{2D})→ [Transit shed at the place of destination]

i) Truck transportation for the entire route.

ii) Railway transportation for the entire route.

iii) Marine transportation via Songkhla port.

iv) Marine transportation via neighbouring ports.

As for the patterns of foreign trade cargo traffic, the preconditions listed in Item 10. must be supplemented by another assumption that import and export cargoes of Thailand are handled at three ports, i,e., Bangkok, Phuket and Songkhla, and that the same freight rate is applied at all the three ports.

On the basis of these assumptions, the following patterns of foreign trade cargo traffic can be considered (See Table 3).

i) Lighter service at Songkhla port, truck transportation.

ii) Loading and unloading on the wharf of Songkhla port, truck transportation.

Table 3 Patterns of Foreign Trade Cargo Traffic

i) Lighter Service at Songkhla Port, and Truck Transportation

→ [Carrier] — Transhipment (N_{2H} for carrier, N_{1L} for lighter) → (Lighter) L_L — Unloading (N_{2L}) →
→ [Songkhla port] (N_{PF}) — Loading (L_{1T}) → (Truck) L_T — Unloading (N_{2D}) → [Transit shed at the place of destination]

ii) Cargo handling on the wharf at Songknla Port, and Truck Transportation

• [Carrier] — Unloading (N_{2H} for carrier) — [Songkhla port] (N_{PF}) — Loading (N_{1T}) → (Truck) L_T →
Unloading (N_{2D}) → [Transit shed at the place of destination]

iii) Lighter Service at Songkhla Port, and Railway Transportation

[Carrier] — Transhipment (N_{2H} for carrier, N_{1L} for lighter) → (Lighter) L_L — Unloading (N_{2L}) →
→ [Songkhla port] (N_{PF}) — Loading (N_{1R}) → (Railway) L_R — Transhipment ($N_{3(R-T)}$) → (Truck) L_T →
— Unloading (N_{2D}) → [Transit shed at the place of destination]

iv) Cargo handling on the wharf at Songkhla Port, and Railway Transportation

[Carrier] —Unloading / N_{2H} for carrier→ [Songkhla port] N_{PF} —Loading / N_{1R}→ (Railway) L_R →
—Transhipment / $N_{3(R\text{-}T)}$→ (Truck) L_T —Unloading / N_{2D}→ [Transit shed at the place of destination]

v) Cargo handling on the wharf at Bangkok Port, and Railway Transportation

[Carrier] —Unloading / N_{2H} for carrier→ [Bangkok port] N_{PF} —Loading / N_{1R}→ (Railway) L_R →
—Transhipment / $N_{3(R\text{-}T)}$→ (Truck) L_T —Unloading / N_{2D}→ [Transit shed at the place of destination]

vi) Lighter Service at Phuket Port, and Truck Transportation

[Carrier] —Transhipment / N_{2H} for carrier, N_{1L} for lighter→ (Lighter) L_L —Unloading / N_{2L}→
→ [Phuket port] N_{PF} —Loading / N_{IT}→ (Truck) L_T —Unloading / N_{2D}→ [Transit shed at the place of destination]

iii) Lighter service at Songkhla port, railway transportation.

iv) Loading and unloading on the wharf of Songkhla port, railway transportation.

v) Loading and unloading on the wharf of Bangkok port, railway transportation.

vi) Ligher service at Phuket port, truck transportation.

12. From the link and node costs shown in Table 4, transportation cost can be calculated for each of the patterns shown ablove. In the case of Pattern iii) of domestic cargo traffic for example, the total transportation cost is the sum total of the link and node costs listed below.

Table 4 Link and Node Costs

	Notation		Cost (Baht/ton)	Remarks
Node	N_{1D}	Shipment from transit shed and loading onto truck	12	Obtained by interviews with forwarding agents in Bangkok city.
	N_{2D}	Unloading from truck	12	
	N_{1T}	Loading onto truck	12	Ditto
	N_{1R}	Loading onto goods wagon	10	Ditto
	N_{2H}	Unloading from carrier (foreign trade cargoes)	21	Average of the rates applied to different cargoes at Kantang port.
	$N_{3(T\text{-}R)}$	Transhipment from trcuk to railway	15	Obtained by interviews with forwarding agents in Bangkok city.
	$N_{3(R\text{-}T)}$	Transhipment from railway to truck	15	Ditto
	$N_{3(T\text{-}S)}$	Transhipment from truck to coastal vessel	10	Obtained by interviews with forwarding agents in Bangkok city and shipping agents in Songkhla city.
	$N_{3(S\text{-}T)}$	Transhipment from coastal vessel to truck		Ditto
	N_P	Port charges (domestic trade cargoes)	5	Obtained by interviewe with shipping agents in Bangkok city; not intended to be applied at a port with well consolidsted facilities.
	N_{PF}	Port charges (foreign trade cargoes)	39	Obtained by interviews with shipping agents in Bangkok city on cargo handling and landing charges collected at Bangkok port. The rate shown does not include customs fee, warfage, etc.
Link	L_T	Truckage	0.3	Obtained by interviews with trucking agents sampled from all trucking agents in Thailand. ETO's standard rate is not employed.
	L_R	Railway transportation charges		Arithmetic mean of SRT's freight tariffs for Classes 2, 4, 5 and 8.
	L_S	Charges for coastal vessel transportation	83	Average of rates applied to different cargoes at Songkhla port; obtained by interviews with shipping agents in Songkhla city.
	L_L	Lighter's charges (inclusive of the terminal charges for C -C)	35	Obtained by interviews with forwarding agents in Songkhla city and consigners shipping cargoes via Songkhla port.

Charges for shipment from transit shed and loading on the truck	N_{1D}
Truckage	L_T
Transhipment charges	$N_{3(T\text{-}S)}$
Port charges	N_P
Charges for castal vessel transportation	L_S
Port charges	N_P
Transhipment charges	$N_{3(S\text{-}T)}$
Truckage	L_T
Unloading charges	N_{2D}

13. The hinterland of Songkhla port in the case of domestic cargo traffic can be obtained by first calculating the transportation cost of all the four traffic patterns between major cities in Southern Thailand

and Bangkok, and then checking those cities from which the cargo transportation by pattern iii) incurs the least cost relative to the other three patterns. Table 5 shows the transportation costs obtained by such calculation. The calculation indicates that the hinterland embracing such cities will cover changwats of Phattalung, Trang, Satun, and Songkhla. Of these changwats, Trang and Satun have their own port, i.e., Kantang port and Satun port. Partly for this reason, and partly for the rather daring assumptions presented above,

Table 5 Comparison of transpotation costs (domestic trade)

Unit: Baht/Metric-Ton. Km

Pattern of Trans-patation / Name of cities	i) Transpotation by truck (from Bangkok)	ii) Transpotation by Railway (from Bangkok)	iii) Transpotation by Coastal vessel (via Songkhla by Truck)	iv) Transpotation by Coastal vessel (via Port Closest to Place of Destination)	
Chumphon	174	157	399	via Chumphone	157
Phangnga	294	251	273		
Phuket	298	254	301		
Krabi	355	23]	249		
Trang	361	198	206	Songkhla	206
Phattalung	380	200	190	Songkhla	190
Hatvai	411	209	157	Songkhla	157
Pattani	454	218	188	Pattani	157
Yala	456	221	189	Pattani	159
Betong		249	227	Pattani	159
Narathiwat	484	227	218	Narathiwat	157
Kantang	369	228	214	Songkhla	214

these two changwats are excluded from the hinterland of Songkhla port which is shown in Fig. 1.

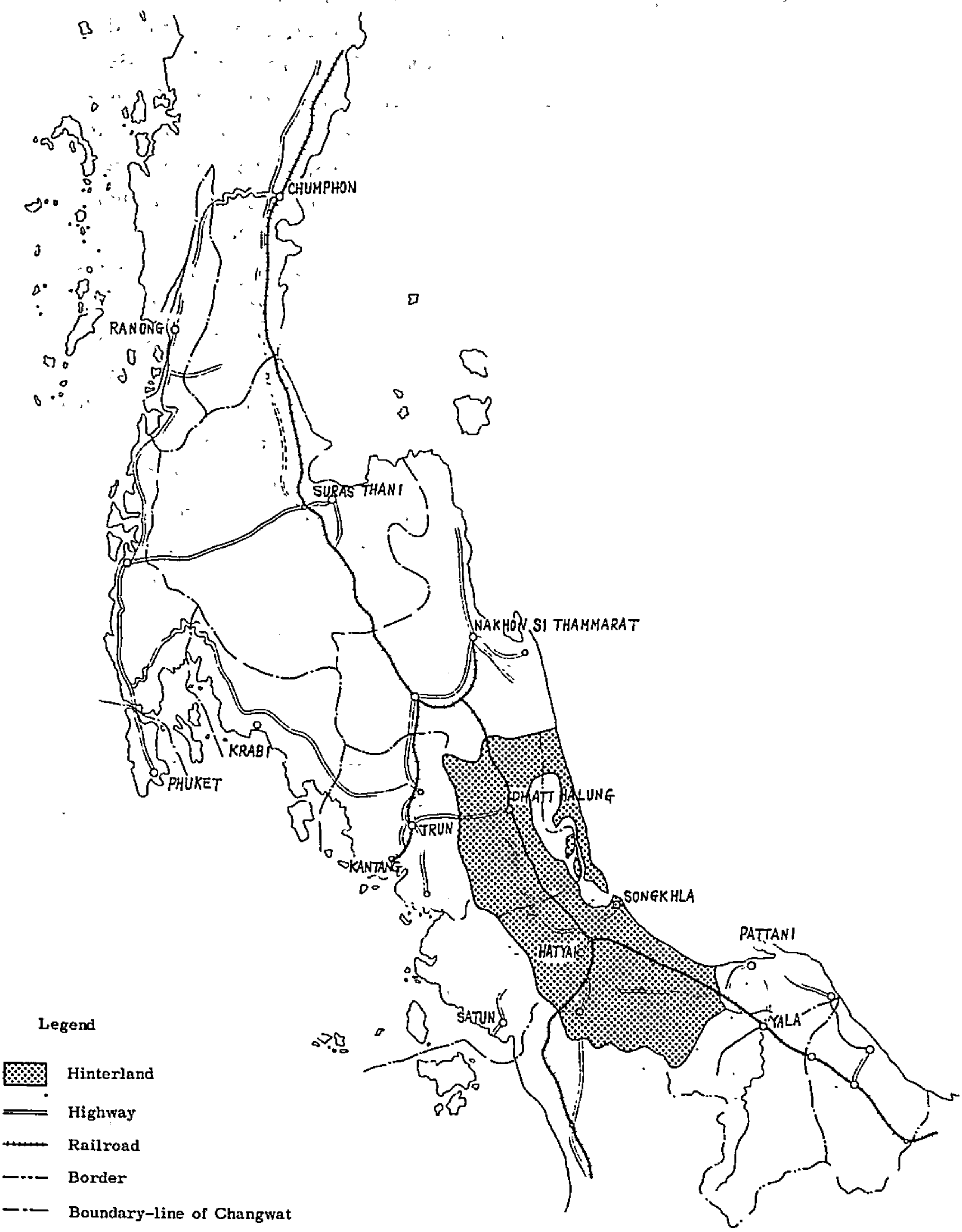


Fig. 1 Hinterland of Domestic Trade

14. The hinterland of foreign trade cargo traffic can be obtained in much the same way as explained above. Table 6 shows the results of calculation of transportation costs, and Fig. 2 prepared on the basis of Table 6 shows the hinterland. As is clear in the figure, the hinterland of Songkhla port's foreign trade covers two changwats at present, i.e., Songkhla and Phattalung. If the port is improved and if Bangkok, Songkhla and Phuket are taken as the only foreign trade ports of Thailand, Satun, Pattani, Yala and Narathiwat will be included in the port's hinterland. If, again, improvement of Songkhla port progresses to the extent that vessels can be moored for cargo handling service on the quay wall, the port's hinterland will embrace part of three additional changwats, i.e., Chumphon, Surathani and Krabi. However, since Chumphon and Krabi have no major cities in areas which will be included in the interland, they should be excluded (by reason of the precondition that origins and destinations of all cargo traffic are represented by cities). Contrariwise, Changwat Surathani embraces all major cities and is therefore be included, together with the above-mentioned eight changwats in the hinterland zone to be expended after the port's improvement.

Table 6 Comparison of transpotation costs (foreign trade)

Unit: Baht/Metric-Ton. Km

Pattern of Transpatation / Name of cities	i) Lighter Service at Songkhla Port and Truck Transpotation	ii) Cargohandling on the Wharf at Songkhla Port and Truck Transpotion	iii) Lighter Service at Songkhla Port and Railway Transpotation	iv) Cargohandling on the Wharf at Sougkhla Port and Railway Transpotation	v) Cargohandling on the Wharf at Bangkok Port and Railway Transpotation	vi) Lighter Service at Phuket Port and Truck Transpotation
Chumphon	371	336	226	191	190	248
Ranong	334	299	254	219	218	212
Suratthani	329	294	204	169		206
Krali	221	186	230	195	264	176
Trang	178	143	197	162	231	214
Kantang	186	151	200	165	233	222
Nakhon Si Thammarat	214	179	189	154	229	233
Phattalung	162	127	170	135	233	233
Thing Song	200	165	187	152	223	
Yala	162	127	174	139	254	
Narathiuat	190	155	181	146	260	

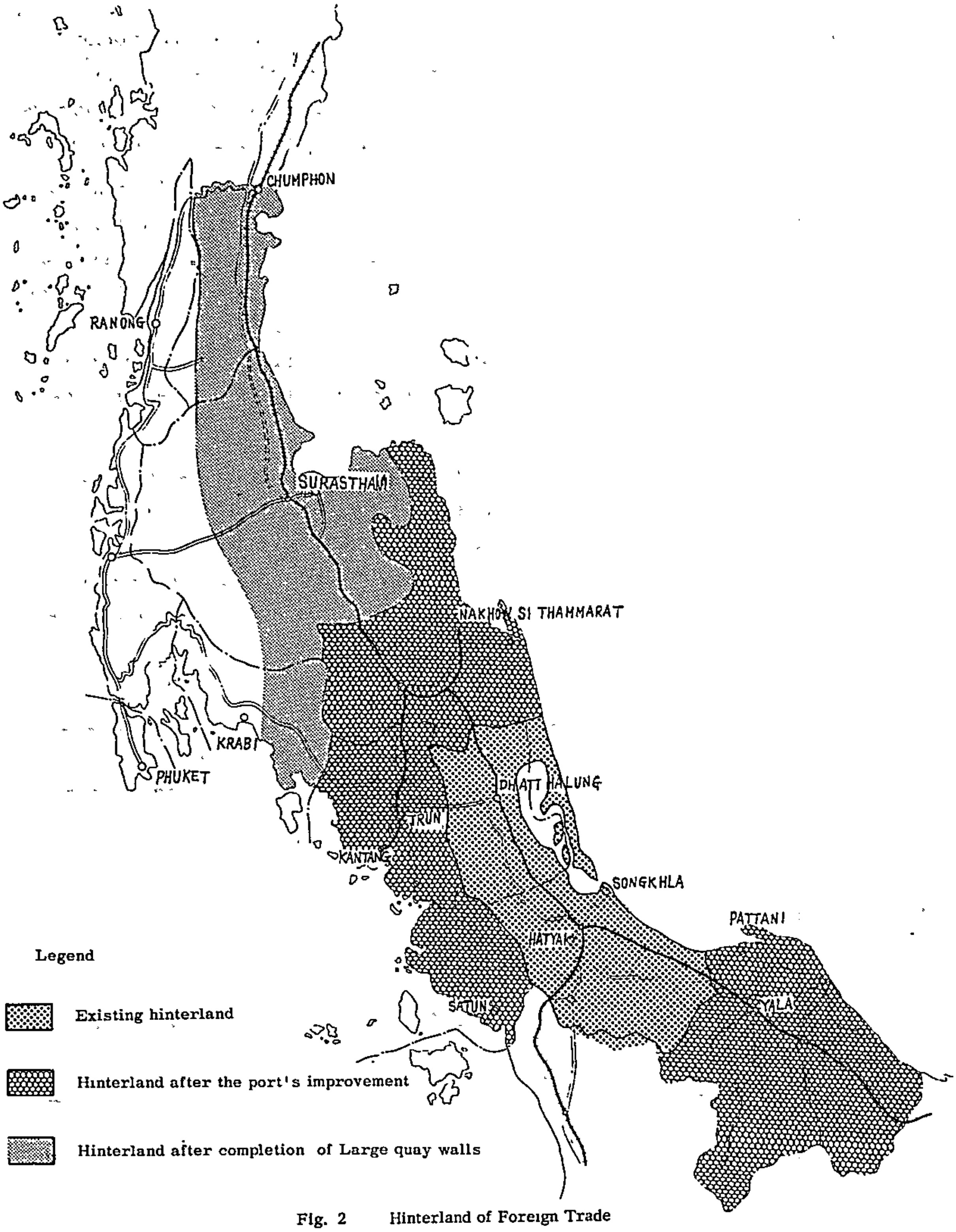


Fig. 2 Hinterland of Foreign Trade

B. Latent Handling Cargo Volume of Songkhla Port

15. The latent cargo volume referred to here is the maximum volume of cargoes that will be handled at Songkhla port when the economic activities in the above-delineated hinterland have mde a smooth profress and the distribution mechanism has been brought to a satisfactory state.

The latent cargo volume is estimated by the macroscopic as well as microscopic method. In the former method, the total cargo handling volume of all Thai ports is estimated to obtain the cargo volume generating in Southern Thailand from its ratio to the nation's total. The value obtained by this method is employed in checking the results of microscopic estimation. In the microscopic method, the cargo volume within the hinterland of Songkhla port is estimated by the king of major commodities.

16. The frowth rates shown in Table 7 are used as the basic economic indices required for the estimation of latent cargo volume. The indices for 1975 are the growth rates envisaged under the Third Economic Development Plan of Thailand (1972-1976), and those for the period from 1977 to 1990 are the values given by National Economic Development Board (N.E.D.B.) of Thailand.

Table 7 Major economic indices

Economic indices	Year	Average annual growthrate	Remark
G. D. P.	1971 ~ 1976	6.0	The 3rd 5 year Economic Development Plan
	1977 ~ 1990	7.0	N. E. D. B.
Population	1971 ~ 1976	2.5	The 3rd 5 year Economic Development Plan
	1977 ~ 1990	2.5	N. E. D. B.
Rubber	1971 ~ 1976	3.0	The 3rd 5 year Economic Development Plan
	1977 ~ 1990	3.0	N. E. D. B.

17. The macroscopic estimation is made as described below.

i) The total cargo handling volume of all Thai ports is estimated for future from its assumptive annual growth rate.

ii) The ratio of cargo volume in Southern Thailand to the total volume thus obtained is assumed, and the cargo volume generating in Sauthern Thailand is estimated. In this case, estimate of mineral products must be made separately because their cargo volume fluctuates largely by year.

Table 8 shows the results of macroscopic estimation.

Table 8 Macroscopic estimation of port cargoes generating in Southern Thailand.

Unit: 1,000 ton

Year	Thailand		Southern Thailand (excl. mineral products)		Southern Thailand (incl. mineral products) Cargo volume	Remark
	Cargo volume	Average annual growth rate	Cargo volume	Share of Southen Thailand		
1959	5,144	(%)	801	15.6 (%)	801	1)Approximation to the growth rate of G.D.P.
1964	9,351	13	832	8.9	832	
1969	14,930	10	1,116	7.5	2,402	2)Draw inference from the past trends.
1975	25,200	9	1,890	7.5	2,290	
1980	39,100		2,730	7.0	3,130	
1990	85,500	8	5,140	6.0	5,540	3)400,000 tons taken for mineral products.

18. The microscopic estimation is made as described below.

i) The cargo handling volume of Southern Thai ports is estimated by major item from:

a) Estimate based on its actual past record, or

b) Its correlation with the relevant economic indices. (See Table 9)

Table 9 Method of Macroscopic Estimation of Sea-borne Cargoes

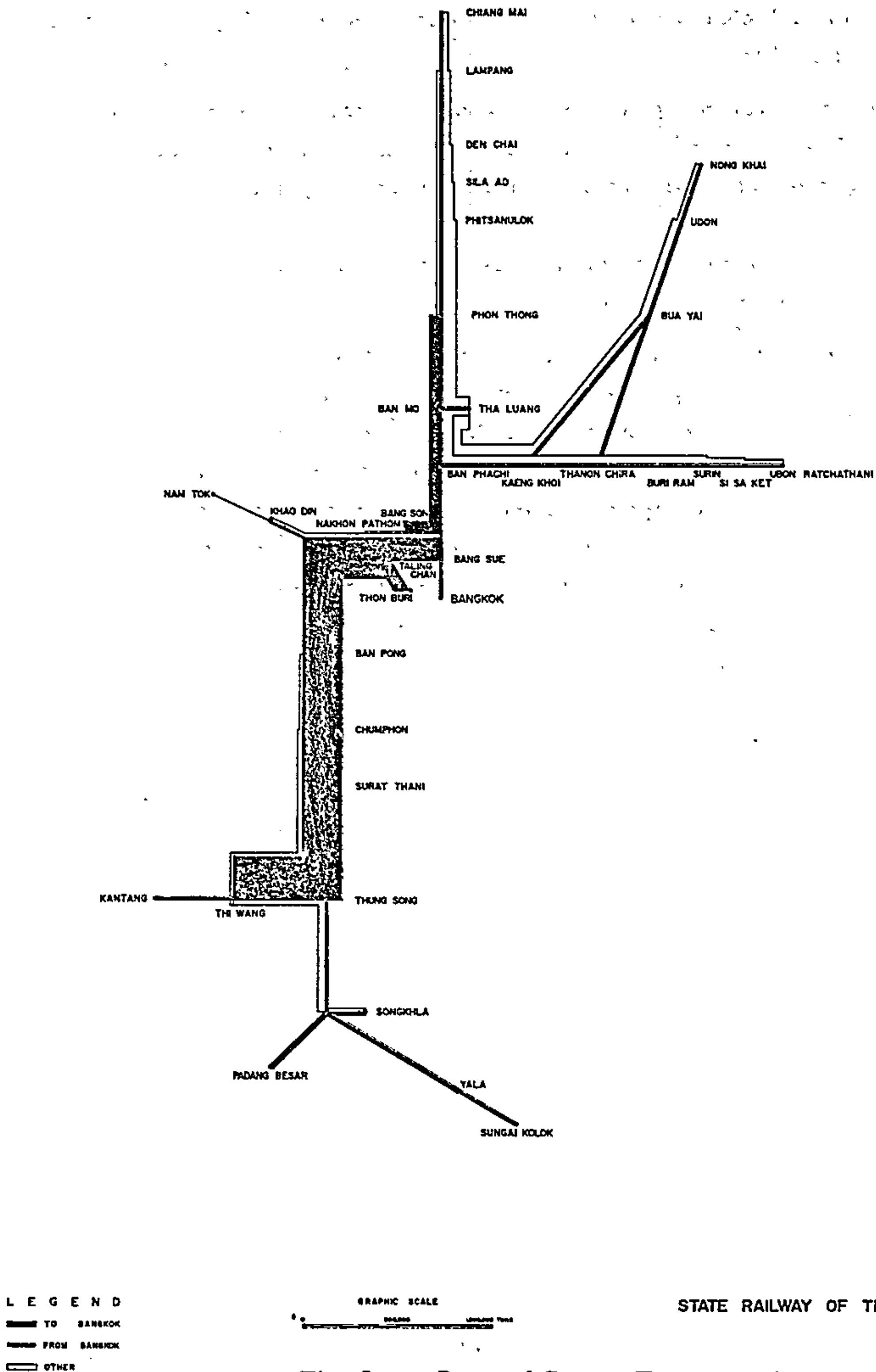
Cargo	Trade	Direction	Group	Item	Method of Estimation
Caroges	Foreign Trade	Exports	Foods	Fish	(Export volume in 1965) x (13.5%/yr for 65 - 75; 10%/yr for 75 - 90)
				Fruits	Export volume in 1965 (export value/unit price) x (10%/yr for 65 - 90) x (share of Southern Thailand)
				Oxen and cows	Export volume in 1965 (export value/unit price) x (5%/yr for 65 - 90) x (share of Southern Thailand)
			Minerals	Tin-metals	(Export volume in 1970) x (2.9%/yr for 70 - 90) x (share of Southern Thailand)
				Manganese	(Export volume in 1970) x (4.6%/yr for 70 - 90) x (share of Southern Thailand)
				Gypsum	(Export volume in 1970) x (1.0%/yr for 70 - 90) x (share of Southern Thailand)
				Lignite	Ditto
			Rubber		Planned export volume in 1975 (5 Year Economic Development Plan) x (3%/yr for 75 - 90) x (share of Southern Thailand)
			Wood		Planned export volume in 1975 (export value/unit price; 5 Year Economic Development Plan) x (3.4%/yr for 75 - 90) x (share of Southern Thailand)
		Imports	Construction Material	Steel	Nation's total demand for steel materials (correlation with the construction investment) x (share to construction work) x (share of Southern Thailand)
			Chemicals	Oil	Nation's total demand for petroluem (correlation with GNP) x share of Southern Thailand (number of motor vehicles) x (import rate)
				Fertilizers	(Fertilizer consumption per unit area) x (farmland area) x (import rate)
	Domestic Trade	Exports	Foods	Fish	(Shipment volume in 1965) x(10%/yr for 65 - 90)
				Fruits	(Shipment volume in 1965) x (growth rate of GNP)
			Minerals	Silica	Planned shipment volume in 1965 (5 Year Economic Development Plan) x (3%/yr for 75 - 90)
				Lignite	Shipment volume in 1970 (1%.yr for 70 - 90) x (share of Southern Thailand)
				Gpysum	Shipment volume in 1970 (1%/yr for 70 - 90) x (share of Southern Thailand)
				Manganese	Shipment volume in 1970 (4.6%/yr for 70 - 90) x (share of Southern Thailand)
			Wood		(Shipment volume in 1965) x growth rate of forest industry (6.5%/yr for 65 -70; 3.4%/yr for 70 - 90)
		Imports	Foods	Rice	(Shipment volume in 1965) x (population growth rate in Southern Thailand)
				Sugar	(Shipment volume in 1965) x (growth rate of per capita consumption) x (population growth rate)
				Drinks	Ditto
				Fish	(Shipment volume in 1965) x (10%/yr for 65 - 90)
				Fruits	(Shipment volume in 1965) x (growth rate of G N.P.)
				Oxen & Cows	Ditto
			Livings	Clothes, drugs, household supplies, etc.	(Volume received in 1965) x (growth rate of GNP)
			Construction Materials	Steel	Nation's total demand for steel materials (correlation with construction investment) x (share to construction work) x (share of Southern Thailand) x (rate of domestic trade)
				Cement	Nation's total demand for cement (correlation with construction investment) x share of Southern Thailand (all for domestic trade)
				Wood	(Volume received in 1965) x (Growth rate of construction investment)
			Chemicals	Oil	Nation's total demand for petroleum (correlation with GNP) x (share of Southern Thailand) x (rate of domestic trade)
				Fertilizers	(Fertilizer consumption per unit area) x (farmland area) x (rate of domewtic trade)

ii) The cargo hadling volume of Sonthern Thai ports is destributed to each changwat by the economic indices pertaining to respective items.

iii) Cargo volumes generating in changwats whithin the hinterland of Songkhla port are summed up. The sum total thus obtained is the latent cargo hadling volume of Songkhla port.

iv) The following corrections must be made for natural rebber, cement and petroleum.

Cement: Demand for cement in Southern Thailand is considered to pursue a steady upward trend in future. However, sice cement is produced in the vicinity of Toong Song, its shipment has long resorted to overland transportation (see Fig. 3), and there is little probability that the existing overland shipment will shift to marine transportation. For this reason, cement is to be excluded from sea-borne cargoes.



STATE RAILWAY OF THAILAND

Fig. 3 Route of Cement Transportation

Table 10 Importing countries of natural rubber (1970)

No.	Name of countries	Export volume (ton)
1	U. S. A.	26,000
2	England	9,006
3	W. Germany	7,155
4	Malaysia	19,493
5	Singapore	17,279
6	France	5,586
7	Denmark	437
8	Belgium	2,020
9	Norway	22
10	Sweden	1,299
11	Netherland	2,078
12	Italy	24,528
13	Spain	5,530
14	Czechoslovakia	887
15	Yugoslavia	7,737
16	Japan	143,529
17	Hong Kong	410
18	Greece	885
19	Portugal	1,123
20	Turkey	2,908
21	Angola	182
22	Israel	5
23	Taiwan	20
24	Morocco	30
25	Poland	508
26	Finland	508
	Total	279,164

Natural: rubber The east coast of Malay peninsula occupies about 70% of total volume of natural rubber exported from Southern Thailand as shown in Table 10. If Songkhla port handles this export volume, its cargo handling volume will account for 70% of the total export volume of Sonuthern Thailand. Therefore, the volume of natural rubber export via Songkhla port is taken at 365 thousand tons or 70% of the total export volume of

Southern Thailand. It may be added that in 1990, the total export volume of natural rubber from Southern Thailand in 1990 is estimated to reach 521 thousand tons, and that the export volume generating within Songkhla port's hinterland delineated above to 467 thousand tons.

Petrolum: Imprted petroleum is carried from Singapore by tankers of 100-600 R/T class and can therefore be supplied, as in the past, via the ports in Southern Thailand. For this reason, the hinterland of Songkhla port for imported petroleum transportation is considred to coincide with that for domestic cargo traffic.

Table 11 shows the results of estimation of latent cargo volume of Songkhla port.

Table 11 Latent cargo volume of Songkhla Port

Unit; (1,000 ton)

	1965			1975			1980			1990		
	Foreign	domestic	total	foreign	domestic	total	foreign	domestic	total	foreign	domestic	total
food stuffs	1	56	57	23	135	158	36	180	216	87	339	426
daily necessities		4	4									
construction material		40	40	48	17	65	79	28	107	187	64	251
petroelum	2	6	8	73	74	147	80	117	197	120	271	391
fertilizers		4	4	19	1	20	21	2	23	31	3	34
mineral products	5		5	32	113	145	36	131	167	46	175	221
natural rubber	56	3	59	236		236	273		273	365		365
timber		4	4	9	38	47	25	49	74	78	81	159
others		37	37									
total	65	155	220	440	378	818	550	507	1057	914	933	1847

C. Planned Cargo Handling Volume of Songkhla Port

19. The volume of cargoes handled at a port is affected by the eomplex interation of various factors such as the condition of port facilities, cargo collecting and distributing mechanism, cargo hadling system, and tariff and port charges. Existence of a huge volume of latent cargo within the hinterland of a port does not promise the increase in the cargo volume actually handled at that port (planned cargo handling volume) if such factors are not favourable ones.

Considering, therefore, that Songkhla port is now capable of performing rather poor functions, it is probable that a considerably long time will be required before port facilities as will as the cargo collecting and distributing mechanism are so improved that the entire latent cargo volume in its hinterland can to be actually handled. Time required for the planned cargo handling volume of Songkhla port to reach the level of the latent cargo volume will vary by the type of trade. In the aspect of foreign trade, the port covers an extensive hinterland and yet the collecting and distributing mechanism is virtually left intact at present. To cover the whole of latent foreign trade cargo volume, therefore, active improvement efforts will have to be made at least for the coming ten years or so. In the aspect of domestic trade, however, a shorter period of about five years will be required since the port has been handling cargoes over the past years and its hinterland is rather small.

20. From the discussion advanced above, the year when the planned cargo handling volume catches up with the latent cargo volume is set at 1985 for foreign trade cargoes and at 1980 for domestic trade cargoes and petroleum. Up to the said target years, annual growth rate from the volume actually recorded in 1970. The relationship between the latent cargo volume and the planned cargo handling volume is illustrated in Fig. 4.

D. Relationship with Phuket Port

21. Songkhla port is situated on the east coast of Southern Thailand whereas Phuket port is on the west coast. These two are the major ports of Southern Thailand. Since it is an imperative to attain maximum effect from the limited availability of funds, prudent care must be taken to avoid needless duplication in investing capitals for the improvement of these two ports. For this reason, studies are made below as to how Phuket port will be influenced by the improvement of Songkhla port.

As described in Item A (Hinterland of Songkhla Port), the hinterland of Songkhla port is limited to Changwat Songkhla and Changwat Phattalung insofar as domestic trade is concerned, and Phuket port can be likewise considered to have a small hinterland. It is therefore evident that there-fore evident that there will arise no competition between the two ports with respect to hinterland, and this holds true with petroleum.

22. However, when the competition in the field of foreign trade is put to an analysis, the following questions present themselves.

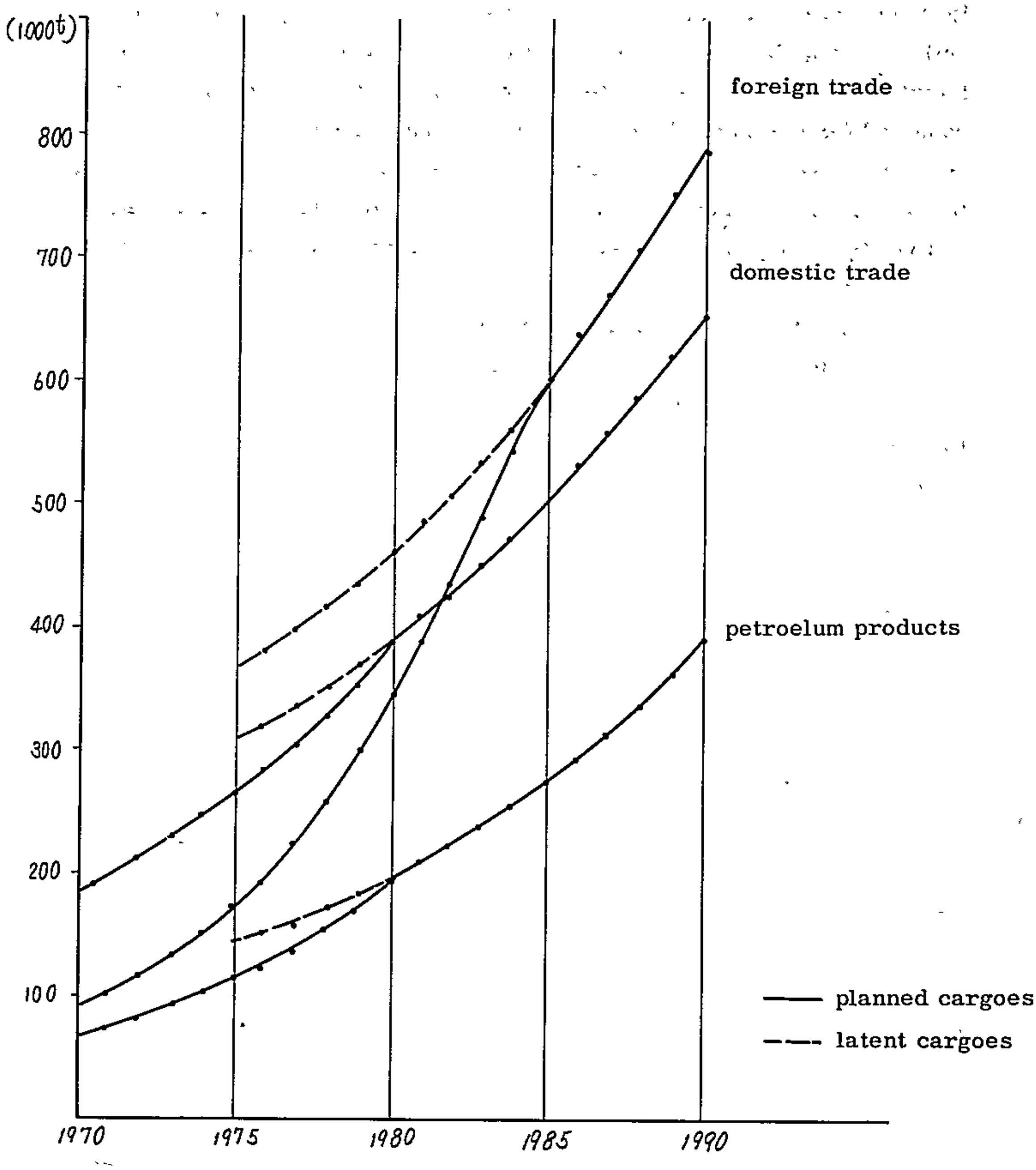


Fig. 4 Volume of Latent Cargoes and Planned Cargoes

i) Whether the two ports are currently in competition with each other for foreign trade cargoes.

ii) Whether overlapping of the two hinterlands will develop when the two ports are improved to the extent that the lighter service can be replaced by the cargo handling service on the wharf.

iii) What are the items and volumes of cargoes in the overlapped part, if overlapping develops.

iv) How will the answers to questions ii) and iii) be affected by the improvement of the two ports and construction of a railway line linking Phuket port and Surat Thani.

23. Study of the above four questions made by way of the analysis of competition produces the following results.

At present, foreign trade centres on the export of natural rubber in case of Songkhla port and on the export of tin and import of pertoleum in case of Phuket port.

The major producing area of natural rubber is found in the southern part of Southern Thailand, whereas that of tin is in the northwestern part. Considering the transportation cost to the shipping port, there is little or no probability that tin will be exported via Songkhla port and natural rubber via Phuket port. As can be deduced from the record of cargoes handled in the past, it can be said, that the two ports are not competing for foreign trade cargoes at present.

24. When Phuket port is improved to offer the cargo handling service on the wharf, parts of the two hinterlands will overlap each other (See Fig. 5). However, However, since the overlapped part has a rather poor productive ability, the cargo volume which will shift from Songkhla port to Phuket port is expected to be no larger than about 18 thousand tons even in 1990, and this is about 3% of the total volume of foreign trade cargoes handled at Songkhla port. Hence, the effect of overlapping on the improvement project of Songkhla port can be disregarded.

When a new railway line is constructed, Changwat Surat Thani will be included in Phuket port's hinterland. The resultant shift of cargoes from Songkhla to Phuket is limited to 65 thousand tons which will not demand virtually no changes in the facilities improvement plan of Songkhla port.

From the above description, it can be said that the two ports function independently of each other, exercising little influence on each other.

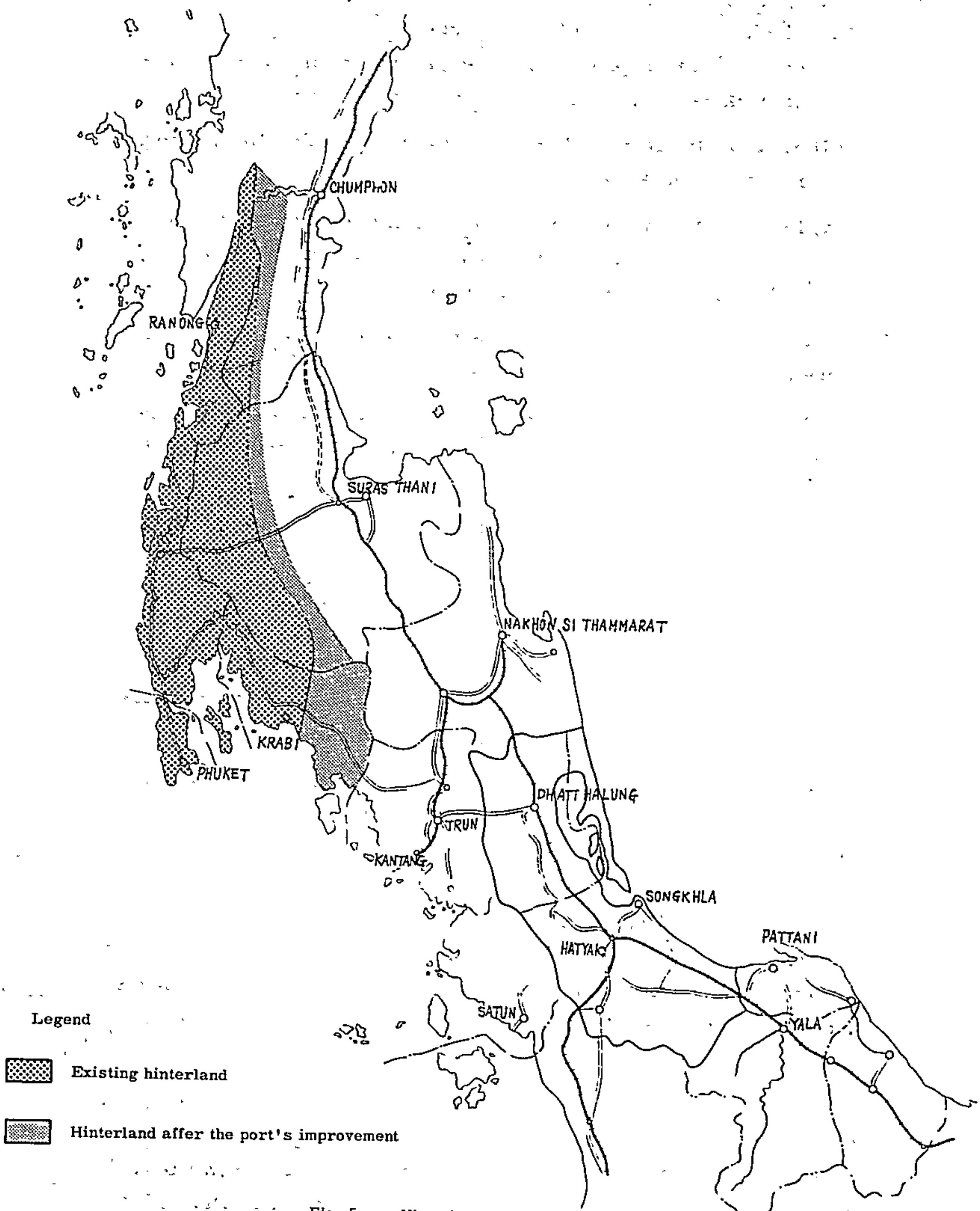


Fig. 5 Hinterland of Phuket Port

III. NATURAL CONDITIONS IN THE NEIGHBOURHOOD OF SONGKHLA PORT

A. Topography

25. The port of Songkhla is situated on the right bank side of the channel leading from Lake Sap to outer sea, and its port facilities allow for the entry of 2,000 D/W class vessels. Lake Sap and Lake Luang combined cover an extensive water surface area of 1,000 km^2. Flat damp land ectends within 20 km from the shore of the two lakes. From the point about 70 km to the southwest of Songkhla port, the mountain range stretches through Malay Peninsula. With the exception of the lake outlet, the coastal area near the port is covered by fine sand grains. The grain size becomes small in places where the water depth exceeds 3 m. As suggested by this grain size distribution, the sea bottom has a mild gradient of 1/200 to 1/300. On the left bank side of the lake channel is found a hill of aqueous rocks called Khao Daeng. The channel course is therefore fixed, and its depth is maintained by the slope current created by the difference in water level between the lake and outer sea. Sand bars are widely distributed in the front part of the lake outlet facing the sea.

B. Climate

26. The area around the port of Songkhla presents climatic features of Asian Monsoon Zone. However, with NE monsoon intercepted by Indo-China Peninsula and SW monsoon by the mountain range stretching through Malay Peninsula, wind produces a relatively moderate effect. NE monsoon blows mostly from east and its average velocity is 6-8 m/sec. SW monsoon blows mostly from southwest and its average velocity is about 3 m/sec.

There is a large difference of rainfall between the wet season and the dry season. Monthly rainfall ranges from 40 mm to 600 mm, and the average annual rainfall is about 2,000 mm. The greater part of this rainfall is recorded in October ~ December period. Number of monthly rainy days averages 20 from October to January and this has a hampering effect on the progress of port construction work.

C. Marine Meteorology

27. Gulf of Thailand is generally shallow and diurnal tide is well developed. In the vicinity of Songkhla port, however, semi-diurnal tide relatively prominent and the tide couves indicate diurnal inequality. However, it is rerely the case that tha tidal range exceeds 1 m.

Record of wave obsevation is completely lacking. The wave height obtained by visual inspection conducted in the neighbourhood of Songkhala port by the Hydrographic Department of Thai Navy is 2.0 m. The wave height and period for structural design estimated by the team from the wind record are shown below.

$$H_{1/3} = 2.2 \text{ m}$$
$$T_{1/3} = 6 \sim 7 \text{ sec}$$

Of these two values, the wave height is considered justifiable, but the wave period of 6 ~ 7 sec is believed to be somewhat shorter than the actual value. It is therefore strongly urged that year-round wave obsevation be conducted at a point where the water depth is approximately 10 m.

Tidal current flows in NW direction at flood tide and in SE direction at ebb tide. The surrent velocity is believed to rise to about 1 knot in the NE monsoon season by the effect of drift current.

D. Hydralics of Lake Outlet

28. Drift sand is believed to move from SE ot NW in the season of NE monsoon. The critical water depth of bed material movement estimated from the waves and the grain size of bed material is within the range from–4.0 m to–5.0 m. The channel between the lake and outer sea is a density current of strong mixing type and its bed is exposed to a large current velocity which produces flushing effect. Since the grain size of bed material is small both in the channel leading out from the lake and in the navigation channel, it is considered that a water depth of 9 m can be maintained with a tractive force of about 15 dyne/cm^2. Curves of channel serve for the maintenance of water depth because the tractive force generally increases in the downstream section. At ebb tide, however, scouring occurs on the left bank side, and this should be prevented by taking a by suitable countermeasure.

E. Soil

29. Sediment transported from Lake Sap is distributed widely in the vicinity of Songkhla port from the head of the existing breakwater to the neighbourhood of Ko Nu. From Laem Sai to the inner harbour area, a fine sand layer having a thickness of 4 to 6 m extends from the sea bottom to a depth of about -11 m. This layer is underlain by a consolidated lateritic clay layer which presents brownish colour and extends downwards to a water depth of about -37 m. This lateritic layer is stratified approximately horizontally. The surface layer about 1 km far from Kao Dang point is composed of coarse sand grains and has a thickness of 8 to 10 m. This coarse sand layer gives place to a stiff consolidated clayey layer from the water depth larger than 15 m. Interposition of lensshaped soft silt layer with a thickness of about 8 ~ 10 m is noticed in the fine sand surface layer extending from the existing breakwater, towards the offing.
Deeper than -11m, soil is composed of compact fine sand. The unconfined compression strength of the said silty layer is as shown below.

$$q_u = 0.166 \sim 0.334 \text{ kg/cm}^2$$

The increase of this strength by depth can be expressed as follows (See Fig. 6).

$$q_u = 0.1 \text{ kg/cm}^2 + 0.05Z \text{ (Base, -6.0 m)}$$

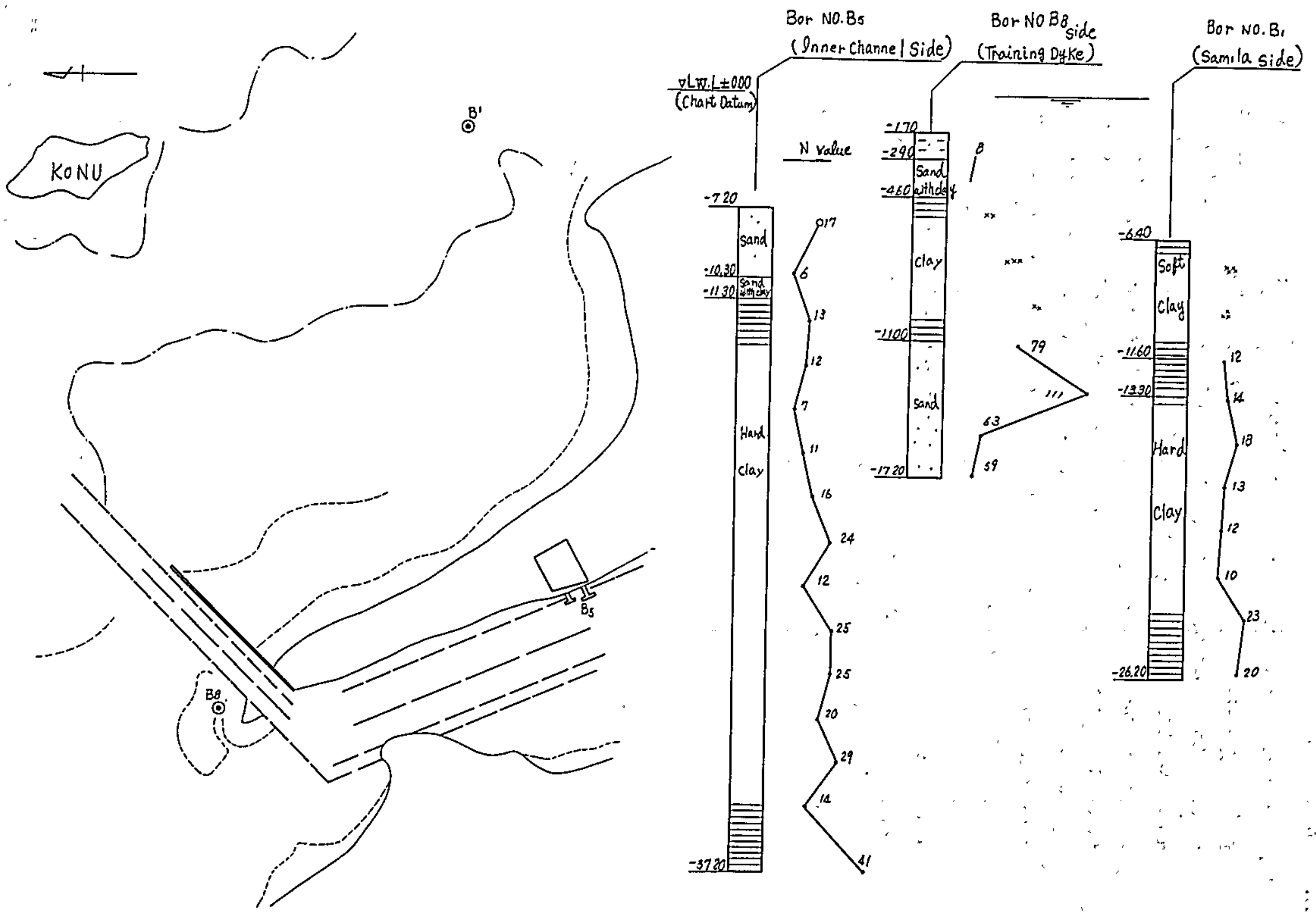


Fig. 6   Location of Boreholes Completed

IV. SONGKHLA PORT CONSTRUCTION PROJECT

A. Fundamental Approach to the Project

30. In Southern Thailand, development efforts should be directed towards fostering primary industries in the immediate futur, and the development of secondary industries can be expected when the basis for their growth have been provided by the development of primary industries. Natural rubber is the major primary product in Southern Thailand. In the hinterland of Songkhla port, in particular, economy is largely dependent on the production of natural rebber. At present, however, the port lacks deepwater wharves for large vessels and this is hampering the export expansion of natural rubber.

For further expansion of consumer economy in the area surrounding Hat Yai, stabilized supply of cheap commodities is indispensable. Commodities consumed in this area are now supplied from Bangkok except for a small fraction that comes from Malaysia. It leaves no doubt that marine transportation incurs the least cost on cargoes shipped from Bangkok, but the facilities currently available at Songkhla port are not sufficient for handling such sea-borne cargoes.

31. The Songkhla port construction project must be a scheme that promises expanded export and better and stabilized livelihood for the people. The fundamental approach to the project is as outlined below.

i) The port facilities should be expanded to allow for the entry of large ocean-going vessels at any time. Further, improvement must be so made that the port will be able to perform its functions in an efficient and safe manner.

ii) The project should be so planned that it will exibhit benefits at the earliest date with a minimum of ecpital input. For this purpose, construction work should be carried out in a concentrated and systematic manner, minimizing the construction of such facilities as breakwater and training dike which do not directly serve to yield income.

iii) The project should be so implemented that the existing and new facilities can be used in an efficient and integrated manner particularly in the initial stage of construction.

iv) The project should leave foom for future expansion of the port.

v) The project shold be planned to preserve the recreation zones found near the port.

vi) Petroleum products will be handled entirely by the State Railway of Thailand as at present. However, if the new port facilities are to be constructed in the outer sea area as proposed by T.C.I., mooring facilities for tankers should be constructed. This is because the maintenance dredging of the existing navigation channel is indispensable for mooring tankers at the existing pier of the State Railway of Thailand, and this incurs a considerably large cost.

B. Determination of Port Scale

32. The scale of a port is usually indicated by the planned cargo handling volume, class of largest vessels expected to call at it, and number of berths.

The planned cargo handling volume of Songkhla port is shown in Table 12. The total volume of cargoes handled at the port in 1970 was about 340,000 tons, and this is estimated to increase to 1,000,000 tons in 1981. Since the percentage of foreign trade cargoes in the total cargo handling volume is estimated to rise from 26% recorded in 1970 to 37% in 1980 and 43% in 1990, Songkhla port will grow into the second largest foreign trade port in Thailand.

Table 12 Planned cargo handling volume of Songkhla port

Unit; 1,000 ton

Year	foreign trade	domestic trade	petroleum Products (foreign & domestic)	total
1970	91	187	66	344
75	170	269	114	553
76	202	289	123	614
77	230	312	142	684
78	263	335	158	756
79	299	362	177	838
80	343	390	197	930
81	391	411	211	1,013
82	447	433	226	1,106
83	510	456	242	1,208
84	563	480	259	1,302
85	604	506	278	1,388
86	638	533	297	1,468
87	674	562	319	1,555
88	712	592	337	1,641
89	751	623	365	1,739
90	794	662	391	1,847

33. Class of vessels calling at Songkhla port is determined as described below. The class of foreign trade cargo carriers is determined on the basis of their class distribution recorded at both Bangkok and Songkhla (See Table 13), whereas that of domestic trade cargo carriers and tankers is determined using their class distribution data reaorded at Songkhla port alone. The class distribution of foreign trade cargo carriers that have entered Songkhla port shows that 96% of all vessels are smaller than 5,000 G/T. Vessels entering Bankok port are larger in average size than those calling at Songkhla port, but about 90% of them have a draught of less than 7.32 m. Further, considering the kinds and volume of cargoes which will be handled at Songkhla port, entry of vessels of extremely large size will not be required and therefore, 7,000 D/W is taken as the maximum size of foreign trade cargo carriers to be accommodated at Songkhla port.

The class distribution of domestic cargo carriers indicates that vessels of 100-300 R/T constitute the majority. 2,000 D/M is taken as the maximum size of domestic cargo carriers in anticipation of some expansion of their size in future. From the same viewpoint, 2,000 D/W is taken as the maximum size of tankers.

Table 13 Class of vessels calling at Songkhla and Bangkok port

Class of vessels calling at Songkhla Port (1970)

(foreign trade)

Class	(A) consigned Southeast Asia		(B) Except Southeast Asia		(A) + (B)	
	Number	%	Number	%	Number	%
0 ~ 200 R/T	63	38.9			63	24.2
201 ~ 400	45	27.8			45	17.3
401 ~ 600	24	14.8			24	9.2
601 ~ 800	24	14.8			24	9.2
801 ~ 1,000	4	2.5			4	1.5
1,001 ~ 1,500	2	1.2	2	2.0	4	1.5
1,501 ~ 2,000			35	35.7	35	13.5
2,001 ~ 2,500			24	24.5	24	9.2
2,501 ~ 3,000			12	12.2	12	4.6
3,001 ~ 4,000			14	14.3	14	5.4
4,001 ~ 5,000			2	2.0	2	0.8
5,001 ~ 6,000			9	9.2	9	3.5
6,001 ~						
Total	162	100.0	98	100.0	260	100.0

(domestic trade)

class	freight vessel		tanker		total	
	Number	%	Number	%	Number	%
0 ~ 50 R/T	57	7.0	11	9.2	68	7.3
51 ~ 100	208	25.6			208	22.4
101 ~ 150	235	28.9	42	35.0	277	29.7
201 ~ 300	173	21.3	4	3.3	177	19.0
301 ~ 400	6	0.7			6	0.6
401 ~ 500	30	3.7			30	3.2
501 ~ 600			39	32.5	39	4.2
601 ~ 700	1	0.1			1	0.1
801 ~ 900	1	0.1			1	0.1
701 ~ 1,000	1	0.1	2	1.7	3	0.3
1,001 ~ 1,500			22	18.3	22	2.4
1,501 ~						
Total	814	100.0	120	100.0	934	100.0

Class of vessels calling at Bangkok Port

Class	1967		1968		1969		1970	
	Number	%	Number	%	Number	%	Number	%
0 ~ 1,000 R/T	86	9.7	95	8.3	117	9.8	89	7.4
1,001 ~ 2,000	148	16.7	160	14.0	143	11.9	217	18.1
2,001 ~ 3,000	236	26.6	260	22.7	207	17.3	199	16.4
3,001 ~ 4,000	194	21.8	217	19.0	263	21.9	269	22.4
4,001 ~ 5,000	168	18.9	169	14.8	186	15.5	153	12.8
5,001 ~ 6,000	65	7.3	149	13.0	162	13.5	140	11.7
6,001 ~ 7,000	30	3.4	50	4.4	52	4.3	49	4.1
7,001 ~ 8,000	25	2.8	40	3.5	27	2.7	27	2.3
8,001 ~ 9,000	1	0.1	3	0.3	13	1.1	13	1.1
9,001 ~								
Total	953	100.0	1,143	100.0	1,172	100.0	1,156	100.0

34. The required number of berths can be obtained by the application of the following equation. The number of berths for foreign trade cargoesis to be checked by the Guecing theory.

$$V = \frac{365 \times d}{t \cdot b} \xi$$

$$t_b = \frac{\xi}{\mu} t_o$$

where,

V : Cargo handling volume per berth (ton/berth).

d : Quay wall occupancy rate.

ξ : Cargo weight per ship (ton).

t_b: Average numver of staying days in the port per ship.

μ: Average daily cargo handling volume (ton).

t_0: Number of days required for preparation for entering and sailing.

Studies indicate that the port should be provided, by 1990, with 5 berths for foreign trade cargoes (in terms of quay wall having a water depth of -8.0 m) and 4 berths for domestic trade cargoes (in terms of quay wall having a water depth of -5.5 m). The present capacity of the quay wall for domestic trade cargoes is assumed to be about 200,000 tons from the past cargo handling record of the port.

C. Selection of Construction Site

35. The construction site of Songkhla port should satisfy the fundamental concept of the project and at the same be able to accommodate the required port facilities. The following are the major conditions to be considered in delecting the constrution site.

i) The site should allow for the construction of facilities for the entry of 7,000 D/W class ocean-going vessels for the present and of 10,000 D/W class vessels in the future.

ii) The site should provide room for future expansion of the port.

iii) The site should assure that the level of port functions can be substantially improved within a short period and at a minimum of capital input.

iv) Cost of construction and maintenance should be low.

v) The site should permit speedy execution of construction work even in the NE monsoon season when marine meteorology is in a detrimental condition.

From the study of these conditions, the following three plans can be conceived of.

36. Inner Harbour Plan

This plan takes avantage of the topographic condition of the inner harbour for protection of port facilities against waves and aims at intergrated utilization of existing and new facilities. Under this plan, it is envisaged that the existing breakwater will be extended in prevention of drift sand intrusion and that a new training dike will be constructed to maintain the navigation channel at the required depth by the flushing effect produced by the current from Lake Sap (See Fig. 7). It is also encisaged that the training dike and the navigation channel running along it will be so constructed that the radius of curvature of their curves does not hamper the maneuvering of large vessels. This plan is advantageous in that it incurs a small construction cost, allows the use of the existing breakwater and navigation channel during construction, and provides room for future expansion that may be required by the future increase in cargo volume. Furthermore, changes in marine meteorology can be virtually disregarded in executing construction since port facilities are to be built in the inner harbour area.

37. Lake Outlet Area Plan

This plan envisages construction of facilities for foreign trade in the area extending from the lake outlet, with the inner harbour area intended to be used exclusively for domestic trade. As shown in Fig. 8, the existing vreakwater will be extended and a new training dike constructed under this plan. While providing the flushing effect as in the case of Plan A, this plan presents no problems for the entry of large vessels and offers room for future expansion. Demerit of this plan is that it incurs a little higher cost than Plan A and a new navigation channel must be dredged because the existing channel cannot be used. Another demerit is that the construction of facilities for foreign trade calls for prudent care since it must be carried out in the outer sea area.

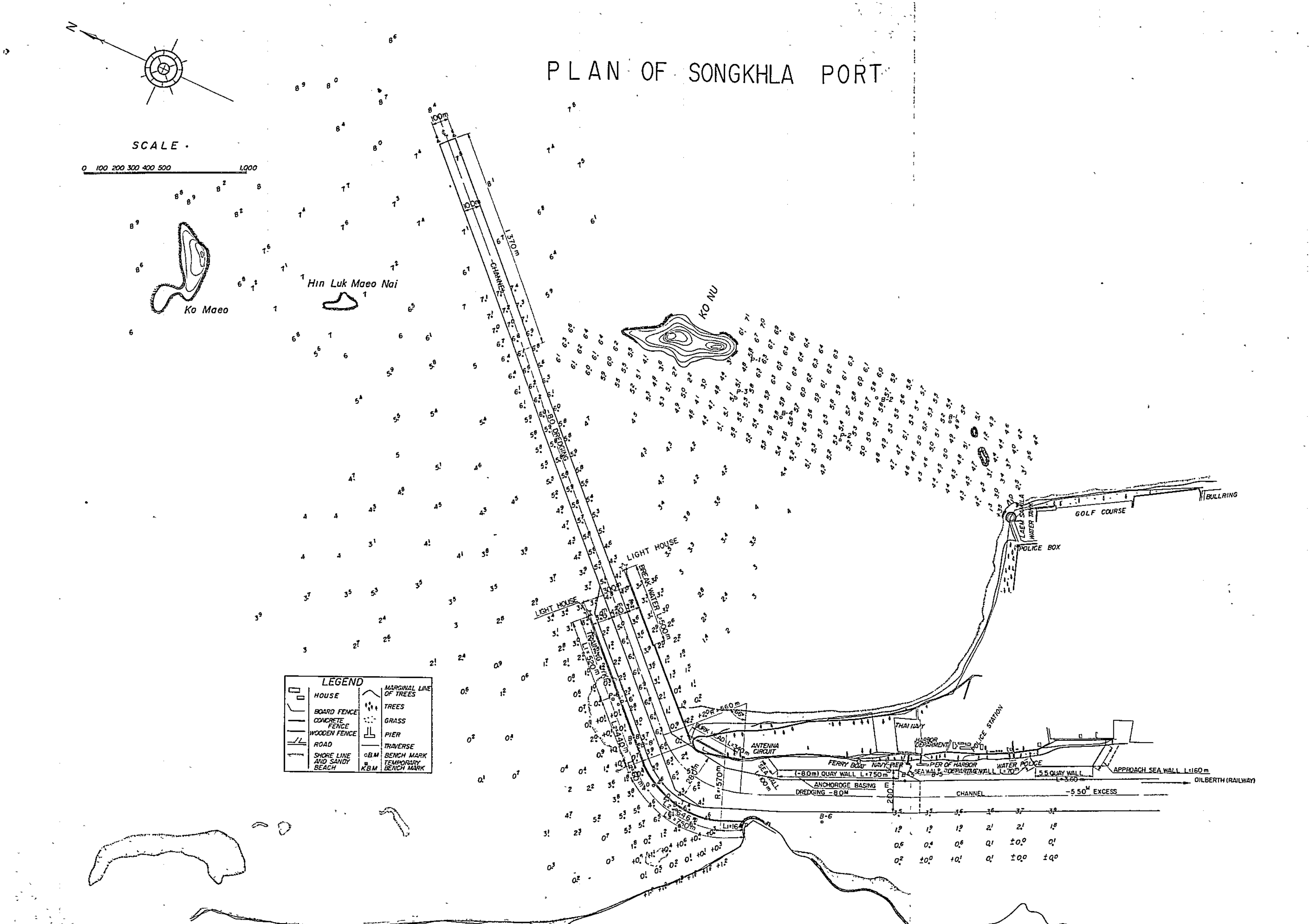


Fig. 7 Inner Harbour Plan

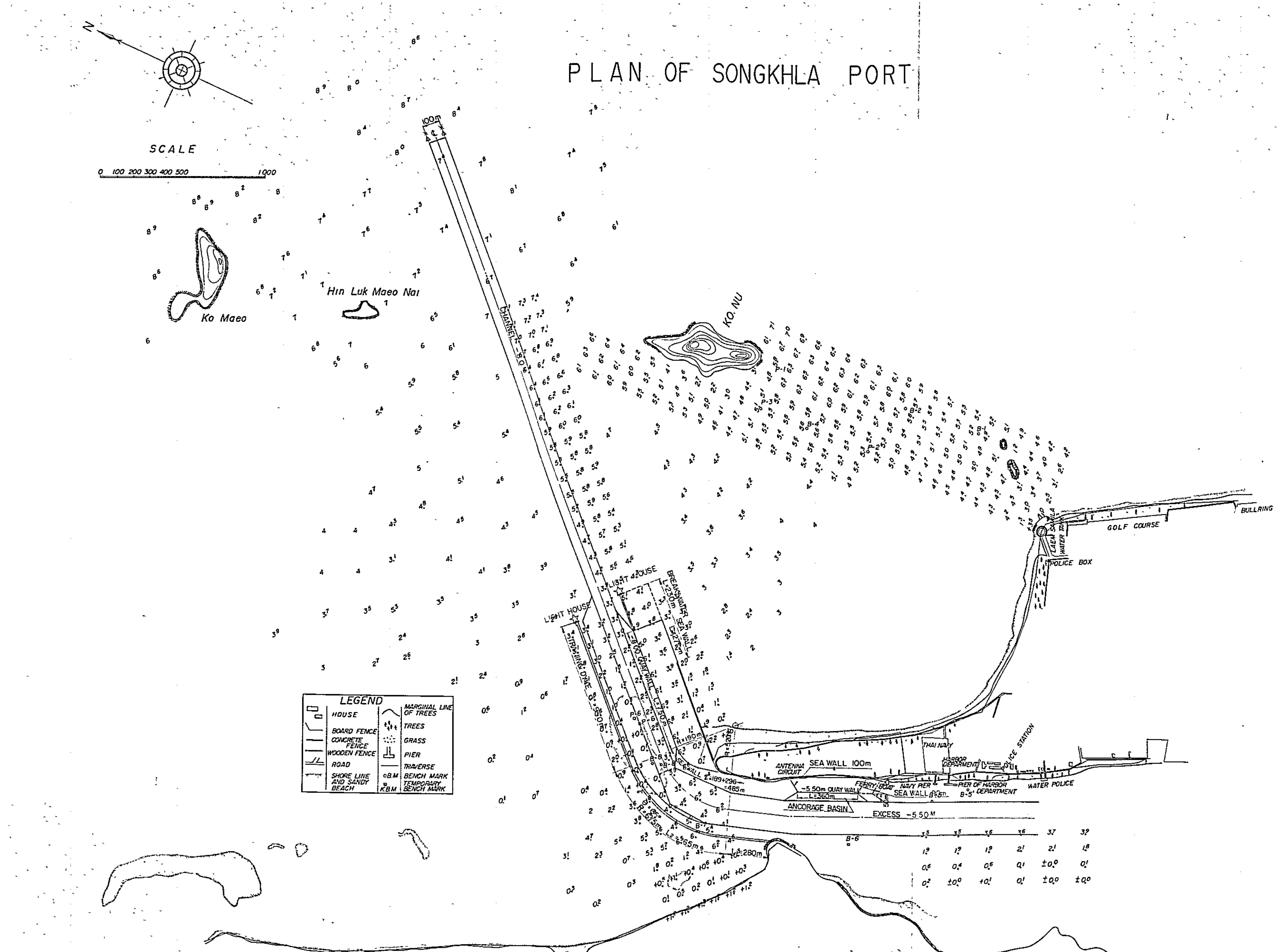


Fig. 8 Lake Outlet Area Plan

38. Outer Sea Area Plan

This plan is intended for construction of a new port in the outer sea area completely severed from the existing facilities. As shown in Fig.9, it envisages construction of mooring facilities in the sea area surrounded by a breakwater extending from the coastline to Ko Nu to intercept waves in the NE monsoon season and by another breakwater intercepting waves from N-NE direction. This plan is advantageous in that it can secure a large basin and allows free approach to future expansion plans. However, since the mooring facilities connot be put in use before completion of both breakwaters, the initial capital input is much higher relative to the other two plans. Further, the poor ground condition of the breakwater construction sites makes the overall construction cost much higher than is required by the other plans, and special consideration must be given to the construction work since it is to be carried out in the outer sea area.

39. Table 14 shows the comparison of merits and demerits of the three plans. On the basis of this study , Plan A is recommended to be adopted.

D. Construction Programme

40. Major facilities of Songkhla port to be constructed by 1990 are as follows.

-8.0 m quay wall	5 berths
-5.5 m quay wall	4 berths
Breakwater	500 m long
Training dike	1,770 m long
Navigation channel	Water depth -8.0 m
	Width 100 m
Transit sheds	2
Warehouses	5

41. The above-listed port facilities are to be constructed in the selected inner harbour area in accordance with the following principles.

i) Construction is to be carried out over two stages, i.e., 1st Stage and 2nd Atage. The 1st Stage is to be divided into Sub-stage I which covers the period from 1974 to 1977 and Sub-stage II which covers the period from 1982 to 1985, whereas the 2nd Stage is to run from 1989 to 1990.

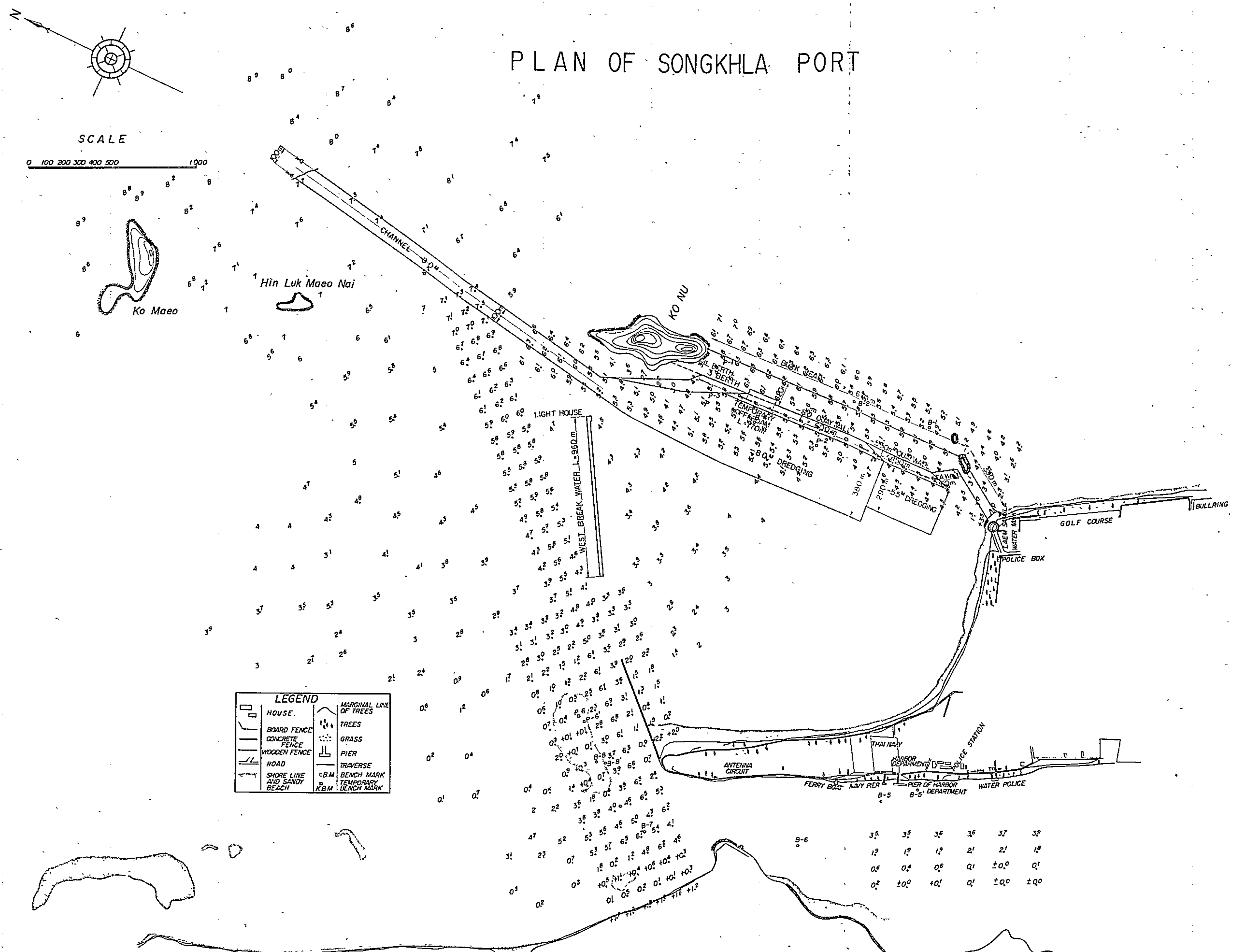


Fig. 9 Outer Sea Area Plan

Table 14 Comparison of Proposed Construction Sites

Item	Inner Harbour Plan	Lake Outlet Area Plan	Outer Sea Area Plan	Remarks
Total capital requirement (in US$1,000)	19,720	22,980	33,960	
Capital requirement in Sub-stage I (in US$1,000)	9,380	10,620	18,100	Capital investment required in the period from 1974 to 1977 for putting in service two berts each at -8.0 m quay wall and at -5.5 m quay wall.
Utilization of existing facilities	Effective utilization of the existing breakwater, navigation channel, and wharf for domestic trade cargoes in the inner harbour area can be assured.	Effective utilization of the existing breakwater and wharf for domestic trade cargoes in the inner harbour area can be assured, but a new navigation channel must be created.	Utilization of the existing facilities is not feasible.	
Room for future expansion	Room for expansion of facilities in the inner harbour area after 1990 is smaller relative to the other two plans.	The port can be expanded by extending the breakwaters and training dike.	Room for expansion is larger than Plans A and B.	
Preservation of recreation xones	Recreation zones can be maintained in the existing state.	Same as Plan A.	The greater part of recreation zones cannot be preserved.	
Exeuction of consturction work	Construction work will be less affected by the changes in marine meteorology than in the case of Plans B and C.	A new navigation channel must be created before -8.0 m quay is put in use.	Construction work will be affected by the changes in marine meteorology to a greater extent than in the case of Plans A and B.	
Calmness in port area	Port area can be maintained calm.	Calmness at -8.0 m quay wall will be somewhat poorer than in the case of Plan A.	Calmness will be poorer campared with Plans A and B.	
Maintenance	Maintenance dreding from the end of breakwaters and training wall towards the offing will be required.	Same as Plan A.	Maintenance dredging of the navigation channel will be required from the harbour entrance towards the offing. Siltation is liable to occur at some parts of inner harbour area.	

ii) Facilities for handling foreign trade cargoes are to be separated from those for domestic trade cargoes.

iii) Facilities for domestic trade cargo handling are to be constructed at positions where the existing facilities can be fully made use of.

42. The following points are to be taken into account in the design and construction of respective port facilities.

i) Structures should be of a simple construction using steel sheet piles or steel pipe piles for the sake of economy and for the efficiency and reliability of construction work (See Figs. 10-13).

ii) Efforts should be made for maximum use of locally available construction materials, machines and equipment.

iii) The breakwater should reach the position with a water depth or 4.5 m which is the critical water depth of bed material movement from east so that it will serve as a groyne as well.

iv) Construction of the training dike should be proceeded with according to the progress of the breakwater construction so that the navigation channel may be free from the intrusion of northeasterly vaves.

v) The direction of the navigation channel should be so determind that vessels passing through it may not be subjected to wind force on the broadside. Room for future expansion of the channel should also be secured.

vi) One of the berths of the quay walls for foreign trade cargoes will have a water depth of -9 m in consideration of the possible future enlargement of vessels.

vii) The construction site of the quay wall for domestic trade cargoes has a water depth of -5.0 to -6.0 m. A unified depth of -5.5 m should be adopted for all berths.

43. Table 15 shows the construction schedule. In the 1st Stage, facilities required for putting in service two berths of -8.0 m quay wall and two berths of -5.5 m quay wall should be completed. The navigation channel should be dredged to have a depth of -8.0 m and a width of 70 m. In the 2nd Stage, quay wall construction will be continued and the breakwaters and training dike extended to enable

Fig. 10

SECTION OF BREAKWATER (Inner port)

S = 1/200
UNIT ; m

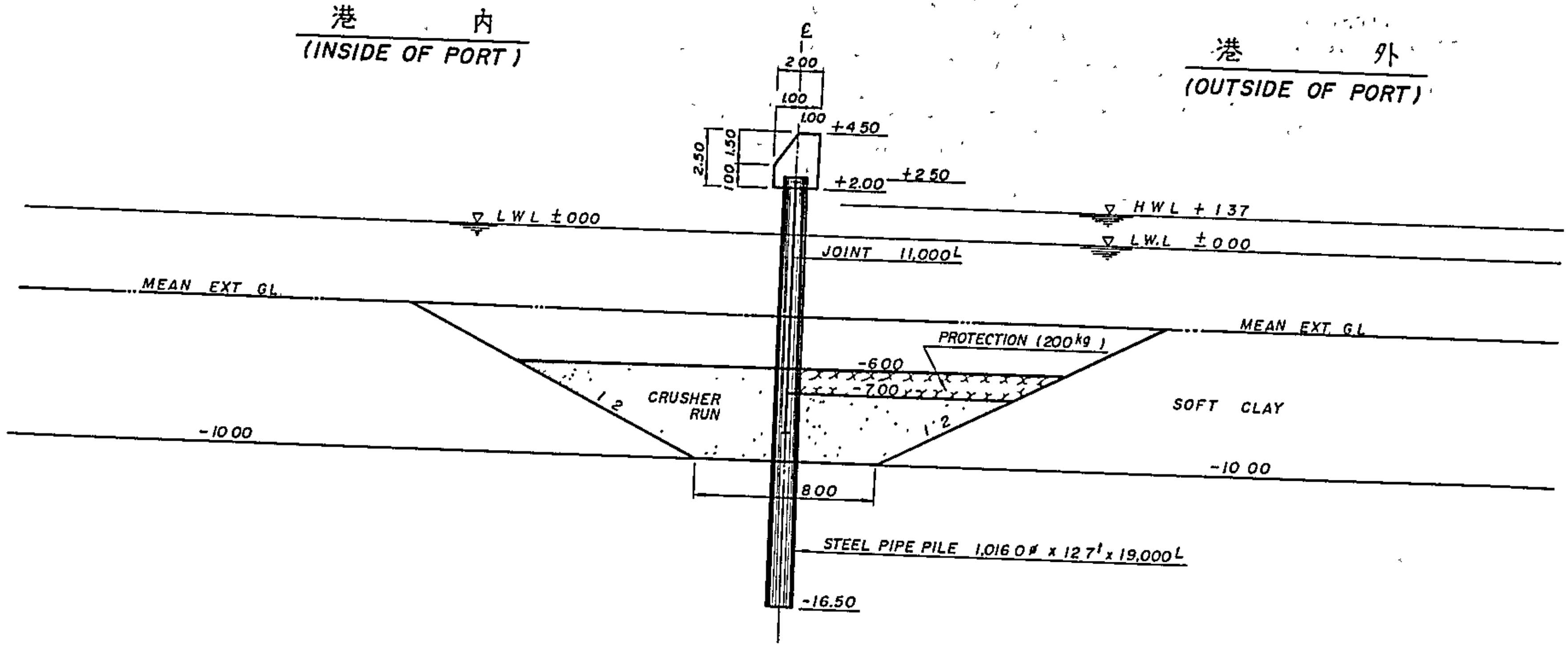


Fig. 11

SECTION OF TRAINING DYKE (Part of Bending)

S = 1/200 UNIT ; m

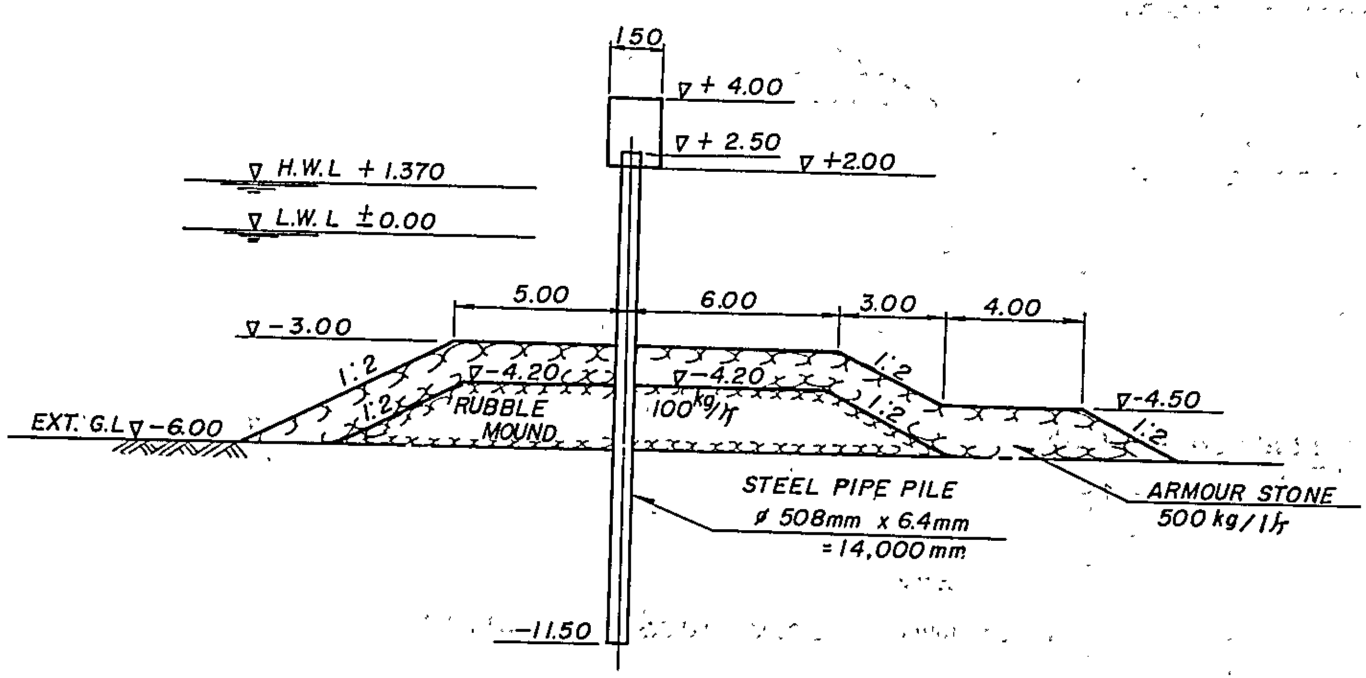


Fig. 12

SECTION OF 8.00M QUAY WALL

S = 1/200
UNIT ; m

A). PLAN (Inner port)

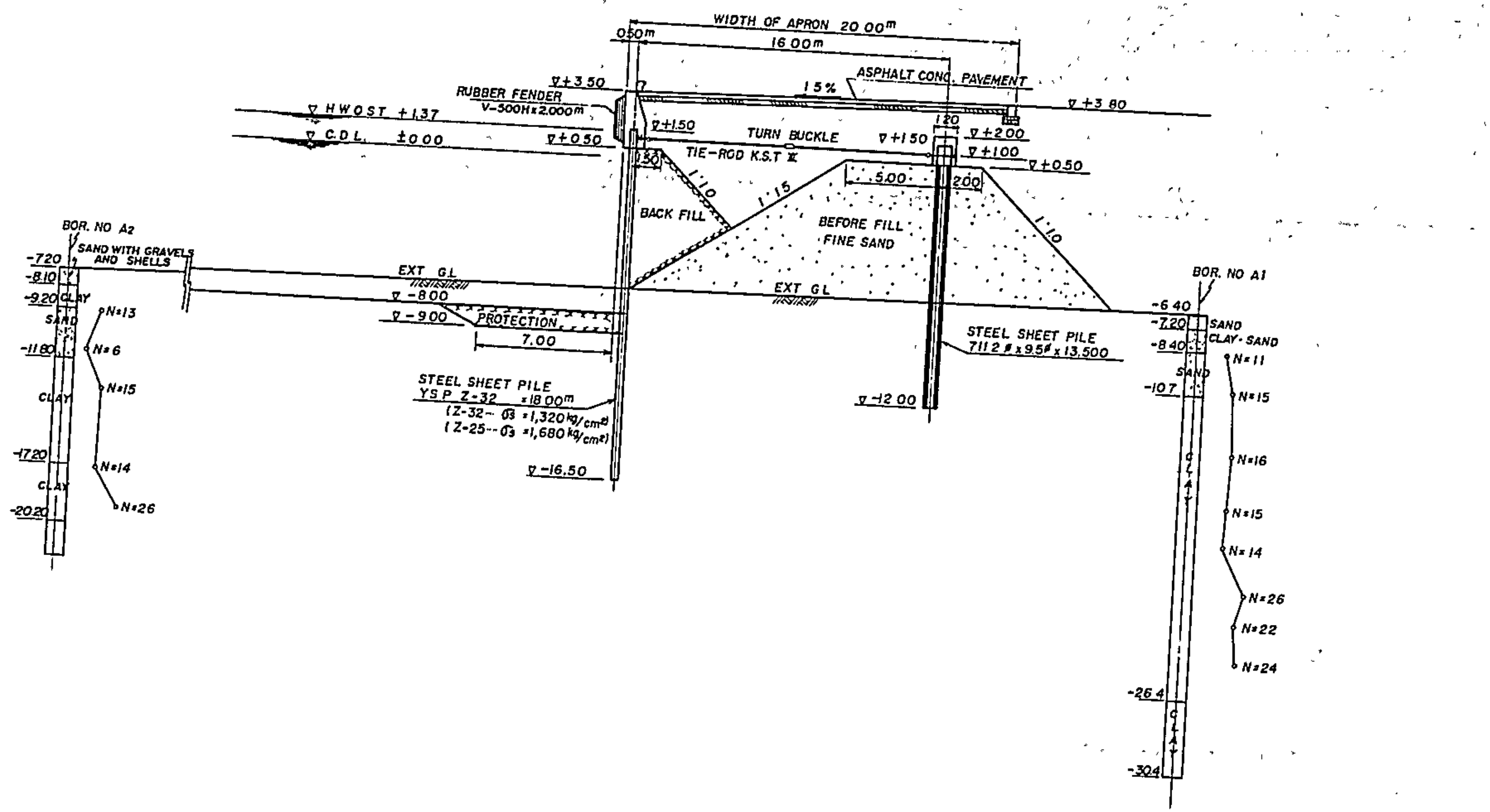


Fig. 13

SECTION OF -5.50M QUAY WALL

S = 1/200
UNIT ; m

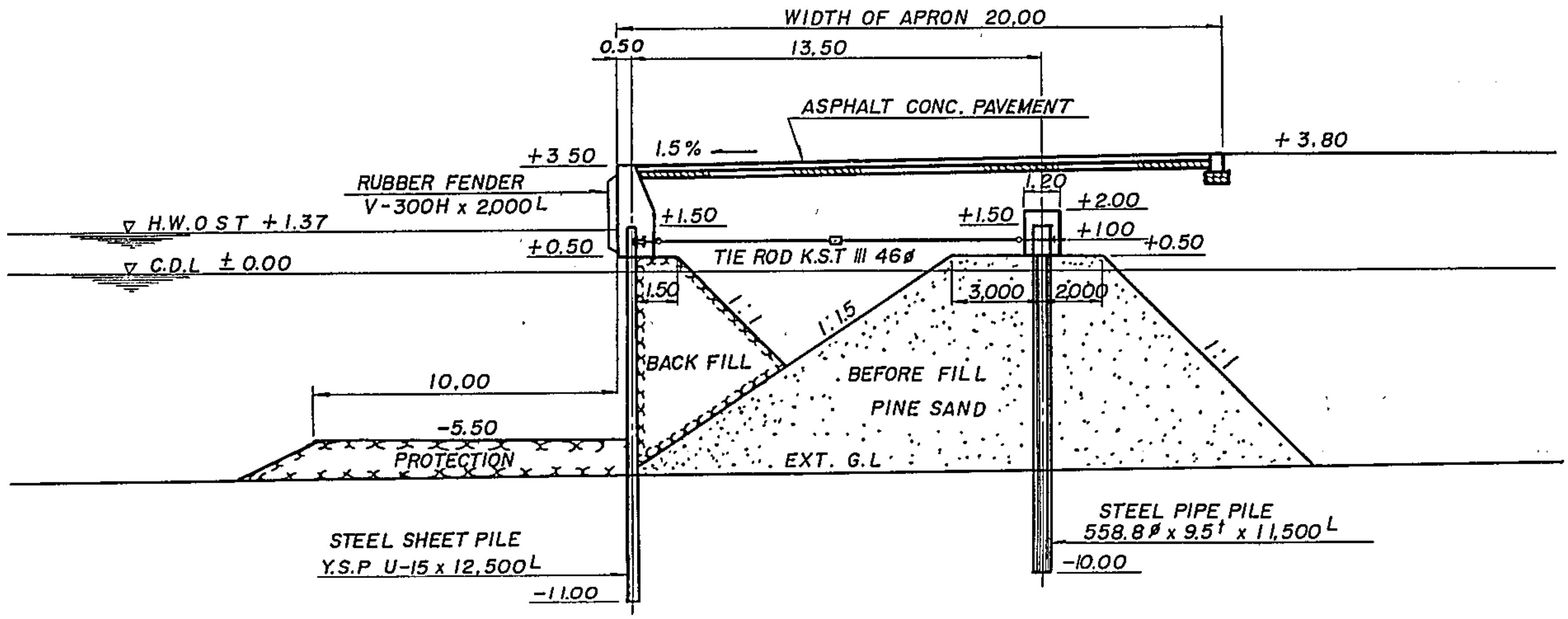


Table 15 Inner Harbour Plan Construction Schedule

Classification of Worko	Quantity	1st stage Sub stage I 1974	'75	'76	'77	'78 '79 '80 '81	1st stage Sub stage II '82	'83	'84	'85	'86 '87 '88	2nd stage '89 '90	Remarka
Break Water	500 m						200			300			
Burk head or Sea Wall	340 m				170		170						
Temporary Cofferdam	150 m				80					70			
Approach Sea Wall	170 m	70											
Training Dyke	1,770 m	280	220	250	250			330	440			100	
Dredging	1.593 million m^3	0.622	0.373	0.32			0.019	0.221	0.019			0.019	
-8.0 m quay Wall	750 m	150	75	75			150		150			150	
-5.5 m quay Wall	360 m	90			90			90				90	
Sea Wall (Domes)	230		160									70	
Reclamation	794,000 m^3	178,000	44,000	44,000	95,000		88,000	95,000	88,000			162,000	
Land grading	101,300 m^2	22,600	5,400	5,400	11,900		10,800	11,800	10,800			22,600	
Pavement	22,000 m^2		4,300		4,300			2,700	1,600	2,700		4,400	
Transit Shed	5		1	1	1		1	1					
Ware house	2				1				1				

the port to perform the expected functions.

As shown in Table 16, the overall investment amount required up to 1990 is US$19,720 thousand. The foreign currency requirement in the overall project is US$11,770 thousand which is equal to 60% of the total investment amount. As shown in Table 17, stage-wise breakdown of construction cost is US$8,680 thousand for Sub-stage I, US$7,790 thousand for Sub-stage II, and US$1,770 thousand for 2nd Stage.

Table 16 Inner Harbour Plan Investment Amount

Unit; 1,000 US$

Facilities	Unit Cost			Sub-Stage I (1974 1977)				Sub-Stage II (1982 1985)				2nd Stage			
	Local currency	Foreign currency	Total	Quantity	Local	Foreign	Total	Quantity	Local	Foreign	Total	Quantity	Local	Foreign	Total
Break Water	0 88	2.01	2.89					500	400	1,005	1,445				
Burk head	0.56	0.75	1.31	170	95.2	127.5	222.7	170	95.2	127.5	222.7				
Temporary Cof-ferdam	0.81		0.81	80	64 8		64.8	70	56.7		56.7				
Approach Sea Wall	1.49	1 34	2.83	70	104.3	93.8	198.1					100	149	134	283
Training Dyke	0.91 0.9	0.94 0 9	1.85 1.8	1,000 m	905	970	1,825	770 m	700.7	723.8	1,424.5				
Dredging	207	311	518	1.315 million m³	272.21	408.97	681.18	0.259 million m³	53.6	80.5	134.1	0.019 million m³	3.9	5.9	9.8
-8.0m quay	1.42 1.71	2.34 2.34	3.76 4.05	300	469.5	702	1,171.5	300	426	702	1,128	150 m	213	351	564
-5.5m quay	1.48	1.34	2.82	180	266.4	241.2	507.6	90	133.2	120.6	253.8	90	133.2	120.6	253.8
Sea Wall (Domes)	0.74	0.99	1.73	160	118.4	158.4	276.8					70	51.8	69.3	121.1
Reclamation	194		194	0.361 million m²	70.034		70.034	0.271 million m²	52.674		52.574	0.162 million m²	31.5		31.5
Land grading	0 000065		0.000065	45,300 m²	2 94		2.94	33,400 m²	2.17		2.17	22,600 m²	1.47		1.47
Pavement	0.013		0.013	8,600 m²	111.8		111.8	7,000 m²	91.0		91	4,400 m²	57.2		57.2
Transit Shed	105	152	275	3	315	456	771	2	210	304	514				
Ware house	77	108	185	1	77	108	185	1	77	108	185				
Navigation Aid		8.1	8.1	2		16.2	16.2	2		16.2	16.2	2	16.2		16.2
Sub-total					2,872.584	3,232.07	6,104.654		2,338.144	3,187.6	5,525.744		657.27	680.8	1,338.07
Eng Construction Suppervision						1,220.9	1,220.9			1,104	1,104			267	267
Others						567.05	567.05			449.98	449.98				
Contingency						789	789			707	707			161	161
Grand Total (Construction cost)					2,872.584	5,809.02	8,681.6		2,338.144	5,448.58	7,786.724		657.27	1,108.8	1,765.07
Investment Amount: Construction cost					2,872.584	5,809.02	8,681.6		2,338.144	5,448.58	7,786.724		657.27	1,108.8	1,765.07
Investment Amount: Interest	F = 0.4 × 0.075 × 4Year					697	697			653	653			133	133
Investment Amount: Total					2,872.584	6,506.02	9,378.6		2,338.144	6,101.58	8,439.724		657.27	1,241.8	1,899 07

1) The construction cost does not include the interest and cost of maintenance dredging.

2) The investment amount is the sum total of the construction cost and interest on the foreign currency portion.

Table 17 Inner Harbour Plan Approximate Construction Cost by Year

Unit; 1,000 US$

Commerce \ Year	1974	1975	1976	1977	1982	1983	1984	1985	1989 1990	Remarko
Foreign	2,196.5	1,772.3	1,524.2	1,403.0	1,837.3	1,449.9	2,108.9	1,344.8	1,217.0	
Domestic	358.0	43.6	711.0	672.6	340.2	371.0	277.9	57.8	548.7	
Total	2,554.5	1,815.9	2,235.2	2,075.6	2,177.5	1,820.9	2,386.8	1,402.6	1,765.7	

V. ECONOMIC EVALUATION OF SONGKHLA PORT CONSTRUCTION PROJECT

A. Method of Economic Evaluation

44. Evaluation of the Songkhla port construction project must be made from two different angles. In the first place, the project must be evaluated from the viewpoint of national economy. In other words, the project must be reviewed by the anlysis of its value to national economy. In the second place, evaluation must be made against the yardstick of port management to study if the project implementation assures sound management of the port. The anaysis is to be made over a period of 25 years from 1974 to 1999, with the benefit-cost ratio calculation worked out at a discount rate of 10%.

45. Construction of Songkhla port is expected to produce a diversity of benefits as outlined below.

i) Increased international competitive power of export goods and stabilized supply of cheap commodities resulting from the rationalization of the distribution mechanism.

ii) Industrial development ensued from the construction of quay walls of large dimensions.

iii) Increased employment opportunities arising from the construction and operation of port facilities.

iv) Net income from the port management (balance between the income from port management and expenditure for port operation).

Some of these benefits are measurable while some are not at present. Benefits to be reviewed for the analysis are therefore limited to measurable ones, i.e., amount of transportation cost savable by the rationalized distribution and net income from the port management.

46. In the transport of foreign trade cargoes, the following cost saving can be expected.

i) Saving of the transportation cost of lighter service cargo handling service on the wharf.

ii) Saving of marine transportation cost from Bangkok by the direct supply via Songkhla port.

iii) Reduction of demurrage cost by the improvement of cargo handling method and quicker dispatch of vessels.

Cost saving of the basically same nature can be expected in the transport of domestic trade cargoes.

47. Of the savings of transportation cost listed above, Items i) and ii) are taken for the purpose of the analysis

The saving of lighter's transportation cost (Item i) varies considerably by the kind and lot of goods and by whether goods are packed or in bulk, but averages 30 Baht/ton, This benefit can be obtained by multiplying the saving rate by the volume of cargoes passing through Songkhla port. Strictly speaking, the distance of overland transportation of commodities from the port increases in proportion to the saving of the lighter's transportation cost, and thereby makes the port's hinterland so much the larger. Accordingly, this benefit is to be obtained not by multiplying all the cargo handling volume by 30 Baht/ton, but by applying this rate to cargoes cistributed within the existing hinterland and half this rate to cargoes newly generating by the expansion of the hinterland.

48. The saving of secondary transportation cost from Bangkok to Songkhla is considered attainable as explained below.

With the exception of petroleum, direct inflow of import commodities into Southern Thailand has been practically zero in the past and this was because the ports in Southern Thailand have no quay walls of large size and the volume of import cargoes was not enough to demand the entry of ocean-going vessles. With the advent of Songkhla port as the foreign trade port of Southern Thailand, however, import commodities that have hitherto been sent to this area by marine or overland transportation from Bangkok will be directly imported, thereby saving the secondary transportation cost from Bangkok to Southern Thailand.

Calculation of the secondary cost can be made basically in the same method as applied for Item i) as described below.

i) 87 Baht/ton, the saving rate of marine transportation cost from Bangkok, can be expected for import cargoes supplied to changwats of Songkhla and Phattalung which are in the hinterland of Songkhla port as well as for import cargoes going to changwats of Trang and Satun.

ii) Saving of a maximum of 87 Baht/ton to a minimum of 30 Baht/ton can be expected for import cargoes which are distributed within the port's hinterland of foreign trade cargo traffic.

iii) Saving of a maximum of 30 Baht/ton to a minimum of zero is expected for import cargoes to be supplied to Changwat Surathani which will be embraced in the port's hinterland after its improvement.

The benefit of saving of secondary transportation cost can be obtained for each of the above three cases by multiplying the respective saving rates by the volume of import cargoes.

49. The net income from port management is to be obtained on the basis of the port charges collected at Bangkok port because it is likely that the examples set by Port Authority of Thailand will be followed in establishing Port Authority of Songkhla. Accordingly, using the data of net income of Bangkok port shown in Table 18, net income at Songkhla port is set at 40 Baht/ton for foreign trade cargoes.

Net income accruing from petroeum and domestic trade cargoes, as calculated on the basis of the rates of port charges currently effective at Songkhla port, is 2.5 Baht/ton.

50. Cost to be adopted for the analysis is the port construction cost.

51. Benefit and cost calculated by the method described above are shown in Table 19.

B. Evaluation Based on Analysis of National Economy

52. This evaluation is intended to bring to light whether the construction of Songkhla port will contribute to the growth of Thailand's national economy. In making an analysis for this purpose, the saving of transportation cost and net income are taken as the benefit and the construction cost as the cost.

The project analysis for Sub-stage I discloses that the benefit-cost ratio in this stage is 1.37 at a discount rate of 10% and the internal rate of return is 14.5%.

Internal rate of return is the rate of profit earned by the unrecovered portion of invested capital and therefore indicates the earning power of unrecovered capital. The said internal rate of return of 14.5% affirms the soundess of the project for Sub-stage I.

Table 18 Net income of Bangkok port

Item	1968	1969	Remark
Revenues (A)	274,082	269,333	
Wharf Rate	4,743	4,965	
Channel Dues	14,534	15,975	
Labor Section	48,209	47,758	
Port Operating	174,121	159,451	
Accesarial Service	2,570	2,730	
Rental	8,208	9,665	not included in the income of Songkhla port
Passenger Baggage	61	72	
Overtime Fees	6,993	7,067	
Others	14,643	21,650	
Expenditures (B)	155,804	173,600	
Maintenance	11,295	15,209	
Depreciation	20,847	24,033	
Labor Section	51,443	60,369	
Executive Admirist	39,837	41,794	
Others	32,382	32,195	
Net income (A)-(B) (1,000Baht)	118,278	95,733	
Traffic (1,000ton)	2,223	2,266	
Net income per unit cargo volume (Baht/ton)	53.2	42.2	

Table 19 Benefit and Cost (1st stage)

Year	Benefit (1,000 Baht)			Cost (1,000 US$)	Remark
	Saving of transpota-tion cost	Net income from the port opera-tion	Total		Net income from port operation in Sab Stage I
1974	0	0	0	2,554.5	0
75	5,767	6,973	12,740	1,815.9	6,973
76	6,478	8,305	14,783	2,235.1	8,305
77	7,488	9,480	16,968	2,075.6	9,480
78	8,640	10,858	19,498	0	10,858
79	10,006	12,330	22,336	0	12,330
80	11,642	14,195	25,837	0	14,195
81	13,560	16,186	29,728	0	16,186
82	13,560	16,223	29,783	2,177.5	16,223
83	18,436	21,040	39,476	1,820.9	16,280
84	21,006	23,220	44,226	2,386.8	16,340
85	23,489	24,925	48,414	1,402.7	
86	24,967	26,353	51,320	0	
87	26,545	27,865	54,410	0	
88	28,221	29,460	57,681	0	
89	29,969	31,098	61,067	0	
90	31,872	32,900	64,772	0	
91				0	
92				0	
93				0	
94				0	
95				0	
96				0	
97				0	
98				0	

53. The project analysis made in the similar way for the 1st Stage produces a benefit-cost ratio of 1.38 and an internal rate of return of 14.9%.

Results of these analyses are tabulated in Table 20.

Table 20 Evaluation Based on Analysis of National Economy

	Benefit-Cost Ratio	Internal Rate of Return
Sub-stage I (1974-1977)	1.37	14.5
1st Stage (1974-1985)	1.38	14.9

As indicated by this table, it can be said that the project is beneficial to national economy.

C. Financial Rate of Return

54. Net income is the only benefit that can be considered in the management analysis of Songkhla port, whereas the port construction cost must be taken as the cost. Analysis made on the basis of these two factors produces a financial rate of return of 5.5%. These values indicate that the management of Songkhla port, if based on the self-accounting system, will run into financial difficulties.

However, in the case of a project of this type which promises to be beneficial to national economy, it is not necessarily required to consider the self-supporting accounting system as a binding condition for management. There are means to maintain sound management. For example, the government may grant the necessary amount of subsidy to the port authority, or the port facilities may be constructed by the government and transferred to the port authority.

55. The difficulty in maintaining the self-supporting management of Songkhla port arises chiefly from the severity of the surrounding natural conditions. To be more precise, the large capital input required for the construction of the breakwaters, training dike and dredging of navigation channel is the major cause of the difficulty.

To offer the possibility of maintaining sound management for this project which is known to be conductive to the enhancement of national economy, the government subsidy granted to the port authority to finance a part of the construction cost will be effective. If the cost required for the construction of outer and harbour facilities (which is equivalent to 44% of the total construction cost) is covered by the government , the financial rate of return to 12.8%.

Description given above is summarized in Table 21.

Table 21-Evaluation Based on Analysis of Port Management

	~~Benefit-Cost Ratio~~	Internal Rate of Return	Remarks
Management by Self-Supporting Accounting System	~~0.73~~	5.5	
Management with Part of Cost Financed by Government Subsidy	~~1.25~~	12.8	Subsidy is equivalent to 44% of total construction cost.

The project can be evaluated as being sound for port management if the government supports it with the above-mentioned subsidiary measure.

APPENDIX

Hydraulic Study on the Maintenance of Water Depth of Lake Outlet

1. As stated in the section dealing with the selection of construction site, maintenance of the water depth in the lake outlet is the indispensable prerequisite to Plan A (construction in inner harbour area) and Plan B (construction in lake outlet area). Hydraulic study made in this appdendix is intended to look into and elucidate the possibility of maintaining the required water depth.

Hydraulic study intended for the said purpose must be made on two factors responsible for the silting up of navigation channel, i.e., littoral drift and sediment load from the lake. To clarify the effect of littoral drift, studies must be made on such elements as the waves, littoral current, grain size distribution of diameter of bed material along the coast, topography and structures; and to grasp the effect of sediment load, attention should be directed to the grain size distribution of bed material in the lake and navigation channel, flow characteristics of the channel in the lake outlet, tractive force, and effect produced by the curves in the channel.

2. Waves in the vicinity of Songkhla port have never been observed by a wave detector in the past. Therefore, wave estimation is the only means left for the present study. Data of Thai navy indicate, however, that the visual observation was conducted in this area from a vessel in NE monsoon season when marine meteorology is in severe condition. The wave height recorded by this observation is 2.0 m, but the wave period is not known.

As for wind, observation has been carried on over the past years at Songkhla airport. From the data available at this airport, those for 1969 were employed for the purpose of the present study, and winds recorded to have blown from the directions between NE and SE were selected. These winds are concentrically observed in January, February, March, October, November and December. Waves in these months are assignable to NE monsoon and they cause drift sand to migrate from SE to NE along the coast. Winds recorded to have blown from the directions between W and NE were also selected, and waves caused by them were considered to correspond to those observed in SW monsoon season. These waves are observed concentrically in June, July, August and September, and are considered to cause drift sand to migrate from NW to SE.

Due to the lack of the weather map for fetch depermination and the extremely large fetch expected on the east side of the Gulf of Thailand in NE monsoon season when waves of great significance are generated, an infinite value was assumed for fetch. Accordingly, the wave height, period, etc. were determined by the wind velocity and duration, and S-M-B method was employed for wave estimation.

The wave height and period were obtained by the above-mentioned method for waves generated over 182 days in NE monsoon season. Fig. 1 shows the frequency distribution prepared by the method of Tohmas plotting. The design wave for structures design is given a height and period equivalent to 99.9% and 99% respectively of the values obtainable from Fig. 1.

$H_{1/3} = 2.2$ m

$T_{1/3} = 6\text{–}7$ sec

If effective and economical control is to be achieved by means of structures with account taken of the critical water depth of bed material movement, then 95–99% and 99% respectively of the height and period obtainaale from Fig, 1 should be sssumed for the design wave.

$H_{1/3} = 1.2\text{–}1.6$ m

$T_{1/3} = 6\text{–}7$ sec

Fig. 2 shows the cumulative frequency distribution of waves generating in SW monsoon season. For the control of drift sand, the design wave should have the following height and period.

$H_{1/3} = 0.5\text{–}0.7$ m

$T_{1/3} = 5$ sec

3. In the offshore area of Songkhla port, tidal current flows in NW direction at flood tide and in SE direction at ebb tide. It is believed that drift current develops in NE monsoon season because of the long duration of wind. Since the drift current tends to deflect towards the right side of wind direction in the northern hemisphere, the said drift current flows in NW direction. In NE monsoon season, therefore, drift sand from NW direction provails by the combined effect of this drift current and waves. The velocity of littoral current is believed to be about 1 knot.

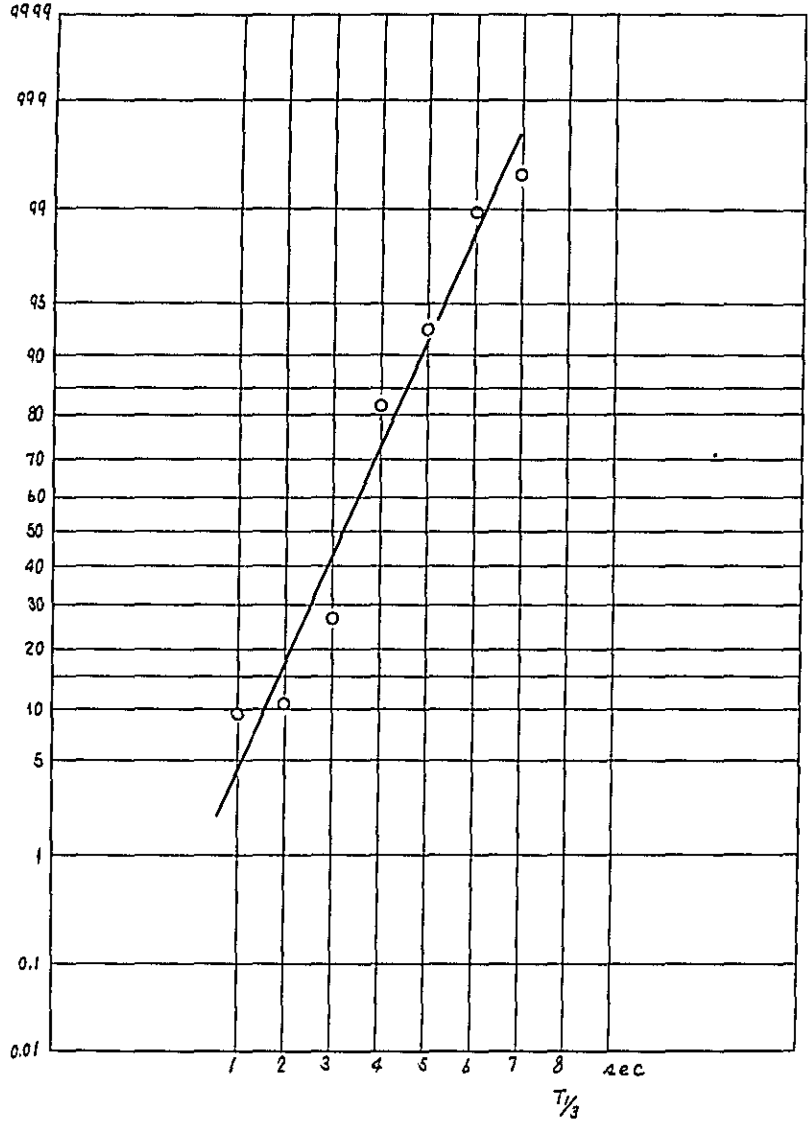


Fig. 1-B NE Monsoon; Cumulative Frequency distribution of Wave Period

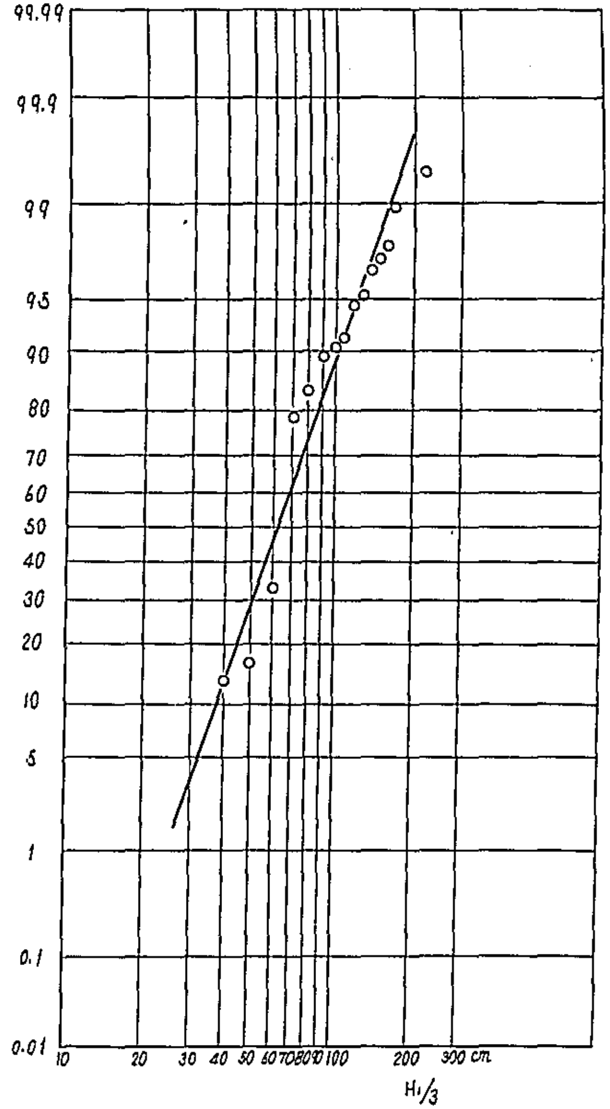


Fig. 1-A NE Monsoon; Cumulative Frequency Distribution of Wave Height

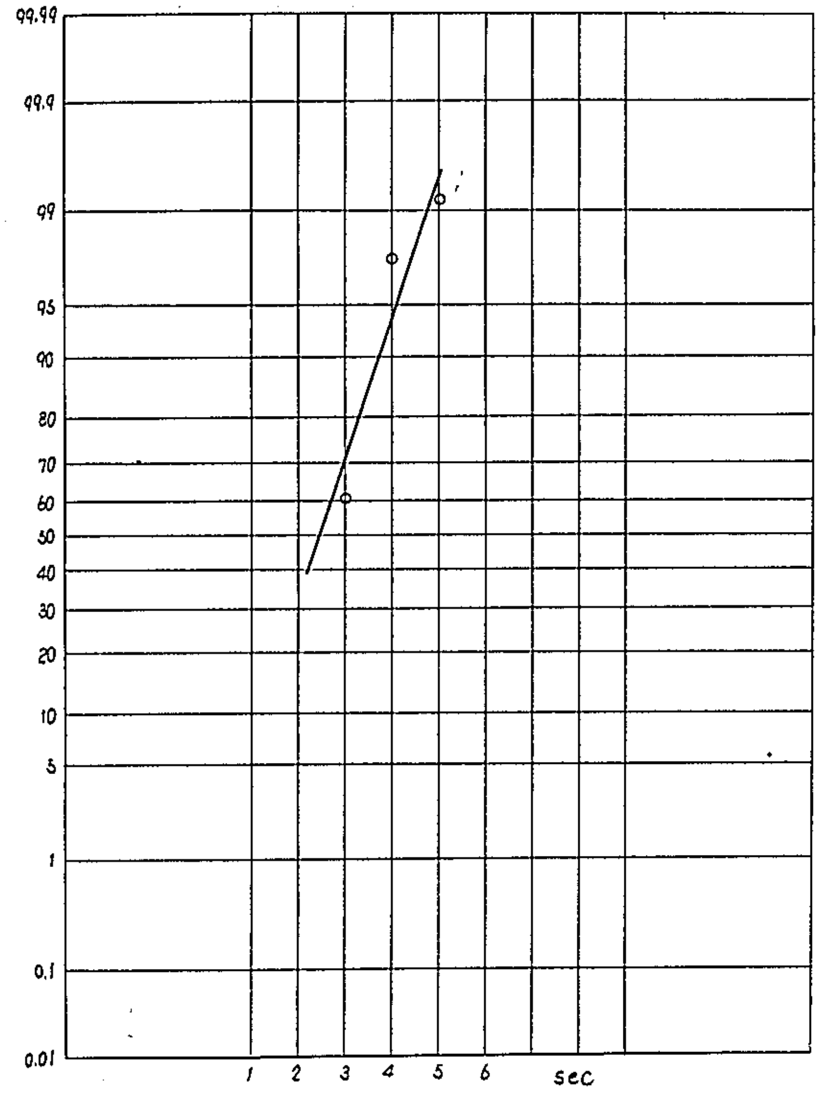


Fig. 2-B SW Monsoon; Cumulative Frequency Distribution of Wave Period

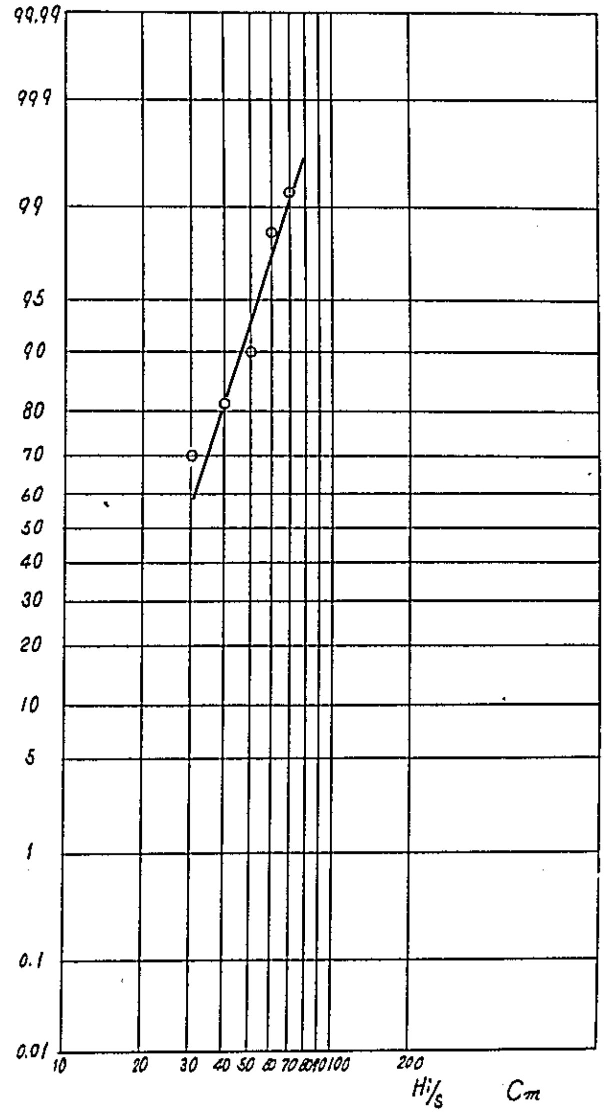


Fig. 2-A SW Monsoon; Cumulative Frequency Distribution of Wave Height

4. As shown in Fig. 3, five survey lines, A, B, C, D and E, were established along the coast of Songkhla, and bottom material was collected at intervals of 1 m between D.L. +1.0 m and D.L. -0.8 m for grain size analysis. Findings of the analysis are as follows.

Between -1.0 m and -2.0 m, the median diameter of bottom material, d_{50}, ranges from 200 to 300 μ, and between -3.0 m and -6.0 m, it is within the range from 50 to 100 μ. At places deeper than -7.0 m, d_{50} = 10-20 μ along all survey lines, indicating that sediment descharged from the lake is widely distributed and deposited. Fig. 4 shows the grain size distribution at each depth along survey line D.

The critical water depth allowing conspicuous movement of drift sand, estimated from Fig. 5 with the wave height and period taken at values described in the preceding item and the mean grain size of bottom material taken at 70 μ, is as follows.

In NE monsoon season : 4.0-5.6 m beneath mean water level

In SW monsoon season : 1.2-1.9 m beneath mean water level

The above findings indicate that it is advisable, for prevention of silting up of navigation channel through interception of the greater part of sand drift invasion, that the breakwaters be extended to the position where the water depth is 5 m beneath mean sea level, i.e., D.L. -4.0 m, and that the training dike be also extended, in view of the large bar in front of the lake outlet, to the position where the water depth is D.L. -2.0 m.

Since breakwater extension work is not planned to be carried out in Sub-stage I, the amount of maintenance dredging of the navigation channel will be larger than in Sub-stage II. The existing breakwater is extended to the vicinity of the place having a depth of D.L. -2.0 m. At present, considerable siltation is observed for about 300 m from its head towards the offing.

5. Bottom material from the lake channel toward lake inside was collected at locations shown in Fig. 6. The grain size analysis of the collected specimens revealed that the mean diameter inside the lake is extremely small, not reaching 30 μ, whereas the values in the lake channel are as shown below.

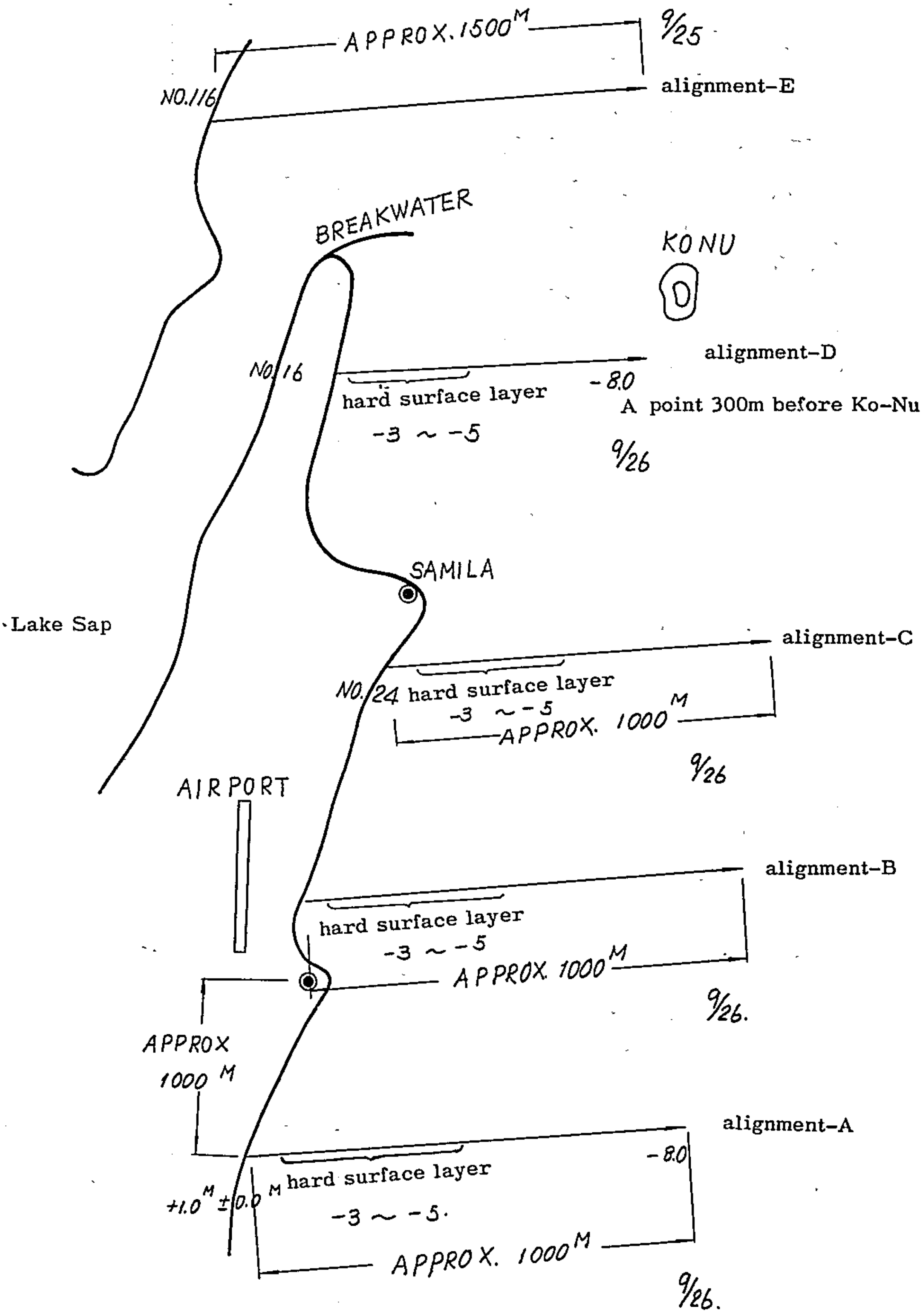


Fig. 3 Bottom Material Sampling Points along the Coast

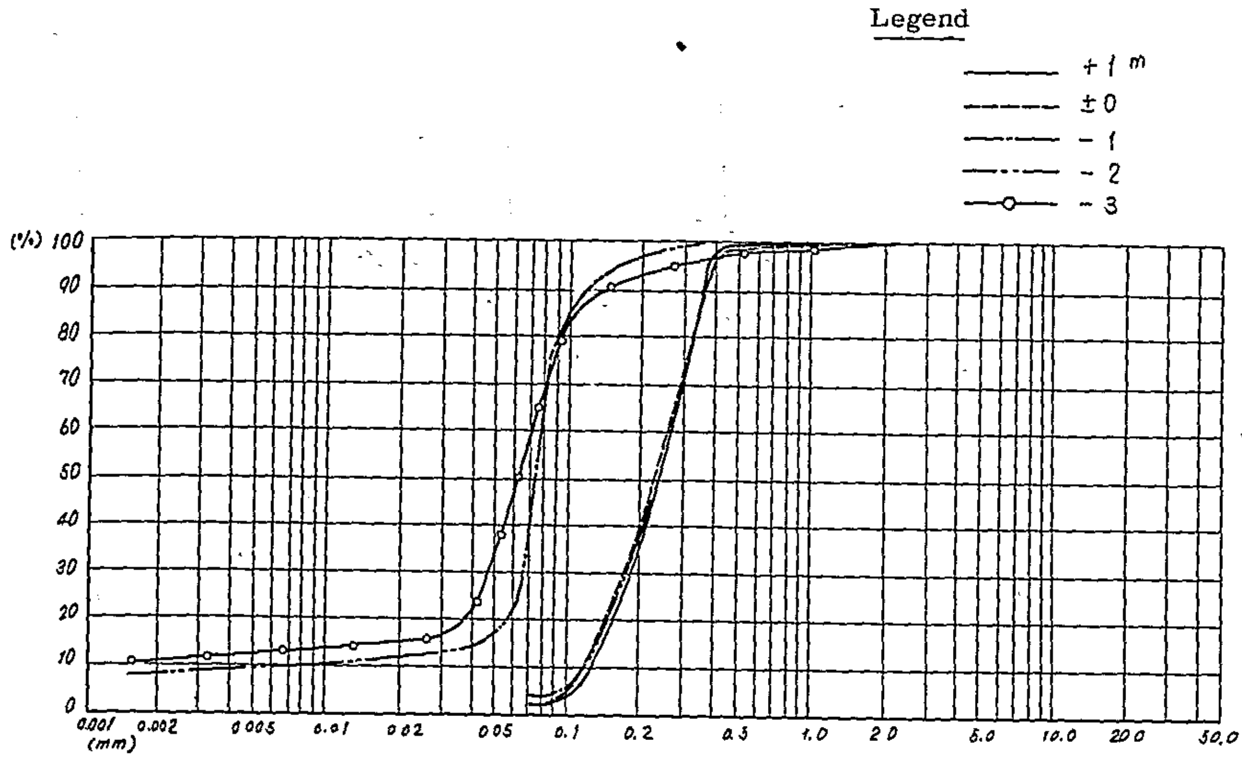


Fig. 4-A Grain Size distribution on Survey Line D

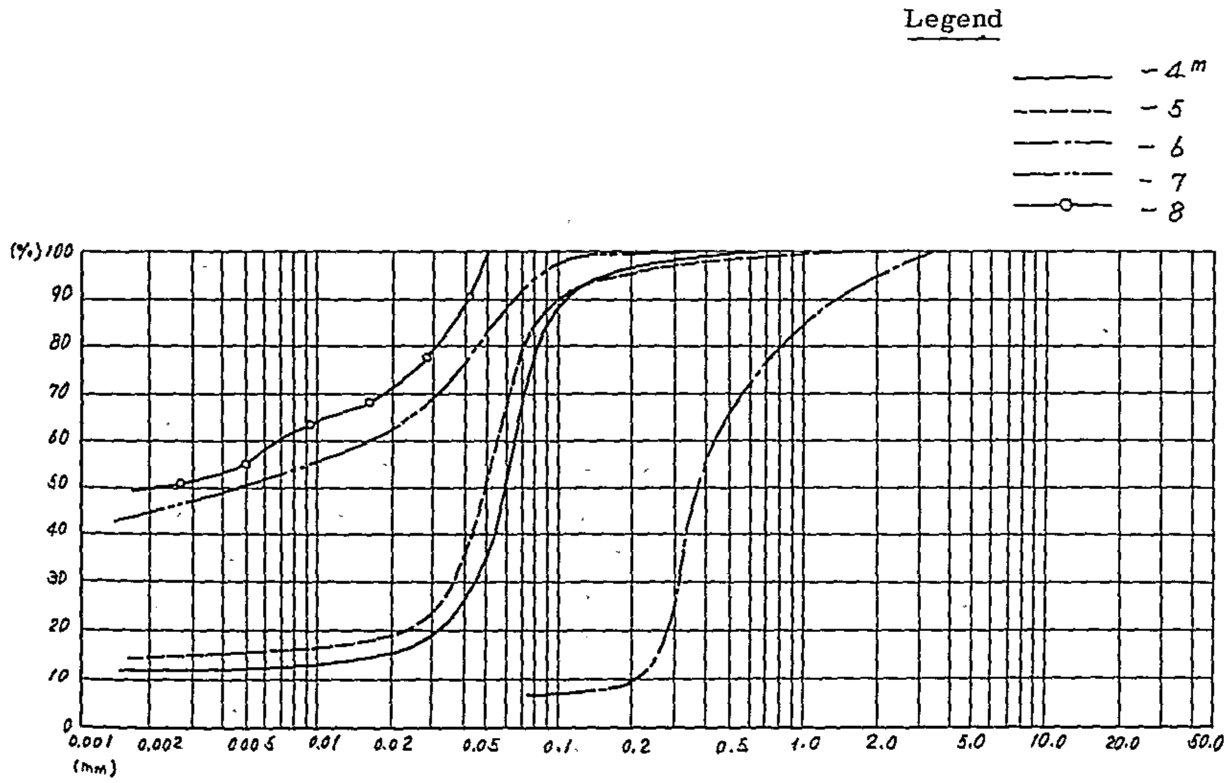


Fig. 4-B Grain Size Distribution on Survey Line D

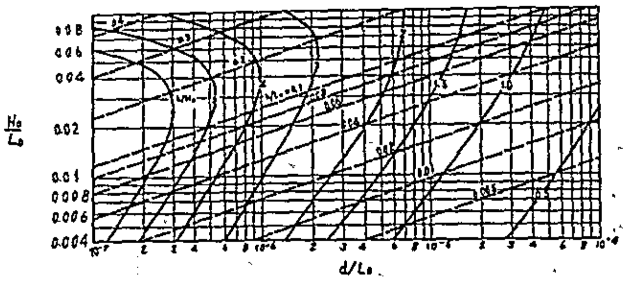


Fig. 5 Nomogramme for Obtaining Critical Depth Showing Conspicuous Movement

No. 1 d_{50} = 500 μ

No. 2 d_{50} = less than 5 μ

No. 3 d_{50} = 100 μ

No. 4 d_{50} = 50 μ

No. 5 d_{50} = 50 μ

The critical tractive force for bed material having a mean diameter of 100 is calculated below.

Kurihara's formula: $U_c^{*2} = \{-76.0 \log_{10} (1.18d) - 37.2\} d$

Iwagaki's formula: $U_c^{*2} = 8.41 d^{11/32}$

where, U_c^{*2} =

τ_c : Tractive force.

ρ : Density of water

d : Mean diameter of bed material

Values of τ_c obtained from the above two formula are as follows.

τ_c : 1.1 dyne/cm^2

τ_c : 1.7 dyne/cm^2

Judging from the data of boring work conducted for siol survey, the mean diameter of bed material in the outer sea navigation channel and lake channel will become smaller than 100 except at Station No. 1 of the navigation channel is dredged to a depth of -8.0 m. Therefore, = 1.5 dyne/cm^2 will suffice.

6. An attempt to maintain the water depth by the flushing effect proves successful in many cases if the tractive force is less than 5 times the critical tractive force. Since = 1.5 dyne/cm^2 as stated in the preceding item, the required tractive force is -

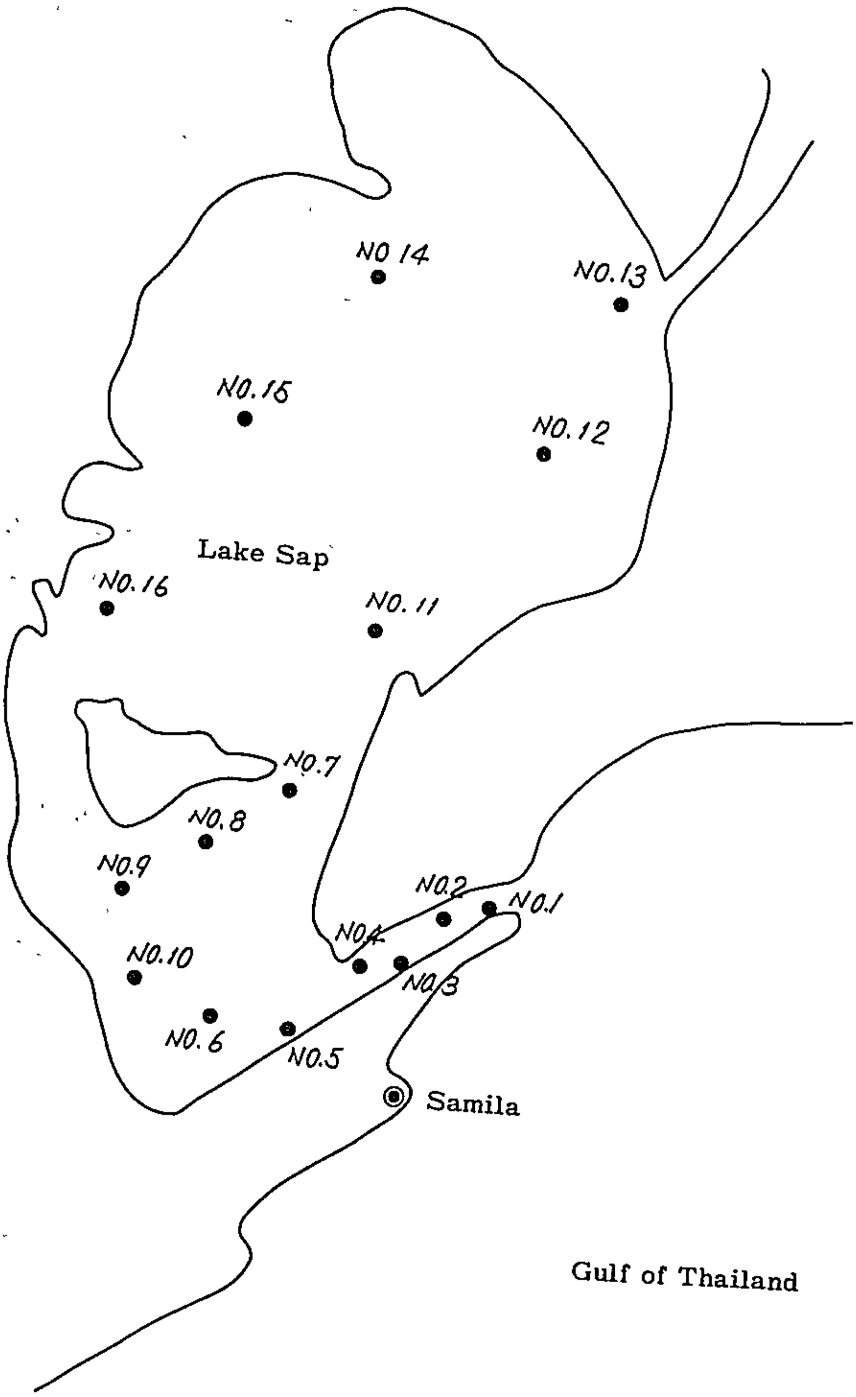


Fig. 6 Bottom Material Sampling Points at Lake Sap

= 10 = 15 dyne/cm^2

Tractive force is expressed by the following equation.

= f. U. U

where,

: Density of water

f : Resistance coefficient (non-dimensional)

U : Flow velocity uniform in the vertical direction.

The value of f is expressed by the following equation.

$f = g.n^2/h^{1/3}$ (Unit: m-sec)

where,

g : Gravitational acceleration.

n : Manning's roughness coefficient.

h : Water depth.

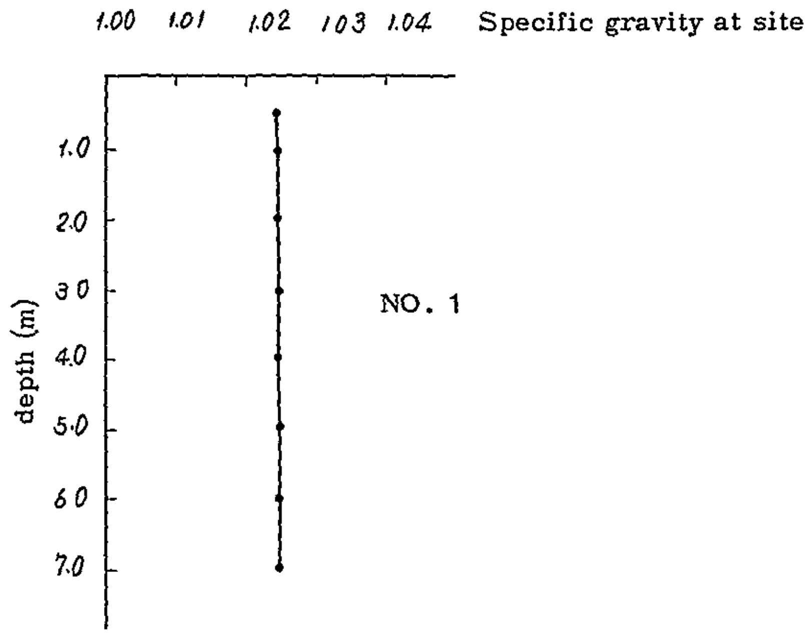
If calculation is to be worked out without regard to curves in the channel, n = 0.020 - 0.025 is taken as in the case of river mouth and h = 9.0 m in view of the mean water level. To obtain a tractive force of = 15 dyne/cm^2, the following value is required of U.

U = 70 - 90 cm/sec

7. The flow observation made at Stations 1 and 3 shown in Fig. 6 disclosed that the specific gravity of water measured at each place is uniform in the vertical direction as shown in Fig. 7. Further, the survey data of Songkhla Fisheries Experiment Station show that the density of water is gradually reduced towards the inner part of the lake. From these facts, the lake channel can be judged to constitute a density current of strong mixing type which, unlike a two-layered flow, produces a large flow velocity that works on the bottom.

Figs. 8 and 9 respectively show the flow velocity measured at spring tide on October 30, 1971 and at neap tide on October 11, 1971 at Station No. 1. Figs. 10 and 11 show the values measured on October 1 and 10 of the same year at Station 3. The values shown in Fig.10 and 11 were measured at a point closer to the right bank side from the centre line of the stream.

Under Plan A, it is envisaged that -8.0 m quay wall will be constructed between Station No. 1 and No. 3. The flow is expected to change by a number of construction works scheduled for Sub-stages I and II including the dredging of the navigation channel to a depth of



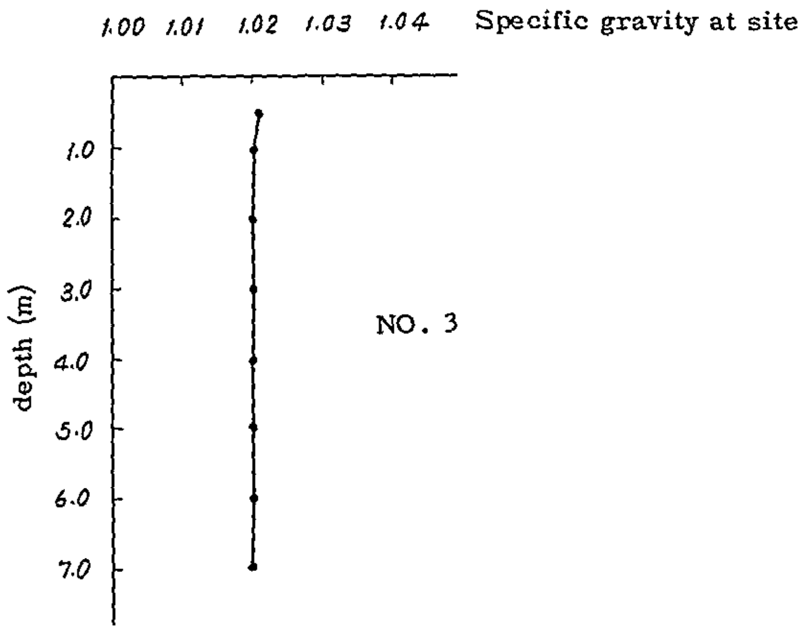


Fig. 7 Specific Gravity Distribution of Seawater in the Vertical Direction

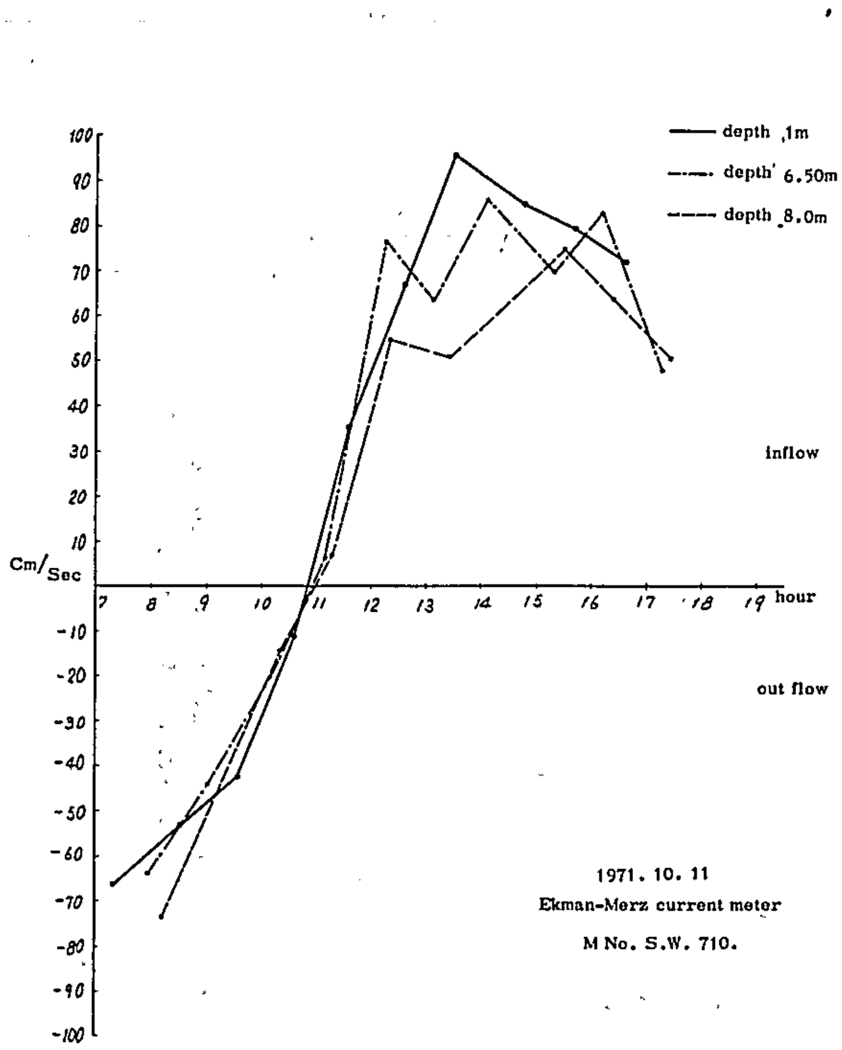


Fig. 9 Flow Velocity at No. 1 at Neap Tide

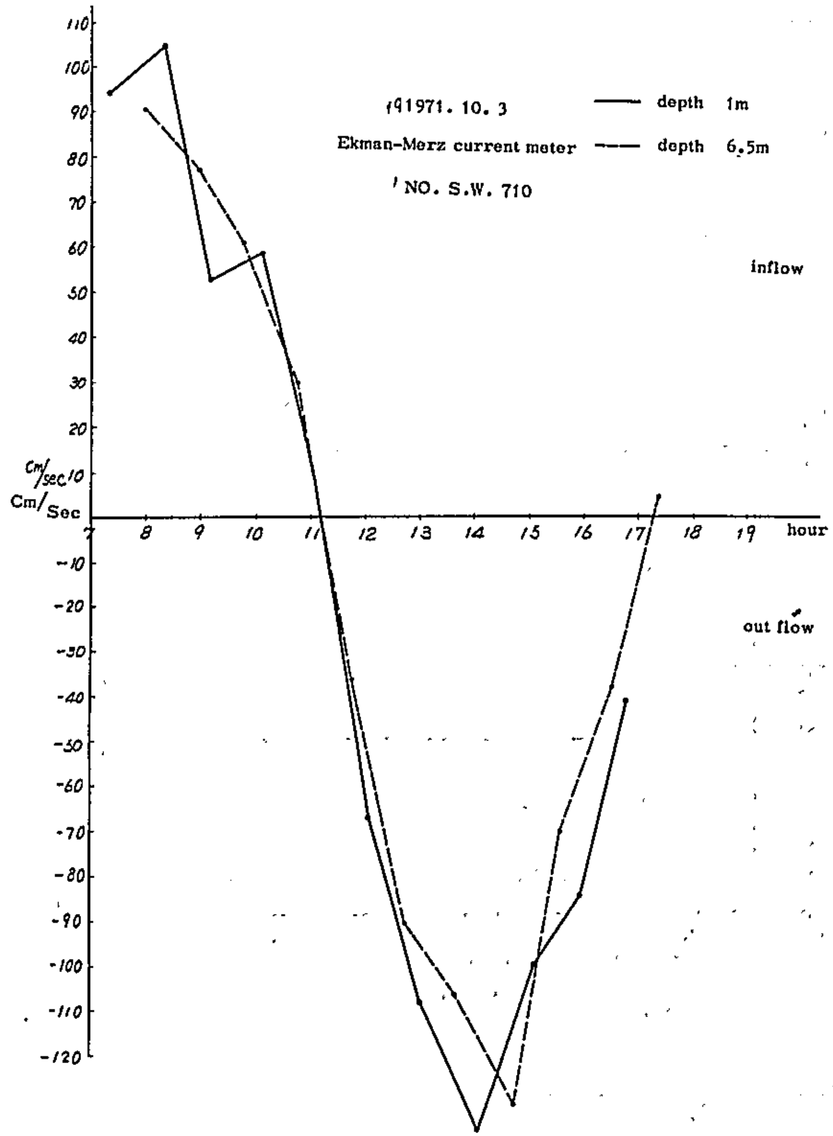


Fig. 8 Flow Velocity at No. 1 at Spring Tide

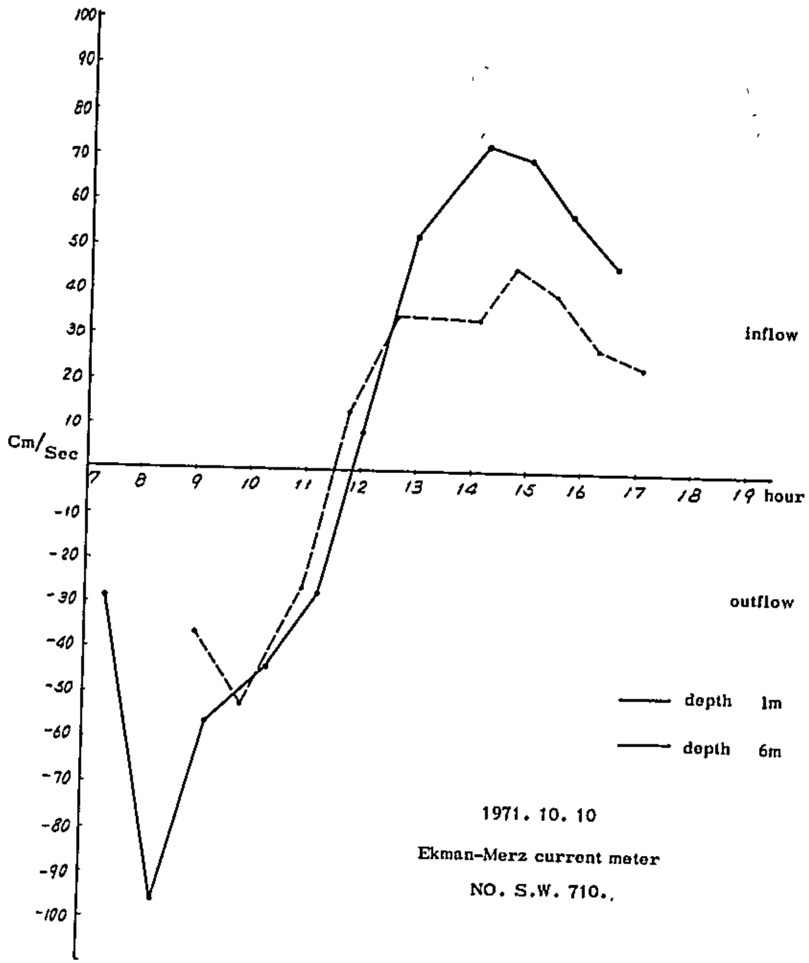


Fig. 11 Flow Velocity at No. 3 at Neap Tide

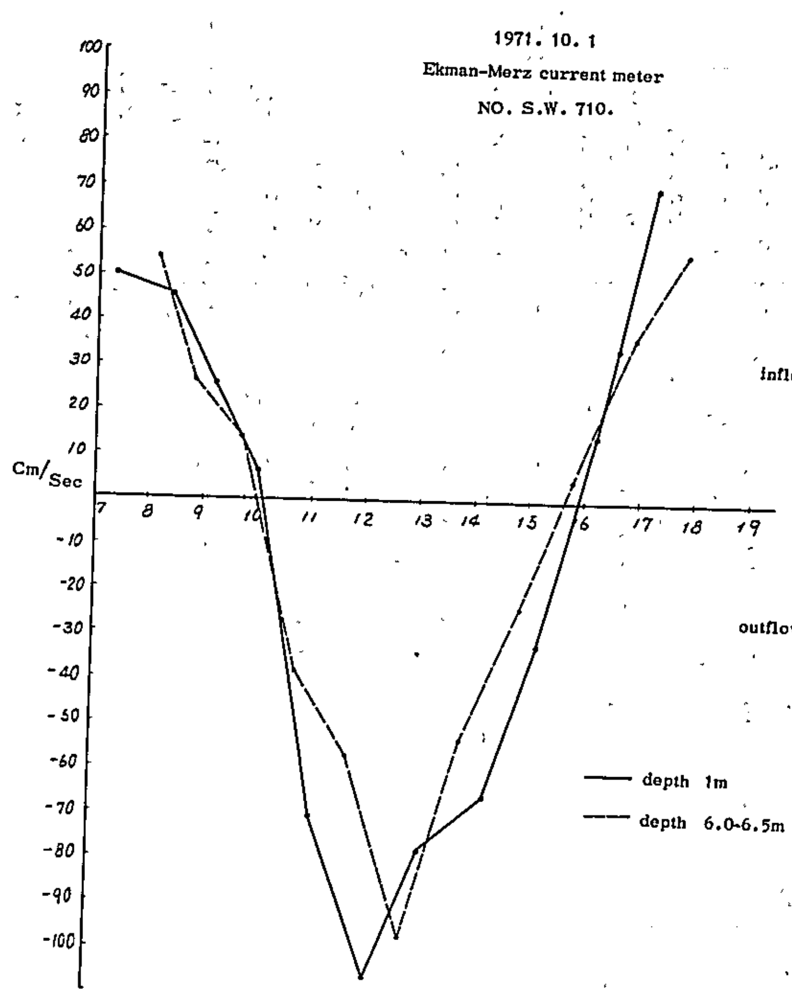


Fig. 10 Flow Velocity at No. 3 at Spring Tide

-8.0 m, extension of breakwaters, new construction of the training dike, etc. However, there will not be any large change in the flow velocity because the increase in the flow resistance resulting from the curved channel and the increase in the water depth by dredging can be expected to be counterbalanced by the eventual improvement of channel course and removal of bars in front of the lake outlet. It is accordingly estimated that a velocity of 70 – 90 cm/sec can be maintained from the navigation channel in the outer sea area to the vicinity of the -8.0 m quay wall. It is to be noted, however, that the velocity will not reach this value near the quay wall at neap tide when the velocity at Station No. 3 becomes small as shown in Fig. 11. Nevertheless, saltation will not take place because the sediment discharged from the lake inside is smaller than 50 μ in grain size.

8. Curves in the channel develop the secondary current which produces helical flow. Factors affecting such flow are the angle of curve (θ), radius of curvature of the ecntre line of the stream (r_c), river width (W), width of river bed (b), and water depth (y_0).

Curved flow causes changes to the tractive force imposed on the channel bottom. In Fig.12 showing the results of model test, $\bar{\tau}_0$ denotes the tractive force before the curve and τ_0 the local tractive force of curved flow. The model test was made under the following conditions.

$\theta = 60^\circ$
$b/r_c = 0.42$
$W/r_c = 0.6$
$W/y_0 = 12$

In the case of Songkhla port, values of these factors in Sub-stage II differ from those adopted for the model test as shown below, but they serve to indicate the aspect of tractive force.

$\theta = 70^\circ$
$b/r_c = 0.5$
$W/r_c = 0.53$
$W/y_0 = 33$

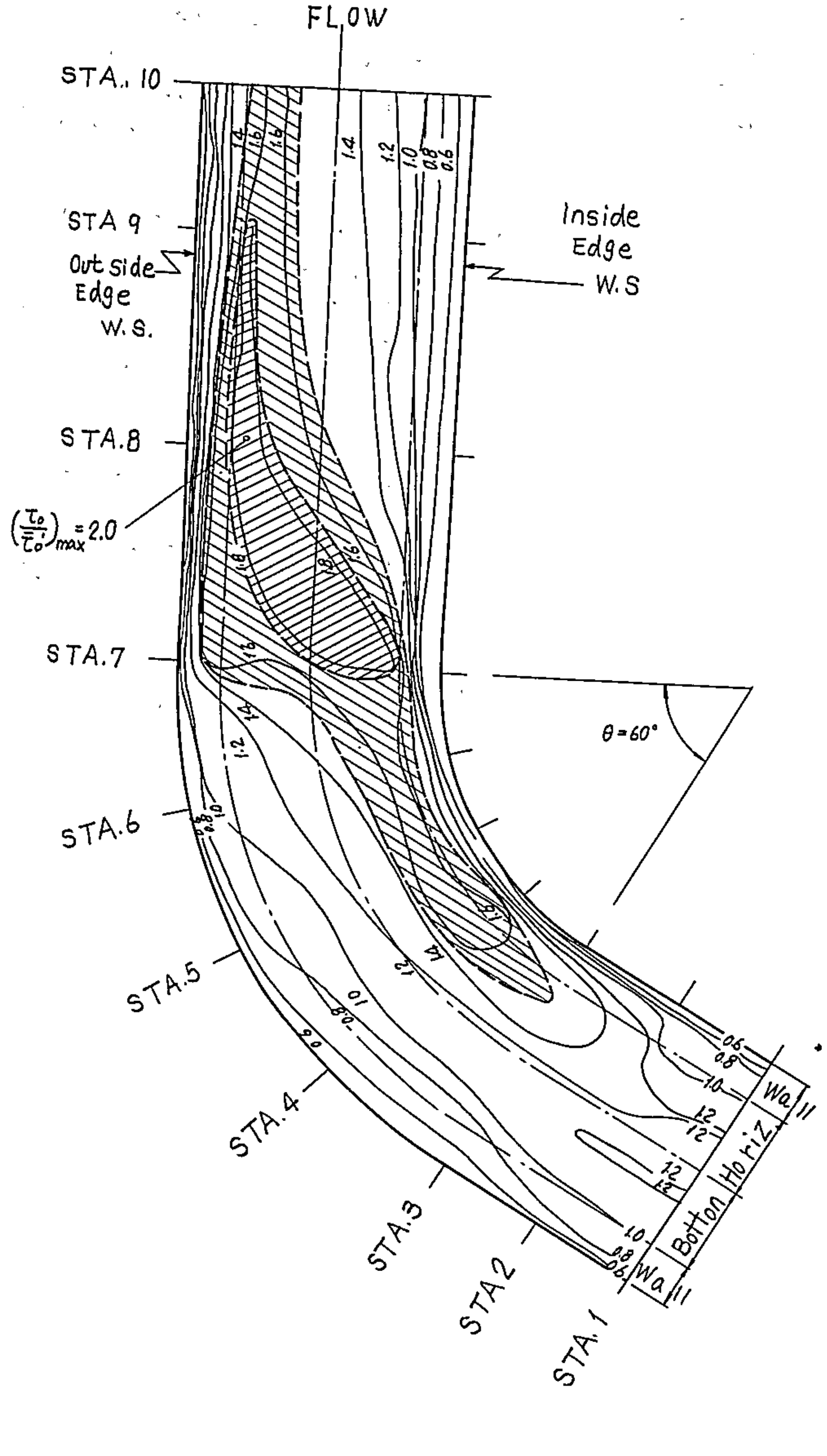


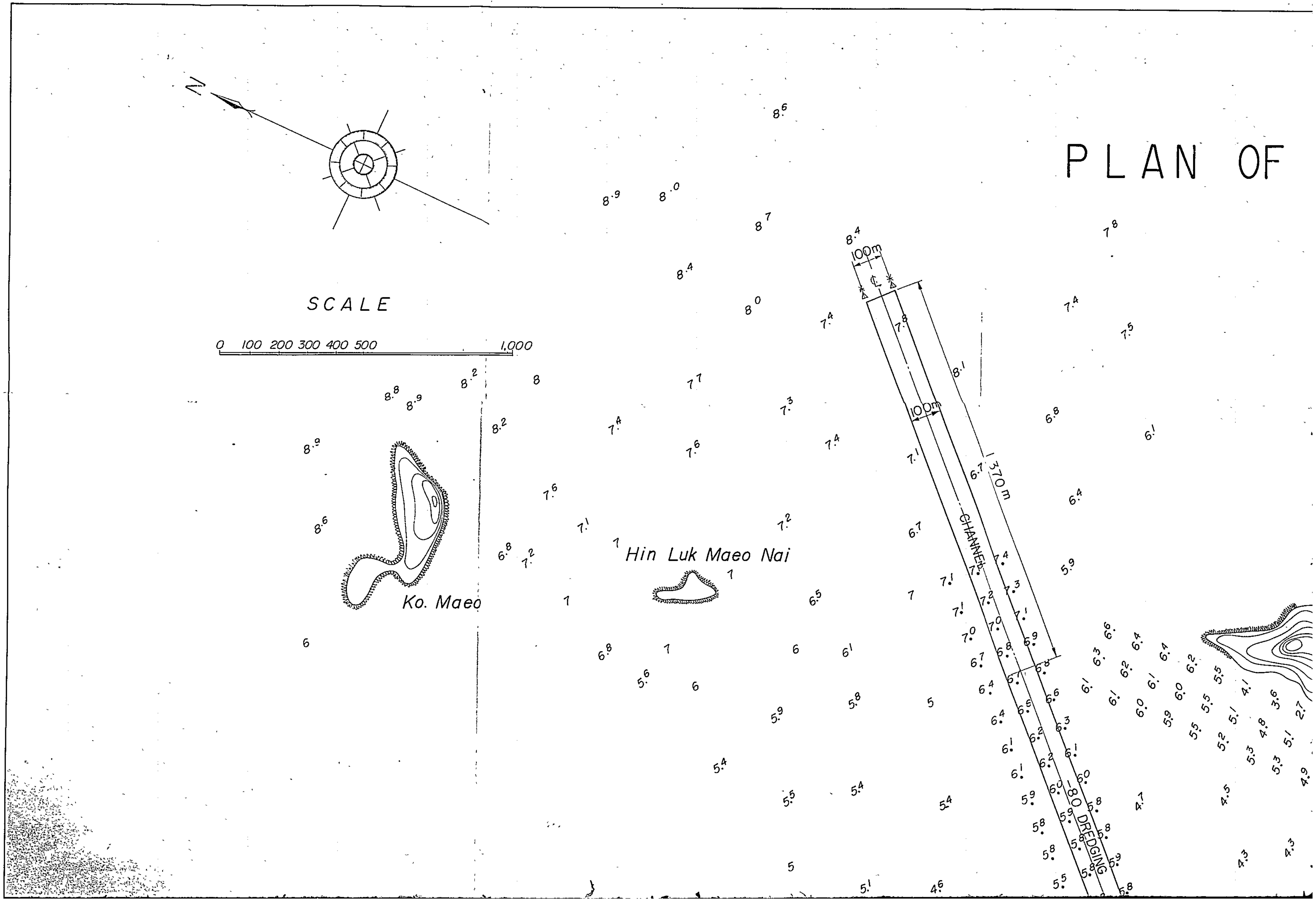
Fig. 12 Trative Force of Curved Flow

It must be taken into account that in the downstream section, the tractive force increases by more than 50% from the centre line towards the left bank and by about 2 times just besides the left bank. Therefore, foot protection of the training dike should be worked our with prudent care.

Inflow from the outer sea area, on the other hand, will result in the increase in the tractive force on the opposite side of the -8.0 m quay wall. Though this will destroy the dredged side slope of the navigation channel, remedy can be brought about by natural traction since the mean diameter of bottom material is less than 50 as observed at Stations 2 and 4.

9. From the studies made in the foregoing pages, it is considered possible to maintain the navigation channel at a depth of -8.0 m through the flushing effect and interception of drift sand that can be expected from the extension of breakwaters and training dike having a channel width of 300 m which is the same as the width of Station No.1.

It is evident, however, that the offshore navigation channel will be silted up by the sediment load of small siameter from the lake or littoral drift. Maintenance dredging in this part of the navigation channel must therefore be carried on uninterruptedly.


PLAN OF
N
SCALE
0 100 200 300 400 500 1,000
Ko. Maeo
Hin Luk Maeo Nai
100m
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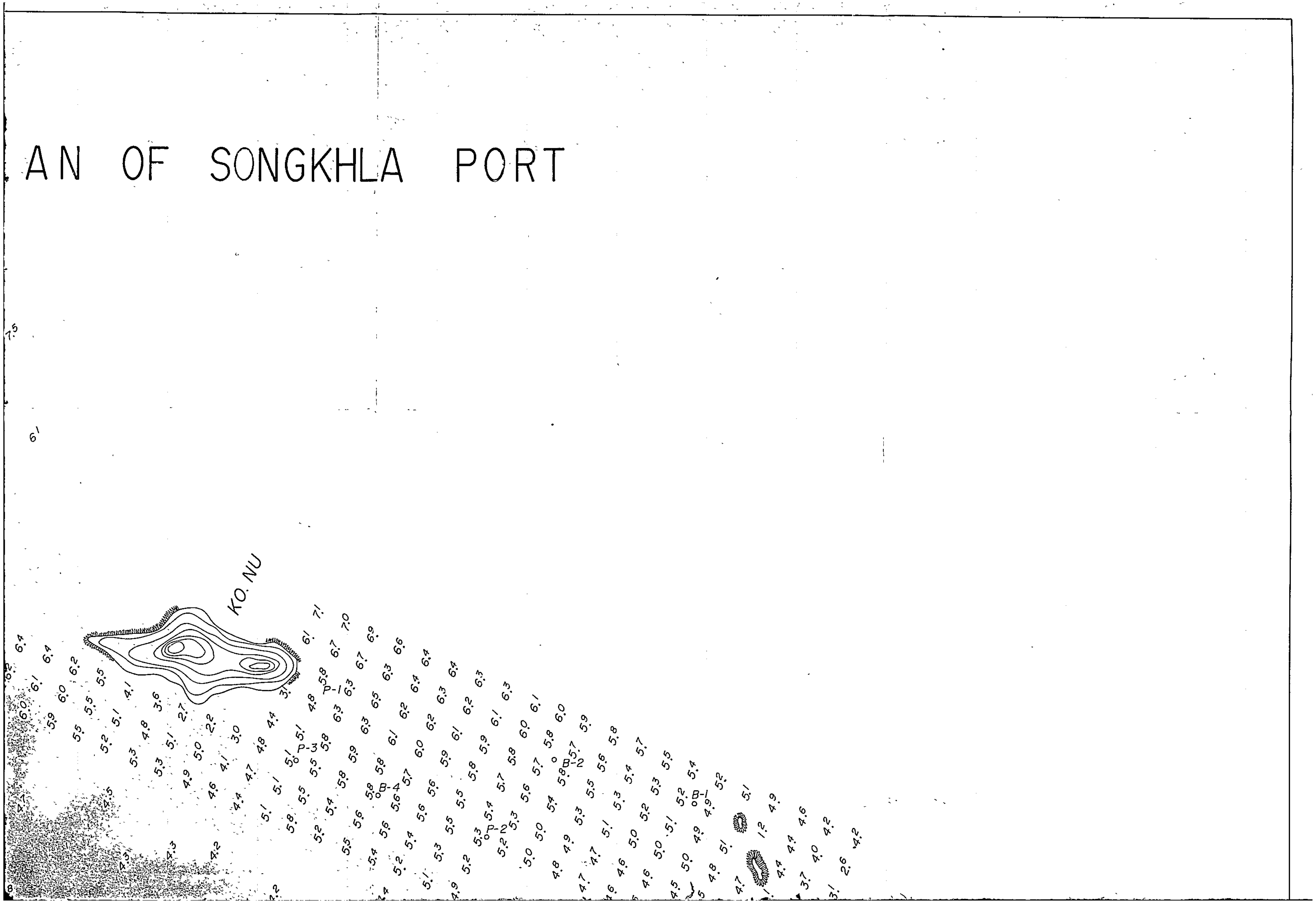
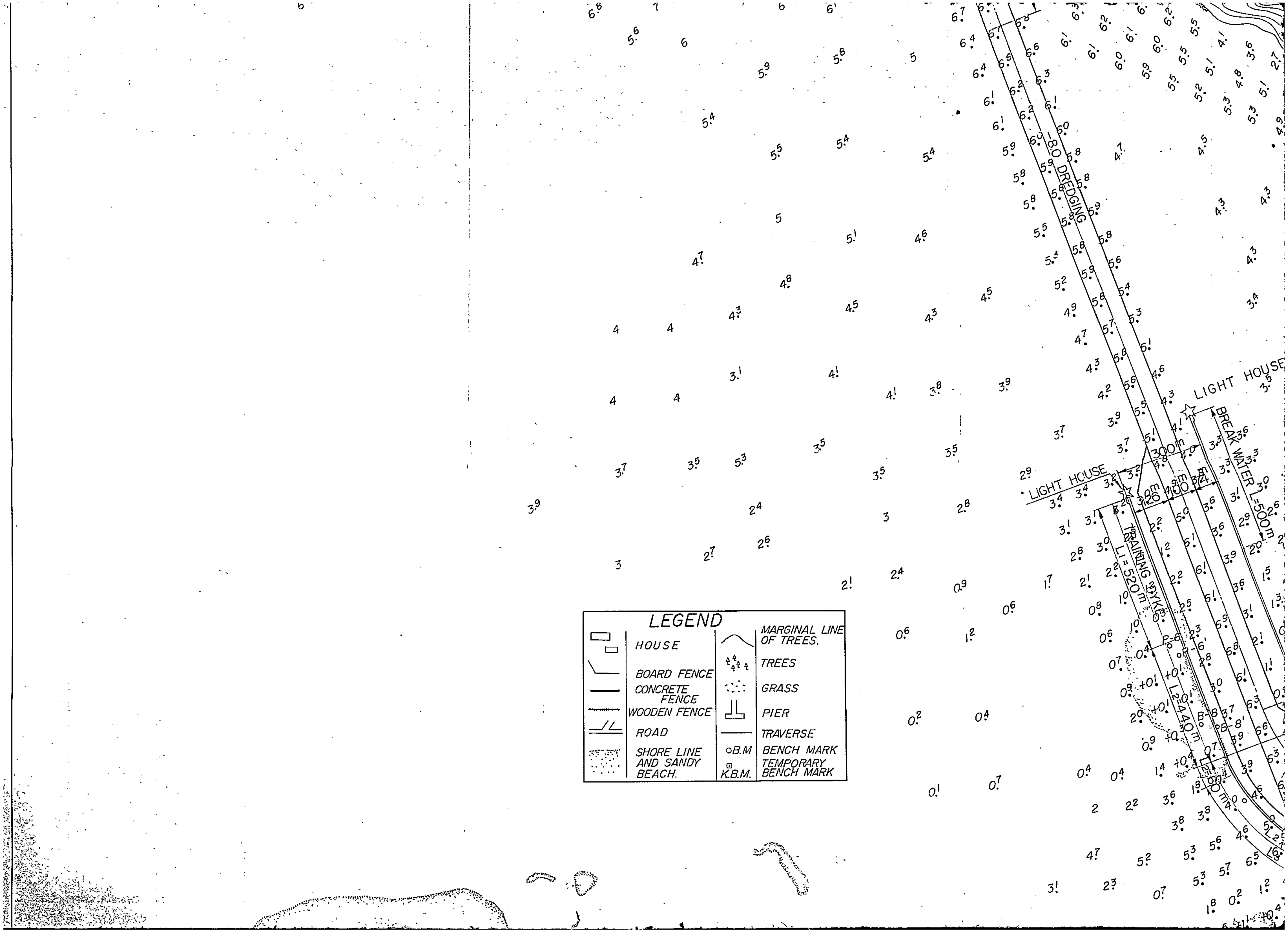
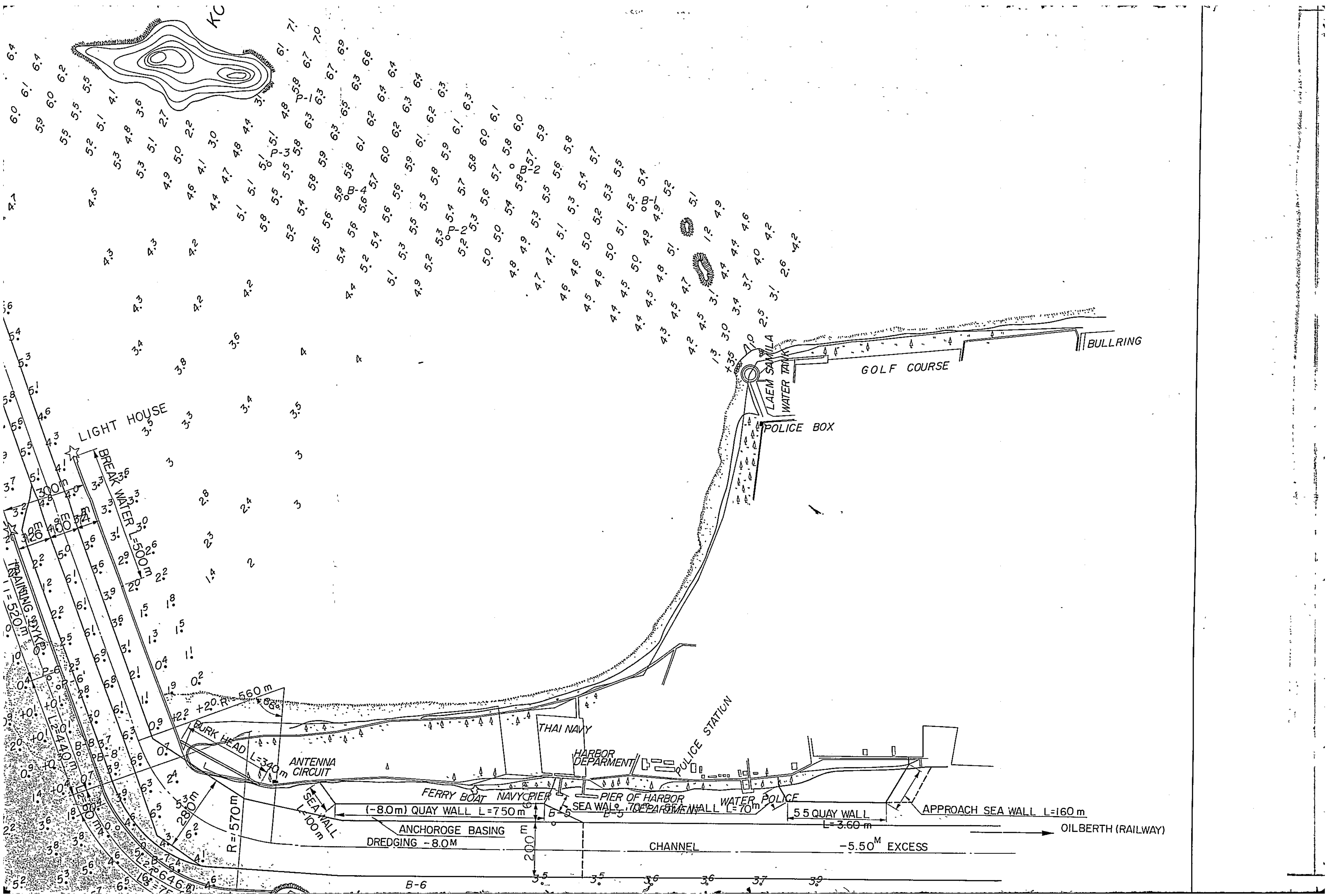
1370m
CHANNEL
-8.0 DREDGING


AN OF SONGKHLA PORT
KO. NU
P-1
P-2
P-3
B-1
B-2
B-4


-8.0 DREDGING
LIGHT HOUSE
LIGHT HOUSE
BREAK WATER L=500m
TRAINING DYKE
L1=520m
L2=440m
300m
LEGEND
HOUSE
BOARD FENCE
CONCRETE FENCE
WOODEN FENCE
ROAD
SHORE LINE AND SANDY BEACH.
MARGINAL LINE OF TREES.
TREES
GRASS
PIER
TRAVERSE
B.M BENCH MARK
K.B.M. TEMPORARY BENCH MARK



LIGHT HOUSE
BREAK WATER L=500m
TRAINING DYKE
L=520m
300m
R=560m
R=570m
280m
BURK HEAD L=340m
ANTENNA CIRCUIT
SEA WALL L=100m
FERRY BOAT
NAVY PIER
THAI NAVY
HARBOR DEPARMENT
POLICE STATION
PIER OF HARBOR DEPARMENT
SEA WALL L=70m
WATER POLICE
(-8.0m) QUAY WALL L=750m
5.5 QUAY WALL L=360m
APPROACH SEA WALL L=160m
ANCHOROGE BASING
DREDGING -8.0M
CHANNEL
-5.50M EXCESS
200m
OILBERTH (RAILWAY)
B-6
LAEM SAMILA
WATER TANK
POLICE BOX
GOLF COURSE
BULLRING
P-1
P-2
P-3
B-1
B-2
B-4

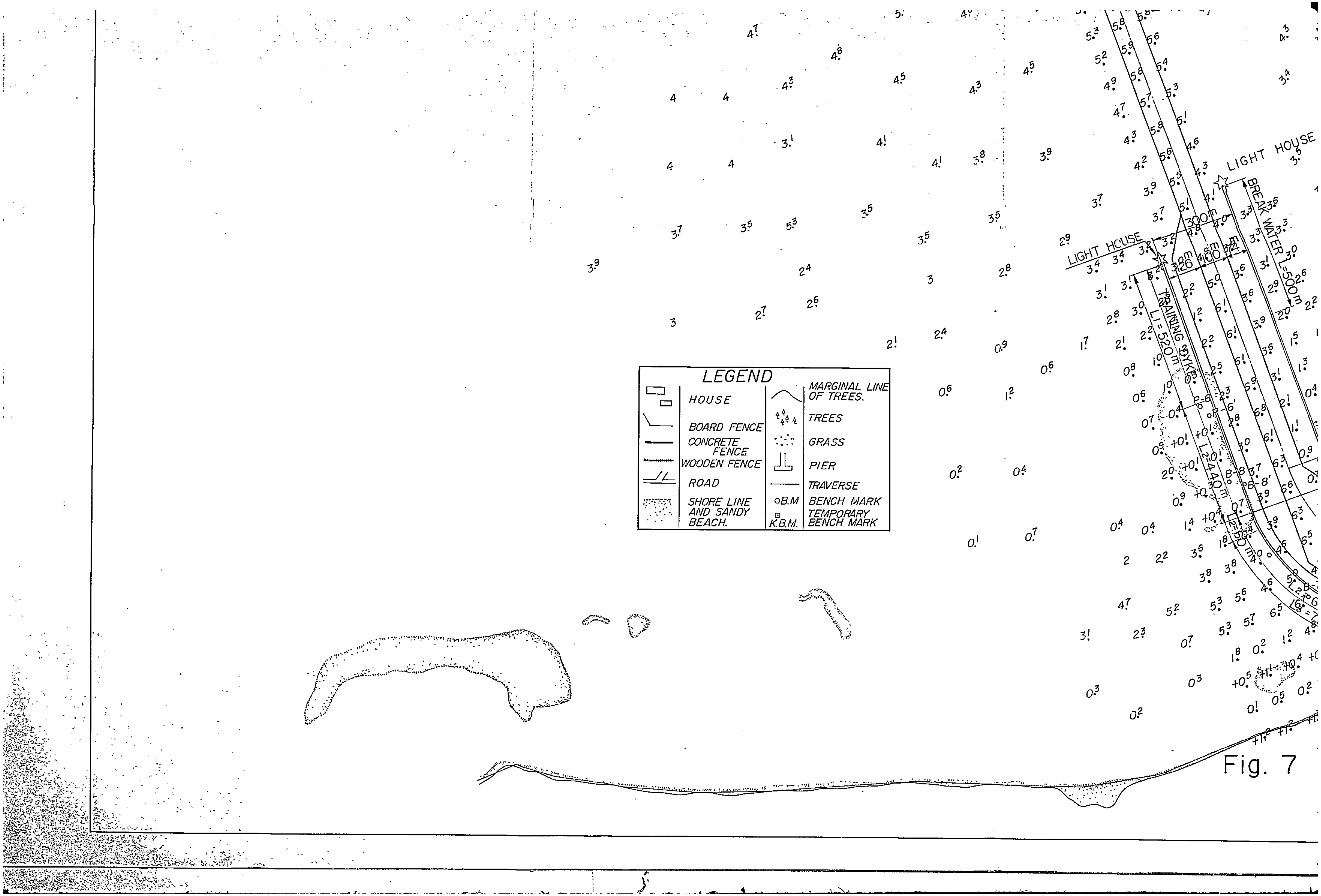

LEGEND
HOUSE
BOARD FENCE
CONCRETE FENCE
WOODEN FENCE
ROAD
SHORE LINE AND SANDY BEACH.
MARGINAL LINE OF TREES.
TREES
GRASS
PIER
TRAVERSE
B.M BENCH MARK
K.B.M. TEMPORARY BENCH MARK
LIGHT HOUSE
LIGHT HOUSE
BREAK WATER L=500m
TRAINING DYKE
L1=520m
L2=440m
300m

Fig. 7

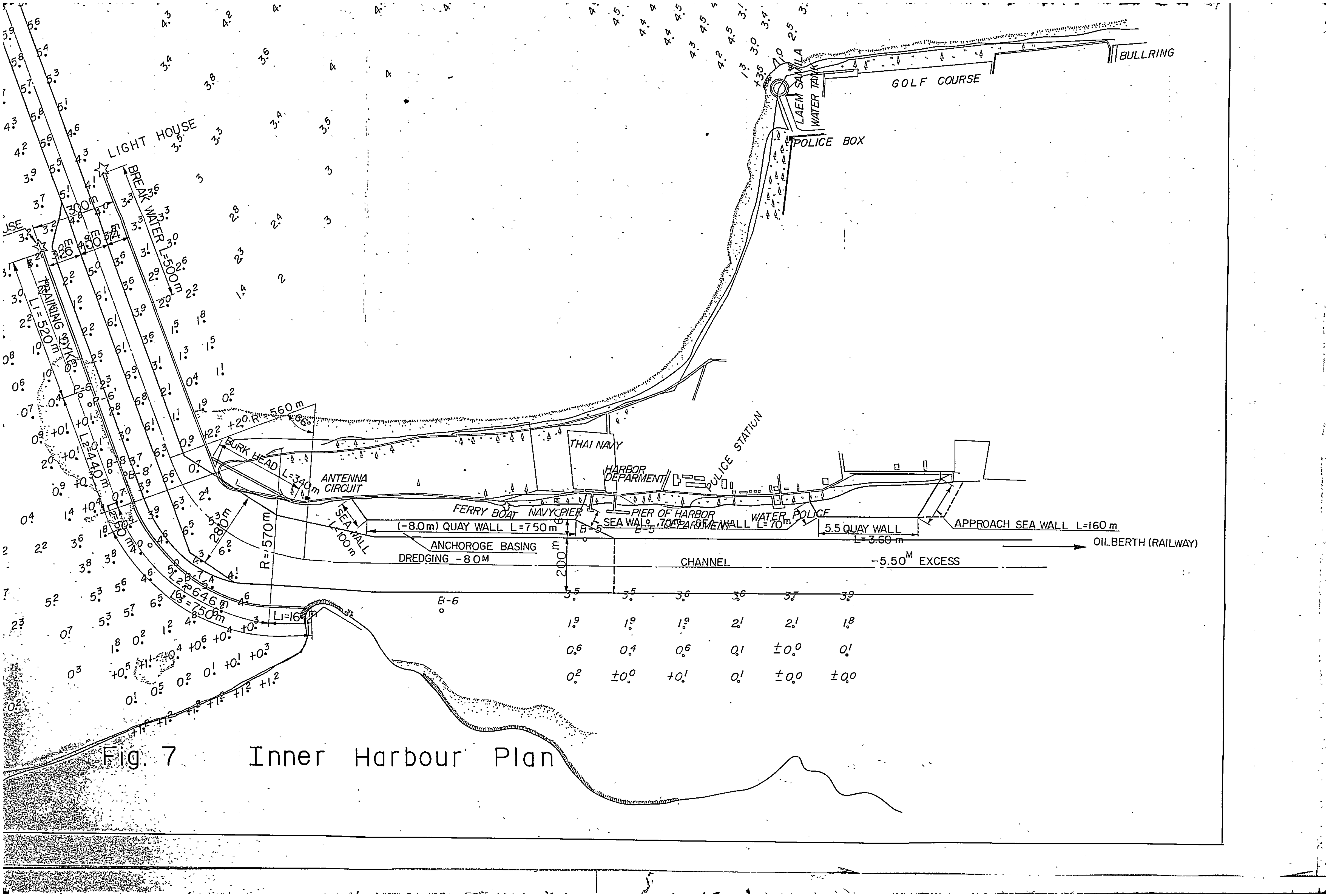


Fig. 7 Inner Harbour Plan