Abbreviations

A	
AADT	Average Annual Daily Traffic
ADI	Alternating Direction Implicit
B	
B/C	Benefit over Cost
BKK	Bangkok
C	
CCF	Consumption Conversion Factor
CDC	Coastal Dredging Center
CDMD	Coastal Dredging and Maintenance Division
CFC	Conversion Factor for Consumption
COD	Chemical Oxygen Demand
CTI	Chaophaya International Terminal Co., Ltd.
D	
DWT	Dead Weight Tonnage
E	
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
F	
FIRR	Financial Internal Rate of Return
ft.	foot/feet
G	
GDP	Gross Domestic Products
GOJ	Government of Japan
GPP	Gross Provincial Products
GRDP	Gross Regional Domestic Products
GRT	Gross Registered Tonnage
H	
HD	Harbour Department
HWL	Highest Water Level

I

IBRD	International Bank for Reconstruction and Development
IEAT	Industrial Estate Authority of Thailand
IEE	Initial Environmental Examination
IUCN	International Union for Conservation of Nature and Natural Resources
IVI	Important Value Index

J

JICA	Japan International Cooperation Agency
JBIC	Japan Bank for International Cooperation

L

LOA	Length Over All
LCP	Laem Chabang Port
LLW	Lowest Low Water

N

NESDB	National Economic and Social Development Board
NPV	Net Present Value

M

MOTC	Ministry of Transport and Communications
MSL	Mean Sea Level

N

NESDB	National Economic and Social Development Board
NPV	Net Present Value

O

O/D	Origin and Destination
ODA	Official Development Assistance
OEPP	Office of Environmental Policy and Planning
OMPC	Office of the Maritime Promotion Commission

P

PAT	Port Authority of Thailand
PDS	Position Detection System
PPP	Public and Private Partnership
PTT	Petroleum Authority of Thailand

R

Ro/Ro	Roll-on/Roll-off
RPM	Revolution Per Minute
RTG	Royal Thai Government

S

SCF	Standard Conversion Factor
SRT	State Railway of Thailand

T

TDRI	Thailand Development Research Institute
TEU	Twenty-foot Equivalent Unit
TSA	Thai Ship Owner’s Association

V

VAT	Value Added Tax

Final Report (Summary)
Contents

EXECUTIVE SUMMARY

Executive Summary

The Master Plan Study
for The Coastal Channels and Ports Development in The Kingdom of Thailand

(January 2001 – March 2002)

1. Background and Objectives

Development of regional economies is one of the major strategies under the implementation of the 8th National Economic and Social Development Plan in Thailand. The development of the coastal transport networks including the establishment of an effective planning for the coastal channels and ports is consistent with the region's urban-industrial development.

In order to promote the social and economic development in the Southern Seaboard, Royal Thai Government has given priority to the arrangement of economic infrastructures.

In the meantime, although Harbour Department is continuing the nationwide maintenance dredging operation year by year, the siltation problems at the coastal ports and channels also remain in a serious situation to have effect on the regional development and the coastal shipping development.

In recognition of the background mentioned above, the objectives of the Study are set forth as follows:

(1) To formulate a master plan for the channels and ports development and their maintenance/management plan including comprehensive dredging management plan up to the year 2020
(2) To formulate a short-term development plan and conduct a feasibility study for the selected channels and ports up to the year 2010
(3) To transfer the technology to HD through study activities.

2. Implementation of Study

The Study implemented the following surveys to formulate a master plan for the channels and ports development, and their maintenance/management plan including comprehensive dredging management plan in the southern coast on the Gulf of Thailand.

- Dredging and maintenance/management condition survey, socio-economic data collection, review and analysis of coastal shipping and existing master plans
- Discussions about promotion measures for the coastal shipping with Office of Maritime Promotion Commission (OMPC) and its consultants to confirm the government policies
- At Sichon, Sakom and Thepha, sand drift condition survey conducted in predominant season of sand drift for analyses of channel siltation and sedimentation

- Environmental conditions survey conducted for formulation of a implementation plan with environmental preservation strategy

Through analyzing and examining of above surveys, the master plan was formulated in priority coastal channels. Based on a selection criteria, Sichon channel, Songkhla channel and Bang Ra Pha channel were selected for the feasibility study. After the natural and environmental condition surveys had been conducted in three channels, the feasibility was examined by economic and financial analyses, and by an environmental impact assessment on the short-term development plans.

3. Conclusions

3-1 Major Findings on Coastal Channels and Maintenance Dredging

- The cutter suction dredgers consist of C-1, C-25, C-37 and C-39. Among them, C-25 and C-37 are designed for excavation at much deeper depths than the channels CDC II is currently maintaining. They are also designed for discharging at much longer distances than the actual operation. Coastal Dredging and Maintenance Division control six trailing suction dredgers (hopper dredgers) and assign them for channel maintenance. In 2001, H-4, H-8, H-10 and H-12 were engaged in maintenance dredging of CDC II channels, mostly Songkhla channel, during the site survey. As far as the observation of H-10 and H-12 hopper dredgers, they are mostly engaged in traveling so that excavation time is too short. Consequently, the dredging output is very small.

- According to “Annual Implementation Report” for fiscal years from 1996 to 2000, the expenses for the maintenance dredging of CDC II channels are allocated as follows: Pak Phanang (53%), Songkhla (22%), Pattani (6%) and other channels (19%). The three major channels required 81% of the spending and other channels consisting of 27 navigation channels and 14 irrigation channels consumed only 19%. In terms of volume, the three major channels share of the total was: 16% Pak Phanang, 51% Songkhla and 6% Pattani. The other 41 channels share only 27%.

3-2 Bottlenecks on Coastal Channels and Maintenance Dredging

- Songkhla: The navigation channel is much shallower than the design depth. The water depth at the quay wall is very shallow (-5 m) in comparison with the design depth of -9 m.
- Pak Phanang: Siltation is heavy and shallow not in the river but in the sea. Dredging in the 27km long channel was conducted almost every year. The navigation channel is shallower than the design depth (-4m).
- Pattani: The present depth for Pattani is -3m against the design depth (-5m). The depth of navigational channel must be maintained to accommodate many large fishing boats.
- Sichon: The single jetty channel is not sufficient to protect the channel from becoming shallow.

- Dual jetty channels: The dual jetties do protect the channel from becoming shallow. Beach erosion is serious on the down stream side of littoral drift.
- No jetty channels: Backhoes are used for maintenance dredging, when channels are aggravated heavy sedimentation.

3-3 Coastal Changes Analyses

- The JICA Study Team conducted bathymetric and shoreline survey at Bang Ra Pha and compared the survey results with the topography in 1996. The deposition on the upstream side of the littoral drift is estimated 45,000 m^3 per year and erosion on the downstream side is estimated 32,000 m^3 per year.
- N-line Model Analysis on the shoreline changes that the team conducted resulted in the estimated rate of littoral transport as Sichon: 2.5 x 10^4 m^3 per year, Sakom: 1.1 x 10^5 m^3 per year and Thepha: 1.0 x 10^5 m^3 per year.

3-4 Cargo Demand at Songkhla Port

- The general cargo demand for the short-term development in 2010 is forecast from 433,000 to 528,000 tons. Since the private coastal shipping berths on the Songkhla Lake are capable of handling only up to 350,000 tons per year and the expansion of private piers is prohibited, one new general cargo berth is required to handle the excess cargoes.

- The forecast for general cargoes to be transported by truck in 2010 between the Study Area ((Songkhla, Pattani and Narthiwat provinces) and Eastern Seaboard (Laem Chabang Port, Map Ta Phut Port) is about 297,000 tons. On the assumption that about half of the cargoes can be shifted from the road to coastal transport, Ro/Ro ships would transport 150,000 tons in 2010. One Ro/Ro berth is, therefore, included in the short-term development of Songkhla Port

3-5 Master Plan

3-5-1 Short-term Development

The JICA Study team recommends 12 projects to be implemented as short-term development. Only two channels should be provided with facilities related to the coastal shipping, namely Sichon and Songkhla. For Sichon, an additional jetty and light beacons should be provided. For Songkhla, a coastal shipping terminal having one coastal berth and one Ro/Ro berth should be constructed. More works on shore protection works should be provided for the channels protected by dual jetties. Sand bypassing should be implemented at three channels: namely, Bang Ra Pha, Tanyong Pao and Panare. Total cost for the short-term development including sand bypassing, but excluding engineering fee, physical contingency and VAT is estimated at about 633.3 million Baht.

3-5-2 Long-term Development

The JICA Study team recommends 10 projects to be implemented as long-term development. For

Songkhla, the coastal shipping terminal should be expanded to have one each of additional berths of both coastal and Ro/Ro. Sand bypassing should be implemented at 10 channels: namely, Songkhla, Na Thap, Sakom, Thepha, Bang Ra Pha, Tanyong Pao, Panare, Bang Maruat, Sai Buri and Narathiwat. Total cost for the long-term development including sand bypassing, but excluding engineering fee, physical contingency and VAT is estimated at about 481.5 million Baht

3-5-3 Site Selection of Coastal Shipping Facilities at Songkhla

The site for the coastal shipping facilities is planned adjoining to the exiting international container terminal (Chaophaya Terminal International Co., Ltd., CTI) on its east side along the navigation channel to the lake. The main reasons for the selection are to avoid the expansion area for the international container terminal and the archaeological preservation area, and to minimize the maintenance dredging for the new berths.

The following facilities are to be provided as short-term development:

- Coastal shipping berth (130 m and 7.5 m deep)
- Ro/Ro berth (150 m long and 6.5m deep) equipped with Movable Bridge
- Transit shed (2,700 m^2 floor), Administration Bldg. (600 m^2 floor)
- Open Yard (7,050 m^2), Parking lots (7,500 m^2), Access Road, Access Bridge, Gate, Utilities

The total project cost is about 420 million Baht and construction will take about four years.

3-5-4 Short-term Development in Sichon Channel

The existing single jetty was constructed in 1996. Since then, sediment deposit has taken place near the jetty and the shallow seabed in the channel hampers ship maneuvering. It probably augments wave intrusion to the fishing village. One more jetty is required to prevent the channel from shoaling and protect the village from storms.

The new jetty is planned identical to the existing jetty: namely, rubble mound type of jetty in parallel to the existing one with 700m length and 4m crown elevation. Provision of four light beacons is recommended. The total project cost is about 86 million Baht and construction will take about 1.5 years.

3-5-5 Short-term Development in Bang Ra Pha Channel

The sand bypassing is more economical than the jetty extension. The extension of the jetties requires four times as many detached breakwaters as the sand bypassing. The recommended project, therefore, consists of sand bypassing of 50,000 m^3 per year and construction of four detached breakwaters. The cost for 6 years is estimated at about 48 million Baht.

3-6 Economic and Financial Analysis

3-6-1 Economic Analysis on Coastal Shipping Facilities at Songkhla Port

Economic benefits of savings in transport costs and road maintenance costs are treated as quantitative benefits. The project cost consisting of initial investment cost, operation cost and maintenance cost are converted to quantified economic costs. Based on the costs and benefits above, the economic analysis computes that the EIRR of the coastal terminal development is 22.0%; the benefit over cost ratio (B/C ratio) is 1.87; and the net present value (NPV) is 240.27 million Baht when the discount rate of 12% is taken into account. It is concluded that the coastal terminal development is worth being implemented from the viewpoint of the national economy of Thailand.

3-6-2 Financial Analysis on Coastal Shipping Facilities at Songkhla Port

Port service fee level, as a key determinant of the revenue, was assumed in such a way that a comparative advantage of port users against road users in terms of transport costs can be assured: that is, 120 Baht/ton for general and container cargos and 40 Baht/ton for Ro/Ro cargos. The cost for the operation and maintenance are estimated referring to existing port activities. Based on these assumptions, the financial analysis reveals a negative FIRR (financial internal rate of return) of -2.3% within the 25 years time horizon, meaning that the coastal terminal development could not be justified from the financial standpoint without a substantial resource involvement of the government sector through a subsidy or another form of special grant for local economy stabilization purpose. In order to make the coastal terminal development financially feasible, about 80% of the initial investment cost needs to be covered with the subsidy.

A sensitivity test also indicates that in order to obtain more than 12% FIRR, a condition with 30% revenue increase and 50% cost reduction is necessary when no subsidy components are taken into account.

3-6-3 Economic Analysis on Short-term Development in Sichon Channel

Benefits which the project will generate are savings in fuel consumption, savings in prevention of loss of marine catches due to reduction of waiting time to enter the channel, and savings in channel dredging cost. The economic analysis concludes that EIRR is 5.6%, Benefit over Cost Ratio (B/C ratio) is 0.61and Net Present Value (NPV) is -19,718 thousand Baht when the discount rate of 12% is taken into account. No financial analysis was conducted since it is obvious that navigation channel does not produce any revenue fees from the fishermen.

3-6-4 Economic Analysis on Short-term Development in Bang Ra Pha Channel

Benefits which the project will generate are the elimination of landing ships on seashore, reduction of transport time and prevention of loss of catch. As there are only 110 small fishing boats, the economic analysis concludes that EIRR is not available. Benefit over Cost Ratio (B/C ratio) is 0.16 and Net Present Value (NPV) is about -26,457 thousand Baht when the discount rate of 12% is taken into

account. No financial analysis was conducted for the same reason as Sichon Channel.

3-7 EIA on Short-term Developments

As resettlement problem is being solved in relation to the expansion of the container terminal of the Songkhla Port, it will thus solve the issue for the development of coastal shipping. Care must be taken for archeological monuments in laying out the port development plan. Regarding the improvement of Sichon channel and Bang Ra Pha channel, no serious environmental impacts are foreseen.

3-8 Recommendations on Coastal Channels and Maintenance Dredging

- **Implementation of Additional Jetty and Sand Bypass**

At Sichon channel, one more jetty is required to prevent the channel from shoaling and protect the village from storms. At every double jetty channel, deposition areas took place in the upstream side of littoral drift and erosion areas in the downstream side. The best measure to protect the navigational channels and to reduce the coastal erosion in the downstream side of littoral drift is to take a sand bypassing system in the study area.

- **Dredger Deployment Plan with Priority on Dredgers**

The dredging operation for the channel maintenance should be planned with the priority put on the equipment. In Songkhla channel, two hopper dredgers (H-10 and H-12) should be used for initial dredging (design depth -9m), and after that, one hopper dredger should be used for maintenance dredging. For maintenance of Pak Phanang channel, it is recommended to use C-25 and C-37 simultaneously.

- **Improvements on Dredging Operation and Management**

- To maintain a proper water velocity inside the discharge pipeline on dredging operation of cutter suction dredgers. To this end, providing diffuser at the end of the discharging pipeline, and/or reducing the diameter of impellers inside the dredge pumps.
- To position the cutter head at such position that the excavating face can be twice as thick as the cutter head diameter. For C-37, readjusting the front end of the ladder.
- To change the shape of cutters to fit the shallow depth.
- To continue the excavation until the time when the weight of the dredged materials in the hopper does not increase any more, or the maximum confinement of the dredged materials in the hopper is practically achieved.
- To instruct specific dredging area to the dredger crew.
- To monitor the progress based on the survey data, loading records and excavation time records.
- To identify the personnel at the manager level at Headquarters responsible for correct and efficient dredging.
- To employ a combination of a long-arm backhoe, grab bucket and suction pump to deepen the quay wall of Songkhla Container Terminal.

3-9 Recommendations on Implementation of Project

- The coastal terminal development at Songkhla Port is worth being implemented from the viewpoint of the national economy, because the computed EIRR of 22.0% is much higher than the opportunity cost of capital (12%) in the current Thai economy.

- At Sichon and Bang Ra Pha channel, from the results of economic analysis, the project is not economically feasible. However, taking into account such qualitative benefits as the aspect of the overall improvement of social stability in the community through job creation and income generation by keeping fishery activities, the project is considered to be worthy as the social welfare.

- For the implementation of the coastal terminal development at Songkhla, in consideration of the difficulty in its financial feasibility, an optimal scheme of PPP (Public and Private Partnership) should be explored. A viable scheme is proposed that the government sector construct the facilities with the subsidy equivalent to 80% of the total investment cost while the private sector assumes the responsibility for the operation and maintenance, introducing a revenue sharing system where the private operator can gain a 15% return on its investment in the long-term and pay the government sector 21% of the total revenue collected from the port service fees. A cashflow analysis implies that by receiving 21% of the shared revenue, the government sector will be able to manage soundly the debt service of long-term loans for the remaining 20% of the initial investment.

3-10 Summary of Conclusion and Recommendations

As discussed in 3-8 and 3-9, the recommendation are summarized as below:

Issues	Measures
1. Sedimentation and Siltation in Channel	
○Shortage of civil structure works	Additional jetty construction, Sand-bypassing
○Inefficient dredging works - Dredger deployment - Dredging Operation - Management	 Appropriate dredger deployment according to capacity of dredger and channel conditions Technical improvement Management organization improvement
○Maintenance Dredging	
- Songkhla	Dredging operation improvement of hopper suction dredger Deepening the quay wall. 2 Hopper dredgers for initial dredging
- Pak Phanang Channel	Adjustment of cutter suction dredge and dredging operation Improvement 2 Cutter dredgers for maintenance dredging
2.Increasing Cargo Demand	2 Berths construction at Songkhla Port

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SUMMARY

1. Introduction

1.1 Background of the Study

Harbour Department of the Ministry of Transport and Communications of Royal Thai Government (HD) maintains many channels: small to large, domestic to international, commercial to fishing and irrigation. At Songkhla on the southern coast of the Gulf of Thailand, the Coastal Dredging Center II (CDC II) of HD maintains 44 channels. Volume to dredge for the channel maintenance every year has been reported for a long time as 6 million m^3. This large demand of dredging work is the fundamental pressure for the HD to have requested the technical assistance of Japan International Cooperation Agency (JICA).

The Royal Thai Government (RTG) has the policy to promote the maritime transport because it is more economical than road transport when the hauling distance is large between the cargo origin and destination. Transport between the southern coast and the eastern seaboard of Thailand is the typical case to be promoted where cargoes can either be transported by truck – approximately 1,088 to 1,250 km hauling distance – or by ship – approximately 610 to 670 km hauling distance. The Office of Maritime Promotion Commission (OMPC) is the agency responsible to conduct study on the coastal shipping in Thailand. To ensure the safe navigation of the coastal channels for the maritime transport, OMPC requested technical assistance.

In response to the request of RTG, the Government of Japan (GOJ) decided to conduct "The Master Plan Study for The Coastal Channels and Ports Development in The Kingdom of Thailand" (hereinafter referred to as "the Study"), within the general agreement framework of technical cooperation between Japan and Thailand, which was set forth in the Agreement on Technical Cooperation between GOJ and RTG on November 5, 1981.

JICA sent a preparatory survey mission to Thailand in October 2000 and conducted preliminary research including field works. As a result of the study of this mission, the "Scope of Work" of the requested study was settled and an "Agreement" was signed by JICA and HD on October 5, 2000. According to the Agreement, JICA dispatched a study team (JICA Study Team) to Thailand in February 2001.

1.2 Implementation of the Study

Since February 2001, the JICA Study Team visited Thailand twice to conduct site surveys and investigations: from February 4 to May 31 and from August 1 to October 18, 2001. HD has been cooperating with the JICA Study Team as the counterpart for the smooth execution of the survey and investigation and providing advice and comments on the Study. For the ports development study, OMPC provided its data and information to the JICA Study Team to coordinate particularly the cargo demand forecast of the coastal shipping.

The JICA Study Team observed the maintenance dredging operation of CDC II, and obtained information about natural conditions along the coastline from Khanom to Tak Bai. The team produced the master plan for the coastal channels and ports development in the area under CDC II management. It also produced recommendations for improvement of the dredging operation. And finally, using the collected data and information, the team conducted feasibility study on the three selected channels.

This report compiles the main results that the JICA Study Team has produced in the order of the logical sequence of the study.

1.3 Usage of the Study Results

The most noteworthy item of the study results is that the quantity the CDC II has annually to dredge is originated from the long-time preconceived operation norms for both the cutter suction dredgers and hopper suction dredgers. In case of the former, they are built for dredging much deeper depth and discharging much longer distance than is actually the case. The channels are too shallow and the disposal area is very near. For the latter, much attention has not been paid to the actual loading of soil into the hopper. Thus operators have spent more time for traveling than for excavating.

The JICA Study Team in this report provides practical recommendations for improvement of operating dredgers. Some crew has already applied the team suggestions and produced better performance. This report will help the field people improve their performance and yield more output. CDC II people should recognize that with the exiting equipment the dredging targets are achievable when their operation is improved.

OMPC is requested to refer to the feasibility study on the short-term port development at Songkhla for the coastal shipping. It is suggested that OMPC review the feasibility and implement the coastal terminal development as soon as possible.

2. Coastal Shipping of the Gulf of Thailand

2.1 Transports in Thailand

In 1999, the total freight volume was 441 million tons in Thailand. The dominant transport mode in Thailand is road transport with 89% of the total freight or 392 million tons. Coastal transport had the second largest share of 5% or 22 million tons. Inland waterways and railways shared 4% and 2% respectively.

2.2 Coastal Transport

Coastal transport has increased at an average annual growth rate of 5.7% during the period 1990 to 1999. However, it has a declining tendency since 1996 because of the economic downturn of the country. Moreover, some commodities, particularly miscellaneous cargoes, have shifted to road transport.

2.3 Freights

Petroleum products represent about 95% of the total coastal traffic volumes. The rest of the traffic is distributed among metal products, rubber, agriculture, cassava, foodstuffs and others (see Figure 2.1). The origins and destinations of major commodities transported by coastal shipping are shown in Table 2.1.

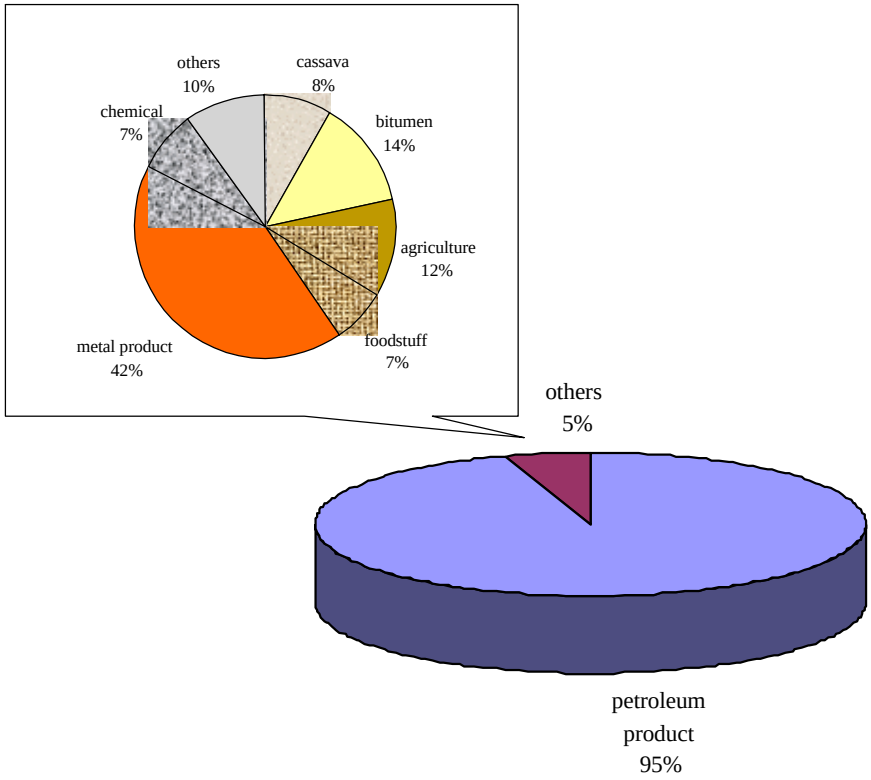


Figure 2.1 Commodity Group Transported by Coastal Vessels in 1999
Source: Transport Statistics by MOTC

Table 2.1 Origin and Destination of Major Commodities Moved by Coastal Vessels

Commodity	Major Origins	Major Destinations	Average Distance (km.)
Petroleum products	Chonburi & Rayong	Bangkok, Samutprakarn, Samutsakorn, Chachoengsao, Suratthani, Songkhla	219
Maize	Bangkok, Chonburi	Songkhla	830
Bitumen	Rayong, Chonburi	Samutprakarn, Suratthani	256
Agricultural products	Suratthani, Chonburi	Chachoengsao, Songkhla	576
Animal Fodder	Bangkok	Songkhla	796
Foodstuffs	Chonburi, Bangkok	Songkhla	704
Metal products	Prachubkirikhun	Bangkok, Rayong	146
Cement	Petchaburi	Chonburi, Bangkok	156
Mineral and Building materials	Suratthani	Chonburi, Petchaburi	454
Fertilizer	Bangkok, Rayong	Songkhla	766
Chemicals	Rayong	Samutprakarn	208
Miscellaneous and Container	Bangkok	Songkhla	677
Equipment	Bangkok, Suratthani	Songkhla	495

Source: MOTC

2.4 Vessels

In 1999, there were 52,469 vessels including fishing vessels accounting for 2.5 million GRT of coastal shipping in Thailand. When fishing vessels are excluded, steel barges and tankers represent 81% of the remaining capacity. (See Table 2.2)

Table 2.2 Number of Coastal Vessels in 1999

Type		Number of Vessels	Gross Tons
Motorized Vessels	General Cargo Vessels	1,067	40,309
	Passenger Vessels	2,302	39,543
	Passenger & Cargo Vessels	566	15,217
	Container Vessels	4	64
	Refrigerated Vessels	1,032	23,666
	Tanker	160	106,063
	Gas Vessels	18	14,050
	Oil and Gas Vessels	6	3,282
	Fishing Vessels	38,476	882,286
	Others	6,502	145,919
Total of Motorized Vessels		**50,133**	**1,270,399**
Non-motorized Vessels	Wooden Lighter	69	6,201
	Steel Lighter	2,131	1,255,290
	Others	136	9,003
Total of Non-motorized Vessels		**2,336**	**1,270,494**
Total of Coastal Vessels		**52,469**	**2,540,893**

Source: MOTC

2.5 Operators

There are only four major carriers offering coastal shipping services by motorized vessels at present. They own 22 coastal vessels available for dry cargoes. Two carriers are servicing liners plying Bangkok-Songkhla-Chonburi and Chonburi-Surat Thani-Songkhla as their regular service routes. (See Table 2.3)

Table 2.3 Profile of General Cargo Carriers

Company Name	Number of Vessels	DWT	Average Age of Vessel	Regular Routes
Harinsut	11	14,555	21	Bangkok, Songkhla, Chonburi
Nam Yuen Yong Shipping	6	1,533	9	Chonburi, Surat Thani, Songkhla
Voranavin	3	3,000	7	No regular routes
Ocean Land Transport	2	3,000	5	No regular routes

Source: Thai Ship Owner's Association (TSA) Maritime Directory 2000

2.6 Issues

At present, besides the proper institutional procedures, the coastal shipping in Thailand lacks basic infrastructures. Most of the channels are shallow and narrow; good linkages with roads and railways networks are often not provided; ports are lacking of cargo handling equipment; fishing nets and stakes are hampering the navigation, etc.

2.7 Coastal Ports in Study Area

The coastal shipping ports in the Study Area (i.e., the southern coast on the Gulf of Thailand covering Nakhon Si Thammarat Province to Narathiwat Province) are Songkhla, Pak Phanang, Tha Sala and Pattani. Among them, Songkhla Port is the important commercial port handling 1,129,972 tons of petroleum products or 65% of the total and 276,248 tons of solid cargoes or almost 100% of the total in 1999. There are four piers handling dry cargoes operated by private companies for the coastal shipping in Songkhla. (See Figure 2.2)

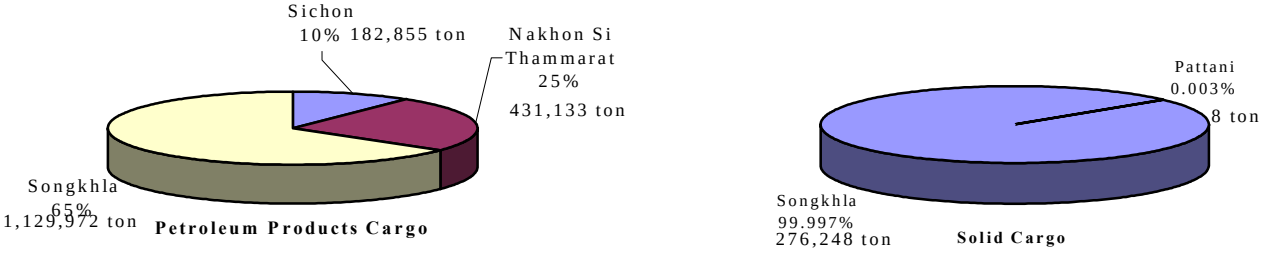


Figure 2.2 **Petroleum Products and Solid Cargo Volume and Share in Study Area (1999)**
Source: Custum House

3. The Southern Coast on the Gulf of Thailand

3.1 Coastal Topography 1 (Northern Part)

In the northern part of the Study Area, small rocky beaches spotted among the capes characterize the coast of the northern area of Sichon being followed by a long sandy beach of about 45 km to Pak Phaying down to the south. Longshore transport from north is predominant. Pak Phanang Bay has muddy seabed as many rivers are debauching sediments to the rather calm water. Rich mangrove forest encloses a half of the bay. (See Study Area map)

3.2 Coastal Topography 2 (Central Part)

In the central part of the Study Area, a long sandy beach continues about 160 km from Laem Talumphuk to Songkhla, a changing point of the curvilinear coastline, being again followed by a sandy beach of about 43 km to Khiao Kieo/ Khao Lon. From there down to Pattani, the coast is composed of sandy beaches except the Pattani Bay, where beaches are muddy. Along the coast in the central part, longshore transport from south, southeast or east is predominant.

3.3 Coastal Topography 3 (Southern Part)

In the southern part of the Study Area, three long sandy beaches exist, each between Laem Ta Chi to Khae Khae, Khae Khae to Khao Tanyong, and Khao Tanyong to Tak Bai. Longshore transport from the southeast is predominant.

4. Natural Condition Survey

4.1 Scope of Natural Condition Survey

The JICA Study Team conducted investigations on natural conditions at several coastal channels in the Study Area. At Sichon, Sakom and Thepha, in order to comprehend the mechanism of the channel sedimentation, the team conducted topographic/bathymetric surveys and investigations on seabed materials, currents and waves, littoral currents, drift sand, water quality, river flow and tides. At Songkhla and Bang Ra Pha, in order to collect natural conditions for the feasibility study on channel improvement and port development, the team conducted topographic/bathymetric surveys, seabed materials survey and subsoil investigation. At Pak Phanang and Pattani, investigation was conducted on the seabed materials. At Sichon, the bathymetric survey was conducted twice in March and September to confirm the results of the channel dredging in the semi-open sea by a cutter suction dredger.

4.2 Major Findings

The site surveys and investigations mentioned above reveal the following major characteristics.

Sichon: (See Figure 4.1)	The single jetty channel is not sufficient to protect the channel from becoming shallow.
Sakom, Thepha, Bang Ra Pha: (See Figure 4.2 to 4.4)	The dual jetties well protect the channel from becoming shallow. However, beach erosion is serious on the down stream side of the jetties.
Songkhla: (See Figure 4.5)	The navigation channel is much shallower than the design depth even though Harbour Department carries out the maintenance dredging. The very shallow channel attributes to considerable siltation and littoral drift. Also found is the fact that water depth at the quay wall is very shallow, -5 m in comparison with the design depth of -9 m.

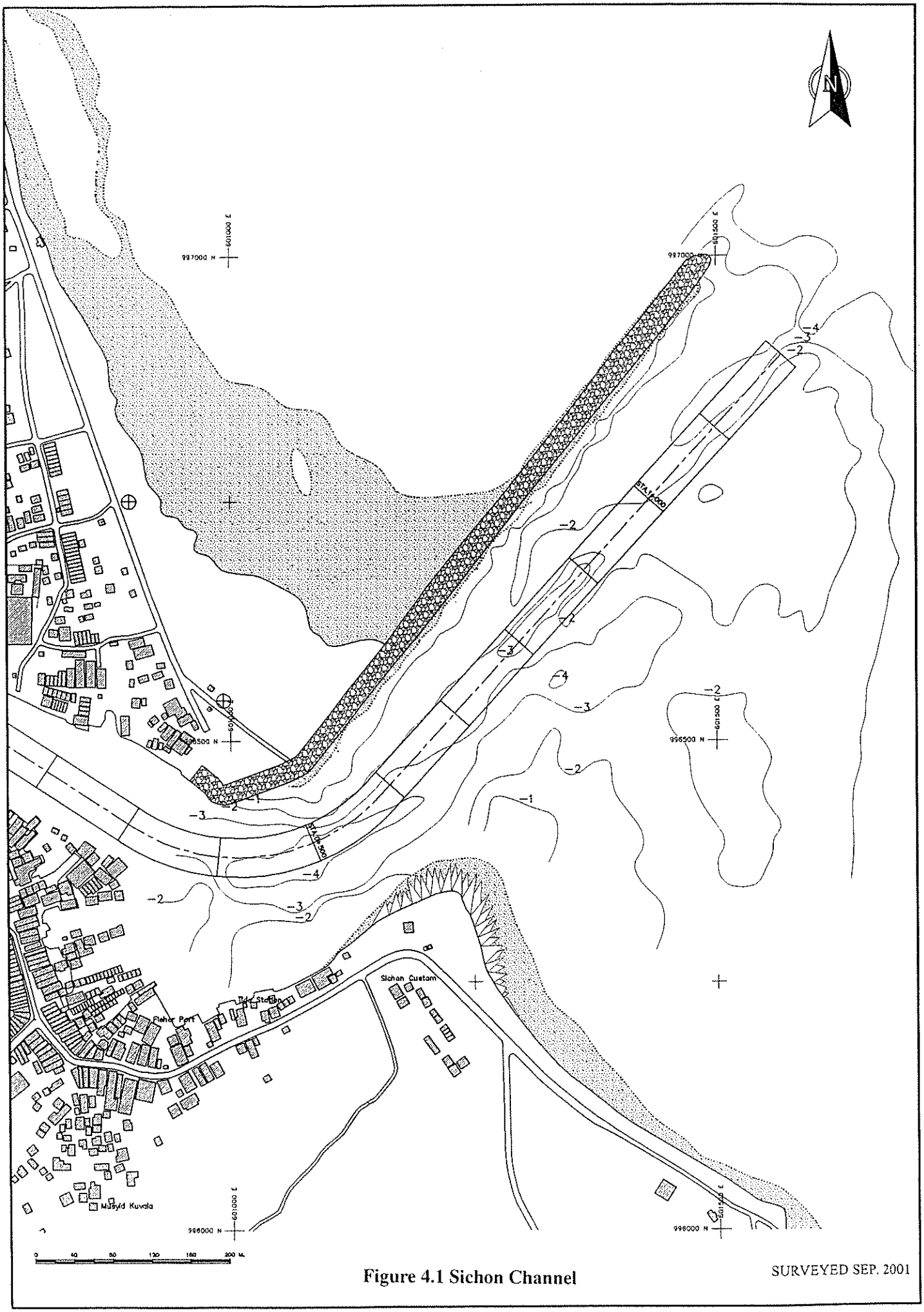


Figure 4.1 Sichon Channel

SURVEYED SEP. 2001

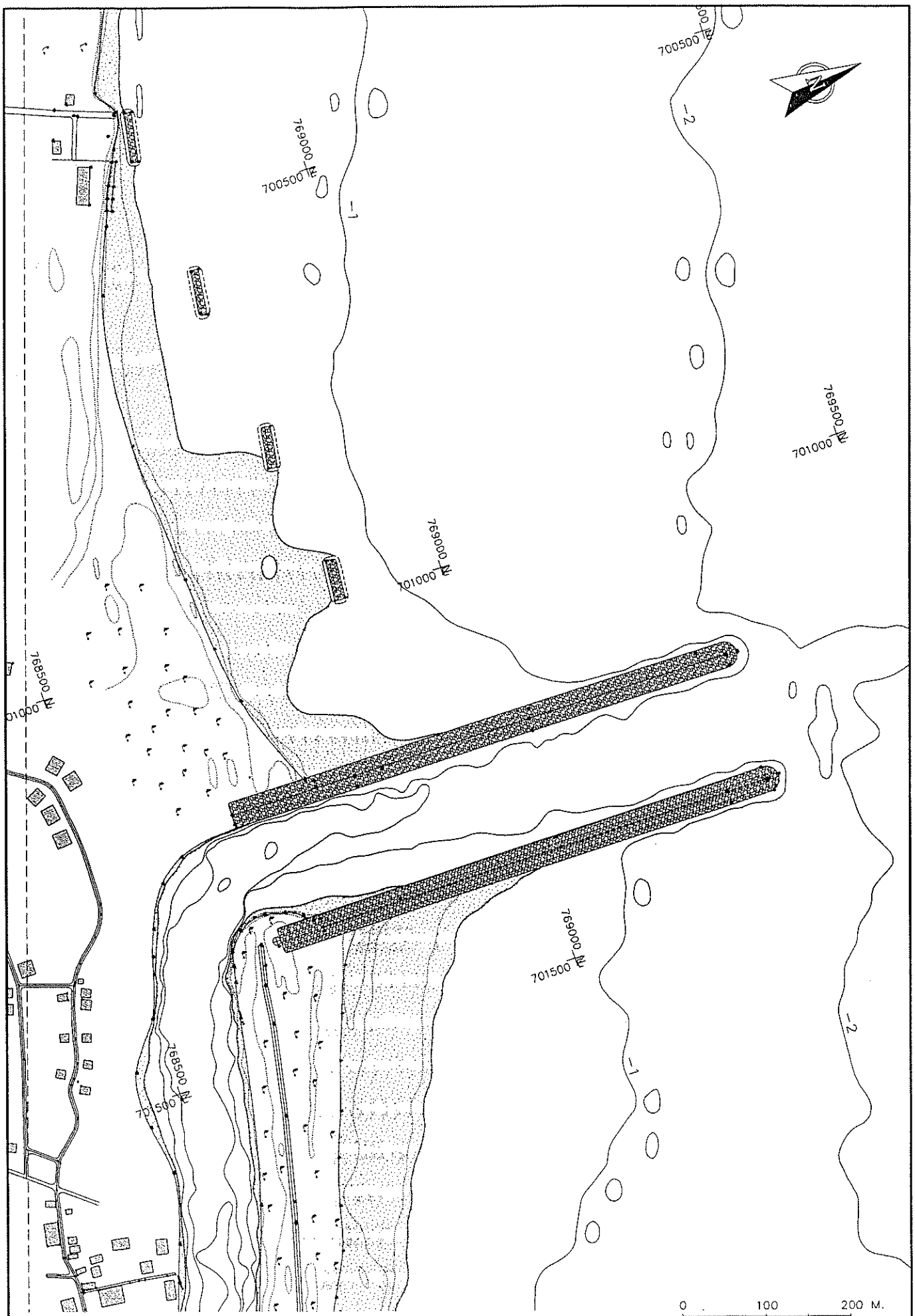


Figure 4.2 Sakom Channel

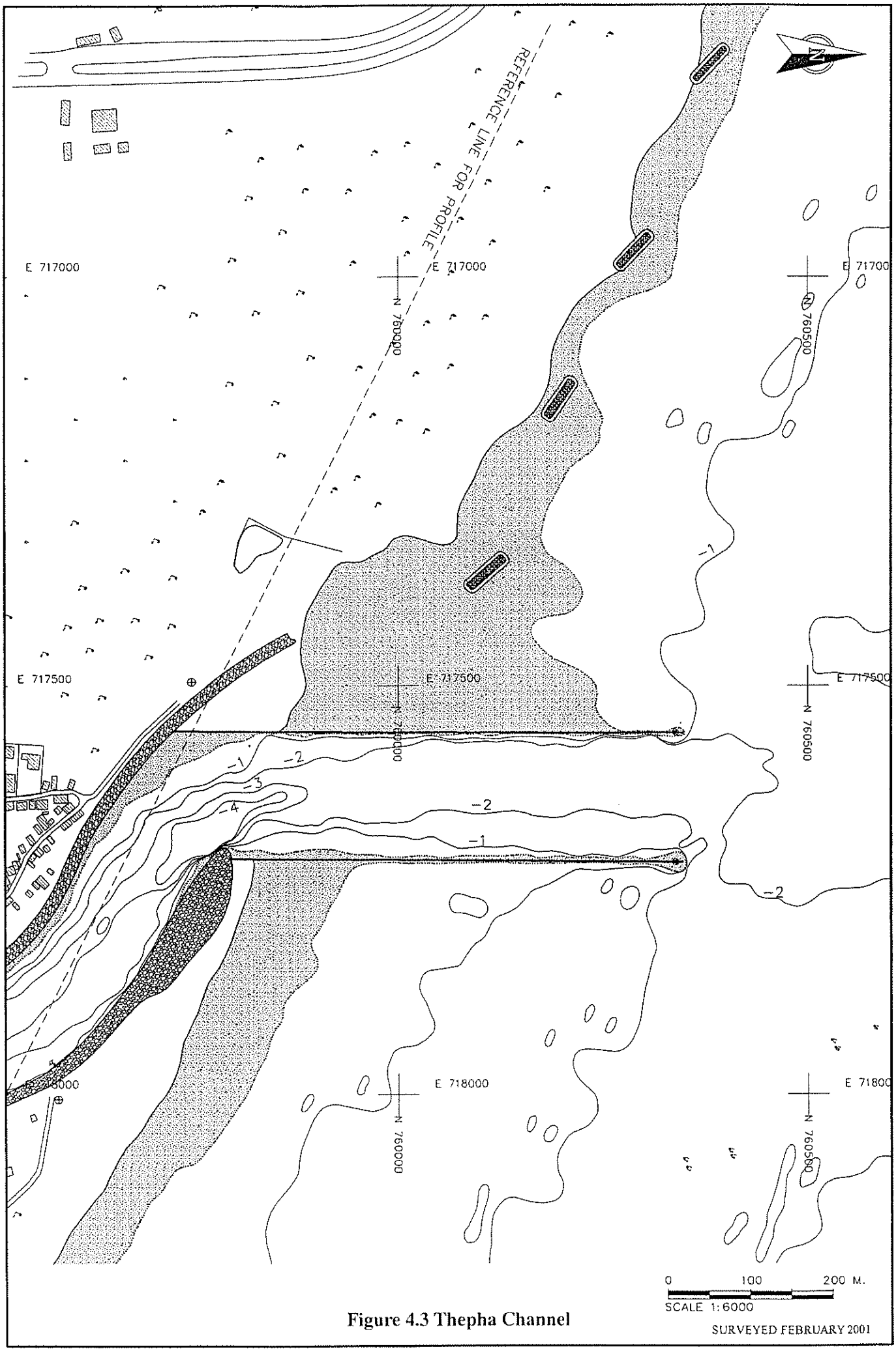


Figure 4.3 Thepha Channel

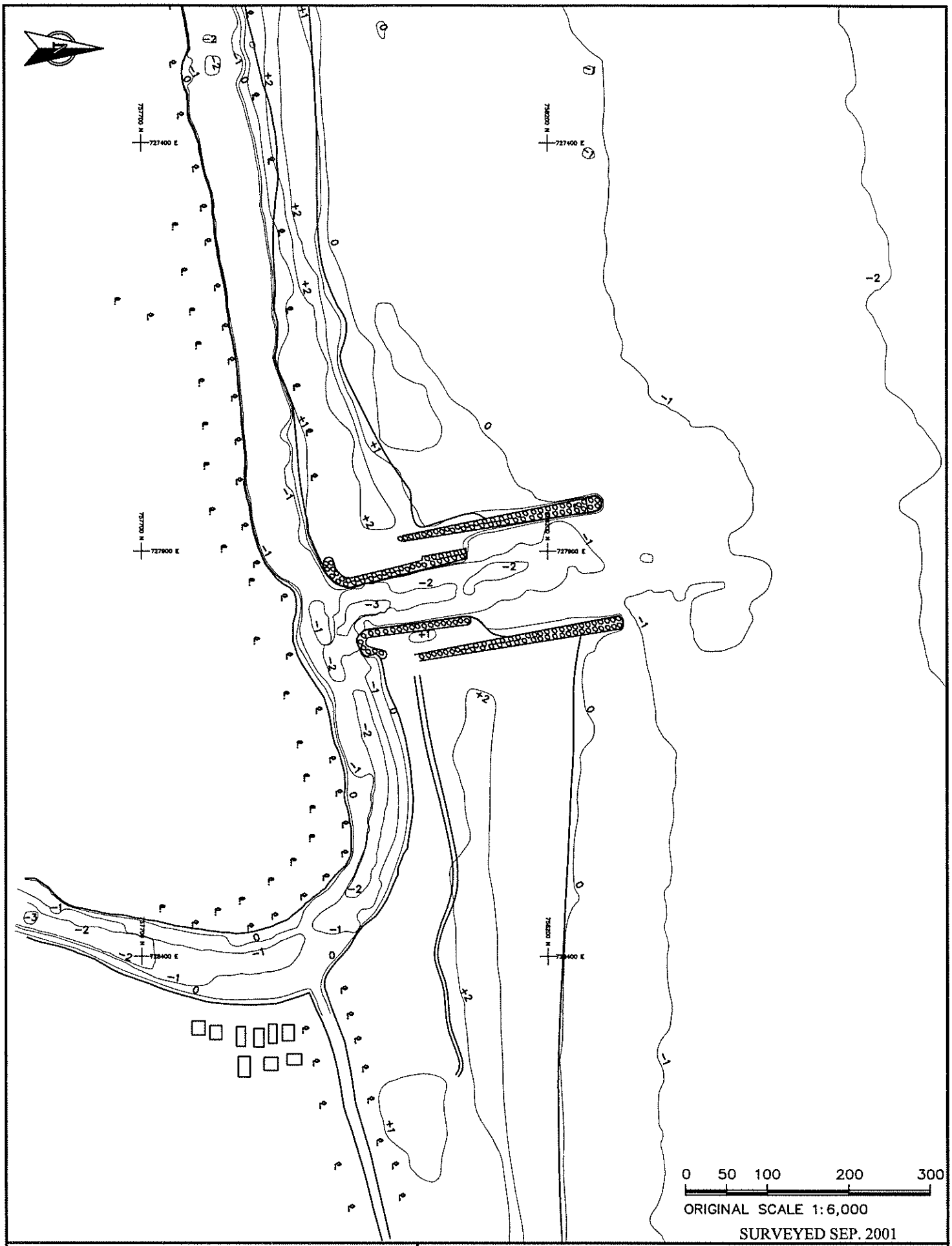


Figure 4.4 Bang Ra Pha Channel

DISTRICT NONG CHIK, PROVINCE PATTANI

• LENGTH	= 1.15	Km.			
• WIDTH	= 30.00	m.	• LLW.	= 0.84	m.
• DEPTH	= 1.20	m.	• SCALE	= 1:6,000	

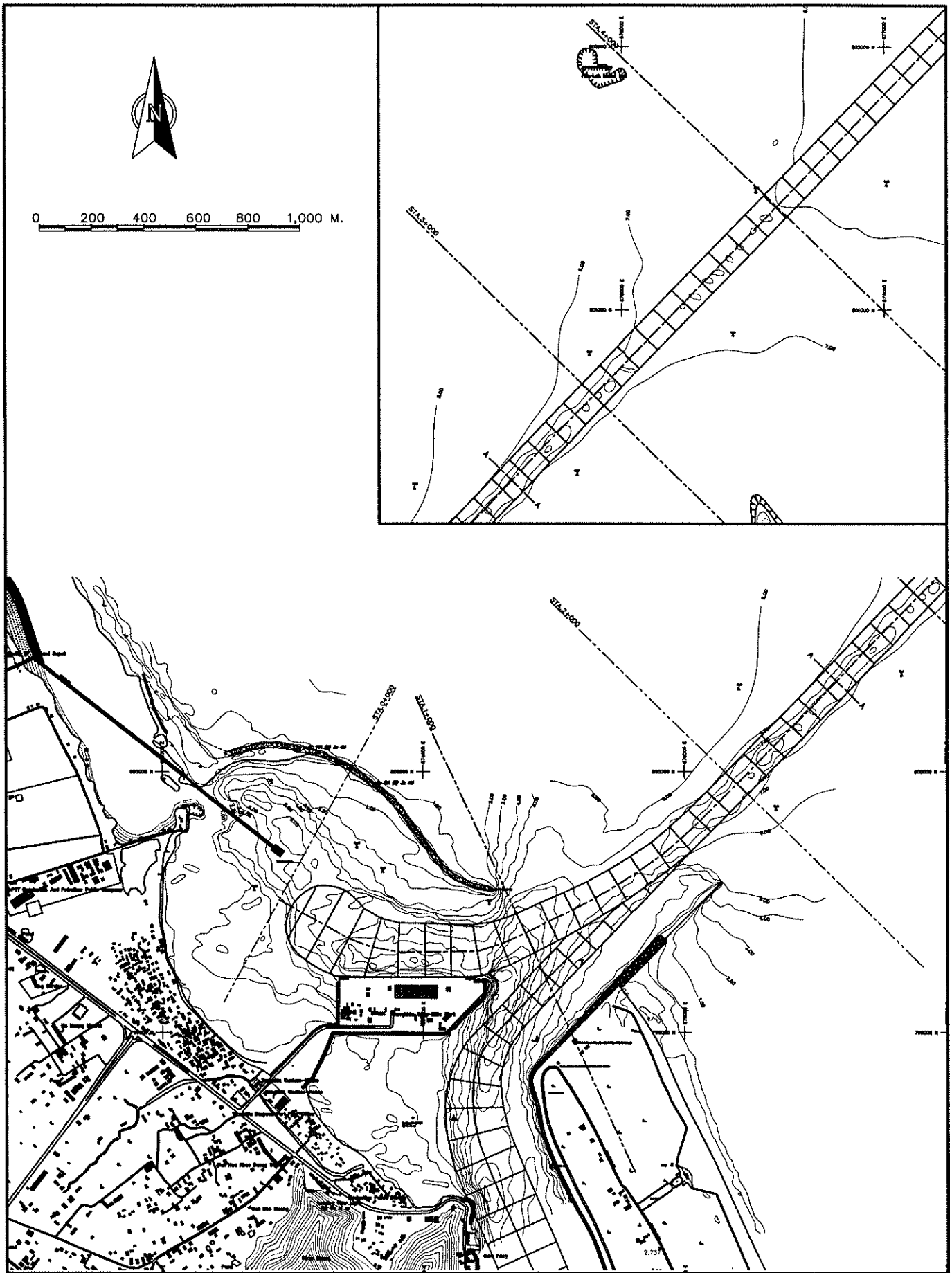


Figure 4.5 Songkhla Channel

DISTRICT SENGHANAKON, PROVINCE SONGKHLA

CHANNEL	OUTER	INNER
• LENGTH	6+000	5+000
• WIDTH	120.00	250.0
• DEPTH	5.00	9.00

- SIDE SLOPE 1:6
- LLW. = 0.96 m.
- SCALE = 1:20,000

5. Coastline Change Analysis

5.1 Comparison before and after Jetty Construction

The JICA Study Team conducted bathymetric and shoreline surveys at Bang Ra Pha where the dual jetties were recently constructed. The survey results were compared with the topography in 1996. With respect to the jetties, the team computed the deposition on the upstream side of the littoral drift and erosion on the downstream side. The quantity of the deposition is estimated to be 45,000 m^3 per year while the erosion is estimated to be 32,000 m^3 per year. The results suggest that the jetty construction on the coast between Na Thap and Bang Ta Wa, where the littoral drift is relatively dominant, is likely to cause deposition and erosion in the magnitude of 30,000 m^3 to 50,000 m^3 per year.

5.2 N-line Model Analysis

N-line Mode Analysis on the shoreline changes that the team conducted resulted in the estimated rate of littoral transport:

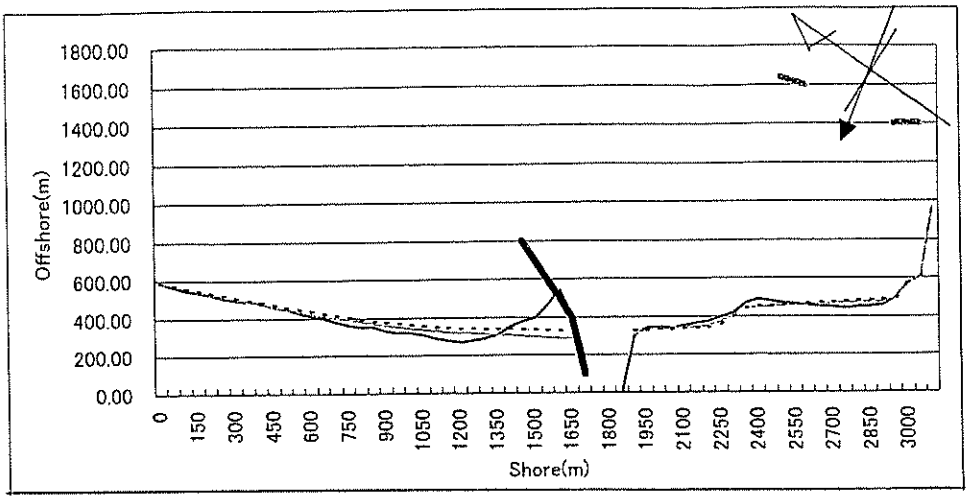
Sichon: 2.5×10^4 m^3 per year

Sakom: 1.1×10^5 m^3 per year

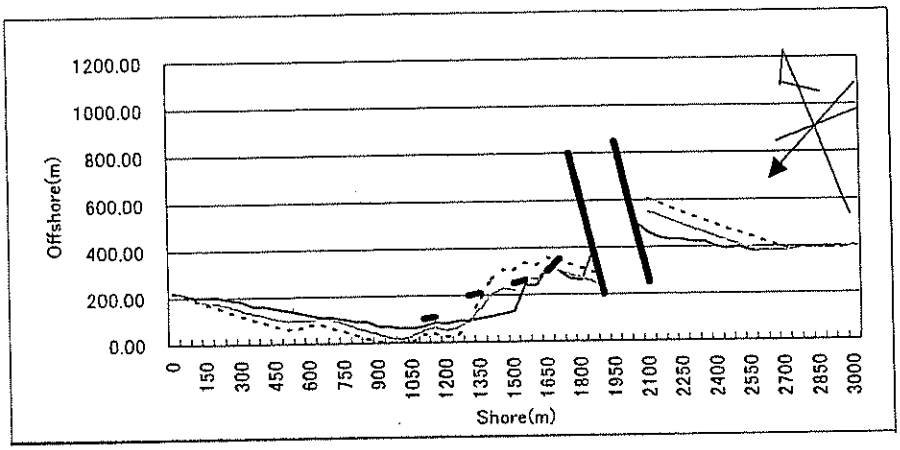
Thepha: 1.0×10^5 m^3 per year.

The results suggest that the littoral drift is considerably large between Sakom and Thepha. (See Figure 5.1)

Sichon Area



Sakom Area



Thepha Area

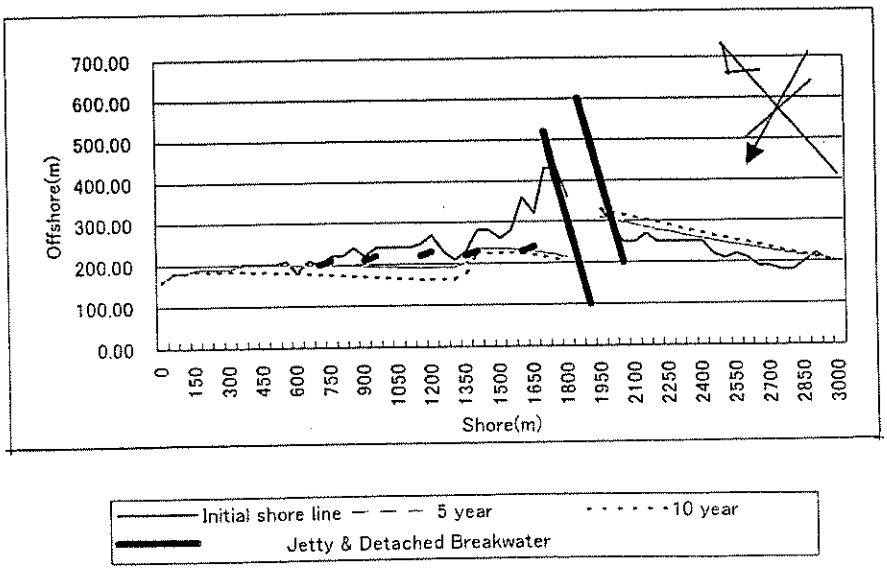


Figure 5.1 Results of Shoreline Change Analysis by N-Line Model

6. Environmental Condition Survey

6.1 Scope of Environmental Condition Survey

The JICA Study Team conducted environmental conditions survey on ichthyics, benthos and algae at Thepha and Bang Ta Wa in order to compare the ecological changes before and after the construction of the channel jetties. No significant changes on the ecology are confirmed. For the feasibility of the channel improvement and port development, the team conducted mangrove ecology survey and wild life inventory survey at Songkhla Lake entrance, Sichon River mouth and Bang Ra Pha River mouth. No significant ecological problem was found by the survey for the implementation of the channel improvement and port development.

6.2 Findings on Environments

Initial Environmental Examination (IEE) pointed out that the development of Songkhla Port might cause resettlement problem (see Table 6.1). However, more detailed survey on the site revealed that the resettlement problem is being solved in relation to the development of the container terminal of the port. Therefore, the development at Songkhla Port for the coastal shipping has no problem on the resettlement of the nearby residents. In conclusion, care only must be taken for archeological monuments in laying out the port development plan. Regarding the improvement of Sichon channel and Bang Ra Pha channel, no serious environmental impacts are foreseen (see Table 6.2).

Table 6.1 Overall Evaluation of Potentially Adverse Environmental Impacts for Songkhla Port（IEE）

Environmental Components	Impact	Study Plan
Resettlement	A	Environmental Impact Assessment
Cultural Property	B	Environmental Impact Assessment
Coastal Zone	B	Analysis of shoreline changes by numerical simulation
Water Pollution	B	Analysis of water diffusion by numerical simulation
Economic Activities	C	Environmental Impact Assessment
Traffic & Public Facilities	C	- ditto -
Water Rights/Rights of Common	C	- ditto -
Fauna & Flora	C	Environmental Conditions Survey (2)
Air Pollution	C	Environmental Impact Assessment
Soil Contamination	C	- ditto -
Noise & Vibration	C	- ditto -
Offensive Odor	C	- ditto -

(Note) Impact Categories

A : Serious impact is expected.

B : Some impact is expected.

C : Extent of impact is unknown.

(Examination is needed. Impact may become clear as study progresses.)

Table 6.2 Overall Evaluation of Potentially Adverse Environmental Impacts for Sichon Channel and Bang Ra Pha Area（IEE）

Environmental Components	Impact	Study Plan
1. Sichon Port/Channel		
Economic Activities	C	Environmental Conditions Survey (2)
Traffic & Public Facilities	C	- ditto -
Coastal Zone	C	- ditto -
Air Pollution	C	- ditto -
Water Pollution	C	- ditto -
Noise & Vibration	C	- ditto -
2. Bang Ra Pha Area		
Traffic & Public Facilities	C	Environmental Conditions Survey (2)
Coastal Zone	C	- ditto -

Table 6.3 Summary of Environmental Impact Assessment (EIA)

Items	Environmental Impact	
	Construction Period	Operation Period
Social Environment		
1. Resettlement	B	X
2. Economic Activities	C	X
3. Traffic and Public Facilities	C	C
4. Rights of Common	C	X
5. Cultural Property	X	X
Natural Environment		
6. Coastal Zone	X	X
7. Fauna and Flora	C	X
Pollutant		
8. Water Pollution	C	X
9. Air Pollution and Offensive Odor	C	X
10. Soil Contamination	X	X
11. Noise and Vibration	C	X

Note : Level of Environmental Impact

A : Relatively high magnitude of impact is expected.

B : Relatively medium magnitude of impact is expected.

C : Relatively low magnitude of impact is expected.

X : No effect is expected.

7. Coastal Channels of CDC II

7.1 Overall View

There are 44 channels under the management of CDC II in the Study Area. Among these, 14 channels are for irrigation. Therefore, CDC II is responsible for maintenance of 30 navigation channels which this study focused on. HD classified the 44 channels into three categories, namely big, middle and small (see Table 7.1 and 7.2). The big channels are the five channels of Khanom, Pak Phanang, Songkhla, Pattani, and Narathiwat. Except Narathiwat channel having four m design depth, their design depths are 5 m or deeper. Songkhla channel having 9 m design depth is the entrance to the international container terminal, private coastal shipping piers and fishing piers located inside the Songkhla Lake. There are 17 middle channels which design depths are 3 to 2 m except Sichon having 4 m design depth. All the middle channels accommodate only fishing vessels. CDC II has eight small navigation channels which are for very small fishing vessels.

7.2 Channel Maintenance Structures

HD has provided dual jetty protections at 12 coastal channels. The JICA Study Team confirmed by bathymetric survey at Tha Sala, Sakom and Thepha that the dual jetty system is very effective to prevent sedimentation in the channels. HD has also provided a single jetty protection at Sichon. Contrary to the dual jetty system, the single jetty system cannot protect the channel from deposition of littoral drift. Worse, the single jetty did lead the invading waves along the channel to hit the fishing village located on the shore when a storm attacked the study area in November 1999. JICA Study Team confirmed by bathymetric survey that a single jetty would complicate the seabed morphology and hamper ship maneuvering at the channel entrance. An additional jetty is to be provided as soon as possible for Sichon channel as planned by HD.

7.3 Shore Protection

Except for Pattani channel, erosion of the beach takes place wherever a jetty is provided for the channel protection. Thus, except for Sichon, Songkhla, Bang Ra Pha and Tanyong Pao, HD has provided shore protection works like groins and detached breakwater at nine coastal channels (see Table 7.3).

7.4 Coastal Shipping Channels

It should be noted that CDC II has only four channels currently used for the coastal shipping: namely, Songkhla, Pak Phanang, Kanom and Tha Sala. Among these four channels, Kanom and Pak Phanang accommodate oil tankers and Tha Sala channel serves for small bulk carriers only.

Table 7.1 Dimensions of CDCII Management Channels

Channel			Width (m)	Length (km)	Depth (m)	Province
1		Khanom (Outer Channel)				Nakhon Si Thammarat
		Outer Channel	80	0.745	5.0	
		Inner Channel Sector 1	180	0.382	4.5	
		Inner Channel Sector 2	140	0.237	3.0	
2	Big	Pak Phanang	60	27.000	4.0	Nakhon Si Thammarat
3		Songkhla				Songkhla
		Harbour	120	6.000	9.0	
		Inner Channel	250	5.000	5.0	
4		Pattani	60	4.000	5.0	Pattani
5		Narathiwat	60	4.000	4.0	Narathiwat
6		Khanom (Inner Channel Sector 3)	40	2.800	2.0	Nakhon Si Thammarat
7		Sichon	40	1.000	4.0	Nakhon Si Thammarat
8		Khlong Tung Ka	30	1.000	2.0	Nakhon Si Thammarat
9		Tha Mak	30	0.600	2.0	Nakhon Si Thammarat
10		Pak Duad	30	0.800	2.0	Nakhon Si Thammarat
11		Tha Sala	40	0.800	3.0	Nakhon Si Thammarat
12		Pak Phaying	40	4.500	2.0	Nakhon Si Thammarat
13	Mid.	Pak Phun	40	3.500	2.0	Nakhon Si Thammarat
14		Pak Paya	30	1.790	2.0	Nakhon Si Thammarat
15		Pak Nakhon	40	3.700	3.0	Nakhon Si Thammarat
16		Na Thap	40	0.800	2.0	Songkhla
17		Thepha	40	1.000	2.0	Songkhla
18		Sakom	40	0.700	2.0	Songkhla
19		Ban Ku Khud-Ban Laem Vang	30	1.850	1.5	Songkhla
20		Sai Buri	40	1.000	3.0	Pattani
21		Panare	30	0.400	2.0	Pattani
22		Bang Ta Wa	30	0.350	2.0	Pattani
23		Tak Bai	40	0.600	3.0	Narathiwat
24		Thale Noi	20	10.000	2.0	Pattalung
25		Khlong Sam Rong	6	10.000	1.5	Songkhla
26		Bang Ra Pha	20	0.070	1.5	Pattani
27		Ban Sai Samo	15	0.350	1.5	Pattani
28		Tanyong Phao	20	0.900	1.5	Pattani
29		Bang Maruat	20	0.800	1.5	Pattani
30		Ta Lo Lae Weng	30	0.500	1.5	Pattani
31		Khlong Gor Tor	30	0.700	1.5	Pattani
32		Laem Ta Chi	20	0.900	1.5	Pattani
33	Small	Khlong Tu Yong	20	0.700	1.5	Pattani
34		Ru Sa Mi Lae	30	0.900	1.5	Pattani
35		Khlong Kok Kean	20	10.000	2.0	Narathiwat
36		Pak Rawa			1.5	Nakhon Si Thammarat
37		Pak Khlong			1.5	Nakhon Si Thammarat
38		Mahakan Ok			1.5	Songkhla
39		Chiang Phong			1.5	Songkhla
40		Mai			1.5	Songkhla
41		Takhria			1.5	Songkhla
42		Hua Pa			1.5	Songkhla
43		La Pam			1.5	Pattalung
44		Sala Tham			1.5	Songkhla

Note: HD defines the channel priorities as Big, Mid and Small.

: Irrigation Channel

Table 7.2 Priority of Coastal Channels and Ports

No.	Channel	Priority Ranking	Dredging		Control Structure			Erosion around Jetties	Sand Drift Affection	No Control Structure Close River Mouth	Max. Draft of Vessel	Number of Fishing Vessel	Cargo Vessel Calling/yr	Type of Vessel and Utilization	Dredger	Dredging Depth (m)	Province
			Dredging times times/12 years	Dredging times times/3 years	F/S by HD	Completion Year of Construction	Control Structure										
1	**Songkhla (Harbour)**	A	12	3	2001(D/D)	1988	Jetty	Mid			9.0 m	1,462	4,266	Cargo Vessel, Fishing Boat	Cutter, Hopper	9	Songkhla
2	**Pak Phanang**	A	10	2							5.0 m	834	550	Fishing Boat, Cargo Vessel	Cutter, C25	4	Nakhon Si Thammarat
3	**Pattani**	B	13	3			Jetty				4.0 m	1,703	91	Fishing Boat	Cutter, Hopper	5	Pattani
4	**Khanom (Outer & Inner Channel Sector 1&2)**	B	6	2							5.0 m	215	100	Cargo Vessel (Mainly Power Station)	Cutter, Hopper	5, 4.5, 3	Nakhon Si Thammarat
5	**Sai Buri**	B	11	3	1989/2000	May 1993	Jetty	Big			4.0 m	244		Fishing Boat	Cutter, C1, Back-hoe	3	Pattani
6	**Sichon**	B	9	3	1992/2001	Feb. 1996	Jetty	Mid			3.0 m	1,327		Fishing Boat	Cutter	4	Nakhon Si Thammarat
7	**Khanom (Inner Channel Sector 3)**	B	3	2							3.0 m	215		Fishing Boat	Cutter	2	Nakhon Si Thammarat
8	**Narathiwat**	B	10	2	1992	Aug. 1996	Jetty	Mid			2.5 m	263		Fishing Boat	Cutter C37	4	Narathiwat
9	**Tha Sala**	C	11	2	1993	Mar. 1997	Jetty	Big			2.5 m	724	45	Fishing Boat, Cargo Vessel	Cutter	3	Nakhon Si Thammarat
10	**Pak Nakhon**	C	9	1							2.0 m	300		Fishing Boat	Cutter, C25	3	Nakhon Si Thammarat
11	**Na Thap**	C	8	2	1991	Jul. 1997	Jetty	Big			2.0 m	154		Fishing Boat, Shrimp Farm	Cutter, C1	2	Songkhla
12	**Sakom**	C	8	2	1994	Feb. 1998	Jetty	Big			1.5 m	155		Fishing Boat, Shrimp Farm	Cutter, C1	2	Songkhla
13	**Thepha**	C	7	1	1994	Sep. 1999	Jetty	Big			1.5 m	247		Fishing Boat, Shrimp Farm	Cutter, C1	2	Songkhla
14	**Panare**	C	8	2	1999	Jul. 2001	Jetty	Mid	Big		1.0 m	200		Fishing Boat	Cutter, C1	2	Pattani
15	**Bang Ra Pha**	C	1	0	1997		Jetty	Big	Big		1.2 m	110		Fishing Boat, Shrimp Farm	Cutter, C1	1.5	Pattani
16	**Tanyong Pao**	C	4	1	1997	Jul. 1999	Jetty	Mid	Big		1.0 m	70		Fishing Boat, Shrimp Farm	Back-hoe	1.5	Pattani
17	**Bang Ta Wa**	C	2	1				Big			1.2 m	180		Fishing Boat, Shrimp Farm	Cutter, C1	2	Pattani
18	**Bang Maruat**	C	5	2	1999	Jul. 2001	Jetty				1.0 m	230		Fishing Boat, Shrimp Farm	Cutter, Back-hoe	2	Pattani
19	**Tak Bai**	C	4	0	F/S by Irrigation Dept		Jetty				2.5 m	272		Fishing Boat	Cutter, C25	3	Narathiwat
20	**Laem Ta Chi (Pattani Outer Channel)**	C	2	0	1994	Feb. 1996	Jetty				4.0 m	700	91	Fishing Boat	Hopper	5	Pattani
21	**Pak Paya**	D	3	0							1.0 m	250		Fishing Boat	Cutter, C25	2	Nakhon Si Thammarat
22	**Pak Phun**	D	3	1							1.0 m	150		Fishing Boat	Cutter, C25	2	Nakhon Si Thammarat
23	**Pak Phaying**	D	1	0							1.0 m	150		Fishing Boat	Cutter, C25	2	Nakhon Si Thammarat
24	**Pak Duat**	D	2	0	2001					○	1.0 m	100		Fishing Boat	Back-hoe	2	Nakhon Si Thammarat
25	**Tha Mak**	D	2	0						○	0.5 m	50		Fishing Boat	Back-hoe	2	Nakhon Si Thammarat
26	**Khlong Tung Ca**	D	2	0						○	0.5 m	50		Fishing Boat	Back-hoe	2	Nakhon Si Thammarat
27	**Khlong Tu Yong**	D	0	0						○	0.5 m	50		Fishing Boat, Shrimp Farm	Back-hoe	1.5	Pattani
28	**Ban Sai Samo**	D	1	1						○	1.2 m	20		Fishing Boat, Shrimp Farm	Back-hoe	1.5	Pattani
29	**Ru Sa Mi Lae**	D	1	1						○	0.5 m	50		Fishing Boat, Irrigation	Back-hoe	1.5	Pattani
30	**Ta Lo Lae Weng**	D	3	3						○	0.5 m	50		Fishing Boat	Back-hoe	1.5	Pattani

Source: CDCII, Fishery Department in Study Coastal Provinces, HD and JICA Study Team estimate

Note: Ranking A: Important for the national and provincial socio-economic development
Ranking B: Important mainly for provincial socio-economic development
Ranking C: Important mainly for local socio-economic improvement
Ranking D: Important mainly for living standard and improvement

Table 7.3 Structures in Study Coastal Channels

Name	Purpose	Type, Size and Direction of Jetty	Shoreline protection	EIRR (%/year)
Sichon Sichon District Nakhon Si Tammarat	-To prevent the sediment on a river mouth -To protect fishery from wind and wave	Single Jetty (rubble-mou Length = 700 m Height = 7.4 m Direction = N45'E	N/A	8.4
Tha Sala Tha Sala District Nakhon Si Tammarat	-To prevent the sediment on a river mouth -To protect fishery from wind and wave	2 Jetties (rubble-mound) Length (NE) = 360 m Length (SW) = 500 m Height = 6 m	4 Detached Breakwaters Sea wall 400 m	6.56
NamSap-Ko Fai Pakphanang Dist. Nakhon Si Tammarat	-To protect shoreline	N/A	19 T type-Groins (rubble-m Head length = 50 m Body length = 40-50 m 4 groins, length = 35-45 m Sea wall, length = 300 m	9.73
Na Thap Jana District Songkhla	-To prevent the sediment on a river mouth -To protect fishery from wind and wave	2 Jetties (rubble-mound) Length (NE)= 200 m Length (SW)= 400 m Height (NE) = 5 m Height (SW)= 6 m	3 Groins Length = 150 m Spacing = 300-400 m	20.72
Sakom Jana District Songkhla	-To prevent the sediment on a river mouth -To protect fishery from wind and wave	2 Jetties (rubble-mound) Length = 650 m Height = 7 m	4 Detached Breakwaters Sea wall 400 m	1.24
Thepha(Praput) Thepa District Songkhla	-To prevent the sediment on a river mouth -To protect fishery from wind and wave	2 Jetties (Sheet pile) Length (NE) = 850 m Length (SW) = 550 m Height = 7 m	4 Detached Breakwaters Sea wall 600 m	4.82
Laem Ta Chi Maung Patthani	-To prevent the sediment on a river mouth	1 Jetty (rubble-mound) Length = 320 m Height = 8 m Direction = N32'W	N/A	9.88
Panare Panare District Patthani	-To prevent the sediment on a river mouth -To protect fishery from wind and wave	2 Jetties (rubble-mound) Length = 350 m Height = 6.14-6.34 m Direction = N44.45'E	4 Detached Breakwaters Length = 50 m Spacing = 200 m	2.84
Bang Maruat Panare District Patthani	-To prevent the sediment on a river mouth -To protect fishery from wind and wave	2 Jetties (rubble-mound) Length (NE) = 330 m Length (SW) = 440 m Height (NE) = 6 m Height (SW) = 4.4 m	3 Detached Breakwaters Length = 50 m	5.74
Sai Buri Saiburi District Patthani	-To prevent the sediment on a river mouth -To protect fishery from wind and wave	2 Jetties (rubble-mound) Length (NE) = 150 m Length (SW) = 800 m Height (NE) = 7.3 m Height (SW) = 7.8 m Direction = N30'W	3 Detached Breakwaters Sea wall 1000 m	27.67
Narathiwat (Bangnara) Maung Narathiwat	-To prevent the sediment on a river mouth -To protect fishery from wind and wave	2 Jetties (rubble-mound) Length (NE)= 350 m Length (SW)= 700 m Height (NE)= 5 m Lower (SW) = 6 m direction = N18.5'E	4 Detached Breakwaters Spacing = 150 m Direction = N65'W	16.31
Tak Bai Takbai District Narathiwat	-To prevent the sediment on a river mouth -To protect fishery from wind and wave	2 Jetties (rubble-mound) Length (NE)= 450 m Length (SW)= 150 m Height (NE)= 6.5 m Height (SW) = 5 m	Sea wall 9 groins Length = 70 m Spacing = 400 m	20.67

Source: HD
Note: ▭ : Shore Protection Structure Provided

8. Dredging Equipment

8.1 Equipment Available

At present, CDC II has a dredging fleet of 4 cutter suction dredgers, 6 trailing suction dredgers and 2 backhoe dredgers for channel maintenance. Management of the operations of the two backhoe dredgers seems very effective.

8.2 Cutter Suction Dredgers

The cutter suction dredgers consist of C-1, C-25, C-37 and C-39. Specifications of each dredger are shown below:

	Digging Depth (m)	Digging Capacity (m^3/hr)	Discharge Pipe (inch)
C-1:	8	100	14
C-25:	16	450	20
C-37:	12	450	20
C-39:	4	50	4

The JICA Study team observed the operation of C-25 and C-37 and found that they are designed for excavation at much deeper depths than the channels CDC II is currently maintaining. They are also designed for discharging at much longer distances than the actual operation. In addition, modification or adjustment of their cutter heads is necessary. Controlling of the excavation sequence and the water velocity inside the discharge pipeline will do much to improve the dredging outputs. Even though the team did not observe either C-1 or C-4 under operation, it could be said that they are appropriate for the shallow channel dredging. Cutter suction dredgers operate well in calm water areas like Pak Phanang and in the channels protected by the jetties, but they are inappropriate in the open sea like at Sichon.

8.3 Hopper Suction Dredgers

Coastal Dredging and Maintenance Division control all the trailing suction dredgers (hopper dredgers) and assign them for channel maintenance. When the study was conducted, 3 hopper suction dredgers H-8, H-10 and H-12 were working at the CDC II channels. Each hopper dredger has the capacity as shown below:

	H-2	H-4	H-6	H-8	H-10	H-12
Hopper Capacity (m^3)	380	400	100	400	800	1400

In 2001, H-4, H-8, H-10 and H-12 were engaged in maintenance dredging of CDC II channels, mostly Songkhla channel. The JICA Study team observed the operation of H-10 and H-12 during the site survey. As far as the observation of these two hopper dredgers, it is concluded that excavation time should be increased.

9. Dredging Performance

9.1 Records in "Annual Implementation Reports"

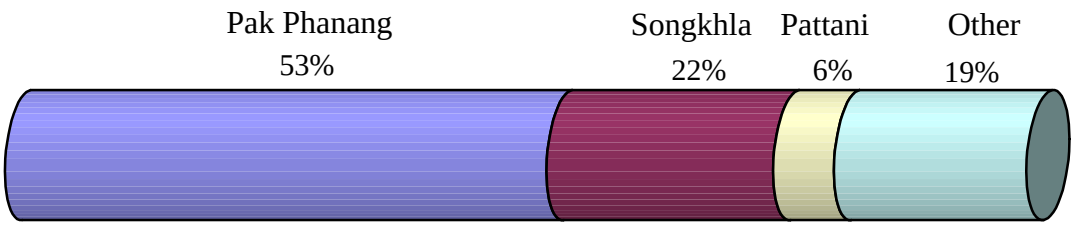
The JICA Study Team analyzed statistics of "Annual Implementation Report" each fiscal year from 1996 to 2000 to obtain a clear view on the outputs of the maintenance dredging produced by CDC II. The findings are rather simple. As far as maintenance dredging is concerned, expenses for the dredging CDC II channels are spent for Pak Phanang (53%), Songkhla (22%), Pattani (6%) and other channels (19%) as shown in Figure 9.1. It should be noted that the two major channels required 75% of the spending and other channels consisting of 28 navigation channels and 14 irrigation channels consumed only 25%. Regarding the dredged volume recorded in the annual reports, the two major channels shared 16% (Pak Phanang) and 51%(Songkhla) of the total. The other 42 channels share only 33%. It is therefore concluded that the CDC II should pay most attention to the maintenance dredging of these two major channels.

Issues	Measures
Songkhla: The navigation channel is much shallower than the design depth. The water depth at the quay wall is very shallow (-5 m) in comparison with the design depth of –9 m.	- To continue the excavation until the time when the weight of the dredged materials in the hopper does not increase any more, or the maximum confinement of the dredged materials in the hopper is practically achieved. - To employ a combination of a long-arm backhoe, grab bucket and suction pump to deepen the quay wall of Songkhla Container Terminal. - To use two hopper dredgers (H-10 and H-12) to achieve design depth –9m. Next stage, one hopper dredger (H-10 or H-12) can maintain the channel and basin.
Pak Phanang: Siltation is heavy and shallow. Dredging in 27km long channel was operated almost every year. The navigation channel in the sea is shallower than the design depth (-4m).	- To maintaining a proper water velocity inside the discharge pipeline of cutter suction dredgers. To this end, provide diffuser at the end of the discharging pipeline, and/or reduce the diameter of impellers inside the dredge pumps. - To position the cutter head at such position that the excavating face can be twice as thick as the cutter head diameter. For C-37, readjust the front end of the ladder. - To use two cutter suction dredgers (C-25 and C-37) simultaneously in parallel for maintenance dredging.

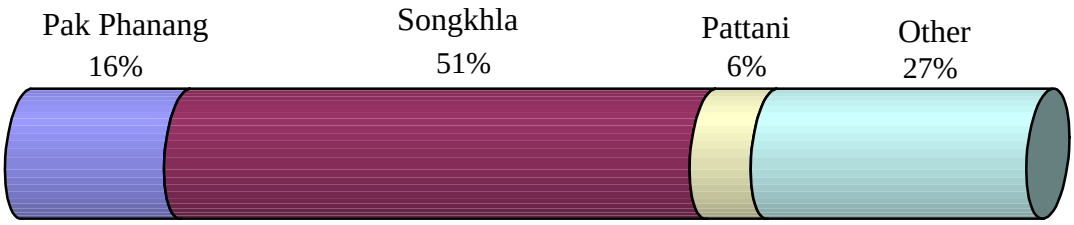
Table 9.1 Share of Expence & Volume for Maintenance Dredging (1996 - 2000)

Name of Channels	Expenses		Volume	
	(Baht)	(%)	(m^3)	(%)
Pak Phanang	93,944,802	53%	2,073,898	16%
Songkhla	39,359,525	22%	6,856,000	51%
Pattani	9,659,110	6%	796,217	6%
Other channels	4,097,495	19%	3,595,176	27%
Total	175,851,564	100%	13,321,291	100%

Source: Annual Implementation Report, CDMD, HD Fiscal year 1996-2000



Expense: 176 mil. Bahts in total



Dredging Volume: 13.3 mil. m^3 in total

Figure 9.1 Share of Expenses & Volume for Maintenance Dredging

Source: Annual Implementation Report, CDMD, HD Fiscal year 1996-2000

10. Major Recommendations on Dredging Operation

10.1 Cutter Suction Dredgers

All the cutter suction dredgers operate at the channels which are much shallower and with much shorter discharging distance than those intended in design specifications. As a result, the water velocity inside the pipeline is too fast to efficiently excavate the soil. Therefore, the following adjustments on equipment or operation should be implemented:

- Maintaining a proper water velocity inside the discharge pipeline. To this end, providing diffuser at the end of the discharging pipeline, and/or reducing the diameter of impellers inside the dredge pumps.
- Positioning the cutter head at such position that the excavating face can be twice as thick as the cutter head diameter. For C-37, readjusting the front end of the ladder.
- Changing the shape of cutters to fit the shallow depth.

10.2 Hopper Suction Dredgers

So far as observation on H-10 and H-12 concerned, the team recommends the following measure:

Issues	Recommendation for Maximum Dredging
After H-12 starts dredging, the hopper (1,400m^3 capacity) was full of muddy water in 15 minutes net dredging hour, and then travels to disposal area for dumping. Figure 10.1 shows that the net dredging hour is about 105 minutes (15 minutes x 7 cycles) per day.	- To Continuing the excavation until the time when the weight of the dredged materials in the hopper does not increase any more - To increase excavation time and thus increase out put per day. Figure 10.1 shows the maximum confinement of the dredged materials in the hopper is practically achieved.

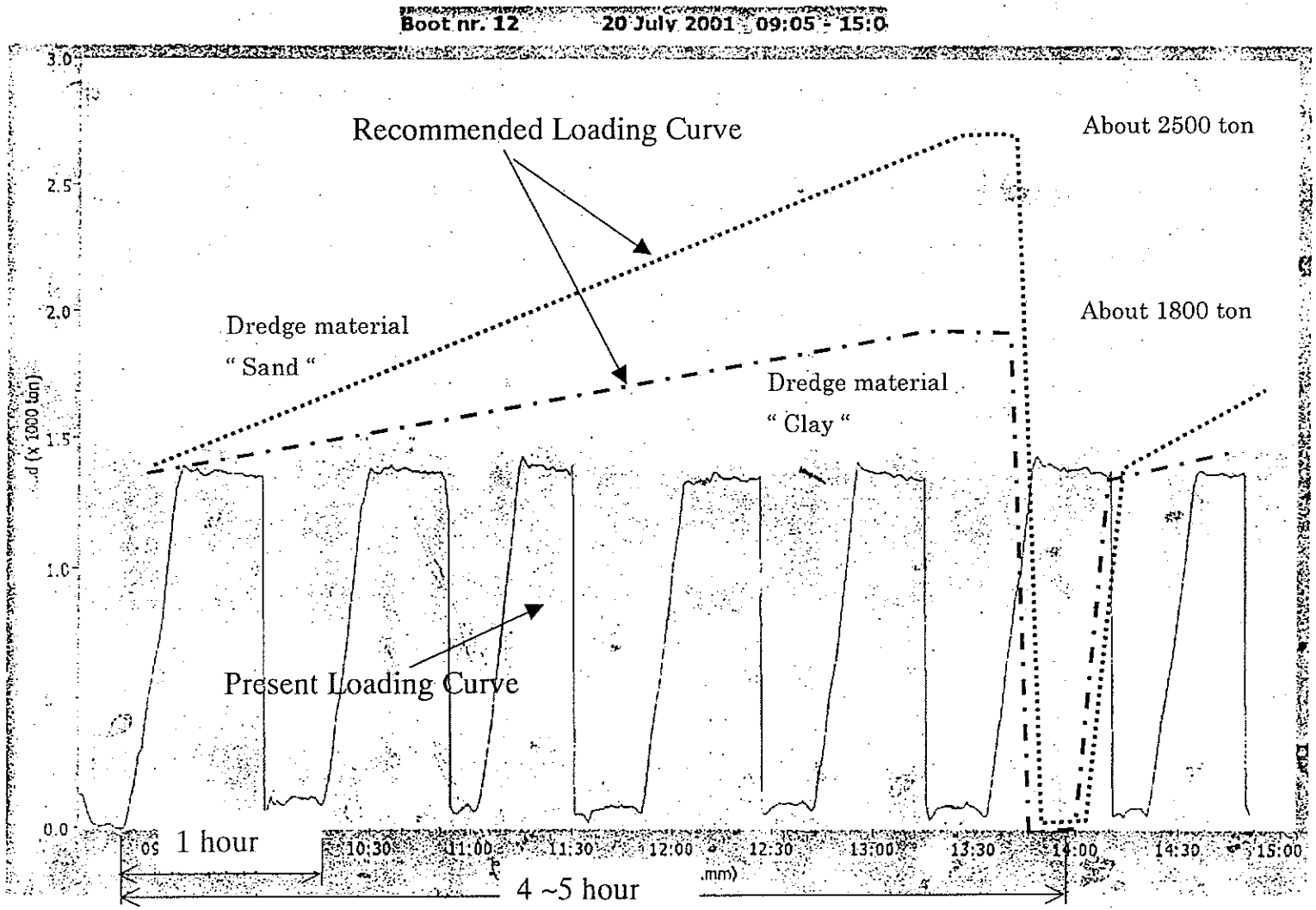


Figure 10.1 Loading Record of H-12

10.3 Management and Control

Besides the technical improvements mentioned above, HD needs to improve management and control on the dredging operation as follows:

- Instruct specific dredging area to the dredger crew.
- Monitor the progress based on the survey data, loading records and excavation time records.
- Identify the personnel at the manager level at Headquarters responsible for the correct and efficient dredging.

10.4 Deepening of Quay Wall of Songkhla Container Terminal

Neither a cutter suction dredger nor hopper suction dredger can deepen the quay wall of the international container terminal or CTI Terminal. As no particular equipment has been prepared at CDC II, the deepening has supposedly not been carried out for a considerable period of time. Thus, the water depth now is only -5 m instead of design depth of -9 m. The shallow quay wall is serious problem for the international maritime transport. A combination of a long-arm backhoe, grab bucket and suction pump should be employed to deepen the quay wall.
(See Figure 4.5)

11. Recommended Dredging Program

11.2 Dredging Program

The hopper suction dredgers are very effective for the maintenance of Songkhla channel, where cargo ships are frequently calling. For the shallow channels, a small cutter suction dredger like C-1, or a backhoe dredger are effective. Therefore, the JICA Study Team recommends that the dredging operation for the channel maintenance be programmed with the priority put on the equipment. The operation of each dredger should be programmed as categorized in Table 11.1.

The channels on the lake under CDC II management can be maintained with backhoe dredgers and C-39 as they are currently doing.

Table 11.1 Recommended Maintenance Dredging Plan

Channel Type - Name	Dredging Equipment
1. Trailing Suction Hopper Dredger	
Songkhla	H-10, H-12
Pattani (Open sea)	H-2, H-4, H-8
2. Cutter Suction Pump Dredger	
(a) 20" type C-25, C-37	
Pak Phanang	C-25, C-37
Pattani (River) Pak Nakhon, Pak Paya, Pak Phun, Pak Phaying, Khanom (Outer), Narathiwat	C-25, C-37, (C-1)
(b) 14" type C1	
Khanom (Inner), Sichon, Tha Sala, Nathap, Sakhom, Thepha, Bang Ra Pha, Ko lok, Panare, Bang Maruad , Sai Buri, Tan Yong Phao, Tawa (Nong Jig), Tak Bai	C-1
3. Back Hoe, C39	
Khlong Tung Ca (Ban Tepa), Tha Mak, Pak Duad, Ban Sai Samor, Rusamilae, Khlong Tu Yong, Khlong Gor Tor, Ta Lo La Veng, Khlong Kok Kean, Chalae (Pak Rawa)	BH
(Lake)	
Thale Noi, Hua Pa, Takhria, Sala Tham, Ban Mai, Khlong Chiang Phong, Khlong Mahakan, Ban Ku Khud-Ban Laem Vang, Lam Pam, Khlong Sam Rong	BH, C-39