BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR CONSTRUCTING
THE NAKHON SI THAMMARAT FISHING PORT
IN
THE KINGDOM OF THAILAND

AUGUST, 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to the request of the Government of the Kingdom of Thailand the Government of Japan has decided to conduct a basic design study on the Project for Constructing the Nakhon Si Tammarat Fishing Port and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Thailand a study team headed by Mr. Masao Kishino, Deputy Director, Prevention and Coastal Protection Division, Fishing Port Department, Fisheries Agency from April 18 to May 12, 1987.

The team had discussions on the Project with the officials concerned of the Government of Thailand and conducted a field survey in the Nakhon Si Thammarat area. After the team returned to Japan, further studies were made, a draft report was prepared and a mission to explain and discuss it was dispatched to Thailand. As a result, the present report has been prepared.

I hope that this report will serve for the development of the project and cotribute to the promotion of friendly relations between our two countries.

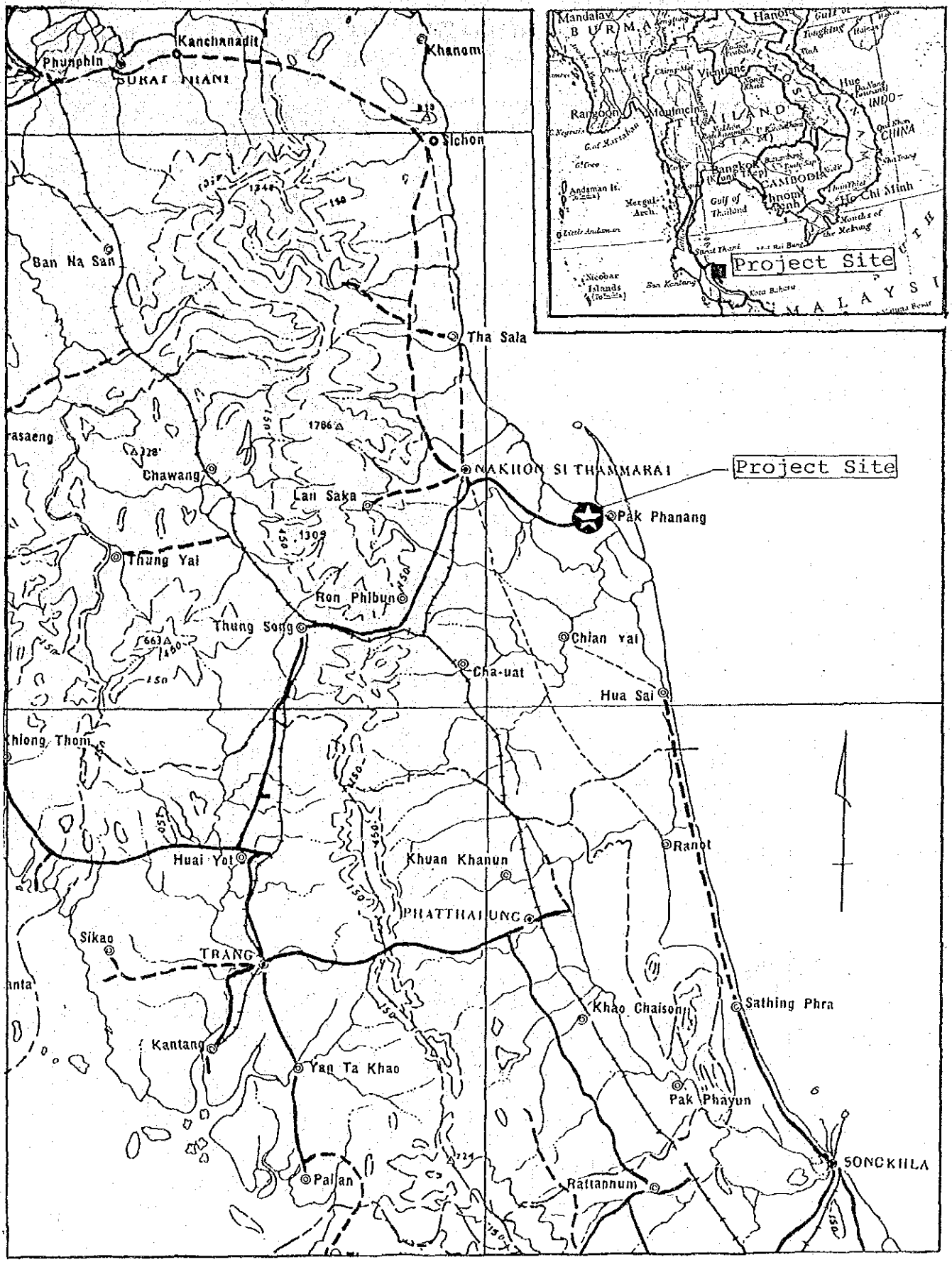
I wish to express my deep appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the team.

August, 1987

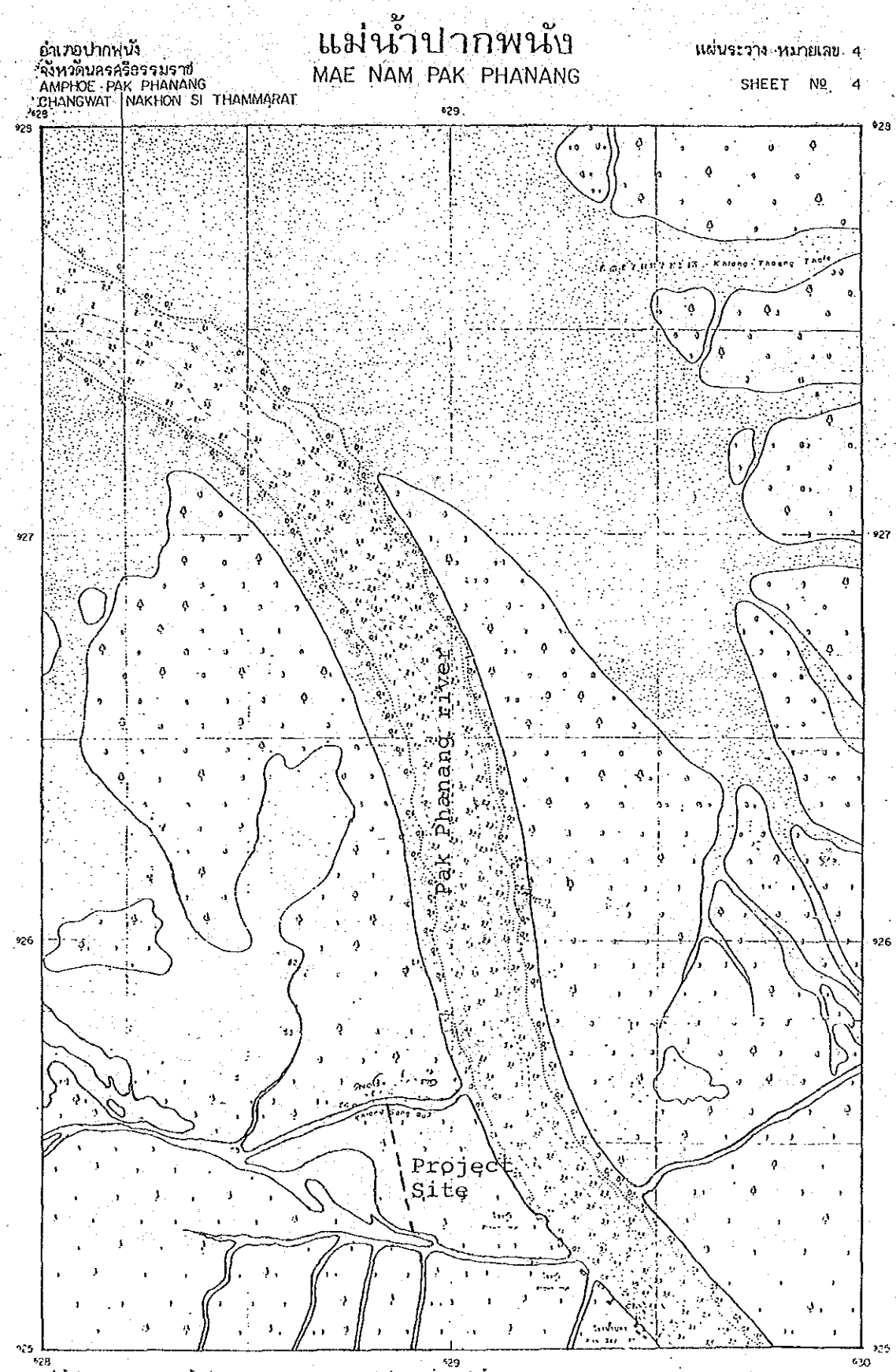
Keisuke Arita

Keisuke Arita
President
Japan International
Cooperation Agency

LOCATION MAP

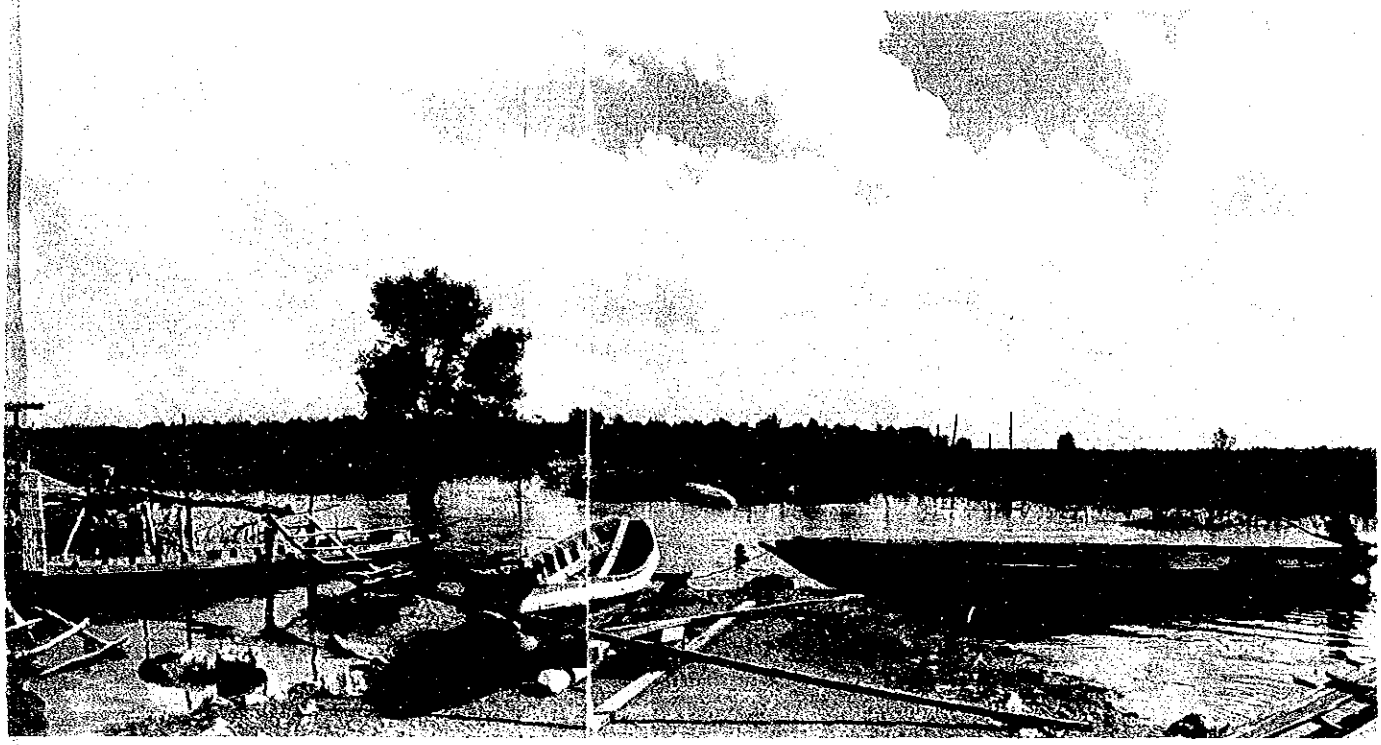


PROJECT SITE MAP

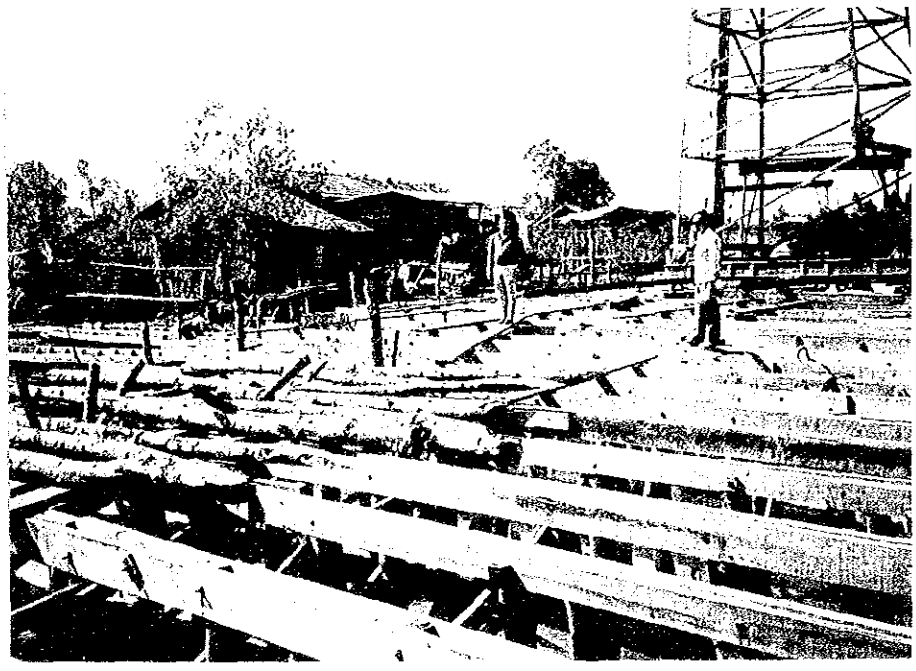


Photograph

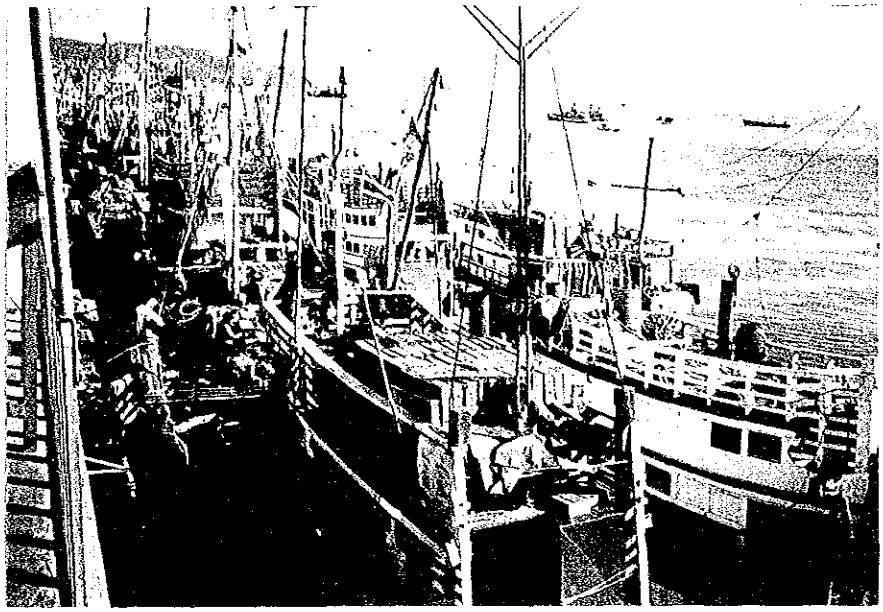
Nakhon Si Thammarat Fishing Port : Project Site



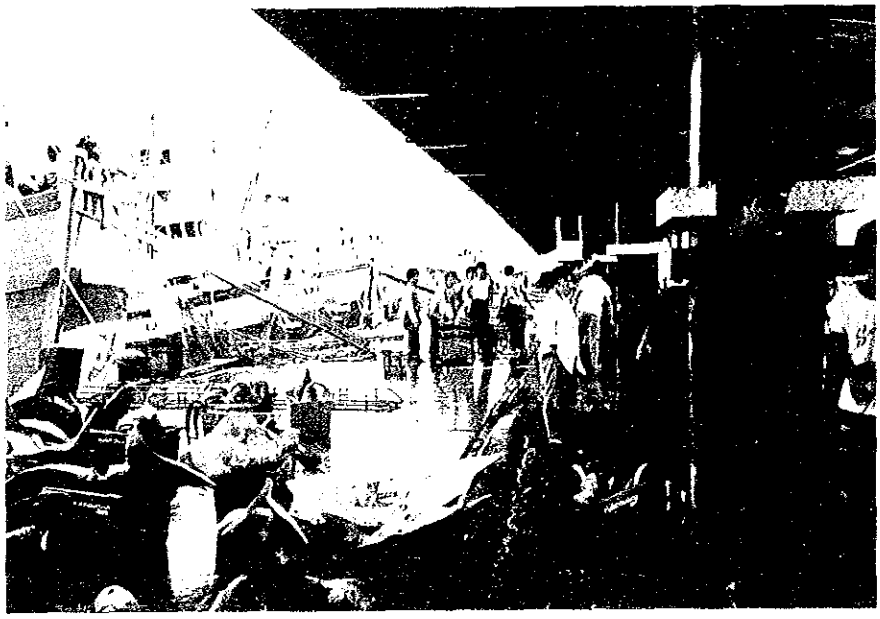
Under construction of access bridge between
the project site and the provincial road
(Pile driving is in progress August, 1987)



Surat Tani Fishing Port



Songkla Fishig Port



Pattani Fishing Port

Summary

SUMMARY

Although Thailand has developed crude oil and natural gas and has attempted to industrialize, the most important industries in the country are agriculture, forestry and fisheries. In the fishery sector, the peak catch of 2,190,000 tons occurred in 1977, however, there was a decline in catches from that time until 1981, when a gradual recovery began. In 1984 the fish production reached 2,130,000 tons which consisted of 1,970,000 tons of marine fish and 160,000 tons of fresh-water fish. Increasing the fish catch has been made difficult due to the imposition of the 200 mile Exclusive Economic Zones by the neighboring countries and to the decrease of fish resources brought on by excessive trawling operations. Recently, the annual fish catch reaches an amount of approximately 15 billion Baht which is about seven percent of the total of the entire agricultural, forestry and fishing industries. As fish continues to be one of the main sources of animal protein, it is anticipated that the fishery industry will remain stable in the future.

The main fishing methods employed by marine fisheries are trawling, purse seining and gill netting. Fifty to sixty percent of the fish were caught by trawling. Fish catches in the northern part of the Gulf of Thailand has been decreasing while, in the area of southern Thailand, it has been increasing. In 1984, the fish catch in the area of southern Thailand reached 1.17 million tons. This figure was about fifty-five percent of the total fish catch in Thailand in that year. In this area, trawl fishing is very prosperous. However, about two thirds of the catches are trash fish and are processed as fish-meal.

The new port is expected to be constructed at Nakhon Si Thammarat province (population 1.3 million). This province, the second largest in southern Thailand, has an area of 1,000㎢. The province is mountainous and is utilized by rubber tree and fruit tree plantations. As there are very few employment opportunities in other fields, a number of people travel to other provinces seeking jobs. The province's 255㎞ shoreline along the Gulf of Thailand is the main reason for the popularity of fishing in the area. Even though the province has the greatest number of trawlers in the country, there is no port having proper facilities. Most fishing boats unload at other provincial fishing

ports, such as Songkhla and Pattani. The activities of these fishing vessels contribute to the fishery industry in southern Thailand, but, at the same time, congest the Songkhla and Pattani fishing ports.

The Government of Thailand requested the Government of Japan to construct the new fishing port under the Grant Aid Program. In response to the request by the Government of Thailand, the Government of Japan decided to undertake a basic design study for the construction of the new fishing port. The Japan International Cooperation Agency (JICA), who conducted the study, dispatched the basic design study team, headed by Mr. M. Kishino, of the Fishing Port Division of the Fisheries Agency, to Thailand from 18 April to 12 May 1987. The team discussed the Request with Government officials and conducted the necessary field investigation and design analysis.

The results of the basic design study are as follows:

- An estimated 125,000 tons of fish are to be landed at the new fishing port yearly.
- It is estimated that the sediment transportation of the river will not be deposited and accumulated in the area of the landing pier.
- It will be possible to erect structures on the soft subsoil at the project site.

Through the study of the Request of Thailand, the facilities and equipment for Japan's Grant Aid Program are evaluated as follows :

1) Basic facilities for the fishing port
   (landing pier, service jetty and revetment)
2) Civil works (road, parking area and drainage)
3) Buildings (administration office, fish agents office, truck scale house, etc.)
4) Utilities (water, electricity supply, sewerage system, etc.)
5) Plant (ice making facility and stand-by power generator)
6) Equipment (weighing machine, equipment for landing catches, etc.)

The implementation of the Project is as follows :

1) The construction work to be borne by Thailand, such as reclamation, repair of the access road and the construction of the access bridge, will be

completed in 1987. Some of the arrangement for utilities will be completed in 1988.

2) The landing pier and service jetty will be the First Stage of construction, with consideration given to the progress of the consolidation of soft sub soil settlement.
3) Except for the landing pier and service jetty, civil works, buildings and other work will be constructed as the Second Stage.

The executing agency of the fishing port will be the Fish Marketing Organization (FMO) which is under the supervision of The Ministry of Agriculture and Cooperation (MOAC). FMO will operate and manage the port during the construction and after the completion. FMO manages three fish markets and 10 fishing ports at present. It is estimated that the expenditures for management and maintenance will be covered by the revenue from the port facilities. Therefore, FMO has the ability to manage and operate this port as the eleventh fishing port.

After the completion of the fishing port, the benefits, such as the reduction in time necessary to unload a catch thereby increasing fishing operation time, are significant. Consequently, the propriety for construction of the port is extremely high. Further, the new port will stimulate the development of local industry and provide increased job opportunities thus stemming the outflow of the province's people.

Therefore, from this point of view, the implementation of the project under Japan's Grant Aid Program is extremely meaningful and the early completion of the project is highly anticipated.

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Chapter 1. Introduction

CHAPTER 1. INTRODUCTION

1 - 1 Objectives of the Study

Thailand has developed such natural resources as crude oil and natural gas together with a plan to establish industrial zones and ports such as Leam Chabang and Maptaput.
Although Thailand is planning industrialization, it remains a big producer of rice as well as a good producer in the fields of agriculture, forestry and the fishing industry.

Regarding the fishery sector, the fish catches in recent years have been steady at approximately two million tons annually. Thailand is the leading fishing nation in Southeast Asia. The major fish unloading operations are moving from central to southern Thailand.

The Nakhon Si Thammarat province in southern Thailand, an area that is under study, has a large number of fishing boats. However, as there are no fishing ports within the province capable of satisfactorily handing the unlroading of fish catches, most of the fishing boats travel to ports in other provinces to conduct unloading operations.

As part of its development plans, the Government of Thailand desires to promote the growth of the fishing industry and industries related thereto in the southern part of the country. Further, it has requested the Japan's grant aid for constructing a new fishing port in the Pak Phanang area in Nakhon Si Thammarat province in order tocurb congestion in neighboring ports.

1 - 2 Mission to Thailand

In January, 1987, the Japan International Cooperation Agency (JICA) conducted the preliminary study by a team headed by Mr. Masao Shinomura of the Cooperation Union Section of the Fisheries Administration Division of the Fisheries Agency.

Based upon the results of the preliminary study, a basic design study was conducted by a team headed by Mr. Masao Kishino of the Fishing Port Division of the Fisheries Agency consisting of two government officials and five consultants.

The basic design study team conducted a site survey from 18 April 1987 to 12 May 1987, and exchanged minutes of discussions with Thai government officials on 27 April 1987. (Refer to Attachment 1-2)

The purpose of this study is to make basic designs for the construction planning of the new fishing port in the province of Nakhon Si Thammarat, checking the specific contents and background concerning the request submitted by the Government of Thailand to build the new fishing port, and, in addition, to investigate the socioeconomic effect of this plan and its propriety as a project implemented under Japan's Grant Aid Program.

The flow and itinerary of this study are shown in Attachments 1-4, 1-5, and 1-6.

1 - 3 Outline of the Study

The basic design study team carried out the following studies to evaluate the feasibility of the project as the Grant Aid Program.

(1) Background and outline of the project, and the propriety of the project
(2) Related project
(3) Project status, especially on the fish marketing
(4) Scale of the facilities
(5) Project agency and its organization, and the confirmation of the work to be done by Thailand
(6) Similar facilities

JICA reviewed the contents of the study carried out by the basic design study team, on the scale of the facilities, construction period and cost , and propriety of the project and then compiled as the basic design study report (draft final report). JICA, then, sent the team headed by Mr. Masao Kishino of the Fisheries Agency to Thailand during 27th July to 5th

August, 1987. The team submitted and explained the draft final report to the authorities concerned and confirmed the contents of the study. And consequently, the both representatives agreed basically on the contents of the study and then signed the minutes of discussion in July 1987.

Chapter 2. Background of the Project

CHAPTER 2. BACKGROUND OF THE PROJECT

2 - 1. Outline of Thailand

In 1984, the National Income of Thailand was about 990 billion Bahts, and the Per Capita National Income was about 19,000 Bahts (equivalent to $807 US). In 1970, the products of agriculture, forestry, and fishery represented 28% of the Gross National Product (GNP), topping all other categories. However, the ratio has been decreasing yearly, and, in 1984, was down to 20%. As the ratio for agriculture, forestry, and fishing lowered noticeably, the ratio for the manufacturing industry has increased remarkably. The actual growth rate of the fishery industry was 9.1% in 1983 and 6.5% in 1984. These figures are higher than those for the agricultural and forestry industries. The growht ratio of agriculture in the southern part of Thailand is greater than in other parts, making it an important industry in that area.

In the sixth National Five-Year Plan that went into effect in 1986, the actual Gross National Product growth ratio was set as 5.1%, while to ratio for the agricultural, forestry, and fishery industries was established as 2.9 % : 2.6% for agriculture, 2.9% for live stock, and 2.3% for fishery.

As for the fishery sector, the annual catch of marine fish has been about two million tons during recent years. The monetary value of about 15 billion Bahts per year represents 7% of the combined value of the agricultural, forestry and fishery sectors' products.

The landing of fish at the major fishing ports on the eastern side of the Malaysia Peninsula of Thailand has been increasing during recent years, while to the North of the Gulf it has been decreasing. Form 1982 to 1984 about 800 thousand tons of fish per year have been unloaded at east coast ports, of which 600 thousand tons were unloaded at ports in the provinces of Songkhla, P attani, Surat Thani, and Chumphor.

2 - 2 Project Site

(1) Outline of Nakhon Si Thammarat

Nakhon Si Thammarat is located on the eastern coast of South Thailand. Having an area of about 1,000 km², it is the second largest province in southern Thailand and, in 1984, had an estimated population of 1.3 million. The Province, facing the Gulf of Thailand, has a 255 km long shoreline which amounts to 12 % of the country's total shoreline. Fishing is one of the province's most important activities. Other than for rubber tree and fruit tree plantations, there are but a few industries in the area. Thus, in order to find work, many of the local residents must seek employment outside of the province.

(2) Condition of the Project Site :

The project site covers an area of 18 hectares. It is located along the Pak Phanang River, 4 km from the mouth of the river and 5km downstream form the Pak Phanang municipal area.

The plan for the construction of a new fishing port at the proposed project site has already been approved by the National Environmental Board and the Forest Department (refer to Attachment 2-2 and 2-3).
The implementation of the project must not effect the environmental conditions in the vicinity of the project site.

The access bridge over the klong and the temporary construction road to the project site, including the reclamation of the site, will be constructed by the Fish Marketing Organization (FMO) by the end of 1987. The access road from Pak Phanang to the project site will be improved by the Provincial Office. Electric, water supply, and telephone lines will be installed during the latter part of 1988.

Presently, of all the provinces, Nakhon Si Thammarat has the most fishing boats. Also, there are many fishing craft in the vicinity of the project area at Pak Phanang. Fishing boats that are currently unloading their catches at nearby fishing ports and existing fish landing facilities in the Pak Phanang district are expected to use the new fishing port upon its completion and when fish agents have set up their new operations.

The people of the province have great expectations for the construction of the new fishing port and for its early completion.

As the site is located near the mouth of the river - a swampy area having a forest of mangrove trees - special attention must be paid to the siltation problem in the vicinity of the fishing port's pier and to the stability of structures at the reclamation area after construction.

2-3 The Status of Fisheries in Southern Thailand

2-3-1 Background of Thai Fisheries

The fish catch in 1984 totalled 2.13 million tons (1.97 million tons of marine fish and 0.16 million tons of freshwater fish). Thailand is the leading fishing nation in Southeast Asia and is ranked 9th in the world. However, after steadily increasing until 1977 (the year in which the total fish catch set a record of 2.19 million tons), fish catch has been stagnating (Table 1, Attachment 2-4). The current fish supply does not meet an increasing population. This is mainly caused by the stagnant level of marine fish catch which contribute over 90% of the country's total fish catch. The following are possible reasons behind the stagnation of fish catch.

(1) Reduction of fishing grounds due to the imposition of 200 mile Exclusive Economic Zone (EEZ) by neighboring countries

Due to the declaration of the 200 mile EEZ by neighboring countries such as Cambodia, Malaysia, Indonesia, Burma and Bangladesh in the late 1970's, Thai fishing boats were largely affected in terms of fishing grounds. About 30% of the former public waters surface in the Gulf of Thailand was absorbed on account of the Exclusive Economic Zones of the neighboring countries. The Government of Thailand has been making great efforts negotiating with neighboring countries and has succeeded in gaining fishing rights for some Thai fishing boats to operate within the 200 mile EEZ of Indonesia and Bangladesh.

(2) Excessive trawling operations in the Gulf of Thailand

The most important fishing activity is trawling, which provides about 60% of the total marine fish catch. However, catches by trawlers have gradually decreased, while those by purse seiners and gill netters have increased (Table 2, Attachment 2-4). This is mainly caused by the over-exploitation of demersal fish resources in the Gulf by excessive trawling operations. The country's Catch Per Unit Effort (CPUE) has declined since 1970 (Table 3, Attachment

2-4). The decline of CUPE forced fishermen to extend hours of operation and reduce the net mesh size. Nets with reduced mesh size catch small juvenile fish of economically important species which are then treated as trash fish.

2-3-2 Characteristics of Fisheries in Southern Thailand

(1) Fish landing volume

Fish catch in southern Thailand in 1984 was 1,175 thousand tons, contributing up to 55% of the country's total fish take. About 99% of the fish catches in southern Thailand is composed of marine fish, while freshwater fish is only 12,000 tons approximately. Marine fish landings on the eastern coast of southern Thailand increased from 602,000 tons in 1977 (29% of total fish catch) to 821,000 tons in 1984 (41.6%), while those of central Thailand, which was the major fish landing area in the country in 1977, has been decreasing (Table 4, Attachment 2-4). The causes behind such changes are as follows:

(a) Trawling has caused an over-exploitation of demersal fish resources in the Gulf of Thailand, especially in the inner parts of the Gulf. CPUE has decreased more rapidly and trash fish composition in the trawl catch is higher than those of the outer parts of the Gulf.

(b) The main fishing grounds for Thai purse-seiners operating in the Gulf of Thailand are waters lying between Prachuab Khiri Khan and Surat Thani and waters off Pattani during the southeast monsoon season (May to November). Fishing is prohibited for five months in the former region from February to May and from September to November. Fishing grounds for purse-seiners have therefore been shifting to southern Gulf waters and they use Pattani or Songkhla ports as landing bases. In addition, 60 Thai purse seiners are presently operating in the Indonesian waters in accordance with a fishing agreement signed by the two countries. Being closest to the fishing grounds, their landing sites are located in southern Thailand.

Southern Thailand has gradually replaced central Thailand as the major fish landing site. It is further forecast that trawling fishing grounds will also move southwards because of the aforementioned resource conditions. However, since the number of fishing days and the operational cost of trawlers will increase, there is a high possibility that fishing ports located in southern Thailand will be used as fish landing sites for fishing boats coming from central Thailand.

(2) Fishing boats

Registered fishing boats operating on the east coast of the southern Thailand make up 40-50% of the total number of boats in the country (Table 5, Attachment 2-4). The three provinces of Nakhon Si Thammarat, Songkhla and Surat Thani are those having with the highest proportion of fishing vessels in Thailand. The actual number of fishing boats is probably higher than the figures indicate, since southern Thailand thrives with unregistered boats. Nakhon Si Thammarat province has the highest number of trawlers in the country and these make up 75% of all boats in the province. This is far above the national figure of 57% for trawlers. In the provinces of Songkhla, Pattani and Chumporn, there is a comparatively large number of purse-seiners and gill netters, while Nakhon Si Thammarat has no purse seiners and a limited number of gill netters besides small shrimp gill netters. This seems to be reflected by the following facts:

1) Compared to neighboring provinces, Nakhon Si Thammarat Province is further away from purse-seine fishing grounds.

2) Fishermen in Nakhon Si Thammarat Province are not accustomed to purse-seine and gill net fishing.

3) There are no adequate port facilities in Nakhon Si Thammarat that can accommodate purse-seiners.

(3) Fish marketing in southern Thailand

Southern Thailand is the largest fish landing area in the country, yet its population of approximately seven million comprises only 13.2 percent of country's total population. Modern fish processing industries are not adequately established in handle fish catches brought to this region. Thus, large quantities of fresh fish are either being transported to Bangkok or exported to Malaysia.

The fish catch in southern Thailand in 1984 was of approximately 1.175 million tons, of which 1.163 million tons was marine fish. A total of 0.8 million tons was processed locally and 0.07 million tons of fresh fish were consumed locally. The remaining 0.3 million tons of fresh fish were transported to Malaysia (0.06 million tons) and Bangkok (0.24 million tons).

The flow of fresh fish in southern Thailand can be pictured in Figure 1, Attachment 2-4 by taking into account the size of the fish catch, the volume of fish processed and the estimated local consumption.

The status of fish marketing in southern Thailand can be summarized as follows:

1) The marketing center of southern Thailand is Hat Yai in Songkhla Province, where the processing plants having the largest capacities can be found. Hat Yai possesses access roads connecting to Malaysia, so that fresh fish from neighbouring provinces, such as Pattani and Satul are first collected in Hat Yai before being sent to either Bangkok or Malaysia.

2) The surplus of fresh fish from provinces in the northern part of southern Thailand, such as Phuket, Phangnga, Surat Thani, Chumporn and Prachmab Khri Khan, is transferred to Bangkok. The center of marketing in this area is Surat Thani. It is difficult to expect an increase in the amount of fish landing in Surat Thani Province without large-scale and regular dredging of navigation routes in Ban Don Bay which is characterized by shallow waters. Surat Thani is located at the

junction of the main roads leading from the Indian Ocean side and the Gulf of Thailand side to Bangkok and it is expected that there will be further development of fish marketing and processing in that area.

2-4 Fisheries and Fishing Port Development Plan

2-4-1 Fisheries Development Plan

The fisheries development plan incorporated in the sixth Five-Year National Social and Economic Plan (1986-1990) emphasizes a quanlitative improvement of fisheries having the following objectives:

1. Rehabilitation of fishery resources and their effective use
2. Improvement of fish products

In the course of the improvement of the marine fish catch level, the Department of Fisheries (DOF) has a policy to strengthen the management of fish resources, as well al to promote fishing agreements and joint fishing operations with neighboring countries. In order to conserve marine fish resources by protecting the spawning grounds and fingerlings, the DOF set up regulations, such as the restriction of certain types of fishing gear and net meshes, and covering the provinsions pertinent to the closed season and to prohibited areas. Regarding excessive trawling, which decreases fish resources, the DOF intends to control the number of trawlers operating in the Gulf of Thailand. However, it is difficult to set up regulations limiting the number of trawlers without taking appropriate measures to assure the livelihood of fishermen engaged in trawling.

Attaching importance to this situation, the DOF has been considering the following measures:

(1) Improvement of fish marketing and processing industries (stabilization of producer prices, improvement of fish product quality).

(2) Increase of job opportunities for fishermen (development of fishery

related industries, fish farming, fish processing, etc.)

(3) Extension of purse-seine and gill-net fishing, and conversion from trawl fishing (strengthening of technical training).

(4) Development of deep sea fishing and exploitation of new fishing grounds (research and investigation of resources, strengthening of technical training).

It is expected that the project port, as one of the important fishery infrastructures for taking these measures, will contribute to the development of fisheries in southern Thailand. In addition, the improvement of fishing ports in rural areas will be significant from the viewpoint of the "Correction of Regional Differences of Income" policy which is emphasised in the current Five-Year Plan.

2-4-2 Improvement Plan of Fishing Ports & Fish Markets

The volume of fish landed in southern Thailand has been increasing yearly, and Songkhla and Pattani fishing ports have consequently become highly congested. Accordingly, the volume of fish to be transported to Bangkok has increased, resulting in the congestion of the Bangkok and Samut Sakhon fish markets due to the increased number of trucks calling. (Table 6, Attachment 2-4). The congestion status at each fishing port and fish market can be explained as follows:

(1) Many fishing boats of Nakhon Si Thammarat are landing fish at Songkhla Port where there is no possibility for expanding either the landing pier or the sorting area.

(2) The number of purse seiners, including other provincial boats, at the Pattani fishing port has been increasing yearly. This port offers good possibilities to act as an landing base for purse-seiners.

(3) At the Samut Sakhon Fish Market, space for trucks loading is often used inappropriately by trucks unloading. Thus, it is difficult

for fish buyers to load fish onto their own trucks. The total number of trucks per day is beyond the capacity of the parking area.

(4) The only entrance road to the Bangkok Central Fish Market is narrow. The parking area cannot handle all of the trucks calling.

In addition, all markets and ports are congested because of acess by outsiders to the sorting and auction areas, causing problems such as fish robbery, lower working efficiency, etc. In order to control the number of workers in the sorting and auction areas, FMO is presently making efforts to introduce a system to register the workers of fish agents and a system to identify workers by requiring the wearing of uniform in Bangkok, Samut Sakhon and Samut Prakan Fish Markets.

The following problems also hamper operations of the FMO's fishing ports and fish markets:

(1) Insufficiency of unloading facilities.
(2) Lack of an appropriate weighing system for consumable fish.
(3) Lack of a market information network.

Based on the above-mentioned situation, the FMO set up the following improvement plan for fishing ports and fish markets under the Sixth Five-Year Plan.

A. Establishment of Nakhon Si Thammarat Fishing Port
   - Relief of congestion at Songkhla & Pattani fishing ports.

B. Expansion of Pattani Fishing Port
   - Enlargement of landing pier and sorting area.

C. Improvement of Bangkok Central Fish Market
   - Enlargement and increase in the number of roads into the market.
   - Separation of freshwater fish market.

D. Establishment of Samut Songkhram Fish Market
   - Relief of congestion at Bangkok and Samut Sakhon Fish Market.

E. Improvement of Equipment & Facilities

- Establishment of an appropriate weighing system.
- Establishment of a market information network.
- Increase of the unloading capacity.

Among the above-listed projects, the FMO puts first priority on the Nakhon Si Thammarat Fishing Port Project, taking into consideration the current landing pier congestion in Songkhla and Pattani Fishing Ports caused by Nakhon Si Thammarat boats.

2 - 5 Request of the Government of Thailand

In response to the request of the Government of Thailand, the Japan International Cooperation Agency (JICA) decided to proceed with the preliminary study and conducted the area study from 28 January to 10 February 1987. As a result, it was proven reasonable to proceed with the basic design study for the construction of the new fishing port. Based on the results of the preliminary study, the basic design study commenced.

The items requested by the Government of Thailand to be provided by Grant Aid in the construction of the new fishing port at Nakhon Si Thammarat are listed below (the basic design study team reconfirmed the required Project items established by the preliminary study team):

1) landing pier
2) ice making facilities
3) cold storage
4) storage
5) fuel tank and fuel supply system
6) water supply system
7) fishermen's center
8) fisheries' office
9) retail market
10) parking area
11) embankment
12) construction of the road within the fishing port
13) electricity
14) drainage
15) telephone
16) project equipment
17) vehicle
18) others

Chapter 3. Project Status

CHAPTER 3. PROJECT STATUS

3-1 Fisheries Status of the Project Area

3-1-1 Fish Production

(1) General

In 1986, the total number of fishery households in Pak Phanang was 1,846, totalling 15,575 persons. Out of that, about 28% (4,357 persons) were engaged in fisheries as their main occupation. Trawl fishing (otter board trawl and pair trawl), in which 10,190 persons (65% of the total fishery population in Pak Phanang) were involved, and gill net fishing were the major fishing methods used in this region. In addition, small-scale fishing is operated in Pak Phanang Bay - push net (306 households with 918 persons), fish corral (641 units) and fish farming (479 households and a total pond area of 187 ha).

(2) Fishing boats

1) Number of boats

In 1986, the Pak Phanang Chamber of Commerce reported a total of 1,558 fishing boats in Pak Phanang, and was composed of 966 in-board engine and 592 out-board engine type boats. Over 60% of the total (approx. 960 boats) were small boats of a length less than 14 meters and the remaining (approx. 600 boats) were medium or large boats of a length over 14 m (541 otter-board trawlers, 54 pair trawlers and 5 king mackerel gill netters). The estimated number of Pak Phanang fishing boats is shown in Attachment 3-1.

2) Percentage of registered boats

The percentage of registered boats (over 14 meters long) to the total was at a low of 54% in 1986, showing the existence of many

non-registered boats. Most small boats (less than 14 meters long) are non-registered. Some of the reasons for the low number of boats registered are as follows:

a) Boats that are timeworn or ill-equipped cannot pass the annual inspection by the Department of Harbours.

b) Fishing gear is not adequate to meet regulations set by the DOF.

c) Applications for renewal of registration are not submitted by boat owners.

In the case of Pak Phanang fishing boats, the main reason for the number of non-registered boats seems to be b). Despite the DOF's policy of controlling the number of trawlers to conserve demersal fish resources in the Gulf of Thailand, the number of registered Pak Phanang fishing boats (most of which are trawlers) will decrease, but the actual number of boats will remain the same.

3) Characteristics of Pak Phanang boats

The number of Pak Phanang fishing boats accounts for only 20% of the total number of boats in Nakhon Si Thammarat Province. However, 53% of 14-18 meter boats and 75% of 18-25 meter boats in this province are located in Pak Phanang, while 98% of small fishing boats are located in other fishing towns such as Sichon, Tha Sala and Khanorm (Table 2, Attachment 3-2).

4) Variation in the number of fishing boats

The number of the Nakhon Si Thammarat's now fishing boats was totaled 240 units from 1982 to 1987 (This includes boats under construction and being ordered, but excludes 1985 data). Out of this, about 80% consisted of medium or large boats. From this fact it can be said that the size of fishing vessels have become larger in recent years.

A number of orders for the building of new boats were made from late 1986 up to the present day not only in the province but within the country. Due to the limited supply of hull materials (local woods, "Takien" or "Kiam") it is anticipated that only about half of the 138 boats planned will actually be built by 1987. The average number of new fishing boats in Nakhon Si Thammarat Province can be estimated at 34 units per annum (Table 3, Attachment 3-2), while those in Pak Phanang are as follows:

Less than 14 meters long	0 (units)
14-18 meters long	7
18-25 meters long	11
Total	18 units/year

On the other hand, there is the prospect that from now on there will be about twenty boats abandoned each year in Pak Panang. The reason for this is that presently there are approximately 600 Pak Phanang boats that are over 14 meters long having life spans of about thirty years (trawlers were introduced into the country during the early 1960's). Therefore, the total number of fishing boats in Pak Phanang will not vary significantly if new boats are launched at the current rate.

5) Ownership of boats

The average number of boats owned by one person is 2.1 units; 50% of boat own only 1 boat. There are, however, some owners have more than 10 boats, and 16% of all Pak Phanang fishing boats are owned by those multi-boats owners (see table 4, Attachment 3-2). Most of single boat owners engage in fishing activities independently, while multi-boats owners work mainly in fish marketing and processing.

6) Fish landing site

Out of 600 units of Pak Phanang fishing boats of over 14 meters in length, 318 boats (53%) land fish at Pak Phanang 270 boats (45%) off load at Songkhla port. The remaining boats off-load

other ports outside Nakhon Si Thammarat Province (Table 5, Attachment 3-2). There is no particular size difference between Pak Phanang boats and those using other ports. At each landing site, about 70% of the boats are 18-25 meters long while 30% are 14-18 meters long (Table 6, Attachment 3-2).

(3) Fish landing volume

As shown in Table 7 and 8 of attachment 3-2, the fish catch by Pak Phanang boats in 1983 was about 117,800 tons. It is estimated that 131,400 tons of fish was caught annually based on present fishing boat capacity. Considering the loss in fishing days caused by time spent waiting to unload at Songkhla port, the actual catch can be estimated at approximately 128,600 tons (Table 9, Attachment 3-2). Thus the annual catch is increased 11,000 tons from 1983 as a result of the use of larger fishing boats. In addition, based on the fact that fish landings at Pak Phanang has been increasing since 1983, Pak Phanang boats apparently have been returning to their own landing site.

3-1-2 Fish Marketing

(1) Fish Marketing at Pak Phanang

Consumable fish is off-loaded at the wooden piers belonging to local fish agents. Trash fish is off-loaded directly at local fishmeal plants. About 50% of the consumable fish purchased by fish agents from fishermen is composed of high-valued fresh fish for Malaysian markets and fish for frozen and canned foods (squid, cuttlefish and shrimps) processed in the vicinity of Bangkok. The remaining 50% of consumable fish is purchased directly by local fish buyers, and are mainly sold at local markets in the province, e.g. Muang, Tung Song and Tha Sala. Some fish is transported by local buyers to places farther away, such as Mahachai, Samut Sakhon Province. The major marketing channel for fish off-loaded at Pak Phanang is indicated in Figure 1, Attachment 3-2.

There are presently 14 fish agents (5 large- and 9 small-scale) and

about 40 fish buyers are engaged in fish dealing at Pak Phanang. Some boats owners act as fish agents, buyers and/or sometimes manage fishmeal and ice plants. Because of the irregularity and uncertainty of the time and place of fish landing, it is difficult for buyers from outside Pak Phanang to participate in fish purchasing there. This is a reason why such buyers are seldom seen at Pak Phanang.

(2) Fish Marketing at Songkhla Fishing Port

The fish marketing channel at Songkhla Port is shown in Figure 2, Attachment 3-2.

1) Marketing of trash fish

All trash fish is also directly to fishmeal plants by fishermen at the port. Before and after loading trash fish onto the truck, the weight of the truck is weighed on the FMO's truck scale. Three scale slips indicating the weight are prepared and handed to the fisherman, fishmeal plant and the FMO. The price of trash fish is usually determined by bargaining between the fishermen and fishmeal plants and the fisherman sends the bill later. The FMO collects a port service charge (0.02 Baht/kg) from fishmeal plants.

About 90% of trash fish landed at this port is utilized at local fishmeal plants. The products are mainly exported to Malaysia and Singapore.

2) Marketing system of consumable fish

A. Fish marketing at port

At the FMO's fishing port, the sorting, weighing and selling of fish is generally conducted by boat owners or fish agents acting as wholesalers. Should a fisherman entrust a fish agent with a fish sale at the port, the entrusted fish agent settles the account by deducting their sales commission from

gross sales, or wholesaler and fisherman settle the price through bargaining without concern to the actual selling price to buyers.

Most at fish is sold to fish buyers or fish collectors as a result of price bargaining; seldom by auction. Fresh fish for Malaysia is generally marketed by fish agents acting indipendently. They do the packing to transporting to Malaysia and Singapore through their own channels without utilizing the services of local buyers.

Large-scale fish agents usually own several fishing boats and hold wide marketing channels from producer to consumer markets not only in the country but also overseas.

B. Destination of fish

Almost half of fish landed at Songkhla port are exported to Malaysia as fresh fish, reflecting the geographical advantage of Songkhla. Most of the processing plants procuring raw materials from this port are located in this province. The volume of fish transported to Bangkok Central Fish Market from Songkhla Province totals only about 1,200 tons per annum. Therefore most fresh fish destined for Bangkok and its vicinity is handled through special channels owned by marketing bodies.

(3) Fish Marketing at Pattani Fishing port

The flow of fish landed at Pattani port is shown in Table 3, Attachment 3-2.

1) Marketing of trash fish

The marketing system for trash fish here is the same as that of Songkhla port. All trash fish landed here is utilized at local fishmeal plants.

2) Marketing of consumable fish

The fish transaction system in this port is almost same as that of Songkhla port. In this port, larger quantities of fish are handled by boat owners themselves. This is because many purse-seiners from other provinces utilize this port, the latter collect and handle fish on their own. About 40% of consumable fish landed at this port is handled by fish collectors because a large proportion of fish is used as raw materials at processing plants. Most raw materials are shipped to other provinces such as Songkhla, Samut Sakhon, and Trang. Only about 800 tons of fish are brought annually to Bangkok Central Fish Market from Pattani Province.

3-1-3 Present Status of Songkhla and Pattani Fishing Ports

With the establishment of the project port, it is expected that the ports of Songkhla and Pattani will be relieved of their current congestion. The present status of each fishing port is explained below.

(1) Songkhla Fishing Port

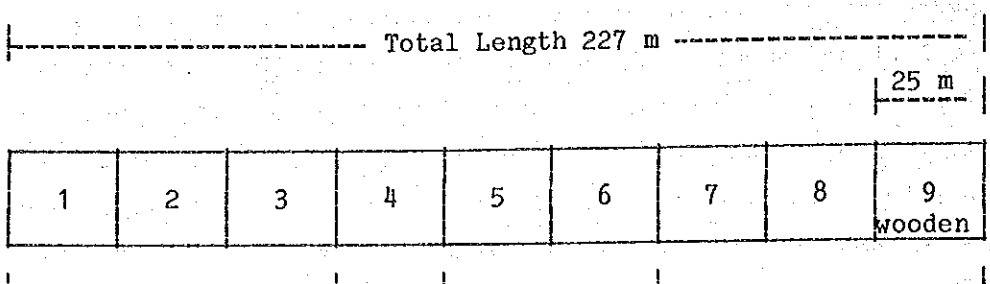
1) Outline

This port, which was opened in February 1966, has a comparatively long history. The length of the landing pier totals 227 meters (concrete 200 m and wooden 27 m) with 9 berths. After Bangkok, this is the largest fishing port in Thailand.

2) Operational status of landing pier

An average of 75 boats calling at Songkhla port daily; 40 are medium and large boats (25 trawlers, 5 purse-seiners and 10 gill netters). About 40% of the boats (10 per day), are trawlers from Pak Phanang. Mooring berths are allocated for each type of

fishing boat. Along-side mooring (double row) system is used by trawlers while headway mooring (single row) is used by purse-seiners and gill netters. The operational system of each berth is as follows.



for trawles	for small trawlers netters	for purse-seiners/gill	for trawlers	(Type of boat)
along-side (double)	along-side (double)	headway (single)	along-side (double)	(Mooring method)
6 units	4 units	5-6 units	6 units	(Mooring capacity)
10-15 boats	30-50 boats	15 boats (5 purse & 10 gill)	10-15 boats	(No. of boats calling/day)
2-3 times	10 times	3 times	2-3 times	(No. of landing cycles/day)
	(for trawlers)	(for other boats)		(Landing time)
(Trash fish)	7:00-14:00	-		
(consumable fish)	15:30-complete	7:00-complete		

Excluding small boats, about 150 boats call at this port on peak days. On such days the port is opened for a full day and the landing patterns for trash fish and consumable fish are repeated from 7:00 pm to 7:00 am. However, it takes about 3 days to complete the off-loading of fish from all 150 boats.

At Songkhla port the average waiting period from port call to the commencement fish unloading is estimated at about 1 day as shown below:

No waiting condition : The condition under which boats can continuously moor at the landing pier from the time of port call to the time of completion of unloading of both trash and consumable fish (landing cycle : Once a day).

Mooring capacity for trawlers (a) :

12 boats/time/day (6 berths x double along-side)

Average No. of trawlers calling (b) : 25 boats/day

Average waiting time : 1.08 days ((b-a)/a)

In the case of trawlers, trash fish and consumable fish, landing times are scheduled separately because of different unloading and transaction methods. At the Songkhla fishing port, where the number of trawlers calling is twice its mooring capacity, unloading activities are conducted by shifting boats. This is the reason why the port is always congested causeing low unloading efficiency. In addition, boats must return to port at a later time in order to land consumable fish, thereby resulting in an uneconomical situation.

3) Fish landing volume

The annual fish landing volume at Songkhla port is between 160,000 to 170,000 tons (average 165,000 tons average). The ratio of trash fish to total volume is over 70%, according to the FMO's statistical book. However, as some of boats calling at this port are purse- seiners and gill netters which carry a smaller proportion of trash fish, the actual trash fish ratio estimated to be 60% of the total at the most. The actual fish landing volume at this port therefore might be as follows;

Landing volume according to the FMO's statistical book :

Total 165,000 tons per annum

trash fish : 116,000 tons

Therefore, 116,000 : x = 60 : 100

Actual fish landing x = 193,000 tons

trash fish : 116,000 tons

consumable fish: 77,000 tons

Because the FMO does not have a weighing system for consumable fish, some quantities of fish are not reported by fish agents or boat owners.

The fish landing volume at this port varies seasonally. Although the fishing intensity does not change the fish catch volume does vary in accordance with season. Large volumes of landings can be made during the southwest monsoon season (May to November). In 1985, the monthly fish landings varied from 10,220 tons to 19,017 tons, with an average monthly landing volume of 13,743 tons. Maximum fish landings approximate 1.4 times the average.

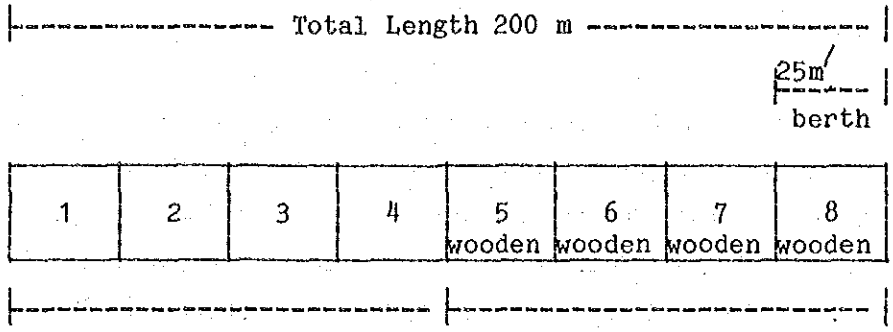
(2) Pattani Fishing Port

1) Outline

This fishing port, which is comparatively new, opened in September 1982. The length of the landing pier is 200 meters (concrete 100 m and wooden 100 m), with 8 berths (25 m per berth). The number of purse-seiners calling at this port has been increasing in accordance with the shift of the fishing grounds to the southern part of the Gulf of Thailand. This is due to the setting up of a closed season for purse-seine fishing in the northern part of the Gulf.

2) Operational status of landing pier

Currently an average of 30 to 35 boats call at this port daily. Generally, the daily total is 10 trawlers, 16-20 purse-seiners and 5 gill netters. Most of those are large or medium sized boats. Only 12 boats from Pak Phanang are currently using this port for fish landing; Which means that only one boat calls every other day. Four berths are assigned to trawlers and four other boats are assigned. Firm landing times are not established in this port. There are about 280 purse-seiners using this port, 130 are from other provinces. The operational status of the landing pier is as follows:



for purse seiners/gill netters	for trawlers	(Type of boat)
headway (single)	along-side (single)	(Mooring method)
10-12 units	8 units	(Mooring capacity)
20-25 boats (16-20 purse & 5 gill)	10 boats	(No. of calling boats/day)
2 times	2 times	(No. of landing cycles/day)
No restriction but usually starting from early morning (In the case of trawlers, consumable fish unloading starts after trash fish unloading)		(Landing time)

3) Fish landing volume

The annual fish landing volume at Pattani port is reported at about 110,000 tons. As in the case of Songkhla port, however, some weights of consumable fish is not correctly estimated because of the lack of an appropriate weighing system. Trash fish landing is about 42,000 tons, so that landings by trawlers is estimated at about 70,000 tons. Depending on the number of calling boats the catch by purse-seiners and gill netters might be around 60,000 tons. Thus, total landings are estimated to be 130,000 tons per annum, 88,000 tons consisting of consumable fish.

3 - 1 - 4 . Utilities

(1) Fish Industry

Facilities on the fishery industry in Pak Phanang consists of five ice making facilities (total daily max. capacity is 4,850 blocks), seven fishmeal facilities (total daily max. capacity is 140 ton), six ship building/repare yards (including 2 ship building) and 2 freegzer/cold storage facilities (freezing capacity is 60 ton and cold storage capacity is 2,150 ton) as shown in Table 10, Attachment 3-2.

The distribution of ice and ice facility are as follows :

1) Ice distribution

In Pak Phanang daily ice production capacity is 4,850 blocks and distributed to local cold storage (800 blocks), inland transportation (600 blocks) and fishing boat (3,450 blocks).

In Thailand, the traditional method for showing ice capacity is by indicating the number of 150 kg blocks of ice used per day.

2) Ice making facility

An ice-making factory is usually a simple structure made of reinforced concrete or steel columns, having brick or hollow block walls, and a corrugated asbestos roof.

The only one of exception seen during the study was a two-story reinforced concrete building at Songkhla fishing port where ice-making equipment is installed on the second floor.

All refrigration machines and equipment are installed in the same room adjoining the ice making tank but not in separate machine room.

Industrial refrigeration facilities, including freezing and cold storage, use ammonia as the refrigerant. Freon is no longer being used.

Salt - not calcium chloride - is being used for the brine in the making of ice.

Compressors made in China are installed in several factories. Compressors made in England and Japan were found to install in some of the factories. The reason why compressors made in China are being widely used in Thailand is mainly due to their low

price. On the other hand, it is considered that the compressors made in China are reliable, are of good quality, and rate relatively high in performance, and, therefore, have captured a substaintial share of the market in Thailand.
The following types of condensers were studies: atmospheric, evaporative, and a combination of cooling tower and horizontal shell and tube type.

(2) City Water

The source of city water is situated 4 km away from the project site and the main pipe line is being installed up to the half way to the site.

Suppliable capacity is :

Total capacity	330.0 cub.m/hr
Present consumption	187.5 cub.m/hr
Balance	142.5 cub.m/hr

This quantity is enough for the consumption by the intended facilities.

Though the supplied pressure of the city water is 2.2 kg/cm^2, a reservoir and an elevated tank, considering a pressure drop in long pipe line, should be utilized.

(3) Electricity

It was explained by the Provincial Electricity Authority (PEA) in Nakhon Si Thammarat that the main power line having a capacity of 2,000 to 3,000 kw is being installed up to a point about 2.5km away from the project site, and it was suggested that an emergency generator is used for the power supply. Electricity will be supplied with high tension current of 33 KV.

Electric power for general use is 380 V, 3 phase 50 hertz. Power for lighting is 220 V, single phase 50 hertz. There are no restrictions as to the manner and device for starting electric motors, but it is better to apply a star-delta starter for large motor.

3 - 2 Guideline for the Project

Basic concept for the planning of the new fishing port is to provide facilities and conditions for unloading the fish catches of the fishing boats that use near-by fishing ports and landing facilities at the Pak Phanang district.

In addition to the fish landing pier, auction hall, wholsale market and other fundamental facilities, there are requirements to provide facilities for encouraging fish agents to establish businesses to handle the fish product after landing, and a facility for the training and instruction of fishermen. An ice making facility is to be constructed that will supply ice to fishing boats at the service jetty - it is expected that there will be a great increase in the number of fishing vessels once construction of the new port is completed. It will be arranged to use existing facilities for supplying ice and fuel to most of the fishing vessles, and to provide a rest area for fishery personnel.
Port facilities will be examined carefully through the investigation of the functioning of existing PMO fishing ports, and in consideration of PMO's future development plan.

3 - 3 Roles of the Project

Upon completion of the new fishing port at the Pak Phanang district in Nakhon Si Thammarat, fishing boats in Pak Phanang area are going to utilize the new port in order to avoid the congestion at other exsisting fishing ports and will share the benefits of the local port.

After completion of the new fishing port in Nakhon Si Thammarat, it will be possible for fishing boats to unload their own catches at the facilities in their province. This will cause the fishing industry to become active and it is expected to have the following effects on the investment:

- When it becomes possible for fishing boats to land their catches at facilities in their own province, it is expected that there will be an

increase in the output of fishery products. This will lead to the acceleration of improvements to fish processing and related industry facilities and will stimulate the growth of industry within the province.

- Reducing the outflow of people seeking work outside the province by increasing job opportunities within the province after the development and expansion of fish processing and related industries.
- Shorten the unloading waiting period - as compared to that experienced in existing ports - by decreasing the degree of congestion and by reducing the cost entailed by waiting.
- Increasing the size of the fish catch by enabling more time to be spent on fishing activities once the unloading waiting period is decreased.
- Relieving the congestion at existing fishing ports by moving Pak Phanang fishing boats to the new fishing port. After this move is made, it can be expected that there will be a increase in fish products as a result of the reduced unloading waiting periods at the fishing ports.
- The shorter transportation distance from the new port to Bangkok, compared with that from the Songkhla fishing port, will reduce the damage rate to fish. Consequently, the quality of fish being delivered will be higher and will bring increased market revenues.
- An improved fish distribution system in Pak Phanang will aid in stabilizing fish prices and the income of fishermen.

Chapter 4. Outline of the Project

CHAPTER 4. OUTLINE OF THE PROJECT

4 - 1 Objective of the Project

The following are the objectives for constructing a fishing port in the Pak Phanang district. In the entire province, there are no fishing ports with proper landing piers, ice making facilities, ice and fuel aupply facilities, etc. :

- To provide a new fishing port for use by the province's fishing boats.
- To provide facilities for the establishment of an auction system in the port area.
- To reduce the time wasted and the cost incurred by the fishermen aboard Pak Phanang boats presently sailing to Songkhla or Pattani fishing ports to unload their fish catches.-
- To imporove the fishery and its related industries and to increase job opportunities by increasing the amount of the fish landing.
- To relieve the congestion at the Songkhla and Pattani fishing ports that are currently crowded with fishing boats from Pak Phanang.
- The Project will stimulate FMO's activities.

Through the implementation of the above, the development of fisheries in the southern part of Thailand is anticipated.

4 - 2 General View of the Request

The outline of the Government of Thailand's request for the construction of the fishing port is described in Chapter 2.5. However, the details of the scope and arrangements of the Project must be implemented pursuant to this basic design study.

There are many fishing boats at Nakhon Si Thammarat, but, due to the lack of facilities within the province, most of them unload their catches at ports in other provinces. This, of course, hampers the development of the province's fishery and related industries.

After the completion of the new fishing port in the Pak Phanang district, fishing boats will be able to unload their catches in their own province. Along with establishment of the fish distribution system, the Project

objectives, as described in Chapter 4-1, will be achieved.

4 - 3 Project Development

(1) Project Agency and its Organization

The distribution and unloading of fishery product in Thailand are controlled by the Fish Marketing Organization (FMO). FMO is an autonomous body under the supervision of the Ministry of Agriculture and Cooperation (MOAC) and it is established in 1953. The Department of Fishery (DOF) functions as the facility for the investigation and guidance in promoting and developing fisheries. FMO functions for handling the matters of fishery product distribution and improvement of the welfare of fishermen.

FMO has three fish markets and ten fishing ports at present.

The main objectives of FMO are as follows:

① To undertake various activities in the development and improvement of wholesale fish markets, local fish markets and the fishing industry in general.
② To arrange, control, supervise and render services to fish agents including transportation and other activities connected with the business transactions of fish agents.
③ To improve the living standard and to promote welfare and profession of fishermen and their communities.
④ To encourage the establishment of fisherman cooperatives or fisheries associations on fisherman groups in the country and render support to these activities.

The new fishing port to be built under the Project will be FMO's eleventh fishing port. And FMO will be the executing agency of the Project.

The organization chart of FMO is shown in Figure 4-1.

The executing agency during construction of the project port will be also FMO. FMO has experiences in the construction of the fishing ports, such as Samutprakarn Fish Market and Songkhla Fishing Port. The construction of the project must be carried out in close cooperation with the General Admidnistration Div., especially the Engineering Section, and the Finance Div. of FMO.

(2) Development Plan

The construction site of the project is on the left bank of the Pak Phanang River in the Pak Phanang District, Nakhon Si Thammarat. The development plan will be based on the results of the basic design study requested by the Government of Thailand (refer to section 2-5, Request of the Government of Thailand).

(3) Inventory of Facilities

Based on the request for the Project, the inventry of the facilities for the project are classified and listed below:

1) Basic civil facilities for the fishing Port:
   Landing pier
   Service jetty
   Revetment

2) Civil Facilities:
   Road
   Parking area
   Drainage
   Earth work

3) Building:
   Auction hall with administration office
   Fisherman center
   Fish agents office
   Wholesale market
   Ice making building
   Saind-by generator house

Service control house
Truck scale house
Guard house
Public toilets
Warehouse

4) Utilities:
Water supply
Fuel supply
Electricity supply
Telephone
Sewerage

5) Plant:
Ice making plant
Generator

6) Project equipment:
Weighing machine(truck scale and balance)
Equipment for landing fish catch(conveyor, etc.)
Equipment for transportation (fish container)
Communication (SSB, etc.)
Announcing system
Vehicle
Equipment for port operation

(4) Undertaking by the Government of Thailand

As the result of the site investigation and discussion with the staff of FMO and related authorities in the Province, the plan and scope of the work which will be carried out by the Government of Thailand are as follows:

1) Repair of the road from Pak Phanang city to the Project site:
The access road from the city to the site is about 3.5 km long and bears the scars of many wheel tracks; a number of muddy spots also exist. Certain parts of the road are inundated during the rainy season. Under the auspices of the Provincial Office, the widening of the road

to six meters will be accomplished during the period of August to October 1987.

2) Construction of a temporary road in the site and an access bridge to the site:

The reclamation work, and the construction of a temporary road and an access bridge over the khlong located at the south side of the site will be carried out by FMO as follows:

Construction work	Period
a) Temporary road in the site	Aug. to Nov. 1987
b) Reclamation in the site	Aug. to Dec. 1987
c) Access bridge to the site	May to Nov. 1987

3) Arrangement of utilities;

(a) Electricity;

Up to 3,000 KW of electricity will be available. The installation of the power line to the project site will be accomplished by the end of 1988 by the Provincial Electricity Authority (PEA).

(b) Water;

There is a water treatment plant with a capacity of 330 m^3/hr in the Pak Phanang district. Presently, it supplies 187.5m^3/hr of water to the district. The distribution line to the project site will be installed by the end of 1988.

(c) Telephone;

The installation of telephone lines capable of handling forty circuits at the project site will be accomplished by the Telephone Organization of Thailand (TOT).

(5) Operation Plan

The new fishing port will be managed by a self-supporting system. Expenditures, such as staff salaries and maintenance costs, shall be covered by the revenue from the port facilities. The operation of the Fishermen's Center at the port will be subsidized by the FMO's Fishery Promotion Fund, and will amount to 300,000 Baht per year. The new fishing

port's organizational chart is shown in Figure 4-2. All fish markets and fishing ports are under the control of the FMO's Operations Section. Port operations are divided into two departments: the Port Operation/ Management Department and the Ice and Supply Department. The Port Operation/Management Department will carry out the general management of the ports. This department has an administration section consisting of an accountant, financial clerk, office clerk, general administration clerk, credit officer and two technicians. It also has a field work section comprised of three statisticians, three weighing machine operators, two traffic controllers, and a premise man. The Supply Department handles and controls the work for making ice, supplying ice, fuel and water.

The Preparation Committee, during the port construction period, will establish the general concept for the management and operation system of the new port. The committee will consist of a Project Manager, who will be the chairman, two of the port's managers, and several staff members of the FMO's Fishery Development Division.

The Committee will negotiate with fishermen, fish agents, buyers and retailers, and will coordinate matters pertaining to the construction and management of the new port with other related governmental authorities. The report on management and operations prepared by this Committee will be submitted to the Board of the FMO Committee for approval.
The new port will be managed in accordance with the approved management and operation system. In order to improve the system in a smooth and efficient manner, the Evaluation Committee will establish the most appropriate system for the new port. The Committee will consist of the Project Manager as the chariman, staff members of the FMO's Fishery Development Division and two port managers as secretaries.

As a part of port management, the Evaluation Committee will scrutinize the system for making ice, and for supplying ice, water and fuel. This will be done in order to improve port operations by establishing the most efficient systems at the port.

FMO Organization Chart

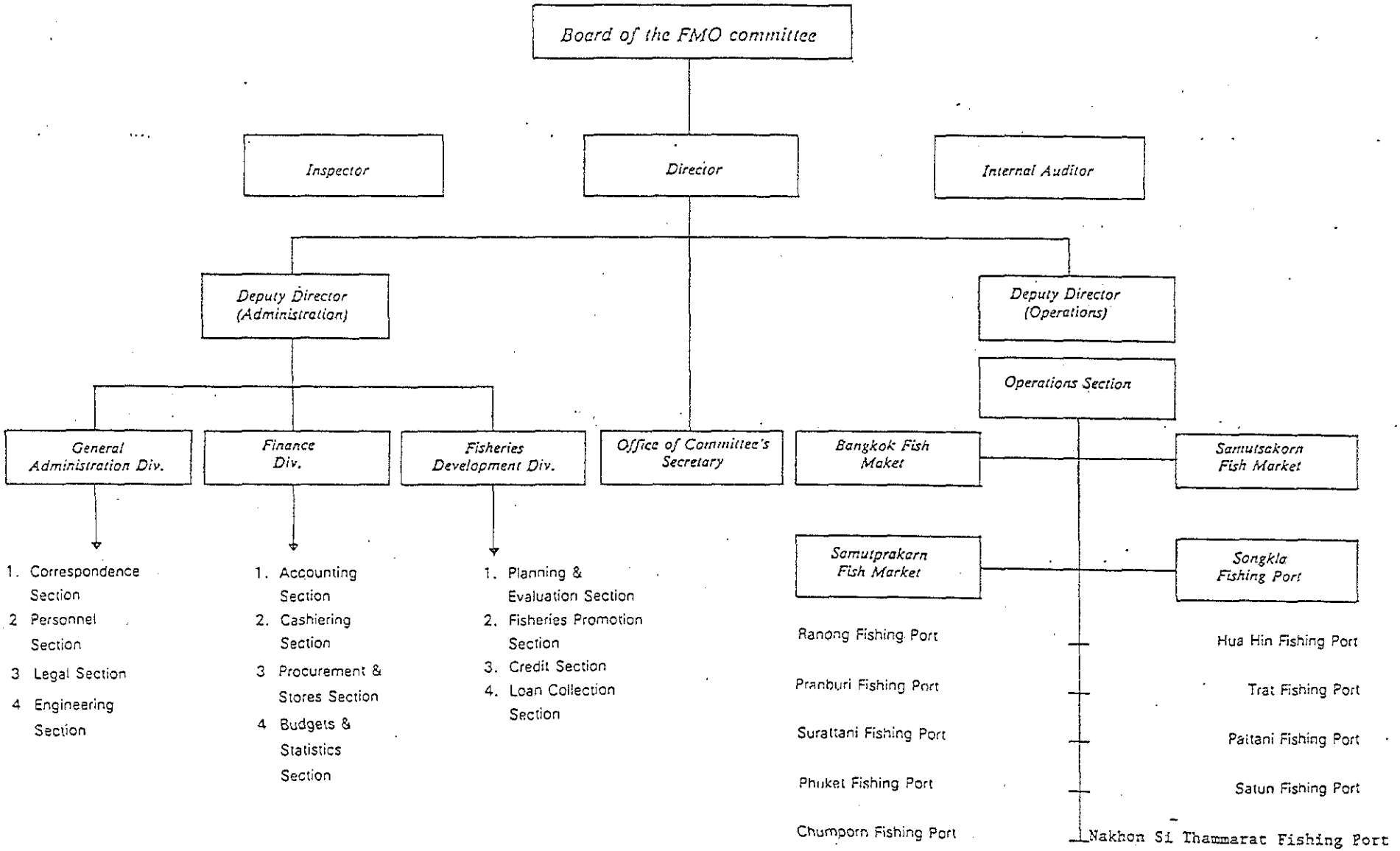


Figure 4-1 FMO Organization Chart

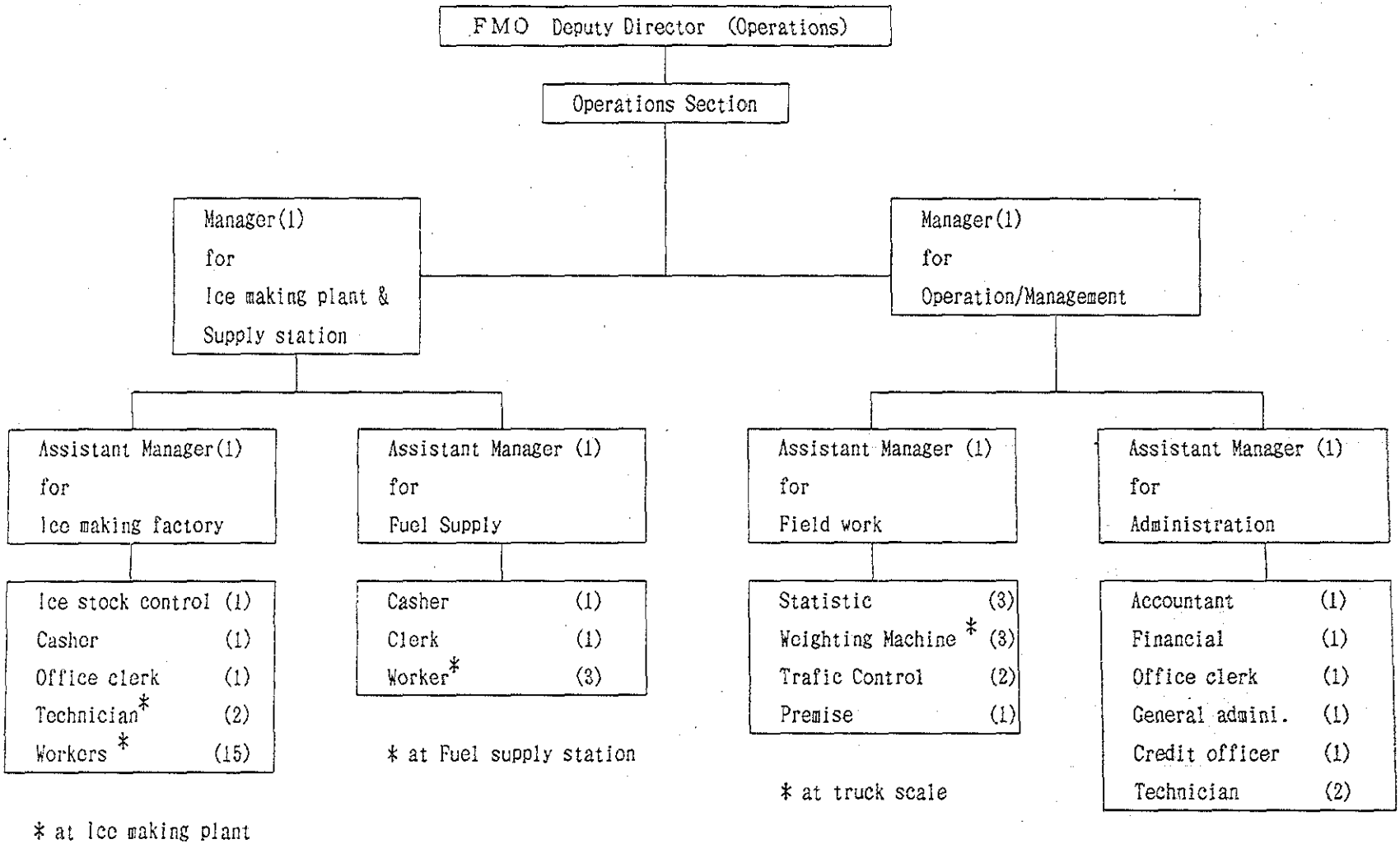


Figure 4-2 Management and Organization Chart for Nakhon Si Themmarat Fishnig Part

Chapter 5. Basic Design

CHAPTER 5. BASIC DESIGN

5 - 1 Design Concepts

The basic design of Nakhon Si Thammarat fishing port was carried out based on the following basic design concepts.

(1) Rational scope and characteristics of the initial development of the Project.
(2) Fitness of the design to the site conditions.
(3) Fitness of construction materials and types of structures to the conditions in Thailand.

Detailed design concepts that concern each design concept shown above are as follows:

(1)Rational Scope and Characteristics for the Initial Development of the Project

- Accurate forecasts of fish consumption and the number of fishing vessels calling at the port must be conducted in order to determine the demands to be met by the new fishing port.
- The characteristics of facilities to be introduced must meet the spirit of the Japanese Grant Aid Program, and be within the scope of the requests made by the Government of Thailand.
- The initial investment cost, a part of which may be supported by the Japanese Grant Aid Program, must be estimated based on the method shown in the guidelines of financial assistance to developing countries.
- New facilities shall be designed to meet local conditions for fish production and distribution and shall be of types to minimize operational and management costs.

(2) Fitness of Design to the Site Condition

- Topographic condition, tidal current and tidal range have to be reflected in the basic design.

- The present siltation phenomenon has to be studied considering the sediment transport of the Phanang River. The volume of siltation in the landing pier area has to be estimated and countermeasures have to be studied if required.
- Geotechnical conditions must be reflected in the structural design, especially those having an effect on the settlement and sliding of soft clayey layers.
- Countermeasures to environmental pollution must be considered.

(3) Fitness of Construction Materials and Type of Structures to Thai Conditions.

- Structures must be simple, durable, and require easy maintenance.
- Construction materials and methods have to be studied to meet the local conditions. First priority must be given to those which are available in Thailand economically.

5 - 2 Study of the Project Site

5-2-1 Site Condition

(1) Present Site Condition

The project site is 18 hectares of lowland located along the western side of Pak Phanang river, 4km upstream from the river mouth and 5km downstream from the Pak Phanang City.

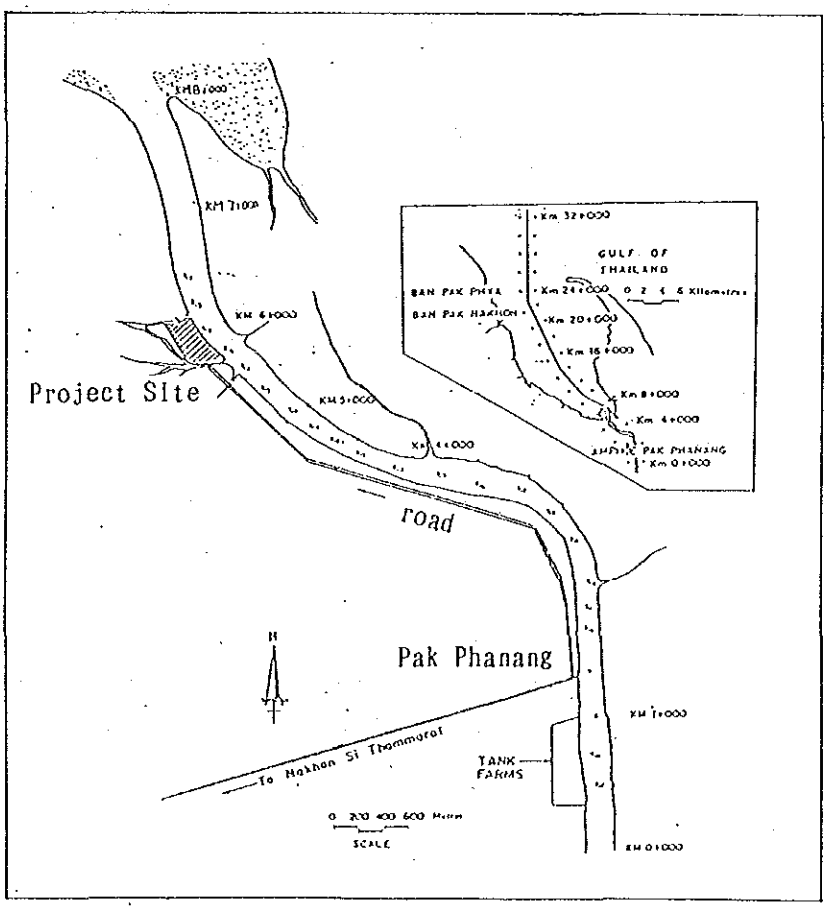
It is located at latitude 8° 22'10"N and longitude 100° 10'30"E.
The project site is shown in Fig 5-1.
The Project site is rhombic-shaped and is surrounded by waterways approximately 10m wide and 1 m deep. Although the mangrove trees have been cut down, their roots still remains in the ground.
The land surface is flat and the ground elevation is +2.63m which is approximately 40cm higher than M.S.L.(+2.22m) and nearly equal to H.M.W.S (+2.57m) of the Pak Phanang River.
In the central area, the embankment of the temporary road is +3.35m high.
The top layer of the soil at the Project site is organic clay of 1.5m thick. It is very soft, but possible to walk in the area because of the remains of the mangrove roots.

Below the top layer, there is a soft silty clayey layer with a thickness of 16 m, covering a hard clayey layer existing underneath.

The river line gradually curves clockwise. Since the slope of the river bed is very flat (0.00002), the tidal current intrudes up to 12km from the river mouth. The river is about 250m wide and about 6m deep at its center. The central part of the river is used as a navigation channel for 1,500DWT oil tankers travelling to and from the tank farms at Pak Phanang City. The depth of this channel is being kept to -3.0m from L.L.W. The Harbour Department conducts maintenance dredging at various times.

Only access to the Project site from Pak Phanang is by an unpaved road. This road comes up to the waterway on the south side of the Project site. The construction works for an access bridge and road are slated to commence in May of 1987. After its completion, the land reclamation works at the Project site is planned to get underway.

Figure 5-1 Location of Project Site



(2) Natural conditions

1) Climate

South Thailand is in the tropics and, as are other parts of Thailand, is under the influence of tropical monsoons.

During the northeast monsoon season, from November to February, dry cold wind blows from mainland China to the northern part of Thailand.

But in the south, the weather is usually hot and humid with heavy rainfall, especially near the east coast.

Between May and September, the moist warm air brought in by southwest monsoons from the Indian Ocean causes heavy rainfall throughout Thailand.

The season between February and May brings the change from the northeast monsoon season to the southwest monsoon season; maximum temperature and minimum rainfall occur during the period.

In this study, meteorological data covering the period from 1956 to 1985 collected at the weather station in Nakhon Si Thammarat province were used. The exact location of this weather station is Latitude 8° 28'N and Longitude 99° 58'E, which is about 30km northwest of the project site.

The general climatic conditions at this weather station is summarized as follows:

① Temperature

There is little change in the average monthly temperature due to the influence of tropical monsoons as previously mentioned. The average temperature is around 27.5℃. During last 30 years, the lowest temperature recorded as 17.1℃ while the highest temperature was 38.0 ℃

② Relative Humidity

The monthly relative humidity at this station is quite high, ranging from 76% to 86% with an annual average of about 81%.

③ Rainfall

As Nakhon Si Thammarat is located on the east coast, it rains thoughout the year. During the northeast monsoon season, from November to December, the rainfall is heavier than during the southwest monsoon season.

Average annual rainfall is about 2,382mm. The heaviest rainfalls occur in November with an average rainfall of 610mm. The highest rainfalls recorded for any 24 hour period during the last 30 years was 433mm.

④ Wind

Average wind condition at the Nakhon Si Thammarat is as follows:

Table 5-1 Wind Direction and Speed

Month	wind Direction	Wind Speed	Notes
Jan.~Apr.	E	1.9 ~2.5 m/sec	–
May ~Sep.	SW	1.9 ~2.5 m/sec	southwest monsoon
Oct.~Dec.	N	1.7 ~2.5 m/sec	northeast monsoon

The maximum wind speed was 28.3 m/sec.

2) Tropical Cyclones

During 1951 - 1975, 9 cyclones passed over Nakhon Si Thammarat province. This represents about 40% of the total number recorded in southern Thailand. Two voiolent tropical cyclones causing most severe damage were "HARRIET", during October 25 - 26, 1962, and "RUTH", during November 29 - 30, 1970.

Six of these nine cyclones occurred in November, causing heavy rainfalls, river flooding, strong winds, and very rough sea conditions.
From the record previously described, it is anticipated that cyclones, depressions, and tropical storms tend to pass over Pak Phanang, especially during the months of October and November.

5-2-2 Geotechnical Investigation

In the past investigation (Nakornsrithamarat Fishing Port Project Report on Subsurface Investigation : 1985, January), three boring holes have been drilled, one at landing pier, one at reclamation area, one at access bridge.

Soil characteristics and N value have been obtained for structure designing. But consolidation test required for calculation of the settlement due to consolidation of soft clayey layer have not carried out yet. Furthermore, face line of landing pier has only one boring.

Therefore, this time, three borings as indicated on Figure 5-2 have been executed to confirm soil design parameters (C, γ) required for fishing port facilities's basic design, consolidation characteristics values (Cc, Cv) of soft soil and its thickness, and depth of pile's supporting hard layer.

Contents of geotechnical investigation by JICA

Boring position	(Refer to Figure 5-2)
No of boring hole	3 holes
Boring depth	40.45 m from the existing ground surface

Field work

o Standard penetration test and sampling of disturbed materials at each 2 m interval

o Sampling of undisturbed materials of 10 samples

Laboratory test

o Physical properties test 45 samples

Moisture content	W
Specific gravity	Gs
Bulk density	γ t
Liquid limit	Wl
Plastic limit	Wp

o Unconfined compression test qu 10 samples

o Consolidation test Cc, Cv 10 samples

At site, boring work has been done at the same time (from A pril 27 to April 29) by three units of boring machines after the completion of

scaffolding work(from April 21 to April 26).
Then , laboratory test has been conducted by Asian Institute of Technology (AIT).
The contents and results of this investigation are detailed in site investigation report of separated volume supplement.

Figure 5-3 shows the boring logs carried out by JICA B・D study.

Figure 5-2 Location of Boring Holes

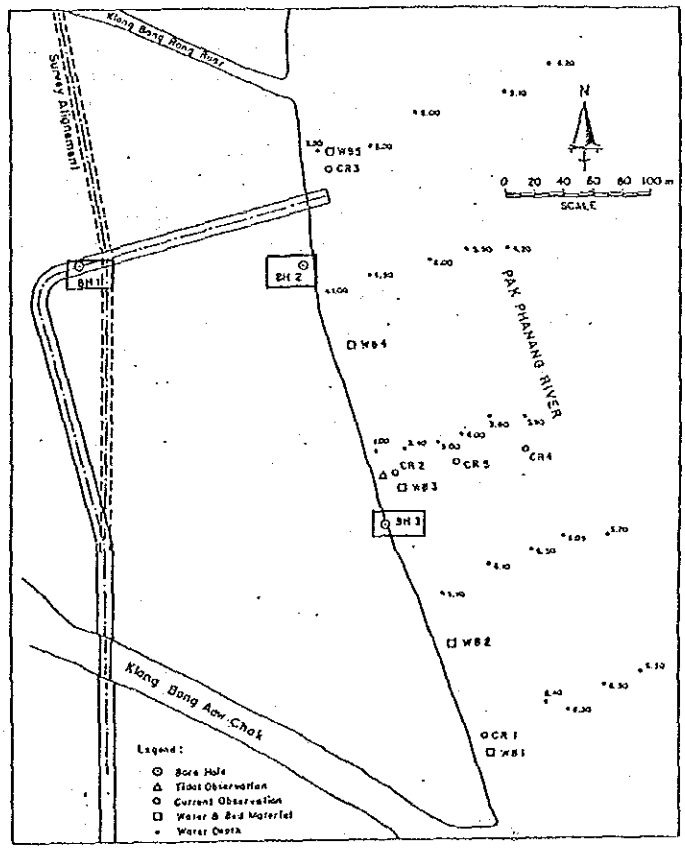
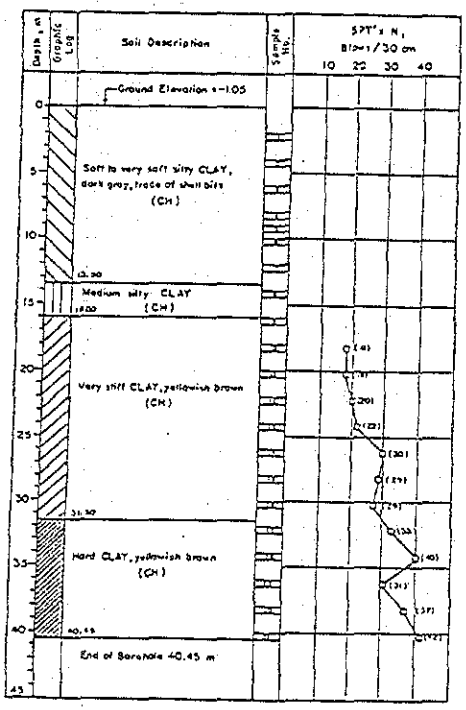
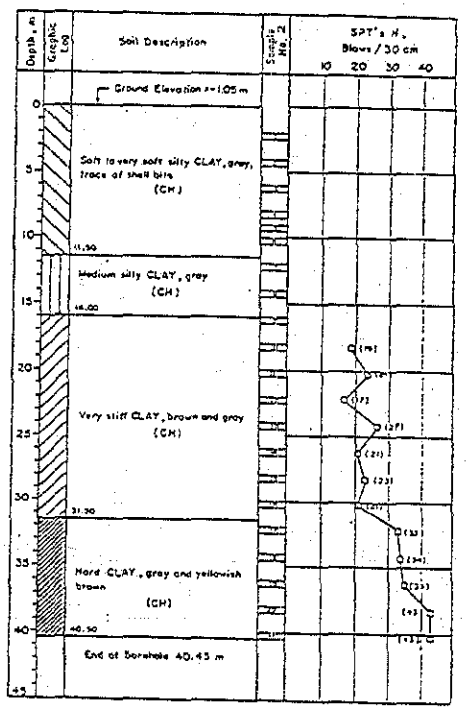


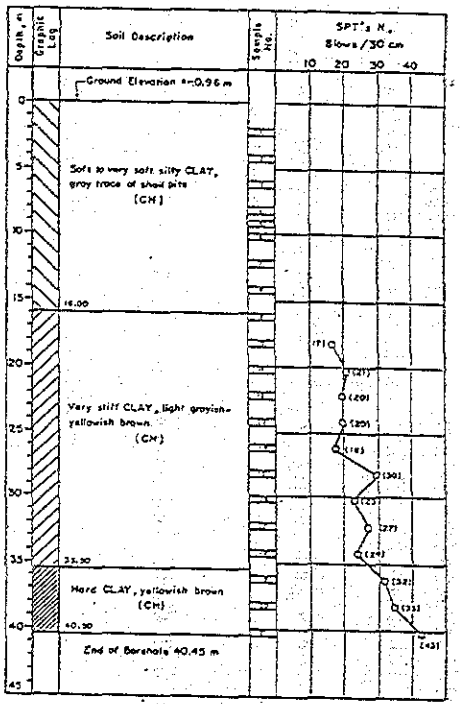
Figure 5-3 Boring Logs



Soil Boring Log , Borehole BH - 1



Soil Boring Log , Borehole BH-2



Soil Boring Log , Borehole BH-3

5-2-3 Current Observation

As the proposed Project site is located near the river mouth, the siltation is expected to occur at the entrance/approach channel and in area of the landing pier.

To know the mechanics of siltation around the Project site, current observations were performed for three days at the location and are shown in Figure 5-4. At the same time, water samples were taken and the contents of suspended solids were measured. Samples from the river bed were taken to analyze its grain size distribution.

The period and location of the measurements are as follows.

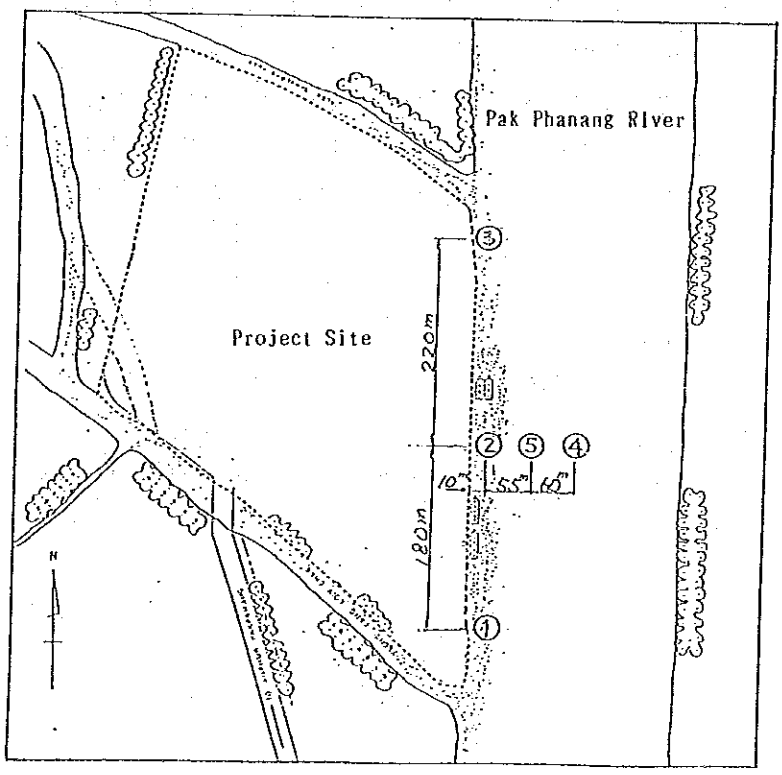
Period : 25～28 April (3 days)

Location : Western side of Pak Phanang river as shown in Figure 5-4.

Table 5-2 Location and Period of Current Observation

Period	Location of Current Observation		
April 25～26 (24hrs)	St.①(middle)	St.②(middle)	St.③(middle)
April 26～27 (24hrs)	St.②(middle)	St.⑤(middle)	St.④(middle)
April 27～28 (24hrs)	St.⑤(surface)	St.⑤(middle)	St.⑤(bottom)

Fig 5-4 Location of Current Observation



(1) Observation Results

The maximum velocity of flood and ebb current flow is summarized in Table 5-3. The measured current fluctuation at each station is indicated in Figure 5-5. From the observation results, it can be known that the variation of current velocity follows semidiurnal pattern.

Table 5-3 Maximum current velocity

Location	Flood (m/sec)	Ebb (m/sec)
St.①	0.40	0.30
②	0.35	0.30
③	0.40	0.33
St.②	0.30	0.30
⑤	0.35	0.35
④	0.48	0.48
St.⑤ (Surface)	0.50	0.25
⑤ (Middle)	0.48	0.20
⑤ (Bottom)	0.35	0.20

Results are summarized as follows:

a. The difference of current velocity along the riverside is slight.
b. Velocity is maximum at the center of the river and gradually reduces toward the riverside.
c. The velocity gradually reduces from the surface to the bottom.
d. The maximum flood current and ebb current were 0.48m/sec respectively.
e. Current velocity fluctuation was under the influence of the semidiurnal period.

(2) Harmonic Analysis

The harmonic analysis of tidal current was conducted to determine the principal velocity constituents.

The principal velocity constituents (M2, S2, K1,O1) are summarized in Table 5-4.

Figure 5-5 Observed Current Velocity

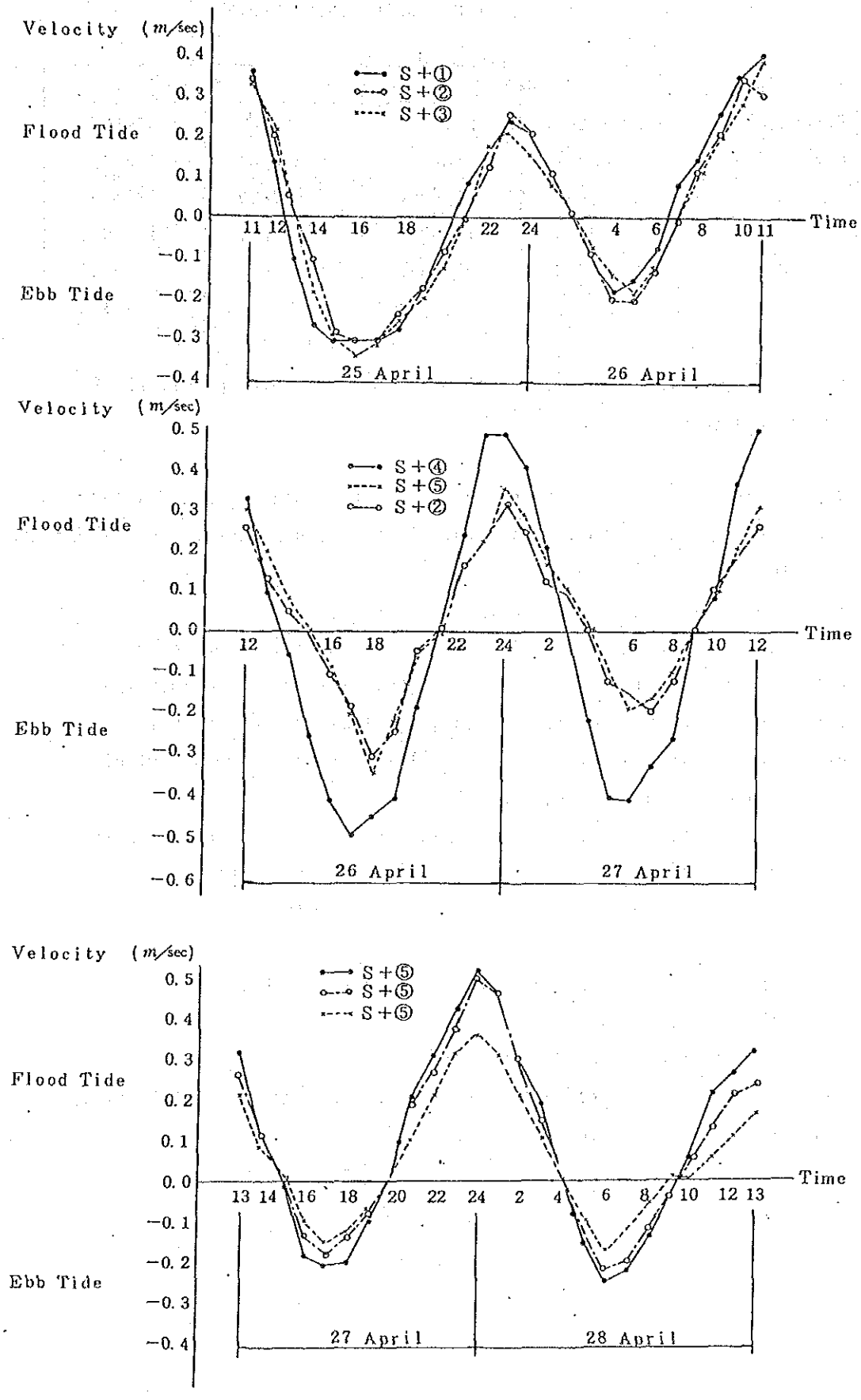


Table 5-4 Tidal Current Harmonic Constituents

Tidal Current Harmonic Constituents	St. ②		St. ⑤	
	Ampritude (m/sec)	Period (hr)	Ampritude (m/sec)	Period (hr)
M_2	0.2608	12.4206	0.2620	12.4206
S_2	0.2686	12.0000	0.2594	12.0000
K_1	0.1020	23.9346	0.1033	23.9346
O_1	0.1135	25.8194	0.0956	25.8194

From the above table, the total of principal velocity constituent is calculated to 0.73 m/sec.

Results of the harmonic analysis show that the tidal current can be classified as mixed type, consisting of semidiurnal constituent M2, S2 and the diurnal constituents K1, O1.

From March to September, there is so little rainfall that the range of velocity of river flow is 0.03~0.05m/sec. It is presumed that the velocity is dominated by fluctuations of tidal current velocity.
From November to January, much rainfall is expected and the velocity will be increased by the influence of river flow.
Variation of current velocity during spring tide was measured by the Harbour Department in January 1979. It was reported that the maximum flood current and ebb current were 0.77m/sec and 0.69m/s.

(3) Concentration of Suspended Solids and Grain Size Distribution of Riverbed Material

1) Concentration of Suspended Solids:

The concentration of suspended solids were measured in the laboratory and the results are shown in Table 5-5.

Table 5-5 Concentration of Suspended Solids

(Unit: gr/m³)

Location / Depth	St. ①	St. ②	St. ③	St. ④	St. ⑤
Surface	74	64	77	39	58
Middle	60	55	114	53	48
Bottom	118	64	56	63	97

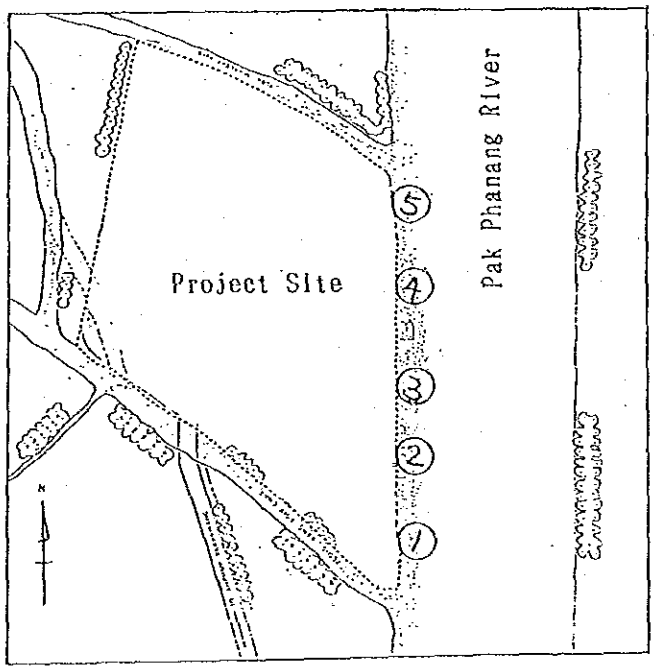
2) Grain Size Distribution of Riverbed Materials

Deposided material in the estuary contains sediment transported by the Pak Phanang River. Therefore, it is very important to analyze the deposited material in order to estimate the amount of the sediment transported by the Pak Phanang River.

Samples of the riverbed material were collected at five locations, as shown in Figure 5-6, and analyzed in the laboratory to determine their size distribution.

It was found that the grain size of the riverbed material ranged between 1 and 100 microns. 95 percent of the riverbed material is silt.

Figure 5-6 Sumpling Points of Riverbed Material



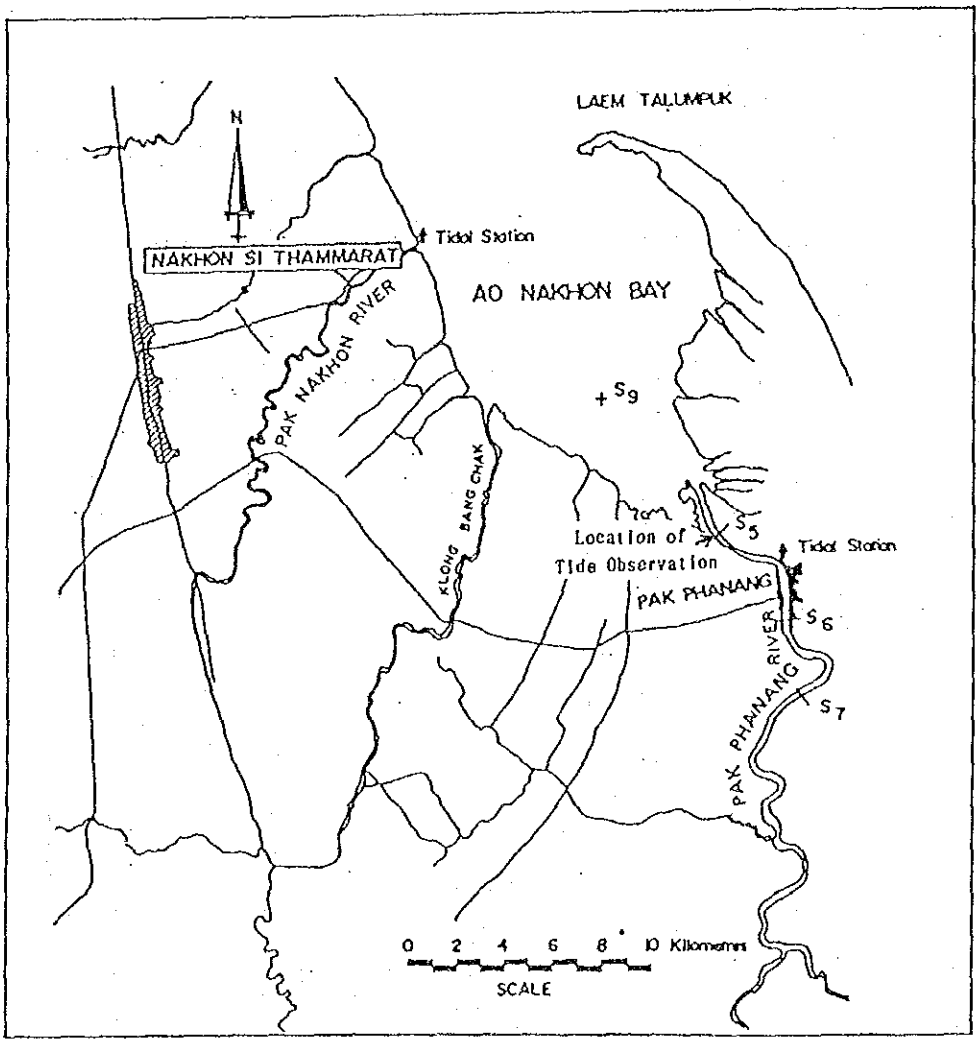
5 – 2 – 4 Tide Observation

Tide observation was performed for 15 days to decide the datum line for design and construction work.

Observation Period : 23 April ~ 8 May (15 days)

Location : Western side of Pak Phanang river, as shown in Figure 5-7 which is Latitude 8° 22' 10" N, Longitude 100 ° 10" 30" E:

Figure 5-7 Location of Tide Observation



(1) Observation Results

The observed tidal range was 1.13 m and the primary tide levels during the observation period were as follows.

Highest Water Level : + 1.87 m
Mean Water Level : + 1.30 m
Lowest Water Level : + 0.72 m

The above measurements can be converted based on the Pak Phanang tide station of the Harbour Department Office as follows:

Highest Water Level : + 2.99 m
Mean Water Level : + 2.42 m
Lowest Water Level : + 1.84 m

(2) Tidal Harmonic Analysis

The tidal harmonic analysis was conducted to determin the principal tidal constituents. The principal tidal constituents (M_2 , S_2 , K_1 , O_1) were obtained as shown in Table 5-6.

Table 5-6 Tidal Harmonic Constituents

Constituents	Amplitude (m)	Period (hr)
M_2	0.1810	12.4206
S_2	0.0550	12.0000
K_1	0.2001	23.9346
O_1	0.1547	25.8194

Zo value is determined by adding up four(4) principal tidal constituents (M_2 , S_2 , K_1 , O_1) as follows.

$Z_o = M_2 + S_2 + K_1 + O_1 = 0.5908$ m

By substituting the above Zo into the formula M.S.L $\pm$Zo, H.W.L = +1.89m and L.W.L= +0.71m is obtained; they are close to the primary tide level described above.

Harmonic Analysis results show that the tide can be classified as mixed tide, consisting of semidiurnal constituent M_2 and diurnal constituents K_1 and O_1 .

(3) Tide Record

Tide data was recorded by the Harbour Department on the bank of the Pak Phanang River in front of the local district administration office.

This tide gauging station, situated at the location with latitude 8° 20' 58" N and longitude 100 ° 12' 07" E, is about 3.5 km from the Project site.

Various tide levels which were recorded during 1973 to 1985 are shown in Table 5-7.

All tide levels are in decimeters above zero of the staff gauge.

Table 5-7 Tide Record of Pak Phanang Harbour

Year	H'est HW	MHWS	MHW	MSL	MLW	MLLW	L'est LW
1973	32.0	24.1	22.4	20.0	18.6	17.7	10.2
1974	31.1	25.0	23.2	21.2	19.2	18.4	13.4
1975	32.0	23.9	22.9	21.0	19.5	18.2	12.6
1976	32.6	23.8	20.6	19.6	16.5	17.4	11.2
1977	33.1	23.9	23.1	22.7	19.4	17.9	11.6
1978	30.4	22.4	22.5	18.3	17.2	17.3	6.8
1979	32.0	23.9	23.6	20.8	17.9	17.6	10.6
1980	31.0	23.4	22.4	20.0	18.0	17.2	6.2
1981	37.4	26.0	23.9	21.8	19.8	19.1	8.8
1982	37.6	29.5	28.8	25.9	23.4	23.1	18.2
1983	36.3	29.0	28.3	25.4	22.8	22.5	17.8
1984	37.3	28.7	28.3	25.3	22.7	22.3	12.7
1985	36.0	30.5	29.8	26.4	23.5	23.3	15.5
Average	33.8	25.7	24.6	22.2	19.9	19.4	12.0

Where:
- H'est H.W : Highest High Water
- MHWS : Mean High Water Spring
- MHW : Mean High Water
- MSL : Mean Sea Level
- MLW : Mean Low Water
- MLLW : Mean Lower Low Water
- L'est LW : Lowest Low Water

(4) Basic Tide Level

Basic tide levels were determined from the average of tide level records measured at the Pak Phanang station during the past 13 years. The slope of the riverbed is very gentle and the tidal current intrudes about 12 km upstream from the river mouth.

The tide levels were almost the same at the Project site and the Pak Phanang tide station. Therefore the principal tide levels at Pak Phanang are used as the basic tide levels.

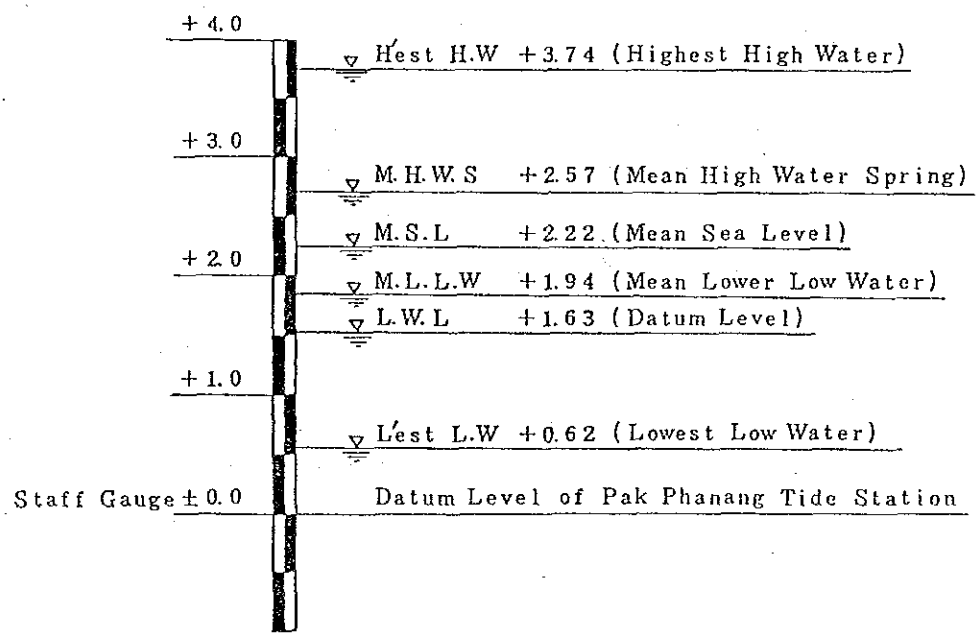


Figure 5-8 Tide Level of Project Site

The average value of mean sea level during the past 13 years at Pak Phanang tide station was adopted for calculation of the datum line. The datam line is calculated as follows:

$$\text{Datum line} = \text{M.S.L} - Zo$$
$$= 2.22 - 0.59$$
$$= +1.63\text{m}$$

5－2－5 Sediment Transport and Siltation Study of Pak Phanang River

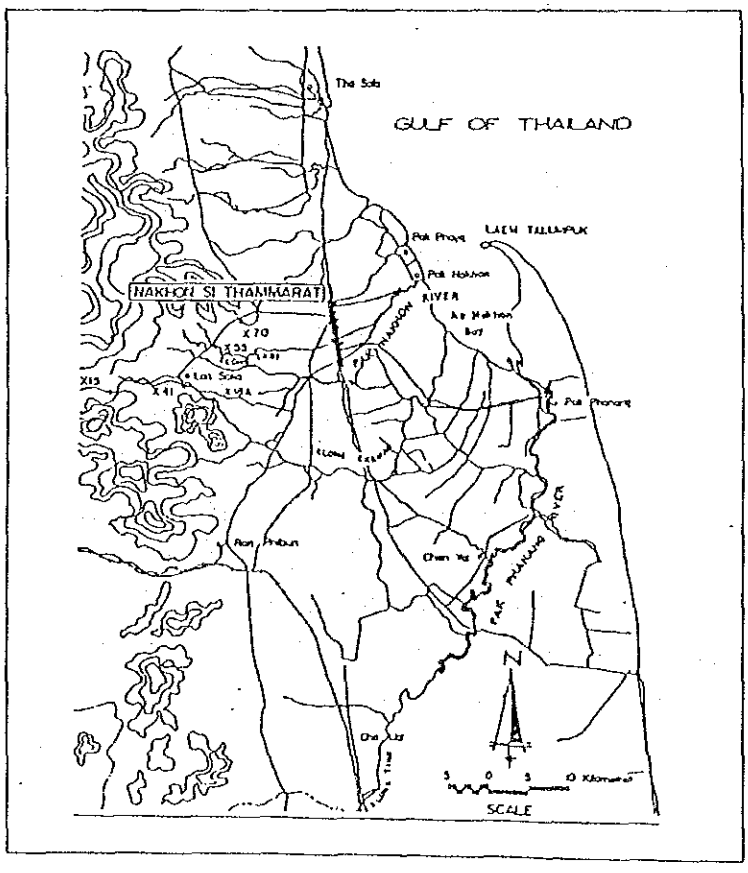
(1) General Characteristics of Pak Phanang River

The Pak Phanang River originates at Ban Plai Tong, passes through Chian Yai town and Pak Phanang city, and flows into the Ao Nakhon Bay from Pak Phanang Estuary. The river length is approximately 110 km. This river is meandering and many canals are connected it.

The slope of river bed up to 50 km from the river mouth is about 0.00002. Tide, with the range of about 0.5～1.0 m goes up about 12km upstream from the river mouth and this section of the river is influenced by both the river water flow and the tidal current flows. The river is about 250m wide and about 6 m deep.

The sediments are composed of mud, clay, and very fine silt . These fine colloidal materials flocculate in contact with salty water and deposite in the Ao Nakhon Estuary cansing the siltation problem in the navigation channel of Ao Nakhon Bay.

Figure 5-9 River System of Pak Phanang River



(2) Average annual Discharge and Sediment Transport of Pak Phanang River

1) Average annual Discharge

The average annual discharge of the Pak Phanang River was estimated with the following regression equation based on the recorded annual discharge and rainfall date gathered for a ten year period(1964－1973) at five gauging stations located in the Phum Duang River, Tapi River, Klong Phrasang River, and Klong Yan River in the districts of Bamdon and Song Khla which are on the northern side of Nakhon Si Thammarat and have very similar climatic and geographic conditions to Nakhon Si Thammarat:

$$Qa = 5.05 \times 10^{-12} \times A \times R^{2.92}$$

where Qa : annual discharge (m^3/sec)

A : catchment area (km^2)

R : annual rainfall (mm)

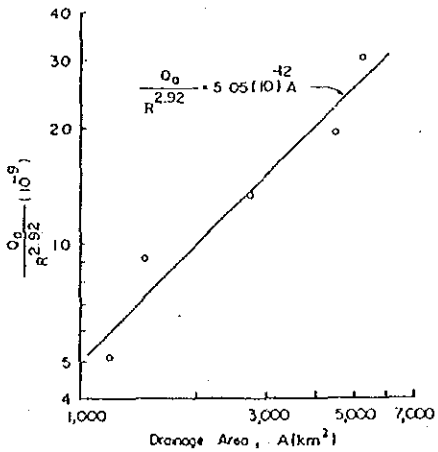


Figure 5-10 Regression Line Between Qa/R and A

Using the above equation, the average annual discharge at five gauging stations of Nakhon Si Thammarat district were calculated, and were compared with actual measured discharges at the same stations. The average difference between those calculated and measured discharges was only 11.2%. Therefore, it is considered reasonable to estimate the average annual discharge of the Pak Phanang River using the above equation.

Substituting a catchment area A=1,071 km^2 and an average annual rainfall R=2,382mm, the average annual discharge of the Pak Phanang River was obtained as follows:

$$Qa = 5.05 \times 10^{-2} \times 1,071 \times 2,382^{2.92} = 39.2 m^3/sec$$

2) Monthly Discharge

The average monthly discharges were calculated by multiplying the estimated average annual discharge and the dimensionless monthly dirscharge ratios Q／Qa, which were obtained from recorded date at three gauging stations in Klong Chamao.

These twelve values of Q／Qa and results of monthly discharge are listed in Table 5-8.

Table 5-8 Monthly Discharge

Month	Q／Qa	Monthly Discharge (m^3/sec)
April	0.36	14.1
May	0.44	17.2
June	0.35	13.7
July	0.37	14.5
August	0.43	16.9
September	0.45	17.6
October	1.06	41.6
November	2.71	106.2
December	3.15	123.5
January	1.68	65.9
February	0.56	22.0
March	0.41	16.1

It can be seen that the average monthly discharge of the Pak Phanang River has the lowest discharge of 17.3m^3/sec in June and the highest discharge 123.5 m^3/sec in December.

3) Sediment Transport

The sediment transport of the Pak Phanang River is estimated from the following regression equation based on the average annual discharge and sediment transport which were obtained from seven years records (from 1960 to 1966) of the station X18A in Klong Chamaoe River.

$$Qs = 6.44 Qa^{0.76}$$

where Qs = annual sediment transport (× 1,000 t /year)

Qa = annual discharge (m³/sec)

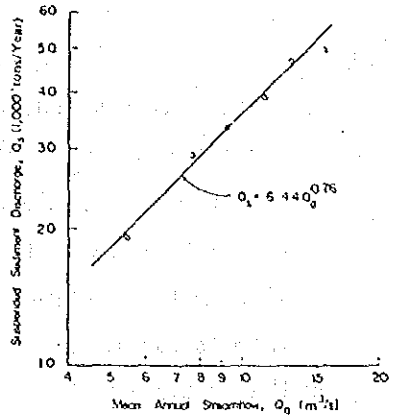


Figure 5-11 Regression Line Between Qs and Qa

Substituting an average annual discharge Qa = 39.2m³/sec, the sediment transport was obtained as Qs = 104,660 ton/year.

To evaluate the mean monthly sediment transport, the ratios between the mean monthly sediment transport and annual sediment transport, $\overline{Qs}$ / Qs at X18A were applied.

It can be found from Table 5-9 that the minimum monthly sediment transport is 25,000 tons in August, and the maximum is 389,000 tons in December, with an annual total of about 1,258,000 tons.

Table 5-9 Monthly Sediment Transport

Month	$\overline{Qs}$ / Qa	Sediment Transport (tons/month)
April	0.276	28,890
May	0.563	58,920
June	0.286	29,930
July	0.254	26,580
August	0.239	25,010
September	0.315	32,970
October	0.815	85,300
November	2.453	256,730
December	3.720	389,340
January	2.108	220,620
February	0.696	72,840
March	0.296	30,980
Total		1,258,110 tons

(3) Siltation Analysis

1) Sediment Transport of Pak Phanang River

Three periods of field surveys were conducted by the Asian Institute of Technology in June, August, and, November, December, 1974 to measure the current velocity, the suspended solid concentration with the corresponding tide elevation, and the salinity of water at three stations.

The locations of the stations, S5, S6, and S7 are shown in Figure 5-7.

Station S5 was located near the river mouth, and station S6 was in Pak Phanang City but station S7 was about five kilometers upstream from station S6.

The values of average sediment transport in 2 hours interval and the average daily sediment transports of station S5, S6, and S7 were measured and shown in Table 5-12.

The suspended sediment transport was estimated based on the actual measurement and analysis conducted by the Asian Institute of Technology in 1974. The analysis seemed most reliable because of the long term observation data on the river flow, suspended solid concentrataion and salinity is necessary for sediment transport analysis under such special hydraulic conditions as the periodic fluctuation of velocity, the direction of riverflow, and the strong infleuence of salinity and tide effect to the sediment transport.

The calculation results of suspended sediment transport at these stations are shown in Table 5-10.

As the project site is situated at the middle of S5 and S6, the average amount of suspended sediment transport of S5 and S6 was considered.

Table 5-10 Suspended Sediment Transport of Pak Phanang river

Sediment Transport	S7	S6	Project Site	S5
Daily Sediment Transport (t/day)	2,506	2,699	3,000	3,318
Annual Sediment Transport (× 1,000t/year)	915	985	1,095	1,211

From Table 5-10, it can be seen that the annual sediment transport at the river mouth of the Pak Phanang River is estimated as 1,211,000 tons.

This value is almost the same as that estimated amount in paragraph (3), Sediment Transport (1.258 million tons per year).

This means that the net average amount of sediment transport from the river into the bay is about 1.2 million tons per year.

This amount is higher than the amount of sediment supplied from upstream. It is considered that local erosion of the land surrounding the down stream supplies the difference.

2) Consideration of Siltation at the Project Area

Table 5-13 shows the amount of annual suspended sediment transport through four cross sections (km12, km16, km20, and km24) along the navigation channel which are dredged providing a bottom width of 60 m and a depth of -4m.

Adding the suspended sediment transport at S5, S6, S7 and the Project site, obtained in Table 5-10, to the above values, the Correlation Table of the suspended sediment transport for eight sections is shown in Table 5-11.

Table 5-11 Correlation of Suspended Sediment Transport

Station	Pak Panang River				Navigation Channel			
	S7	S6	Site	S5	km12	km16	km20	km24
Sediment Transport (×1,000 t/year)	913	986	1,095	1,211	570	615	349	260
Deposition (×1,000 t/year)	− 73	− 109	− 116		− 45			
				+641		+ 266	+ 89	

Sediment deposition was calculated as the balance of sediment transport between each station. The plus (+) sign designates the decrease of the sudsepended sediment transport, and the minus means (-) sign designates the increase of sediment transport.

From Table 5-11, it can be seen that 1.21 million tons of suspended sediment is discharged from the river mouth into the navigation channel of Ao Nakhon Bay, and 641,000 tons are deposited between S5 and Km12 and 355,000 tons are deposited between Km16 and Km24.

Therefore, about 1.0 million tons are deposited in the navigation channel of Ao Nakhon Bay and is the cause of shoaling in the navigation channel.

Accordingly, there may be no sediment deposit, in spite of increased sediment transport, in front of the project site throughout the year.

The general plan and the center line elevation of the Pak Phanang River and its navigation channel are shown in Figure 5-12. As the Figure shows, the Pak Phanagn River (approximately 8km section from Pak Phanang City to downstream) is about 250m wide and about 5～6 m deep from M.S.L. However, the section between the river mouth to station km 12 is shoaling, because of the deposits of the suspended material due to the reduced flow velocity (because of the increased river width) and the increase of salinity.

The maintenance dredging of the navigation channel in Ao Nakhon Bay is conducted by the Harbour Department every two year.

Table 5-12 Amount of Sediment Transported in Pak Phanang River Obtained from Field Surveys.

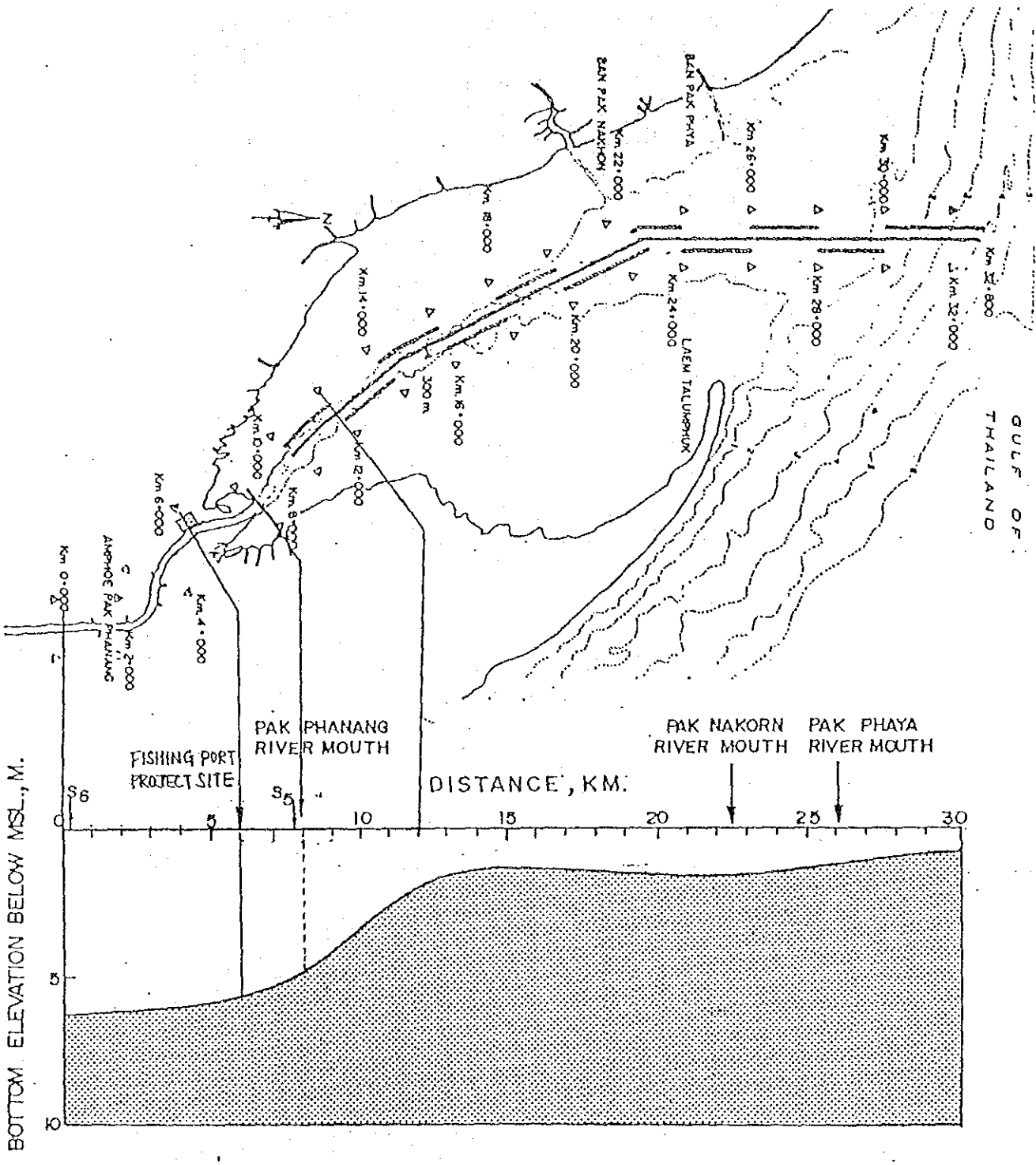
Date	Station S7 (Tons/day)	Station S6 (Tons/day)	Station S5 (Tons/day)
21-22 June		− 848.31	− 4,716.45
26-27 June	1,575.78	1,187.81	1,229.98
24-25 Aug.	42.27	− 132.65	—
27-28 Aug.	− 371.65	− 427.30	− 691.20
28-29 Nov.	7,397.02	15,011.53	11,501.17
1-2 Dec.	6,317.09	6,469.30	7,188.78
4-5 Dec.	3,305.09	3,475.12	3,818.78
9 Dec.	2,390.08	1,918.88	2,913.69
10 Dec.	1,771.35	1,284.70	2,562.91
11 Dec.	1,359.53	1,254.37	2,428.54
12 Dec.	833.22	1,313.40	1,343.63
13 Dec.	1,485.54	517.42	1,451.49
14 Dec.	1,081.66	− 412.74	345.20
15 Dec.	2,234.28	− 722.96	—
16 Dec.	3,634.92	4,580.07	7,255.05
17 Dec.	3,453.82	4,813.74	6,621.20
18 Dec.	3,435.96	4,563.64	5,115.41
19 Dec.	2,678.47	3,257.96	3,742.87
20 Dec.	2,485.91	4,190.17	4,299.13
Total	45,110.34	51,285.26	56,409.66
Average/Day	2,506.13	2,699.22	3,318.22

Table 5-13 Average Monthly Sediment Transport in the Navigation Channel

(Unit : ton)

Month	km12	km16	km20	km24
April	22,598	47,914	18,903	13,071
May	21,263	42,087	17,998	12,824
June	22,957	46,459	19,360	13,667
July	11,172	18,760	9,724	7,416
August	8,890	14,324	7,775	6,001
September	45,234	110,491	37,285	24,860
October	43,676	113,357	43,744	32,440
November	121,001	40,065	22,680	18,713
December	64,433	86,425	62,304	53,486
January	156,064	43,877	64,801	49,191
February	20,322	40,127	18,358	13,518
March	31,429	10,657	25,897	15,124
Total	570,039	614,543	348,829	260,311

Figure 5-12 General Plan and the Bottom Profile along Center Line of River and Navigation Channel of the Pak Phanang River



Bottom Profile Along Center Line of River and Navigation Channel of the Pak Phanang Estuary