CHAPTER 6 PROJECT IMPLEMENTATION AND MANAGEMENT

6-1 METHOD OF CONSTRUCTING THE MINE

Almost all of of the equipment and machinery to be used inside and outside of the mine is to be imported. It will also be necessary to smoothly accomplish a variety of tasks prior to the start of mine operation, such as designing of various mine facilities, and their fabrication or construction; study, procurement and shipment to the mine of machinery, materials, etc.; civil, mechanical and electrical construction work; inspection and testing. It will also be necessary to simultaneously proceed with three construction jobs: construction related to ground facilities of the mine, underground work (primarily excavation) of the mine, and construction of the mine town and infrastructure, and it will therefore be necessary to coordinate this construction work. In view of the diversity and complexity of the work to be undertaken, it is expected and recommended that an internationally experienced company be retained to undertake the work on the basis of a lumpsum contract.

6-2 FUNCTION AND ROLE OF THE CONSULTANT AT THE CONSTRUCTION PHASE

It is anticipated that an internationally-experienced consultant will be retained for assistance in detailed preparation for bidding as well as for technical services noted below, as part of the effort at promotion of this Project.

1. Check of the basic design and detail design submitted by the contractor, and assistance in providing the contractor with directions concerning the design.

2. Being present at time of inspection of main equipment, and assistance regarding checks of such equipment.

3. Assistance related to field supervision during construction.

4. Assistance in establishing systems for overall project management and budget control, and assistance in complying with reporting obligations for to financial institution.

	1 Yr	2 Yr	3 Yr	4 Yr	Remarks
Engineering and Estimate					9 Months
Procurement					
Mine Site Construction					18 Months
Town Site Construction					18 Months
Decline Shaft					11 Months
Excavation for Plant					6 Months
Plant Construction					7 Months
Training					3 Months
Production					
Remarks					

PROJECT IMPLEMENTATION SCHEDULE-ROCK SALT MINE

It will be necessary for the joint venture to acquire the services of three senior-level mining consultants during the construction period, in order to acquire the necessary assistance.

6-3 CONSTRUCTION SCHEDULE

Construction of the mine will start at the time that detail design is begun, and will require three years, after which shipments of mine product can begin, as shown in the schedule below. The construction work can be broadly classified as being (a) mine site construction, (b) town site construction, and (c) excavation. Of these, the excavation work in particular will lie on the critical path. Work which will define the critical path comprises the decline shaft opening, excavation for the plant, and construction of the plant.

6-4 CONSTRUCTION PERIOD

Construction will require three years, as noted above. Construction work is to be performed by three shifts.

6-5 ADDITIONAL INVESTMENT FOR INCREASED MINE PRODUCTION

In order to increase mine production from 1.2 million to 1.8 million t/y, construction of housing for the additional workers will be required; this will cost US$695,000.

6-6 REPLACEMENT

It will be necessary to replace the L.H.D. used in the mine at intervals of production volume of 9.17 million tons. The cost of replacement is US$1,081,000. If the mine is operated at 1.2 million t/y, replacement will have to be carried out in the eighth year.

6-7 COST OF FOREIGN ASSISTANCE

For a period of four years after the start of mine operation it will be necessary to employ foreign specialists to assist in supervision and management of the mining.

CHAPTER 7 ORGANIZATION AND MANNING

7-1 GENERAL

This mine is so planned as to be a modern mine, where modern, large scale equipment is used. The quality of the workforce, therefore, must be high. On the basis of the field study, it is thought that it will be difficult to recruit workers of high quality in the area of the proposed mine site, and it therefore will be necessary to employ workers from Bangkok and other Thai cities, and develop their abilities.

Further, considering that this will be the first large-scale mine in Thailand, the wages of the workers should be expected to be higher than that of ordinary levels currently prevalent in the country.

It will be necessary to set the wages for heavy equipment operators at a higher level than that of plant operators, because the performance of the former will directly and immediately influence mine production performance. Moreover, after the start of production, it may prove beneficial to pay bonuses based on the quantity of salt produced by the mine as one of the incentives for workers.

7-2 ORGANIZATION

The organization chart for the mine (i.e., excluding the organization at the head office) is as shown on the next page.

ORGANIZATION CHART OF ROCK SALT MINE

- Mine Manager 1
  - Safety Director 1 ---- *
  - Assist. Mine Manager 1
    - Production Supt. 1
    - Maintenance Supt. 1
    - Engineering Supt. 1
    - Office Manager 1

Staff

Production Supt.		Maintenance Supt.		Engineering Supt.		Office Manager	
Production Engr.:	2 (3)	Surface Maintenance Engr.:	2 (3)	Mining Engr.:	2	– Casher:	1
Shift Boss of		Underground Maintenance Engr.:	2 (3)	Surveyor:	1	– Labor Procr.:	1
Crushing:	2 (3)			Geologist:	2	– Account:	1
Mining:	2 (3)					Store Keeper:	1
Loading:	3 (3)					Purchasing:	1
	9 (12)		4 (6)		5		5

Total Staff: 30 (35)

Labor

Production Supt.		Maintenance Supt.		Engineering Supt.		Office Manager	
Cutting:	8 (12)	Electrician:	6 (9)	Surveyor:	4	Information:	2
Drilling:	8 (12)	Mechanician:	6 (9)	Designer:	2	Assistant of Officer:	5
Elasting:	8 (12)	Mobil Repairing:	10 (15)	Planner:	2	Guard Man:	3
Scaling:	6 (9)	Maintenance:	6 (9)			Clerk:	10
Bolting:	6 (9)	Inspection:	4 (6)			* Assistant:	4
Loading:	8 (12)						
Grading:	2 (2)						
Exploration:	4 (6)						
Waste Storage:	6 (9)						
Crusing and Screening:	10 (15)						
Conveying:	4 (6)						
Storage and Loading:	12 (18)						
Misc., Vacation:	16 (25)	Misc., Vacation:	5 (10)	Misc., Vacation:	1	Misc., Vacation:	4
	98 (148)		37 (58)		9		28

Total of Labor: 172 (243)

CHAPTER 8 TRAINING

8-1 TRAINING

Training of operators is to be done under the supervision of three foreign specialists, for a three-month period prior to the completion of construction. It is not possible, however, to fully train all of the operators during this short time. Because of the learning curve phenomenon, it is assumed that during the first year the operation will be at the level of 68% of capacity, and after the start of operation it will be necessary to maintain a four-man training staff of foreign experts at the mine. They will gradually transfer responsibility for training to mine employees.

8-2 SUPERVISION

Foreign technical advisers are to be employed, as pointed out above, for training of operators, production control, and supervision of equipment maintenance. The job categories and main responsibilities of these advisers are to be as follows. One person for each category will be required.

Senior mining engineer (Mine operation management, over-all supervision)

Senior electrical engineer (Maintenance of electrical systems; supervision of repair; instruction)

Mining engineer (Training of operators; supervision of operation)

Mechanical engineer or electrical engineer (Maintenance of plant machinery and equipment).

These advisers are to be employed for a period of four years starting with the commencement of mine operation.

CHAPTER 9 ENVIRONMENTAL ASPECTS

There are no specific regulations in force in Thailand with regard to salt mines, but full consideration is given to environmental aspects of excavation and production activities.

9-1 WATER QUALITY

Measures are to be taken to prevent penetration of water from the overburden and impermeable bed into the mine. Water which enters the mine from other sources is to be collected at the floor of the mine and pumped to the surface for disposal. At the time of strong rains, there would be some salt-containing runoff from the stockpile and its surrounding area. This, together with water drained from in and outside of the mine, is to be disposed of in a waste pond in such a way as to not pollute drinking or farm water in the area.

9-2 LOOSE SALT DUST

During construction of the mine the crushing and screening of rock salt will be performed outside of the mine, but because the crushing and screening equipment will be inside a building, there is no danger of loose salt spreading in the area. After the start of mine operation, all crushing and screening work is to be performed within the mine, where a dust collector will be used to prevent loose salt dust from becoming a problem, and thus there is virtually no danger of loose salt dust creating an environmental problem outside of the mine. In order to prevent such a problem from arising when rock salt from the mine is handled and transported to the soda ash plant, fine salt (less than 1.2 mm) is to be separated from product salt prior to shipment. Thus, there is very little low chance of an environmental problem arising away from the mine.

9-3 NOISE

A certain amount of noise will be unavoidable during the construction of the mine, but because the surrounding area is almost uninhabited, this noise is not considered to be a problem. Mining operations after the construction of the mine is completed will be entirely underground, and the only sound outside of the mine will be that of the movement of freight cars. The sound level therefore will be quite low compared to that of ordinary industrial establishments. The main ventilator, a source of noise, will be installed within the mine.

9-4 WASTE HEAP

All waste from the crushing and screening plant is to be disposed of within the mine, and there is no need to have a waste heap outside of the mine.

9-5 INFLUENCE IMPARTED TO GROUND LEVEL

For reasons of mine safety, a permanent pillar will be left as mining progresses and this will also serve to prevent influence on the elevation of the ground surface.

CHAPTER 10 CAPITAL AND OPERATING COSTS FOR THE MINE

The capital costs for the mine are stated in Part VI, and the operation costs are stated in Part VII.

PART IV

STUDY OF RAIL TRANSPORTATION OF ROCK SALT

PART IV STUDY OF RAIL TRANSPORTATION OF ROCK SALT

CHAPTER 1 INTRODUCTION

This Project foresees transporting rock salt from the mine at Bamnet Narong to the soda ash plant at Laem Chabang by means of rail. In connection with this plan, the Evaluation Team studied the following:

1. Possibility of using the state railways for rock salt transportation

2. Facilities required as part of this Project in order to be able to use the railroad

3. Rail freight charges for transportation of rock salt

The results of the study of these points are given below. The assumption was made that on the basis of the rock salt production scale proposed by the Evaluation Study Team 1,200,000 t/y of rock salt would be transported.

CHAPTER 2 TRANSPORT CHANNEL

2-1 THE ROYAL STATE RAILWAY (RSR) NETWORK

The network of the Royal State Railway is as shown in Figure IV-1; as it is shown in the figure, construction is now proceeding on a line from Chacheongsao (east of Bangkok) to Sattahip, to the south. Laem Chabang, the location of the soda ash plant, is near the midway point of this line, and completion of its construction is therefore of no small importance in regard to this Project. The GOT plans to complete construction by 1983, so that even if completion of construction is delayed, there is still ample time for the line to be opened prior to the projected 1985 start of the soda ash plant operation. Therefore, it is assumed here that the Project will be able to avail itself of use of this railway line.

2-2 PROPOSED ROUTE

The route having the shortest distance between the rock salt mine and the soda ash plant is to be utilized; this has been identified to be that shown in Figure IV-2. The major stations along this route and distances between them are:

Bamnet Narong	
	165.4 km
Kaen Khoi Junction	
	35.4 km
Ban Phachi Junction	
	82.5 km
Bang Sui	
	62.5 km
Chachoengsao	
	72.0 km
Si Racha Junction	
Total	417.8 km

Although a portion of the existing line requires repair for it to be used for this Project, the Royal State Railway is proceeding with such work as part of its on-going maintenance program, and it is judged that there will be no hindrance to use of the lines for transportation of rock salt.

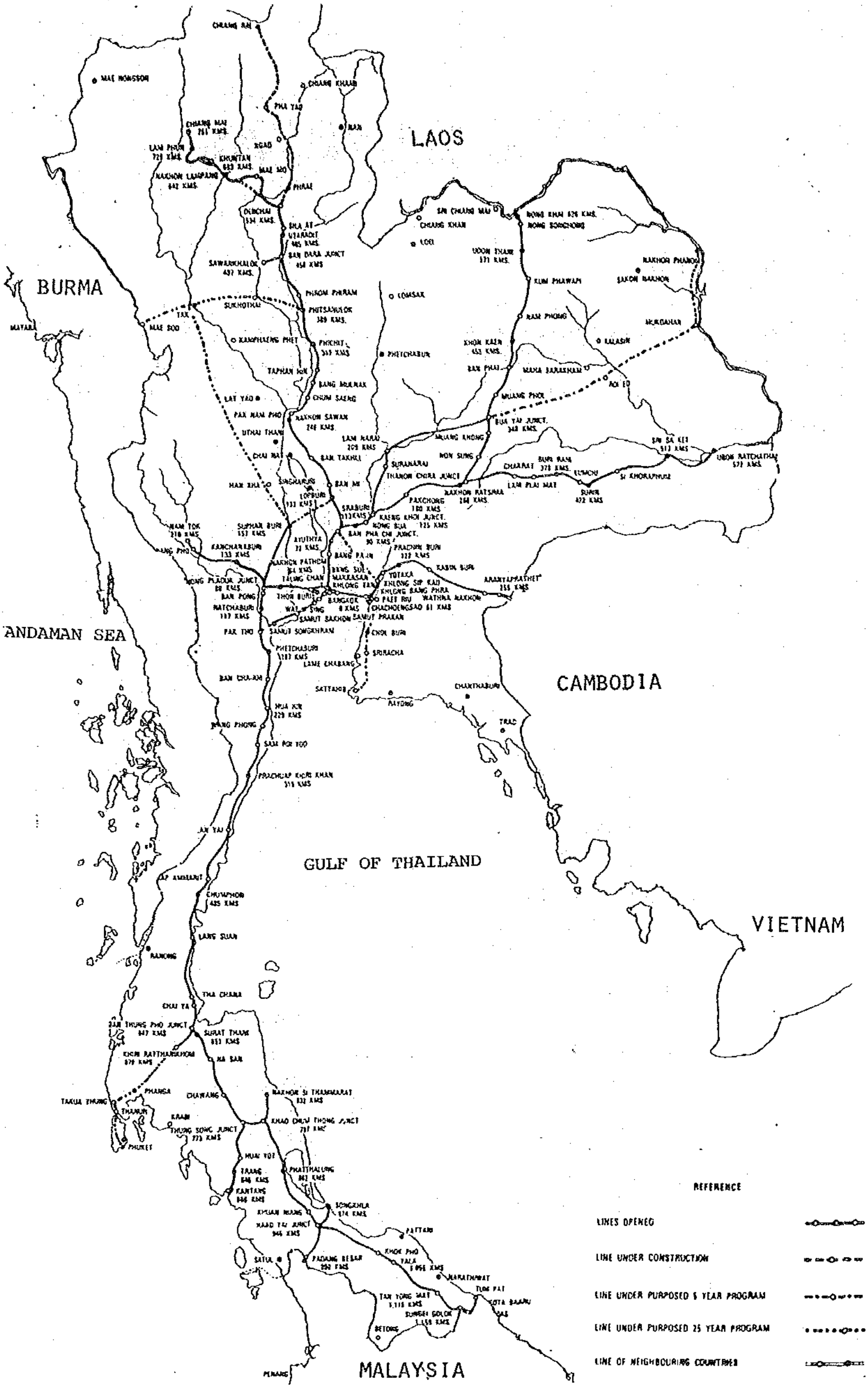


Figure IV-1 LOCATION MAP OF ROCK SALT MINE AND SODA ASH PLANT

CHAPTER 3 GENERAL CONDITIONS OF RAILWAYS IN THAILAND

3-1 ORGANIZATION

Since the opening of a portion of the Northeastern Line between Bangkok and Nakhom Ratchasima in 1892, the total length of the Thai railway systems has been increased and at the present time the total route kilometers of the RSR is 3,735 km (see Figure IV-1). Major statistics, as of 1979, are as follows.

Total route kilometers	3,735 km
Total length of track	4,418 km
No. of stations	444
Rolling stock in use	
Steam locomotives	39
Diesel locomotives	240
Diesel railcars	49
Coaches	1,059
Freight cars	9,137
Train-kilometers	
Passenger trains	$17,784 \times 10^3$ km
Freight trains	$7,682 \times 10^3$ km
Mixed trains	$3,355 \times 10^3$ km
Passenger car kilometers	$189,215 \times 10^3$ km
Freight car kilometers	$352,940 \times 10^3$ km
Traffic volume	
Passengers carried	$64,398 \times 10^3$ persons
Freight tons carried	$6,366 \times 10^3$ tons
Passenger-kms	$7,029 \times 10^6$ passenger-kilos
Freight ton kms	$2,747 \times 10^6$ ton-kilos
Operating revenues	$1,861 \times 10^6$ Baht
Operating expenses	$1,891 \times 10^6$ Baht

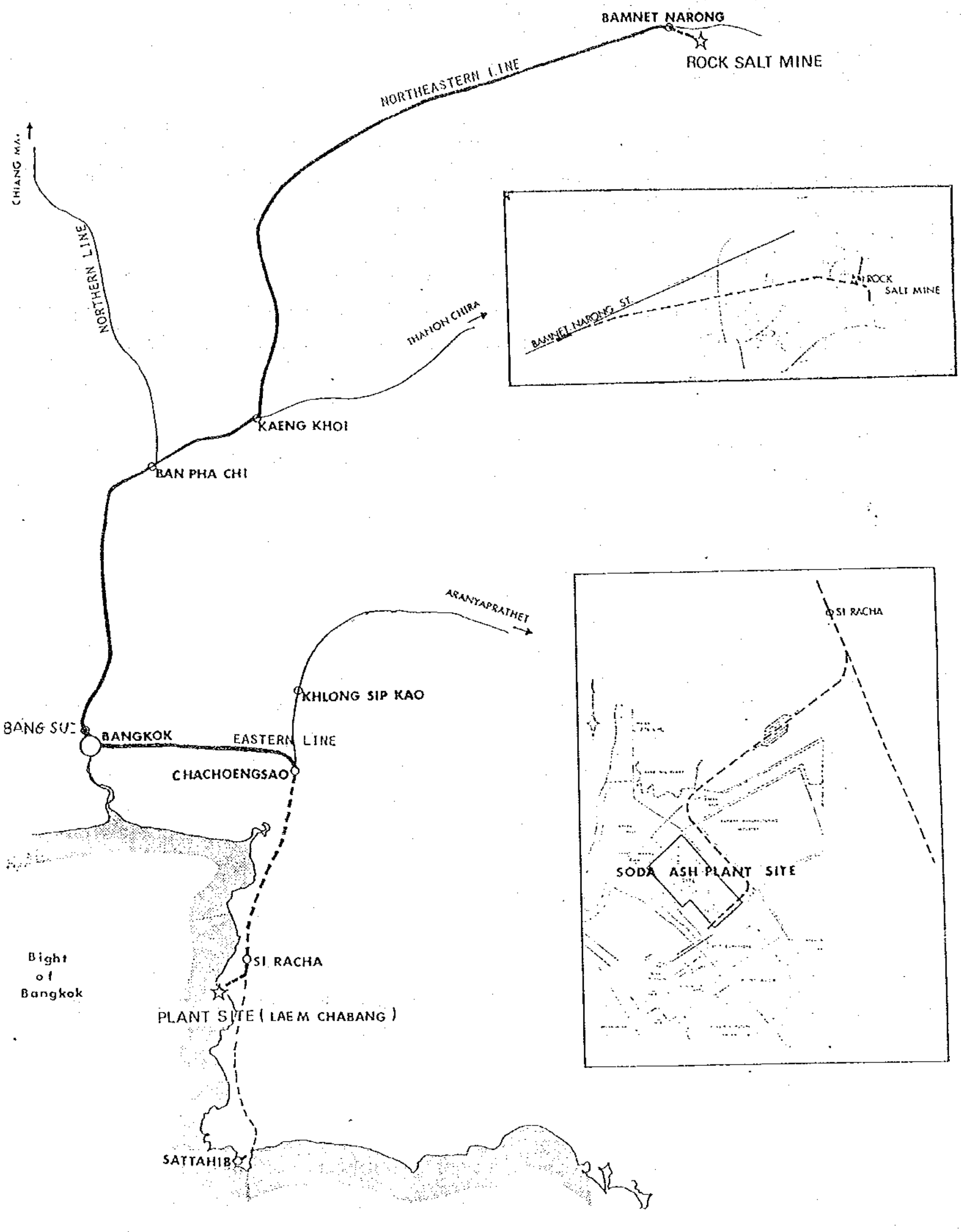


Figure IV-2 LOCATION MAP OF ROCK SALT MINE AND SODA ASH PLANT

3-2 RAILROAD FACILITIES ALONG THE RELEVANT LINES

3-2-1 Track, General

Along the Bamnet Narong-Chachengsao route (see Figure IV-2) only the distance between Bangkok and Ban Pachi is double track and the rest of the distance is single track. The track between Chachengsao and Laem Chabang is to be single.

The maximum gradient is 12 ‰, between Bamnet Narong and Kaeng Khoi Junction, and 10‰ between Kaeng Khoi Junction and Chachengsao. The gradient between Chachengsao and Sattahip is planned to be 10 ‰. The following description of the freight train plan is based on these conditions.

3-2-2 Track Specification

Specifications of the track are to be as follows.

Rail :	70 lb/yard
Fastening :	Spikes
Sleepers :	Wood; interval, 65 cm. (Note: in some sections near Bangkok, the RSR has begun to use concrete)
Ballast :	Gravel (20 cm depth below sleepers)
Turnout point :	Main line, 10# or 12# Siding, 8#

With these specifications, an axle load of 15 t is acceptable, but from the viewpoint of curtailment of maintenance cost, it is desirable to strengthen the track. The track between Chachengsao and Laem Chabang is to be capable of accepting an axle load of 20 t.

3-2-3 Bridges

Between Bamnet Narong and Chachengsao are 227 bridges most of which can accommodate a train with an axle load of 15 t but 27 bridges need reinforcing or replacement in order that all bridges on the route can be made to accommodate 15 t axle load. This is also required from the viewpoint of general rail transportation requirements. The RSR is to assume responsibility for such reinforcing and replacement which is to be completed in accordance with the schedule for implementation of this Project.

3-2-4 Signalling System

Other than use of tokenless block system as the safety method on the line between Bangkok and Ban Phachi Junction, manually-operated token block system is used on the line between Bangkok and Ban Phachi Junction, manually-operated token block system is used on the other lines. The decision to use these systems faces no problem as a result of the increased traffic volume which the Project represents.

CHAPTER 4 TRANSPORTATION PLAN

In the following paragraphs study is made of the Plan for use of rail transport between Bamnet Narong and Laem Chabang as described above in 2-2. Consideration is given to making each train as long as possible, to minimizing the number of trains, to facilitate timetable preparation, and to minimize transport costs.

4-1 ROLLING STOCK TO BE USED AND TRAIN OPERATIONS

4-1-1 Main Line Locomotives

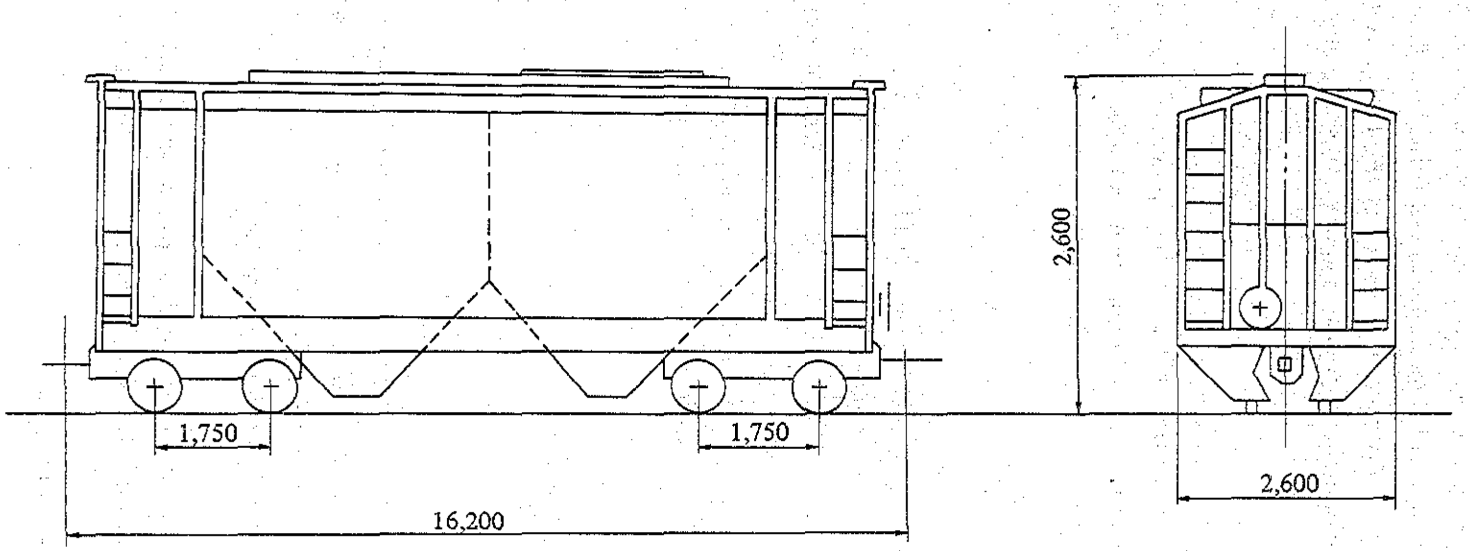
Assuming that the locomotives to be used will be the same as those presently in use by the RSR, in the interest of ease of operation and maintenance, and it is further assumed that the locomotives will be equivalent to the strongest ones now in service, i.e., Alsthom type locomotives. The specifications for them are:

Output/revolutions :	2,400 HP/1,500 rpm
Max. length :	16,258 mm
Max. width :	2,800 mm
Max. height (on rails) :	3,880 mm
Axle load :	13.75 t
No. of axles :	6
Gross weight :	82.5 t
Traction load :	1,398 t

Locomotives are not to be owned by the company undertaking this project, nor are they to be for the exclusive use of this project. Therefore, the project sponsors are not required to provide locomotives.

4-1-2 Freight Cars

In view of the nature of the rock salt loading equipment to be provided at the mine and unloading equipment to be provided at the soda ash plant, hopper cars are proposed to be used. On the basis of the 15 t axle load used by the RSR in planning related lines, the largest capacity cars possible should be used. Dimensions of the cars are as shown in Figure IV-3. Because hopper cars of this size and capacity are not in use in Thailand at present they must be newly acquired. Although it is not yet finally decided, it is the present intention of the



Axle Loading	15 ton
Car Capacity	60 ton
Light Weight	16.3 ton
Load Limit	43.7 ton

Figure IV-3 60-TON CAPACITY COVERED HOPPER CAR FOR ROCK SALT

Ministry of Communication and the RSR to have the cost of acquiring these special cars borne by the Project. Moreover, from the viewpoint of insuring transport efficiency, it is deemed desirable for the Project-sponsoring company to use them only for the Project. However, as is noted elsewhere, the percentage of transportation cost within total cost of rock salt is high, and for the sake of competiveness need exists to reduce the cost of transportation. Further, in addition to this issue with regard to the transportation of rock salt, if in the future there is also development of potash resources, the same question will arise in connection with that project.

In order to promote this Project, need exists for a suitable policy and action by the RSR for general reduction of transportation costs. It is recommended that the Ministry of Industry closely work with the Ministry of Communication and RSR in order to establish such an action program. The Project will require 138 hopper cars (see 4-2).

4-1-3 Trains

The number of cars in a train will be determined by the traction load capacity, as noted in 4-1-1. Because the locomotive's traction load is to be 1,398 t, after deducting 10 t for the van, since each hopper car weighs about 60 t, it will be possible to pull a train of 23 hopper cars. In that case, the length of the trains would be 399 m (16.258 m for the locomotive, 372.6 m for the hopper cars, and 10 m for the van) which will not represent a problem with regard to train movement. The quantity of rock salt which one train can haul is: 43.7 t x 23 = 1,005 t.

4-2 TRAIN OPERATION PLAN

4-2-1 Train Types

Because the rock salt transport trains used between the Bamnet Narong mine and Laem Chabang plant are to be exclusively for transport of rock salt, there will be no re-attaching or uncoupling at stations on the way except for purposes of inspection or repair. The return trip, to Bamnet Narong, will be with empty hopper cars.

Some portion may be unloaded at Bangkok (to the extent of 40,000 to 50,000 t/y). In such case the train must be operated from Bamnet Narong to Bangkok.

4-2-2 Required Number of Trains

Rail transport service for the Project is to be provided 365 days of the year. On this basis the number of trains (trips) to be made on one day is to be as follows.

Annual quantity transported	1,200,000 t
Days of train operation	365
Daily quantity transported	3,287 t (≑ 3,500 t)
Haul per trip	1,00t 5

Therefore, the number of trains/day is 4.

4-2-3 Number of Hopper Cars per Train

(1) Duration of time required for one transport cycle

The time required for one transport cycle between Bamnet Narony and Laem Chabang is calculated by the following method.

Shunting in yard (including turnaround) :	2°00'
Mine–Bamnet Narong station (including waiting time) :	30' (one way)
Bamnet Narong station–Laem Chabang yard :	11°00' (one way)
Laem Chabang yard–plant :	30' (one way)
Unloading at plant (including in yard) :	2°00'

Therefore, one cycle will last 26°00'.

(2) Number of hopper cars per tain

Because it will be necessary to operate four trains a day, as shown in (1), the average interval between trains is to be 6 hours. If a time table is planned is accordance with that interval, then required train operation would be as follows.

28 hr ÷ 6 hr = 4.7 ≑ 5 trains

Allowing one train for repair and maintenance, the total of 6 trains is required. Therefore, for this Project the number of hopper cars is 23 x 6 = 138.

4-3 OPERATION BETWEEN THE MINE AND BAMNET NARONG STATION, AND BETWEEN THE PLANT AND LAEM CHABANG YARD

The times required to operate trains between the specified point are given in 4-2; between these points the trains are to be operated according to the timetable established by the RSR, and using RSR locomotives and personnel, in the same manner as trains on the main lines, and therefore all that is required of the Project is payment of the freight charges. At the present time the schedule of charges which would be applicable for this Project has not been determined, but the Ministry of Industry should hold discussions with the Ministry of Communication on this matter at the earliest possible time.

CHAPTER 5 LOADING AT THE MINE AND UNLOADING AT THE PLANT

5-1 INTRODUCTION

5-1-1 Loading at the Mine

Loading of hopper cars with rock salt at the mine is to be by releasing the rock salt from a hopper bin (regarding the loading equipment, see Part III). This is to be done for two hopper cars at a time, and the cars, coupled will be moved two at a time to and then beyond positions under the hopper bin. The steps to be followed from the time of arrival of a train at the mine to its departure are as given below (regarding the track arrangement in the yard, see 5-2).

1. Train reaches arrival line
2. Truck line locomotive is uncoupled and shunting locomotive is coupled to the cars. The van is uncoupled.
3. Train is shunted to the loading equipment location, and starting with the first two cars, all cars of the train are loaded with rock salt.
4. After transfer of the train to a turn-out track, it is shunted to the departure line.
5. The shunting locomotive is uncoupled, and the main line locomotive is coupled to the train.
6. Pre-departure checks are made.
7. Departure.

5-1-2 Unloading at the Plant

To unload the cars at the plant, the cars are moved into a pit line, where their bottoms are opened, permitting the rock salt to fall into the pit (regarding pit equipment, see Part V.). Unloading is done two cars at a time. Because it is not possible to move the entire train at one time into the plant's yard, as noted in 5-2, two cars at a time are to be moved into position for unloading. The steps from the time of arrival of the train to departure are as follows (regarding track within the plant site area, see 5-2).

1. Train reaches arrival line.

2. Cars are uncoupled so as to make a series of two coupled cars.

3. Truck line locomotive is uncoupled, and a shunting locomotive is coupled to the first car (two cars). The van is uncoupled.

4. Each pair of two cars is moved to the pit in turn for unloading and after shunting empty cars to a riding they are moved to the departure line.

5. All cars are coupled.

6. The shunting locomotive is uncoupled and the trunk line locomotive is coupled to the train. The van is coupled to the train.

7. Pre-departure checks are made.

8. Departure.

5-2 SPURS AND TRACK AT THE MINE AND PLANT SITE

The costs of spurs at the mine and plant site are to be borne as part of the costs of this project; therefore the following study has been made.

5-2-1 Outline of Track Construction

The branch line and spur between the mine and Bamnet Narong station (see Figure IV-4) and from the marshaling yard (Figure IV-6) planned to be constructed for Laem Chabang to the soda ash plant are expected to accommodate annual movement of about 2.9 million tons, as per the following calculation.

Locomotive axle load	82.5 t
Cars and caboose	384.9
	467.4 t
Rock salt axle load	1,005.1 t

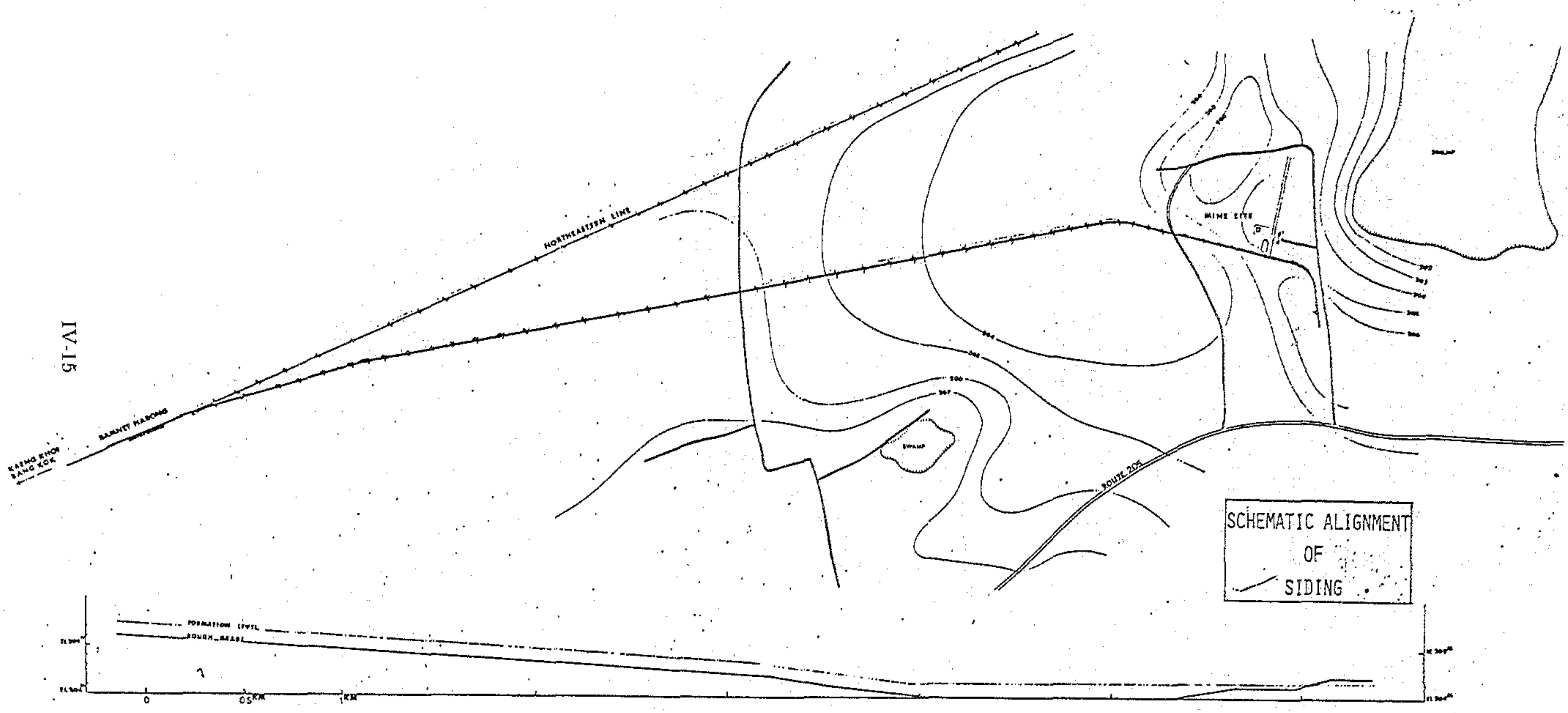


Figure IV-4 SCHEMATIC ALIGNMENT OF SIDING

Therefore the number of tons moved per day over these spurs will be

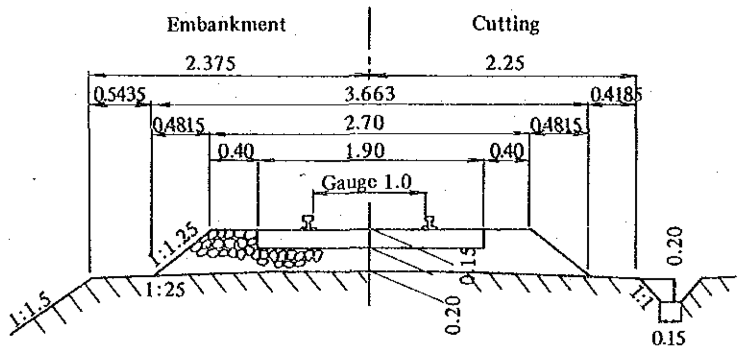
(Loaded) (Empty)
(1,472.5) + (467.4) x 4 ≒ 7.760 t/d

The number of tons moved a year will be

7,760 t/d x 365 days = 2,832,000 t

This quantity of freight transport is such that RSR specifications for 3rd class Line (Branch) and 4th class Line (Spur) are applicable. Therefore the sectional design shown below is to be adopted.

1. Track construction



2. Materials

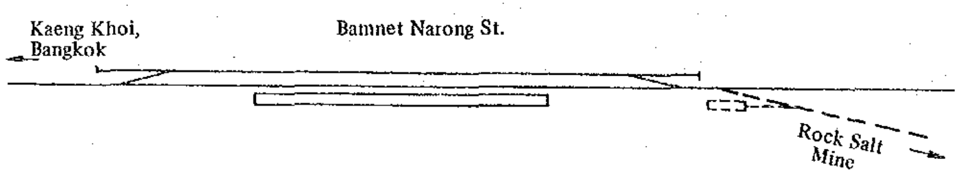
Rail	60 lb/yard; std length, 12.0 m
Fastening	Tie plate, dog spike
Sleeper	Wood; interval, 70 cm
Ballast	Gravel; thickness, 20 cm
Turnout point	8# for spur; 10# for branches

5-2-2 Mine Spur

(1) Bamnet Narong-Mine Spur (see Figure IV-4)

The land over which the spur is to be laid from the Northeastern line at Bamnet Narong to the mine is wilderness which is mostly flat. It will be necessary to raise the grade on which the ballast will be placed by about 1.3 m, for a distance of about 5.7 km; other than two short curves the track will be straight and the vertical gradient is modest, at 1/1,000.

As shown below, within the Bamnet Narong station stabling is provided opposite to the mine spur, and is to be used for trains to (or from) the mine to enter (or leave) the trunk line.



(2) Track in the yard at the mine (see Figure IV-5)

The area at the mine where the loading facilities are to be constructed is nearly flat and will be graded to the elevation of 205.5 m prior to construction. The track in the yard is to consist of the arrival track directly approaching the loading bunker, a reserve track, departure track, and turn-out track.

After the hopper cars are loaded with salt, they are shunted to the turn-out track. This track normally is required to have a straight length equal to the overall length of the train to use it, but because of the arrangement of tracks in the yard at the mine and the plans for housing construction, it will not be possible to have this length. There are two ways to resolve this problem, as follows.

> Separation of the train: Because it will be possible to provide a straight track for the overall length of a 6-car train, loading of cars can be done 4 to 6 at a time, while the waiting cars are turned out, and the two 4-to-6-car trains can be coupled prior to departure.

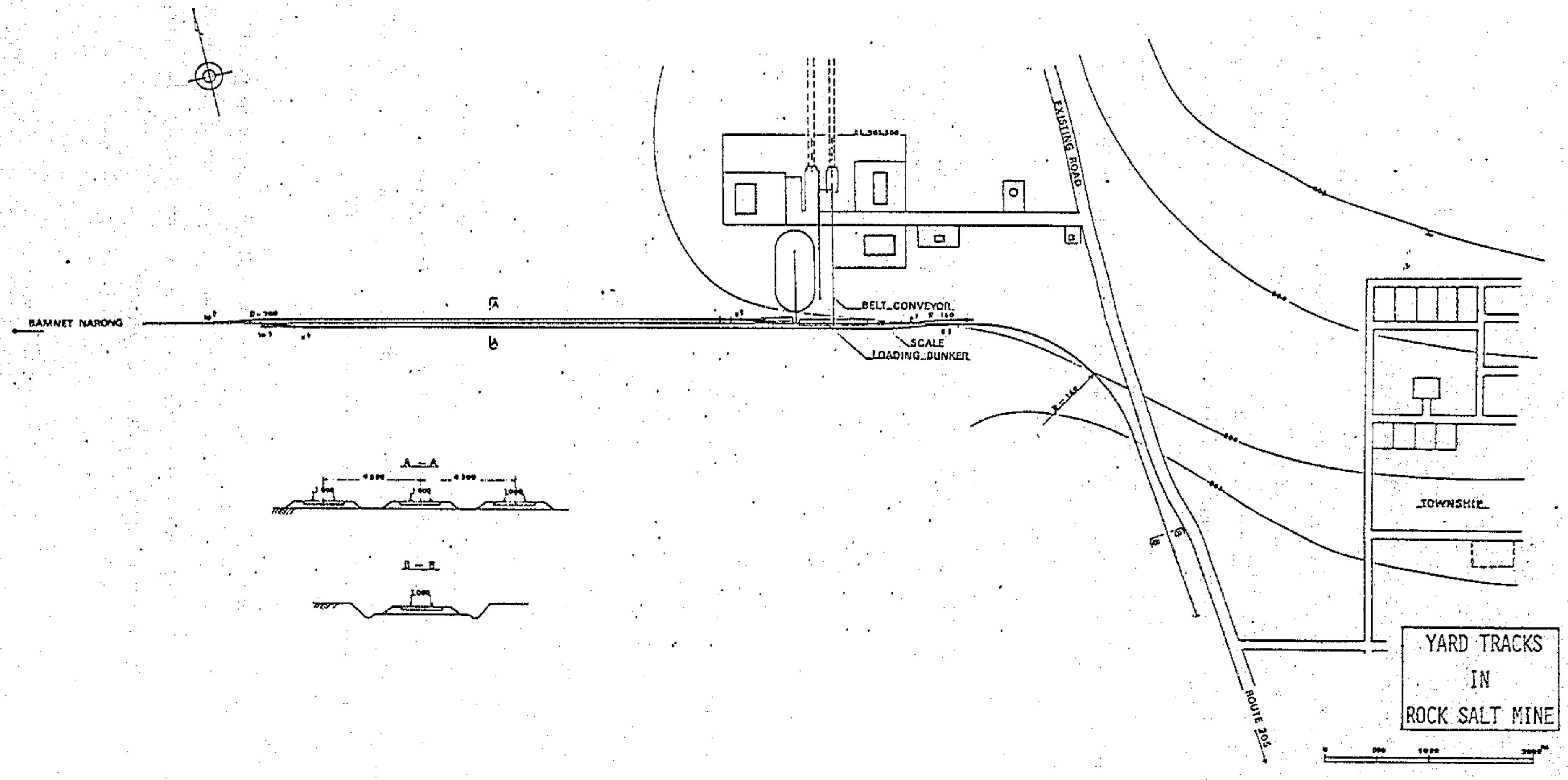


Figure IV-5 YARD TRACKS IN ROCK SALT MINE

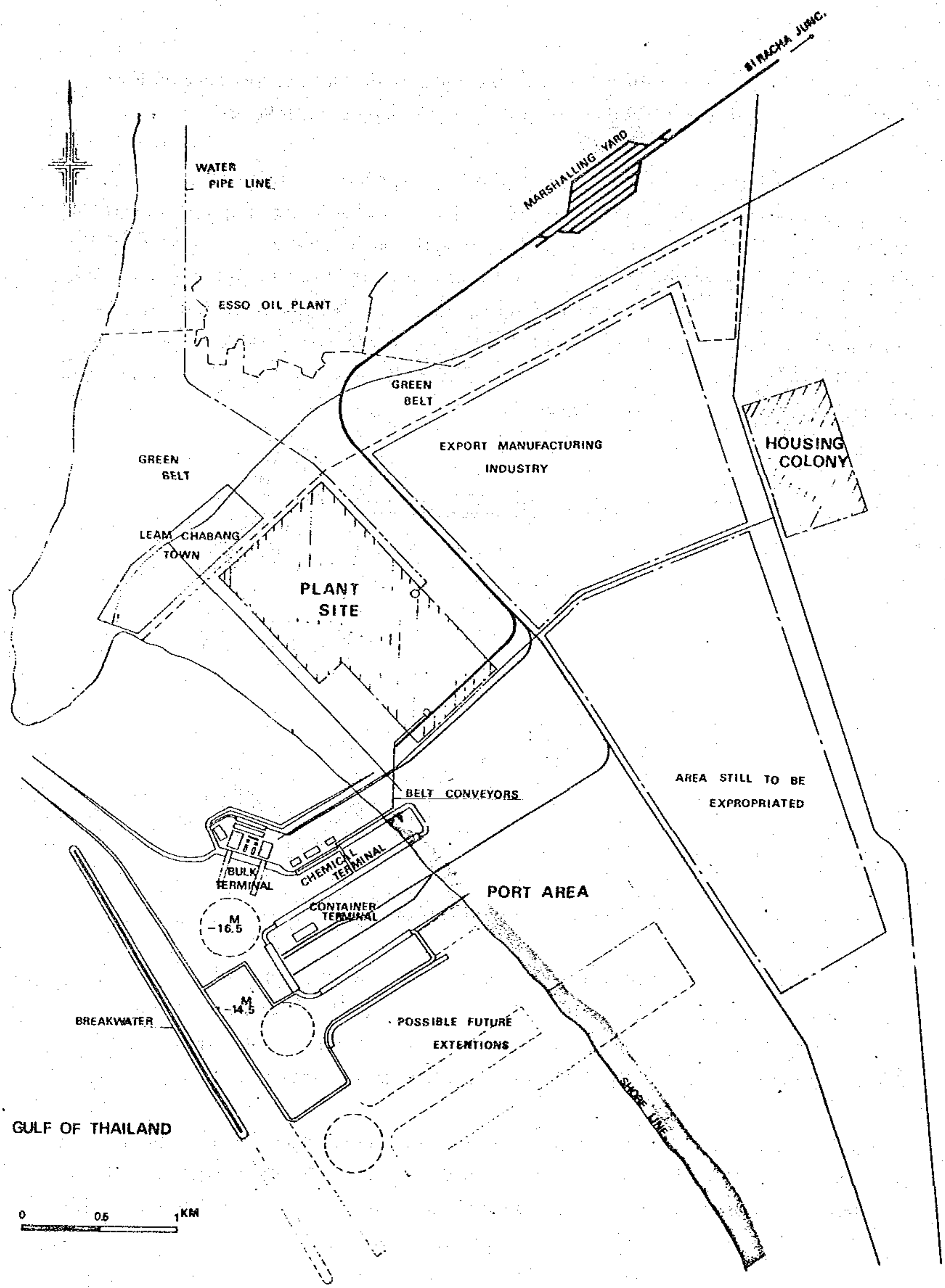
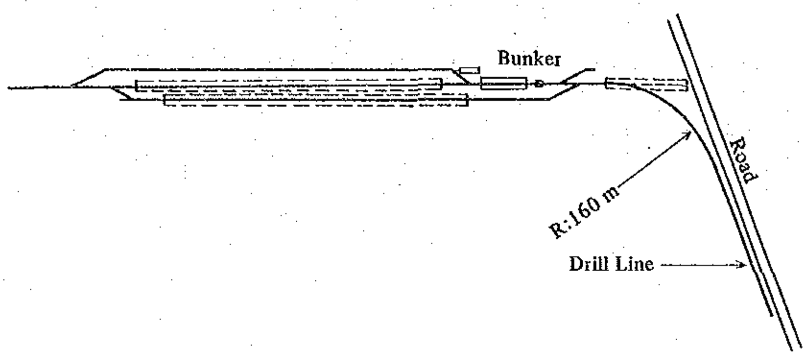


Figure IV-6 SCHEMATIC ALIGNMENT OF BRANCH LINE & SPUR AT SODA ASH PLANT AREA

A curved turn-out track: The entire train can be accommodated if the requirement that the turn-out track be straight is not followed.

In the first of these two cases, it is necessary to turn-out cars from a 23-car train 4 to 6 times, and to couple them before departure, greatly increasing the time required for marshaling the train's cars. The second case would not require as much time as does the first, but the track would have a radius of 160 m due to the road and other conditions, but it is undesirable from the viewpoint of operating the locomotive in the yard. A signal would be required near the end of the turn-out track. Speed of locomotive operation in the yard would be very low, so no difficulty would be encountered, and therefore the second method which would not require as much time as the first, is selected.

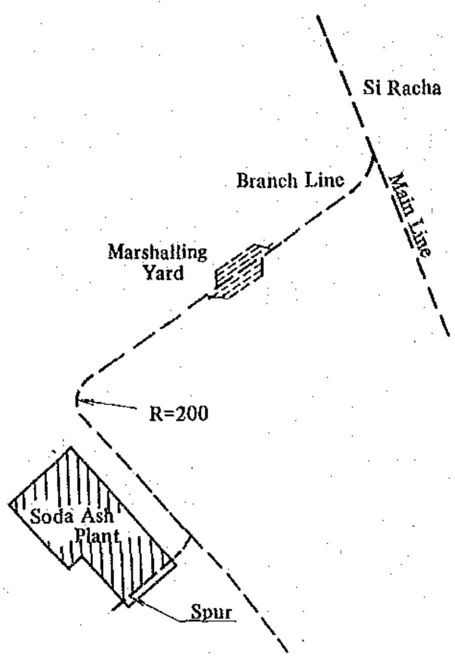


5-2-3 Soda Ash Plant Spur

(1) Spur between the Laem Chabang yard and the plant

It is planned by the RSR to complete the main line from Chachengsao to Sattahip by September, 1983. There is to be a branch from near Siracha station to Laem Chabang, and a spur is to be constructed from the branch line to the soda ash plant (see Figure IV-6). A marshaling yard is to be made by RSR about 3 km from Siracha Junction.

It is planned, for this Project, to lay a spur from the marshaling yard to the soda ash plant, a distance of 3.2 km. There are no topography-caused difficulties which would be encountered, and due to circumstances in the yard, the maximum radius would be 400 m. The structure of the spur track would be banked, compacted earth.



(2) Soda ash plant yard

Because of the location of the unloading pit in the soda ash plant yard (see Figure IV-7) where it is at one end of the yard, the following problems arise.

1. There is a level crossing in the yard (see plan below) and if an entire train is being unloaded, road traffic through that crossing would be interrupted for a long period.

2. A turn-out track is needed for use after unloading, but the yard is much too short for a straight line of track equal in length to the entire train.

3. The distance from where the spur meets the branch line to the yard, is short, and the minimum radius of the track there is 180 m.

To resolve these problems, the track arrangement shown in the plan below has been derived.

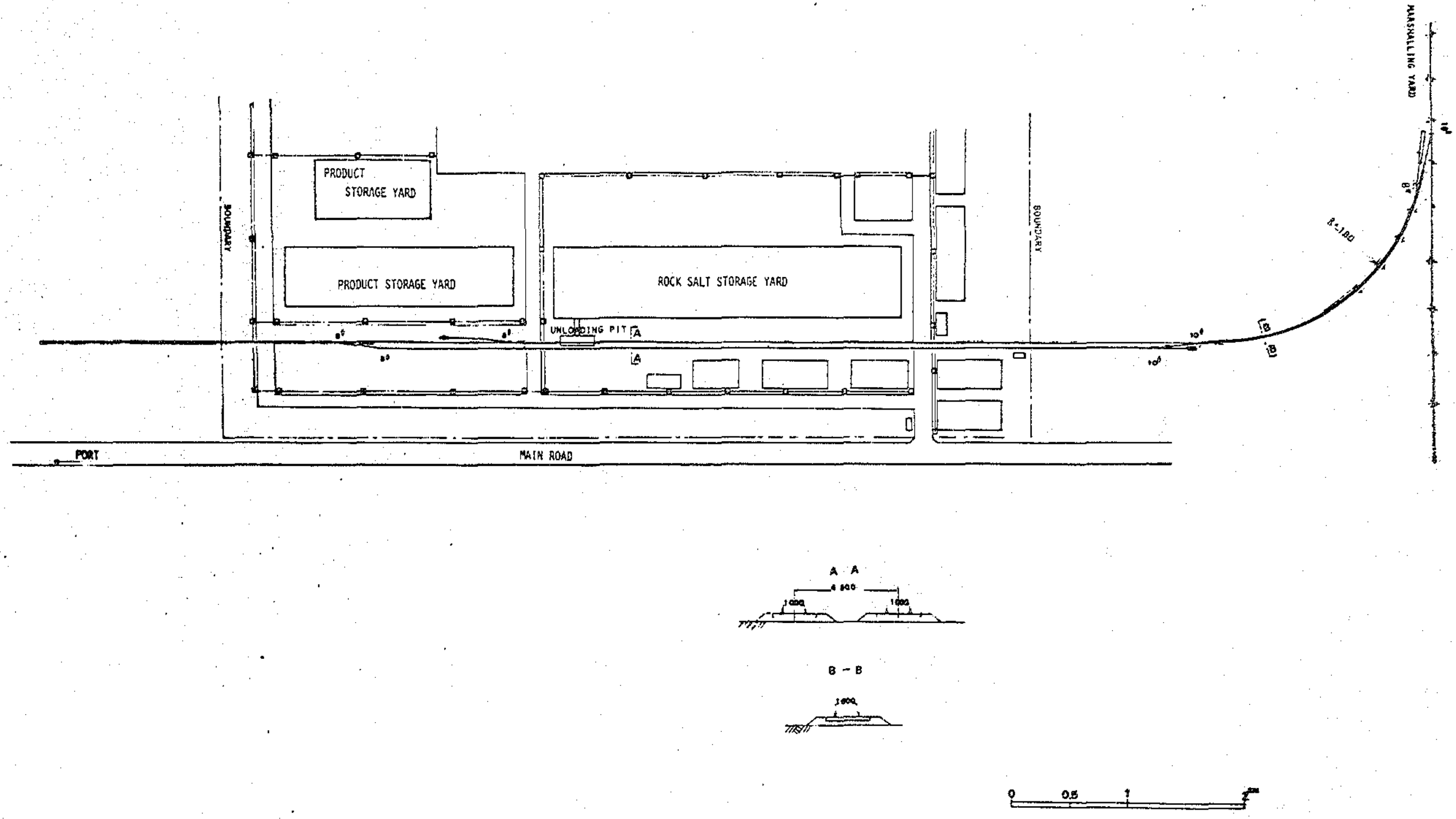
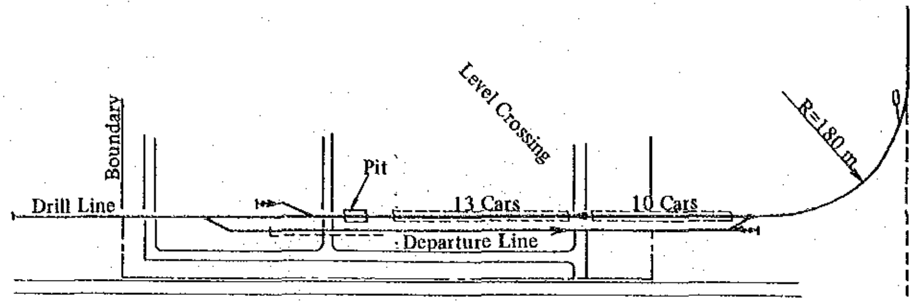


Figure IV-7 YARD TRACKS IN SODA ASH PLANT



If the arriving train is separated into two, and 10 cars are left on one side of the level crossing while the front 13 cars are loaded, they then can be shunted to the departure track to wait there until all cars are loaded and the train can depart. Therefore it will be sufficient if the turn-out track is long enough to accommodate 13 cars, in a straight line, but it will still be necessary to extend the track 150 m beyond the site boundary. It is possible to reduce this additional distance by reducing the number of cars, but the short length of the spur dictates that the train must be separated in 10- and 13-car parts. Further, crossings elsewhere in the yard would be closed for prolonged periods, and where detours by vehicular traffic are possible, priority is given to the trains. Vertical separation of traffic at intersections is possible but in addition to the construction required, the length of service roads is increased and total construction cost is greatly increased, and loading work is somewhat increased, so decision has been made to separate the train two parts.

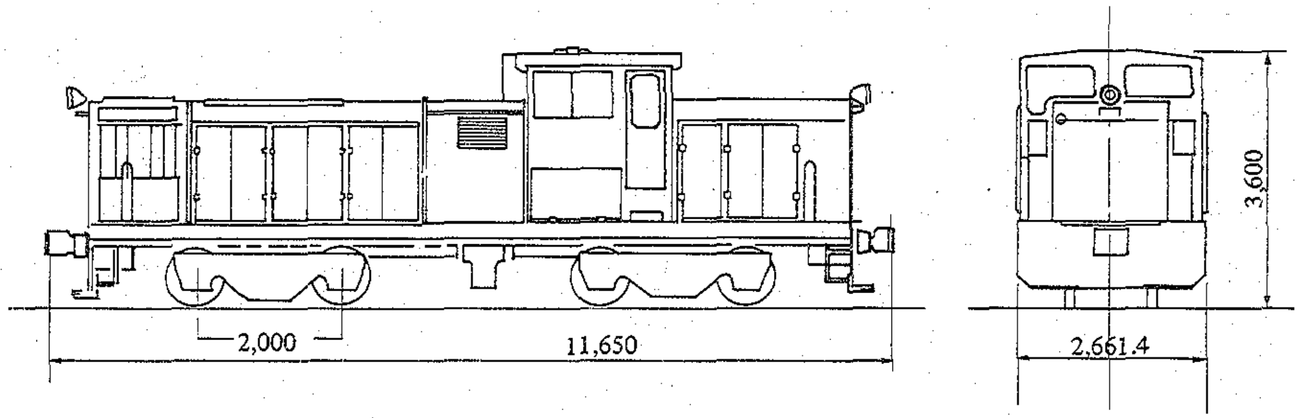
5-3 SHUNTING LOCOMOTIVE

Shunting locomotives will be furnished as part of the Project, for use in moving cars at the mine yard and plant. Specifications are shown in Figure IV-8. One is to be kept at the mine, one as the soda ash plant, and one is for standby use.

5-4 EMPLOYEES

The job categories and number of people needed for loading and unloading work at the mine and plant are as follows:

Locomotive engineer	1
Yardman	3
Loading & unloading workers	4



Unit: mm

Weight in Working Order (ton)	45
Gauge (mm)	1,000
Wheel Arrangement	B-B
Max. Speed (Approx. km/h)	35
Engine Output (p.s.)	500

Figure IV-8 SHUNTING DIESEL HYDRAULIC LOCOMOTIVE

The men are to work three shifts. Allowing for holidays and 50% reserve, the number of men needed is:

$$[(1 + 3 + 4) \times 3 \times 1.5] \times 2 = 72$$

CHAPTER 6 CAPITAL COSTS FOR RAIL TRANSPORT FACILITIES, AND FREIGHT CHARGES FOR RAIL TRANSPORT OF ROCK SALT

6-1 CAPITAL COSTS FOR RAIL TRANSPORT FACILITIES

With regard to the capital costs required for construction or acquisition of the rail transport facilities discussed in this part of the report, whether these costs will be borne either by the RSR or this Project is yet to be determined. Nevertheless, it was assumed that the costs for rail spurs to be constructed at the Rock Salt Mine and the Soda Ash Plant will be borne by this Project, and the costs for the other required facilities (hopper cars and locomotives for marshaling) will be borne by the RSR.

On the above assumptions, the capital costs for rail spurs are included in the capital requirements for this Project as shown in Part VI. The estimates of capital costs required for acquisition of the other facilities, i.e., 138 hopper cars and three locomotives for marshaling are shown for reference in Annex IV.

6-2 FREIGHT CHARGES FOR RAIL TRANSPORT OF ROCK SALT

Freight charges for rail transport of rock salt of this Project are yet to be determined. According to the RSR, it was estimated that the freight charges for transport from the mine to the Laem Chabang will be US$8 per ton of rock salt.

In view of this rate of freight charges, it is quite likely that this amount of transportation costs would substantially increase the cost of rock salt so that not only export competitiveness of the rock salt but cost competitiveness of soda ash and ammonium chloride are adversely affected. The project economics can therefore benefit greatly if the GOT's ministries and RSR officials concerned were able to agree on a preferential rate for the rock salt transport.

Plans also exist for development of potash resources in Northeastern Thailand, and that project too would face the same problem as cited here. It is therefore desirable for the GOT to consider comprehensive governmental measures on reducing rail transport cost, as one of the infrastructure problems to be solved in connection with the development of natural resources.

PART V

STUDY OF TECHNICAL ASPECTS OF CONSTRUCTION PLANNING OF THE SODA ASH PLANT

PART V STUDY OF TECHNICAL ASPECTS OF CONSTRUCTION PLANNING OF THE SODA ASH PLANT

Because there are a variety of technical problems and alternative plans regarding the construction planning of the soda ash plant, a number of case studies are required. That is, the following factors must be given special attention in examining the alternative plans.

1. The soda ash production process (see Annex V-1)

2. Scale of demand for soda ash

3. Production capacity of the soda ash plant

4. Scale of demand for byproduct ammonium chloride

5. Production capacity of byproduct ammonium chloride

The Evaluation Team formulated the following alternative plans on the basis of these factors.

		Production capacity (t/y)	
	Production process	Soda ash	Ammonium chloride
Case A	Solvay	500,000	—
Case B	Partial AC	500,000	380,000
Case C	Full AC	400,000	400,000

Of these, Case C was studied according to the following assumptions.

Case C—D Production quantity of ammonium chloride taken as equal to domestic Thai demand. Therefore, production of soda ash is somewhat reduced.

Case C—E The soda ash plant is operated at full capacity, and surplus of ammonium chloride is exported.

These two variations of Case C were studied as described below.

As a result of evaluation of these alternates in view of the criteria noted below (see also Annex V-2) it was judged that Case C was the best of the three. Accordingly, the discussion presented in this chapter is primarily concerned with the Evaluation Team's investigation of technical aspects of Case C; i.e., the construction of a soda ash plant producing soda ash at the rate of 400,000 t/y and byproduct ammonium chloride in an equal quantity, by means of a Full AC (Ammonium Chloride) Process.

Criteria for evaluation of cases were as follows.

1. Initial investment cost
2. Types of raw materials and the required quantities of each (plant input)
3. Products and waste products (plant output)
4. Standard unit production cost
5. Internal rate of return

CHAPTER 1 PREMISES FOR TECHNICAL STUDIES

This section summarizes the premises taken for this evaluation study of major elements which must be studied and taken into consideration regarding the soda ash plant of this Project. These premises are as stated below.

Selection of the location for construction of the soda ash plant: The GOT, prior to this study, has informed the Japanese Government of the GOT's proposal to construct the plant in the Laem Chabang district. Therefore the present study was to investigate the proposed site, and to evaluate its appropriateness for construction of the plant.

Availability of utilities: The site which has been proposed by the GOT for the soda ash plant is either an area adjacent to the Laem Chabang industrial estate which the Ministry of Industry is planning to develop or within the area designated by the Ministry of Communication for the Laem Chabang Deep Sea Port. It has been confirmed that in consideration of economies of scale, the GOT has a plan for establishing common services to supply utilities to the industrial estate. The Evaluation Team, therefore, proceeded the evaluation study on the precondition that the foregoing common services would be made available for use in time. Nevertheless an alternative study was made in particular of laying a pipe line exclusively for supply of industrial water to the soda ash plant in order to assess its economics (see Annex V-3). This study, however, indicates that it is unrecommendable because this alternative system substantially increases the cost of water.

Availability of infrastructure relative to the Project: The RSR is now proceeding with construction of the Chachengsao-Sattahip rail line, and it is intended that the line will be placed in service in September, 1983. The RSR also has a plan to extend a branch line to Laem Chabang along with the progress of this Project. Therefore this line, and a newly-built spur from the line to the soda ash plant, are to be used for the transportation of rock salt (see Part IV).

Regarding port and harbor facilities, since the Thai Cabinet approved construction of the Laem Chabang Deep Sea Port in October, 1980, this evaluation study is made on the precondition that this port will be completed so that use of this port will be possible. However, in order to ensure the feasibility of the soda ash project even if this port and harbor construction project is delayed, alternate measures have been studied (see Annex V-4).

Environmental assessment: The guidelines of the National Environment Board (NEB) stipulate that, before final decision may be made on use of a specific site for an industrial project, the party concerned must conduct an environmental assessment of the project and submit such a study report to the NEB. NEB evaluates the environmental impacts which the project would have, and decides on that basis whether the proposed project is suitable or not to be located at the site. In this Evaluation Study, full and proper attention is given to technical aspects of treatment and disposal of waste products from the soda ash plant, under the assumption that the plant is constructed at this site, but an environmental assessment study was not included within the scope of work undertaken, because such a study encompass a wide range of problems which are beyond the scope of this study that it reviews and evaluates the feasibility study of this Project.

Regarding the supply of rock salt, reference should be made to Part III.

CHAPTER 2 SITE FOR THE SODA ASH PLANT

2-1 CRITERIA FOR EVALUATION OF THE SITE

The criteria which are to be used for evaluating the suitability of the site proposed by the GOT are as follows.

- Suitability with regard to raw materials transport: The raw materials to be used for this Project are salt (rock salt), ammonia and carbon dioxide. It is necessary that the site be located at an area close to the supply sources of these materials or an area where supply systems for them can be established by means of assuring a stable supply of all three over a long period of time. With specific regard to ammonia, at present there is no source of supply within Thailand, and in this Evaluation Study it is assumed that ammonia will be imported, but consideration has also been given to the possibility of obtaining ammonia from the fertilizer complex which the GOT is now considering as an industrial project to be implemented adjacent to the soda ash plant.

- Suitability with regard to securing utilities supply: The required electric power and water must be supplied at an economical price and in a stable manner.

- Suitability for construction of an industrial plant: For construction of an industrial plant such as the one required by this Project, the site must be reasonably flat and the soil must have adequate bearing strength. It also must be accessible with regard to the delivery to the site of plant equipment and materials most of which are to be imported.

- Suitability with regard to shipment of products: In order to be able to ship the plant's products (soda ash and ammonium chloride) and rock salt not consumed in the plant, to domestic and export markets, the site must be conveniently located with regard to a highway or railroad, and a port at which large oceangoing vessels (in particular, vessels which will carry export cargo) can use.

Suitability of the proposed site is judged on the basis of these criteria, as described in the next section.

2-2 LOCATIONAL CHARACTERISTICS OF THE PROPOSED SITE

2-2-1 Outline

The site proposed by the GOT for construction of the soda ash plant is in the Laem Chabang district on the eastern seaboard. The area of the site is 4 km to the west of Route 3, and the right of way of the Chachengsao-Sattahip rail line. This district is adjacent to the location of the site of the Laem Chabang Deep Sea Port Project which was adopted by the GOT in October, 1980.

Plans exist for construction of an industrial estate (for heavy industry) in this district, and the GOT agencies which are in charge of these projects, namely the Port Authority of Thailand and the Industry Estate Authority of Thailand are in the process of acquiring land. Therefore, a part of the land acquired by the one and/or two Authorities above will be allocated for use for construction ofthe soda ash plant. The industrial estate is planned to include a fertilizer complex and a steel complex in addition to Soda Ash Plant, but final decision on these has not yet been made.

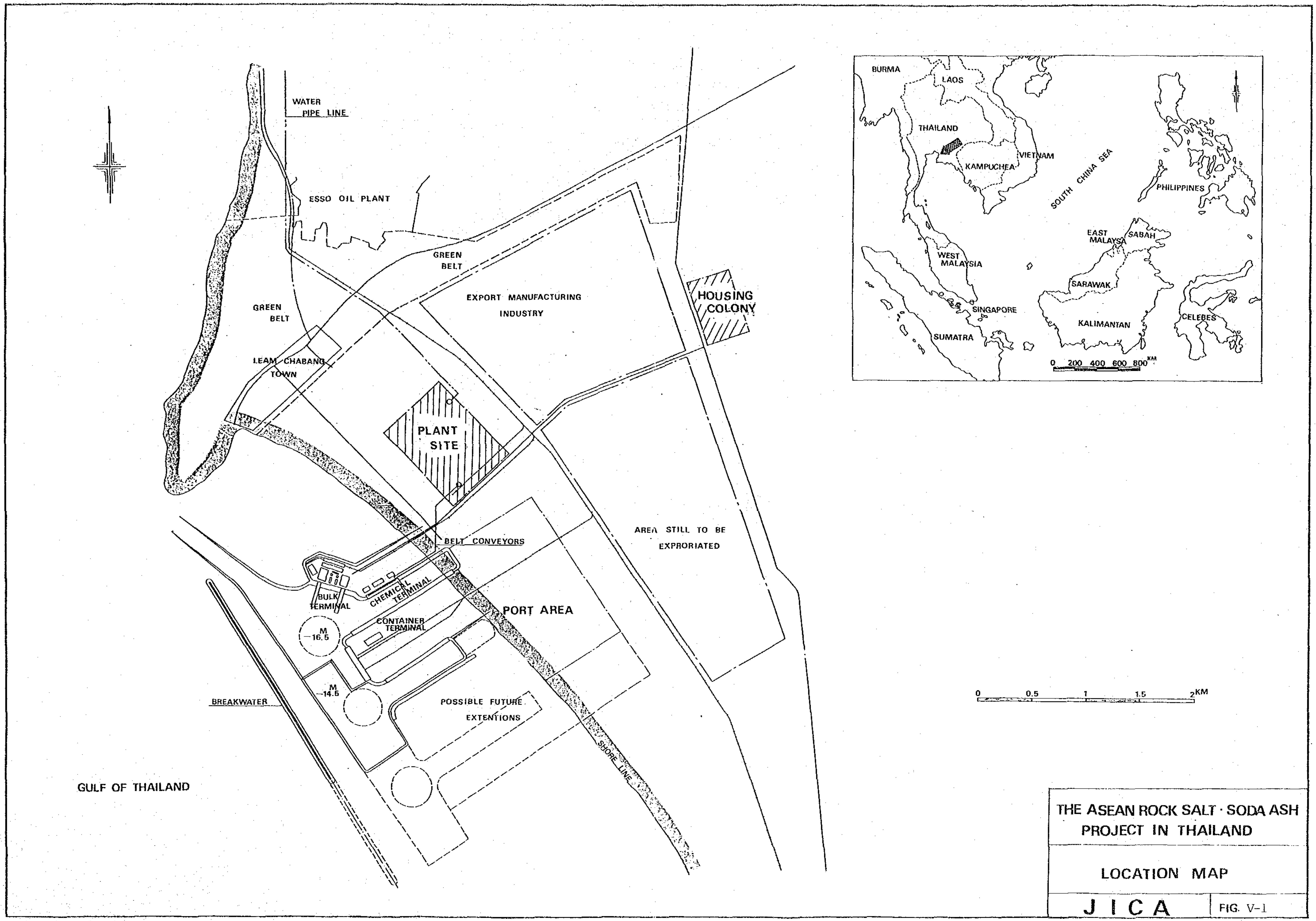
Conditions in the vicinity to the proposed site for the soda ash plant are as shown in Figure V-1.

The above governmental bodies are in agreement regarding use of land in the Laem Chabang district for construction of the soda ash plant, and therefore it is presumed that the entity implementing this project would purchase the land from the appropriate governmental entity.

2-2-2 Physical Conditions

(1) Physiography

The site is at 100°53' eastern longitude and 13°14' northern latitude, in Laem Chabang, on the eastern shore of the Gulf of Thailand. It is about 100 km from Bangkok and faces Route 3. The Pattaya Beach resort area is about 20 km to the south. The Gulf of Thailand's eastern shore has a continuous coastline of large and small curves, and rocky mountains of elevations up to 200 m are present near the shore. The site is to the north of the 12-km-long Ao Bang Lamung coastline and southeast of Khao Laem Chabang Hill (el. 180 m). The site is about 4 km west of Route 3 and is characterized by sandy soil. According to a map issued by the Thailand Secondary Administration Division, the vegetation of the area in which the site is included is orchard plantation and rice fields, but the site is of the nature of tropical rain forest, where coconut, mango, pineapple and other trees and shrubs grow.



THE ASEAN ROCK SALT · SODA ASH PROJECT IN THAILAND

LOCATION MAP

JICA

FIG. V-1

(2) Soil conditions

A thin layer of topsoil (about 0.3 m), containing organic matter, exists and beneath it are layers of sandy silt and sandy earth which continue to about MSL-20.0 m, below which are rock layers. The bearing layer is estimated to be at MSL-12 m.

2-2-3 Locational Conditions Related to Raw Material Transportation

The following are findings based on study of the source of supply and mode of transporting the major raw materials, rock salt, ammonia and carbon dioxide.

(1) Rock salt (see also Part IV)

The rock salt mined in Bamnet Narong is to be supplied to the soda ash plant by rail; part is to be used to make soda ash and the remainder is to be exported. Rock salt is crushed prior to being transported in bulk. The Royal State Railway line, when present work is completed, will extend from Bamnet Narong station about 5 km west of the rock salt mine to Sattahip via Bangkok and Chachengsao. The RSR also has a plan to extend a branch line from Siracha which is the station nearest to Laem Chabang to a marshaling yard which is to be constructed at Laem Chabang. For rail service to be available for the site, a spur needs to be laid from the marshaling to the plant site over a distance of about 3.2 km. Further, laying of a 5.7 km spur at the rock salt mine will enable hopper cars containing rock salt to be pulled to the national railway line and thence to the soda ash plant. There is no technical reason why these spurs cannot be constructed. It is therefore judged that from the viewpoint of transportation of rock salt the proposed location of the soda ash plant is suitable.

(2) Ammonia (see Chapter 3)

At present, there is no production of ammonia in Thailand. This project must depend on imports of ammonia or on acquisition of ammonia from the fertilizer complex which is now being planned. Because ammonia is a gas at normal temperature and pressure, it is ordinarily transported as a liquid, under high pressure or under low temperature in closed containers. If reliance is to be made upon imports, it will be necessary to transport 128,000 t/y of ammonia from its supply source to a nearby port in Thailand by using 5,000 to 10,000 DWT special tankers and to transport it from the port to the site by overland transportation means. Because of the ammonia being transported as a liquid under special conditions, overland transportation by rail or road is to be avoided, and the soda ash plant must be at a distance from the shore so that ammonia can be conveyed to it by pipeline from the port. Construction of a deep sea port in the vicinity of the site has been approved, and it would be possible to receive the imported ammonia by installing ammonia off-loading facilities in the port and also laying a pipeline from the offloading facilities to the soda ash plant. Therefore, from the viewpoint of the conveyance of ammonia, the proposed site is a suitable one for the plant.

On the other hand, the fertilizer complex project now being planned would use natural gas exploited from offshore gas fields located in the Gulf of Thailand, and this complex would produce ammonia from the natural gas to make fertilizer. The GOT, believing this project is suitably undertaken on a joint venture basis, is now selecting its joint venture partner. The location of the fertilizer complex has not yet been decided, but according to the American consultant engaged by the GOT, Laem Chabang was recommended as the best possible site for the fertilizer complex as well as for a direct reduction steel mill. If, as recommended, the fertilizer complex is constructed in Laem Chabang, the proposed sosa ash site would be suitable from the viewpoint of ammonia supply even if the ammonia produced at the complex is used.

(3) Carbon dioxide (see Chapter 3-4)

As is stated in 3-4, it is planned to use carbon dioxide as a substitute for limestone. There are two possible sources of the 133 million m^3/y of carbon dioxide which the project would require. One source is the natural gas processing plant now being constructed by the Petroleum Authority of Thailand (PTT) in the Rayong district; the wellhead gas contains about 18% carbon dioxide which is to be separated and, as no other definite plans for its use are now in existence, is to be released. This carbon dioxide could be delivered by means of a pipeline to the soda ash plant. The second possible source is the planned fertilizer complex which would produce carbon dioxide as a byproduct of the ammonia plant; this carbon dioxide could be conveyed by a pipeline to the soda ash plant. The first of these two possibilities would entail the cost of a pipeline approximately 61 km long and installation of a compressor, and this represents that, although the investment cost would be somewhat of a burden to the project, there are no technical problems for using this source. Nevertheless the pipeline required in the second case would be shorter than that of the former and the second possibility is more attractive, technically and economically, than the first one.

If either of these two possibilities is realizable, the site is suitable from the viewpoint of supply of carbon dioxide.

2-2-4 Locational Conditions Related to Utilities Supply

Annual utilities requirements of the soda ash plant are 200,000 MWH of power and about 10,000,000 m^3 of water.

(1) Electric power

The Electric Generation Authority of Thailand is now constructing a natural gas burning power plant (first phase capacity, 860 MW) at Bang Pakong. In connection with construction of this power plant, two 230 KV transmission lines are to be strung from Bang Pakong along the Gulf of Thailand coast, and it is planned to construct a main transformer station at Ao Phai, about 7 km northeast of Laem Chabang. IEAT plans to string a distribution line from this transformer station to the industrial estate, so that all that is required for the soda ash plant to be supplied with electricity would be for a distribution line to be strung from the IEAT line to the plant. Therefore, use of the proposed site presents no problem with regard to obtaining a supply of electric power for the soda ash plant.

(2) Water

Although there are many reservoirs in the eastern seaboard area (see Figure V-2), the only ones which can supply the 10,000,000 m^3/y of water which the soda ash plant will require are the existing Dok Krai reservoir in the northern part of Rayong or the Nong Pralai reservoir which is being planned. IEAT intends to provide a supply of water to the industrial estate including use by the soda ash plant, by means of laying a pipeline about 60 km in length from one of these reservoirs. It is expected that it will be easy to lay this pipeline because the topography of the land to be traversed is not complicated. An alternative means is for the soda ash plant to lay its own pipeline. A study, however, indicates that it would result in high cost of water. As a conclusion, the most economical way for the plant is to rely on the water supplied by IEAT, and if the IEAT's water supply is available for use by the plant then selection of this site is no problem with regard to water supply.

2-2-5 Locational Conditions Related to Plant Construction

When a site is to be selected for construction of an industrial plant, the criteria used with regard to physical characteristics of the site are

1. Physiography and subsurface soil conditions

2. Ability to move in equipment and materials

(1) Physiography and soil conditions

The difference between points of highest and lowest elevation on the site is only about 2 m, and because the site is so flat construction will be greatly facilitated. The conventional

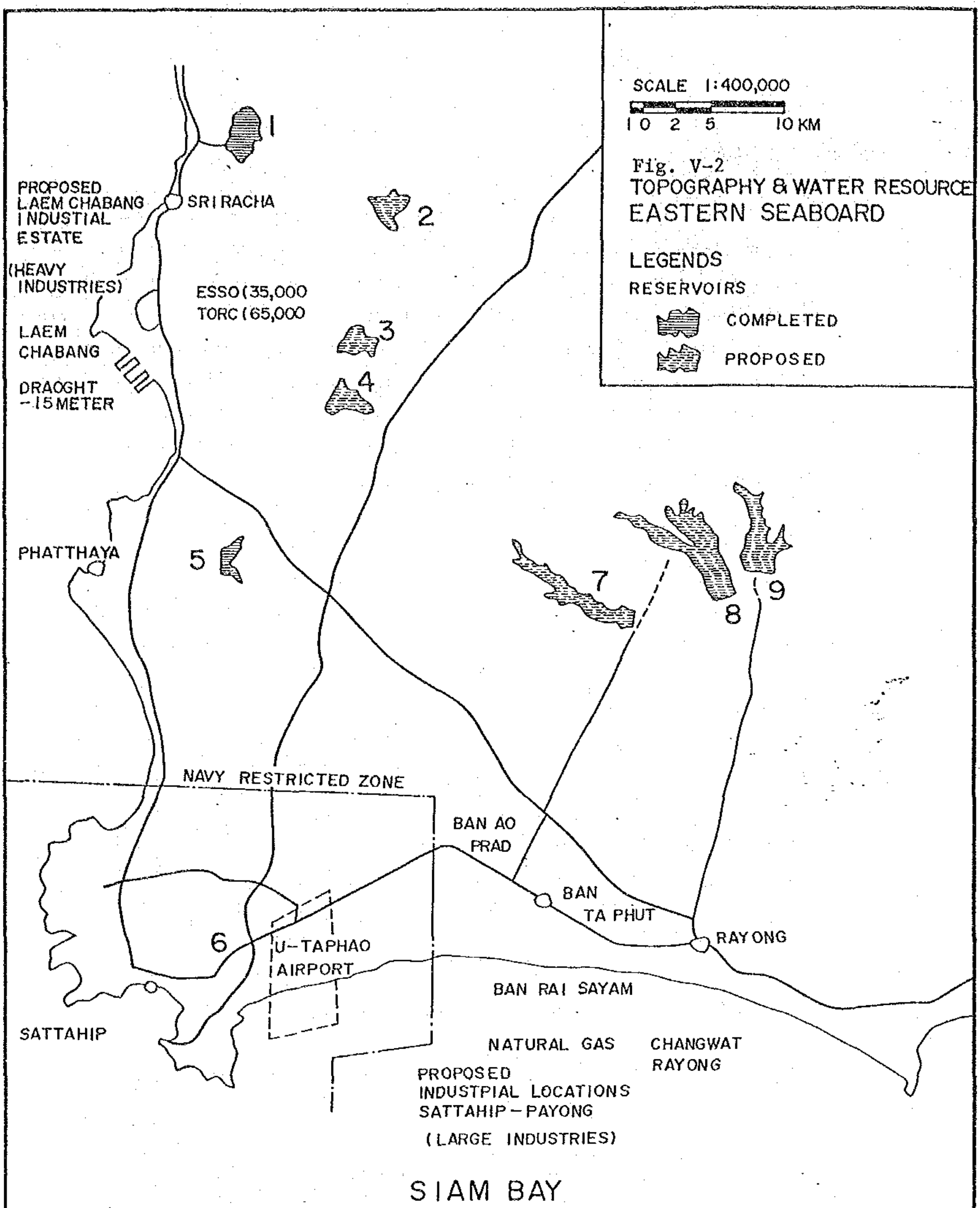


Fig. V-2
TOPOGRAPHY & WATER RESOURCE
EASTERN SEABOARD

LIST OF RESERVOIRS

NO	NAME	QUANTITY M.m³	NO	NAME	QUANTITY M.m³
1	BANG PHR	100	6	PHLU TA LUANG.	2.8
2	NONG KHO	20	7	DOK KRAI	50
3	HUAI BUNG	26	8	NONG PLA-LAI	100
4	TAXHIAN TIA	13.6	9	KHLOG YAI	45
5	MAP PRACHN	15			

practice of planning earthmoving so as to balance cut and fill on the site and minimize earthmoving should be adopted as a matter of course. Concerning the soil conditions, below the surface layer, relatively weak layers of coarse sandy silt and sandy earth are present, and the dense sand layer which is thought to be the bearing layer is at about MSL-12.00 m. In view of this if piles are sunk to the bearing layer, the foundation will be able to bear the weight of the equipment and machinery, and structures, and the vibration during operation.

(2) Moving in equipment and materials

It is estimated that the equipment and materials to be moved to the site amount to about 110,000 freight tons, and include heavy equipment of 150 t as well as long measure equipment of 23 m. It will be necessary to offload these from an ocean-going vessel and transport them to the site. There being a strong possibility that construction of this plant will coincide with construction of the Laem Chabang Deep Sea Port, in which case there may be difficulties in off-loading equipment and materials on the coast of the Laem Chabang district. In such a case, equipment and materials can be offloaded from ocean-going vessels at Sattahip, south of the site, and transported overland to the site. Overland transport would be by Routes 46 and 36, and no special problems or bridges would be encountered. Therefore, the proposed site presents no problem from the viewpoint of moving in equipment and materials.

2-2-6 Locational Conditions Related to Shipment of Products

Products of the soda ash plant will be 400,000 t of soda ash and 400,000 t of ammonium chloride a year, in addition to which there would be shipment of 400,000 t/y of rock salt, for a total volume of shipments of 1.2 million t/y. About half of this is to be shipped to domestic markets, and the remainder is to be exported. Shipments to domestic markets are to be made by means of rail, truck, and coastal vessels, while export shipments are to be carried by ocean-going vessels. Reference has already been made to the operation of railroads and trucks (use of highways), so consideration here is limited to the use of coastal vessels for domestic shipment and ocean-going vessels for export shipments.

As has already been mentioned, construction of a deep sea port at Laem Chabang has been decided. According to the master plan for the port, prepared by the Ministry of Communication, provision has been made for export shipments of rock salt and soda ash, and provided that this port construction plan is implemented, the site is conveniently located with respect to shipment of products. However, if implementation of the port construction project is delayed the use of barges for offshore loading of ships must be considered as an alternative (see Annex V-4). Technologically this alternative is possible but there is a strong likelihood that it would entail a considerable increase in costs, to the detriment of the cost competitiveness of the products shipped by that means. Therefore, it is requisite for the site to be located at Laem Chabang that construction of the deep sea port will precede construction of the soda ash plant.

CHAPTER 3 RAW MATERIALS

3-1 REQUIRED QUANTITIES

As is summarized in Annex V-1, as a result of comparative study of the processes which can be used for soda ash production, and of the alternate production scales, the Evaluation Team proposes to construct a soda ash plant using a Full AC Process and having the capacity of 400,000 t/y of soda ash and 400,000 t/y of ammonium chloride. Required quantities of raw materials in keeping with use of this process and adoption of this production scale are as shown below.

Raw material	Unit consumption (per ton soda ash)	Annual requirement
Crude salt (100% NaCl)	1,371 kg	548,400 t
Ammonia	320 kg	128,000 t
Carbon dioxide	332 Nm^3	132,800 x 10^3 m^3
Quicklime	46 kg	18,400 t
Caustic soda (or soda ash)	42 kg (60 kg)	16,800 t (24,000 t)

The following part of this chapter takes up the sources of these materials and stability of supply.

3-2 CRUDE SALT (ROCK SALT)

As noted in Chapter 3 of Part II, the quality of the salt to be mined for this project is low in comparison to salt now in international trade. In particular, because the gypsum content is high, the concentration of calcium and sulfate ions is high. Therefore, because the soda ash plant will be provided with a crude salt refining process, the requirement of the salt will be about 10% higher than if high-grade crude salt were available. Other than this, however, there is no problem regarding the processing of salt.

In view of the above, the volume of rock salt required in this project is:

Unit requirement:	1,413 kg/ton soda ash
Annual consumption:	565,200 t

3-3 AMMONIA

The volume of ammonia required for this project is 128,000 t/y. Three cases are conceivable for supplying this volume of ammonia, namely:

1. Inclusion of an ammonia plant in this project.

2. Supply from the fertilizer complex now being planned by the GOT

3. Importation

Problems related to each of these cases are as follows.

3-3-1 Self-supply

If the ammonia required for this project should be supplied from an ammonia plant in the project, an ammonia plant having the capacity of 430 t/d at 90% utilization of capacity is to be provided. But this is less than half of the standard scale of ammonia plants which are now in operation (1,000 t/d) and at this reduced scale it would be difficult for the plant to be of the energy-self-balanced type. Therefore from the viewpoints of economies of scale and energy cost, it is judged to be uneconomical to equip the Project with its own facility for the supply of ammonia.

3-3-2 The Fertilizer Complex Being Planned

The Ministry of Industry is in the process of planning a large-scale fertilizer complex which would be based on a supply of natural gas from wells in the Gulf of Thailand. The ministry has adopted the policy of proceeding with implementation of the project through a joint venture with a foreign company and is now studying proposals from foreign firms in order to select its partner. If the fertilizer complex project can be implemented at the same time as the present project and ammonia could be supplied from the former to the latter at an international price, it would be possible to obtain ammonia at a cost lower than imported ammonia by the equivalent of ocean freight, so that it would be highly beneficial to the present project. Moreover, if the fertilizer complex is constructed in Laem Chabang, as has been recommended by the American consultant retained by the GOT, and ammonia could be supplied by means of a pipeline, the storage requirement for ammonia within the soda ash plant site would be reduced, and the financial burden of the Project similarly would be reduced. If this fertilizer complex is constructed, there would also be considerable potential benefit to the present project if carbon dioxide could similarly be supplied from the fertilizer complex, as is discussed below.

3-3-3 Possibility of Importing Ammonia

From the viewpoint of the world balance of ammonia supply and demand it is judged possible to obtain in the world market the volume of ammonia required for this project. It is particularly possible that importation from within the ASEAN region – from Indonesia – could be achieved. A large-scale fertilizer complex is in operation in that country, and a second fertilizer complex, also large in scale, is now under construction.

In this Evaluation Study, it is assumed that ammonia will be imported but consideration has also been given to the possibility of acquiring the ammonia from the fertilizer complex, if it is constructed.

3-4 CARBON DIOXIDE

The following three methods or cases may be postulated for the supply of carbon dioxide to this project.

Calcination of limestone

Use of residual carbon dioxide from the PTT plant

Purchase from the fertilizer complex which is being planned

The residual carbon dioxide from the PTT plant will be produced by the natural gas produced by the natural gas processing plant, a project now being implemented by PTT. PTT will convey natural gas from offshore fields to the Rayong district by an underwater pipeline, and in Rayong, after adjusting its dew point, and removing non-hydrocarbon matters, the gas will be processed for supply to users as natural gas for power generation, and other industrial uses. The gas contains a large quantity of carbon dioxide as shown in the average composition given below. The carbon dioxide will be separated from the natural gas in the PTT processing plant. In view of the volume of natural gas to be processed and its content of carbon dioxide and also because of the fact that the carbon dioxide has no specific uses, it is judged that this is an adequate source of supply of the carbon dioxide required for the project.

Composition of natural gas (vol.%)	
CO_2	18.02
N_2	0.97
CH_4	65.03
C_2H_6	8.57
C_3H_8	4.53
C_4H_{10}	1.97
C_5+	0.90
H_2O	0.01
Total	100.00

(Source: PTT)

Production plan

1985:	600 MMSCFD
1990:	750 MMSCFD

As is noted in Annex V-5, it will be less costly to purchase this carbon dioxide from PTT and transport it to the soda ash plant by pipeline than to undertake calcination of limestone, the first of the three cases. In addition to being economically attractive, this method of obtaining carbon dioxide will not create any problems at all with respect to protection of the environment.

With regard to the third case, namely purchase of carbon dioxide from the fertilizer complex, as is described above in 3-3 in connection with ammonia, benefits could be anticipated but because at this time it is not determined if and when the fertilizer complex will be constructed, in the work done for this Evaluation Study it has been assumed that carbon dioxide will be supplied to the plant by pipeline from the PTT plant in the Rayong district.

If, however, it is decided before the start of construction of this project that the fertilizer complex is to be constructed in the Laem Chabang district, carbon dioxide should be supplied to the plant by a pipeline from the fertilizer complex. The shorter pipeline required in this case would reduce the financial burden of the Project.

3-5 QUICKLIME

In the soda ash plant, quicklime is to be used in order to remove impurities from recirculating liquids in the plant as well as in the purification of crude salt. Suitable quality quicklime would be at least 95% CaO and would contain little impurities such as MgO and SiO_2 and little insoluble matter. Limestone is produced in considerable quantity in Thailand, and carbide producers who use this limestone produce quicklime and slaked lime; it is judged, moreover, that a suitable quantity of the required quality can be obtained for use in the soda ash plant.

3-6 CAUSTIC SODA (OR SODA ASH)

Because chlorine-using industries are not highly developed in Thailand, there is a shortage of caustic soda, which is produced as a byproduct of chlorine production, so the short domestic supply is covered by imports. It is possible that polyvinyl chloride will be included in the petrochemical project which is now being planned and that chlorine production facilities will be constructed in that connection. If this petrochemical project is implemented and caustic soda, obtained as a byproduct of its chlorine production facilities, could be supplied to the soda ash plant, it will be possible for the project to obtain caustic soda at a price lower than the caustic soda price presently prevailing in the market. The evaluation was made on the basis of importation of caustic soda, but it does not necessarily prevent use of local products when they become available in a sufficient quantity and at reasonable prices. An alternative way is to use soda ash instead of caustic soda. In this case the soda ash produced within the plant can be used.

CHAPTER 4 SCOPE OF SODA ASH PLANT FACILITIES

This part of the study report provides details on the scope of the facilities required for the soda ash plant having the capacity of 400,000 t/y of soda ash, while defining in due regards to boundary conditions for the receiving of raw materials and utilities as well as the utilization of related infrastructure.

4-1 SODA ASH PRODUCTION PROCESS, ITS PRODUCTS, AND SCALE

As a result of this study, the Evaluation Team proposes for this Project to adopt the Full AC process and to have the production capacity of 400,000 t/y of soda ash which, further, will be accompanied by production of 400,000 t/y of ammonium chloride. The facilities and related equipment needed are determined on the basis of the requirements for such a plant.

4-2 RAW MATERIALS RECEIVING FACILITIES

The soda ash plant will require the following raw materials. (A brief description of the facilities needed for the receiving of these materials is provided in the following paragraphs.)

1.	Rock salt	565,200 t/y
2.	Ammonia	128,000 t/y
3.	Carbon dioxide	132.8×10^6 m^3/y
4.	Quicklime	18,400 t/y
5.	Caustic soda (or soda ash)	16,800 t/y (24,000 t/y)

4-2-1 Rock Salt Receiving Facilities

The following facilities are planned for the soda ash plant, for receipt of rock salt transported from the mine by rail.

(1) Railway facilities

A spur of about 3.2 km length must be laid. This facility is to be included as part of the facilities for the soda ash plant, but the railway-related facilities discussed in Part IV, other than this spur, are excluded from the scope of this Project.

(2) Rock salt receiving facilities

In addition to installation of unloading facilities matched to the specifications of the hopper cars (hoppers, belt conveyors, etc.), a system for transport of the rock salt to the storage facility is to be provided.

4-2-2 Ammonia Receiving Facilities

In order for the plant to receive ammonia it will be necessary to install an unloading arm on the pier at the Laem Chabang Deep Sea Port when it is constructed, and an insulated pipeline approximately 2 km long from the pier to the ammonia storage facility at the plant site. The pump in the ammonia tanker is to be used for pumping ammonia for unloading and movement through the pipeline.

4-2-3 Carbon Dioxide Receiving Facilities

It is planned to obtain carbon dioxide from the PTT natural gas processing plant under construction in Rayong. In order to receive this gas, the following facilities will be required to be installed by this Project:

1. Compressors for compressing carbon dioxide for transport (in the PTT Gas Processing Plant Site)
2. Equipment needed as ancillary to the compressor
3. Carbon dioxide pipeline (total length, about 61 km)
4. Carbon dioxide receiving holder

The first two of these are to be installed within the PTT plant in Rayong.

4-2-4 Other Raw Material Receiving Facilities

Quicklime is to be purchased in the domestic market and caustic soda is to be imported, but in both cases the quantities required are low and handling of the materials will not present any problem in particular. No special facilities are to be installed for receiving these materials.

4-3 UTILITIES RECEIVING FACILITIES

The utilities requirements of the soda ash plant are as follows.

	Unit requirement (per ton soda ash)
Electric power	391 KWH
Steam	1,800 kg
Cooling water (Circulating qty)	148 m^3
Process water	5 m^3
Fuel oil	20 ℓ

The soda ash plant will purchase unprocessed water, and after processing it in facilities within the plant, will provide it for use as cooling water, process water and boiler feed water. Steam will be generated by a boiler within the plant. Therefore of the above only electric power, water and fuel (fuel oil) must be purchased from outside the plant.

4-3-1 Electric Power Receiving Facilities

IEAT will supply power to the industrial estate at 6.6 KV, after obtaining power through the Provincial Electricity Authority from the EGAT transmission line (230 KV) extending to Ao Phya. For the soda ash plant to receive power it will therefore be necessary to string a 6.6 KV cable a distance of 2 km from the IEAT's supply point in the industrial estate to the plant.

4-3-2 Water Receiving Facilities

IEAT plans to supply water to the industrial estate's reservoir by a pipeline laid from its intake point at Dok Krai reservoir or any other reservoir. The soda ash plant will be able to obtain water by laying a 3 km pipeline from the plant to the estate's reservoir. The equipment required by the soda ash plant for receiving of water comprise this 3 km pipeline and a pump to be installed at the estate's reservoir. The economics of establishing an independent system for supply of water to the soda ash plant, by establishing a water intake and pipeline conveyance arrangement for the exclusive use of the soda ash plant were examined, but it is uneconomical due to a high cost of water as discussed in Annex V-3.

4-3-3 Fuel (fuel oil)

The soda ash plant will require fuel for drying of soda ash and generating steam. Natural gas and fuel oil are the two sources conceivable for satisfying this fuel requirement.

Laying of a pipeline is now being carried out in Thailand in order to supply natural gas from offshore wells, for power generation, as well as other industrial uses. PTT, which has jurisdiction over this pipeline project, plans to install an underwater pipeline to Rayong and thereafter an overland pipeline along Route 33 in order to supply gas from the off-shore gas fields to users. This pipeline will pass an area at a distance of about 30 km from the soda ash plant site located on Route 3. Therefore, laying of a branch pipeline from this main pipeline would be necessary for the natural gas to be used. Because it cannot be economically justified for this project to bear the cost of laying such a pipeline at the present time it is thought not to be feasible for the project to rely on natural gas as a fuel. Nevertheless, if industries which use natural gas such as a fertilizer complex and a direct reduction steel mill are established in the industrial estate in Laem Chabang, this will involve laying a branch pipeline to Laem Chabang, and it will become possible for the soda ash plant to use natural gas as fuel.

Because projects such as the fertilizer complex which could influence the supply of natural gas to the soda ash plant are not yet finalized, the requirement for fuel receiving facilities was studied by the Evaluation Team on the basis of purchasing fuel oil from existing refineries. If the supply of natural gas to the plant does become certain, the soda ash plant planning can be changed at that time. Fuel oil would be delivered by either tank cars (rail) or tank lorries, and the only receiving facilities required is a fuel oil storage tank within the soda ash plant site.

4-4 PRODUCT SHIPMENT FACILITIES

The quantity and form of products to be shipped are as follows.

Product	Annual quantity	Form
Soda ash	400,000 t	Bulk Bagged
Ammonium chloride	400,000 t	Bagged (using large-size bags to be returned after delivery)
Rock salt	400,000 t	Bulk

These products are to be shipped to domestic markets and to export markets.

Regarding the shipment of bagged products, in the case of shipping to domestic markets, it is expected that products will be moved by belt conveyors from the storage points to trucks and freight cars, and in the case of products to be exported, the bags are to be moved by truck to the pier for loading aboard ship. Therefore, no special facilities are required for bagged products.

Products to be shipped in bulk are to be conveyed by belt conveyors from the storage points to the ship loader installed on the pier, for direct loading of the ships. Construction of the belt conveyors and ship loader are considered part of the scope of work of construction of the soda ash plant, provided that other port facilities such as piers are accessible at Laem Chabang Deep Sea Port.

4-5 EMPLOYEE HOUSING FACILITIES

The Laem Chabang district today is primarily the site of farming and fishing activities, and the engineers and operators required for the soda ash plant cannot be hired locally. These employees must be hired in Bangkok and other cities, and it will be necessary to construct housing facilities for them in Laem Chabang.

As the site for such housing, it is planned that land in the area west of Route 3, which is within the jurisdiction of the Town & City Planning Department of the Ministry of the Interior, will be made available.

CHAPTER 5 CONCEPTUAL DESIGN OF THE SODA ASH PLANT

In this chapter a general description of the conceptual design of the facilities of the facilities of the soda ash plant is given, on the basis of the conditions discussed in the preceding part and nature of required facilities. Design criteria are given in 5-1, after which outline specifications of each facility are given, in accordance with the following classification. These specifications are listed in Table V-3.

1. Process unit for soda ash production
2. Utilities facilities
3. Offsite facilities
4. Housing facilities

5-1 DESIGN CRITERIA

5-1-1 Meteorological Conditions

Detailed data on meteorological conditions are given in Table V-1 and Figure V-3. The following values were used as conditions for the conceptual design.

1. Temperature

High	36.9°C
Low	15.0°C
Avr.	28.5°C

2. Relative humidity

High	88%
Low	29%
Avr.	72%

3. Rainfall

Annual (avr.)	1,229 mm
Monthly high	284 mm
Monthly low	6 mm
24-hr, max.	196.3 mm

Table V-1 CLIMATOLOGICAL DATA

(A) Climatological data (1951–1975, Laem Chabang)

Station	Laem Chabang (Koh Sichang)	Elevation of station above MSL	24.90 meters
Index Station	48 460	Height of barometer above MSL	26.09 meters
Latitude	13° 10' N	Height of thermometer above ground	1.20 meters
Longitude	100° 48' E	Height of wind vane above ground	20.00 meters
		Height of raingauge	0.80 meters

	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Pressure													
(+ 1,000 or 900 mbs)													
Mean	12.54	11.43	10.42	09.02	07.23	06.78	06.77	06.82	07.63	09.72	11.37	12.23	09.59
Ext. Max.	22.25	20.21	17.94	17.05	13.58	12.99	13.05	13.73	13.94	16.50	18.98	20.66	22.25
Ext. Min.	05.56	05.00	03.42	01.89	99.68	98.19	98.60	00.51	98.79	01.95	04.62	04.34	98.19
Mean daily range	4.23	4.33	4.41	4.37	4.00	3.35	3.13	3.42	4.00	4.21	4.10	4.12	3.97
Temperature (°C)													
Mean	26.7	28.0	29.1	30.3	29.9	29.6	29.1	29.0	28.3	27.7	27.4	26.7	28.5
Mean Max.	29.6	30.7	31.7	33.0	32.3	31.9	31.3	31.3	30.7	30.3	30.1	29.7	31.0
Mean Min.	22.3	24.5	25.7	26.9	26.6	26.7	26.2	25.9	25.1	24.5	23.8	22.6	25.0
Ext. Max.	33.6	34.4	35.8	36.9	36.2	35.4	34.5	33.7	34.8	33.0	33.0	33.2	36.9
Ext. Min.	15.2	18.4	20.0	21.2	22.5	21.8	21.6	21.9	21.8	19.8	15.5	15.0	15.0
Relative Humidity (%)													
Mean	65.0	71.0	72.0	71.0	74.0	73.0	74.0	74.0	78.0	73.0	71.0	65.0	72.0
Mean Max.	78.8	84.1	84.2	82.7	83.7	80.6	82.1	83.1	87.4	88.1	81.3	76.9	82.8
Mean Min.	58.8	60.7	63.0	61.7	65.8	65.3	66.6	66.6	69.9	70.2	62.9	55.9	63.7
Ext. Min.	29.0	31.0	31.0	39.0	43.0	52.0	54.0	51.0	49.0	43.0	34.0	29.0	29.0
Dew Point (°C)													
Mean	19.3	21.9	23.3	23.8	24.6	24.1	23.9	24.0	24.0	23.6	21.4	19.4	22.8
Evaporation (mm)													
Mean-Piche													
Mean-Pan							No Observation						
Cloudiness (0-8)													
Mean	3.5	3.5	3.6	4.3	5.9	6.4	6.6	6.8	6.6	5.8	4.4	3.6	5.1
Visibility (km)													
0700 L.S.T.	7.9	7.3	7.7	9.1	10.3	10.7	10.3	10.4	10.0	9.2	9.3	8.8	9.3
Mean	9.5	9.1	9.5	10.8	11.8	12.2	11.8	11.9	11.6	10.9	11.1	10.6	10.9
Wind (Knots)													
Prevailing wind	W	W	SW	SW	SW	W	W	W	W	NE	NE	NE	–
Mean Wind Speed	7.9	7.5	7.5	7.5	7.4	8.2	7.9	7.6	6.3	6.4	8.5	8.6	–
Max. Wind Speed	30NE	27NE	33N. WNW	35SW	35SW NE	45W	50W	50W	48W	30E	28NNE	32E	
Rainfall (mm)													
Mean	6.0	24.7	37.5	35.6	194.1	89.7	104.1	124.5	284.1	258.9	55.6	14.5	1,229
Mean rainy days	1.2	3.0	3.5	5.1	14.2	11.4	14.3	15.1	18.6	16.5	6.4	2.2	111
Greatest in 24 hr	25.8	58.1	68.5	57.2	101.5	88.3	93.5	68.5	158.6	196.3	121.7	71.7	196.3
Day/Year	19/75	24/68	18/74	26/61	25.64	2/66	4/60	29/64	18/65	9/74	30/70	1/70	9/74
Number of days with													
Haze	20.6	16.1	15.1	12.2	1.4	0.6	0.4	0.4	0.4	2.5	8.9	15.8	94.4
Fog	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.6
Hail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thunderstorm	1.2	4.3	8.3	15.7	17.6	8.4	8.4	8.7	15.5	16.4	6.1	1.1	122.2
Squall	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

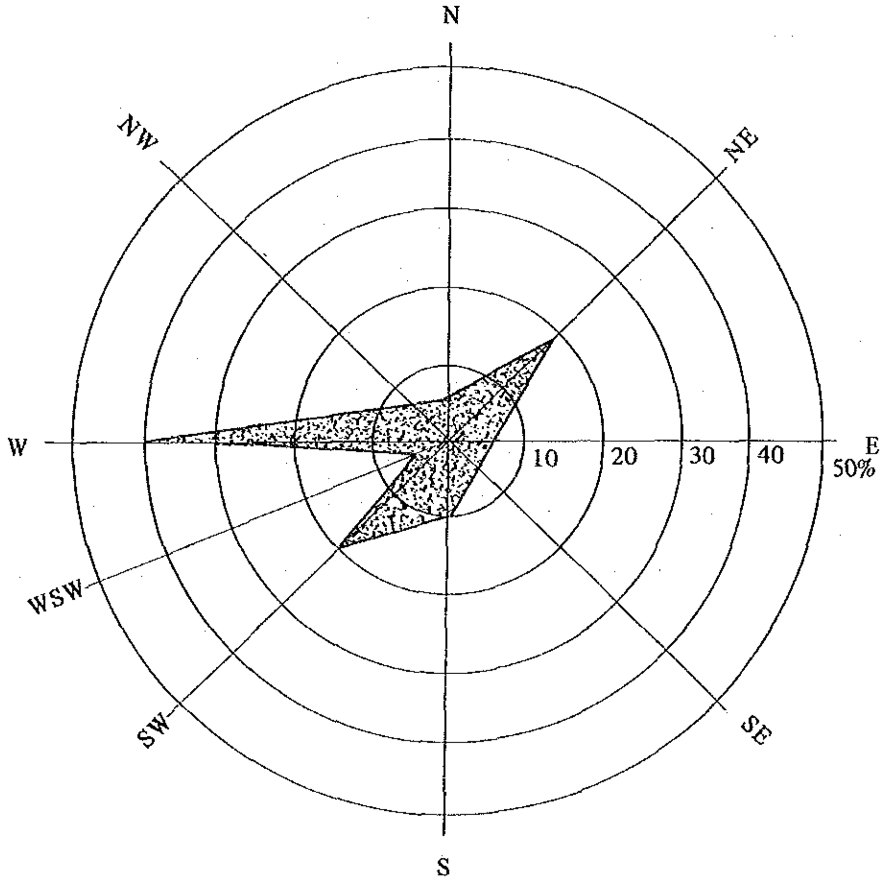


Figure V-3 WIND ROSE (LAEM CHABANG)

4. Wind speed and direction

Prevailing direction:	Jan.–Sept.: W--SE
	Oct.–Dec.: NE

Hourly mean wind speed: 4.4 m/sec.
Instant maximum wind speed: 26.0

5. Tides

Highest high water level:	MSL + 3.50 m
High water level:	MSL + 1.00 m
Low water level:	MSL – 1.25 m

5-1-2 Agronomical Conditions

Regarding soil conditions, on the basis of the "Technical Investigation of the Laem Chabang" report prepared by the Dutch consulting firm, Nedeco, and the reconnaissance by the Evaluation Team, it is estimated that the following are characteristics of subsurface soil conditions: (a) topsoil, 0.30 m thick, (b) silty sand, up to MSL-12 m, and (c) bearing layer, starting at MSL-12 m. The soil column is presumed to be as indicated above.

The seismic coefficient is taken to be 0.

5-1-3 Raw Material Qualities

1. Rock salt

Component	Extent
NaCℓ	97.0% or more
H_2O	0.1 ∿ 0.2% or
SO_4^{--}	1.0% or less
Ca^{++}	0.4% or less
Mg^{++}	0.08% or less
K^+	0.001% or less
I.M.*	0.5% or less

*I.M.: Insoluble matter

2. Ammonia

Purity	99.9%
Water	0.1%
Oil	5 ppm or less

3. Carbon dioxide

Purity	98.5 Vol. %
Inert gas	1.5 Vol. %

4. Quicklime

Component	Extent
CaO	95.0% or more
MgO	0.3 ∿ 2.5%
SiO_2	0.2 ∿ 1.5%
$A\ell_2O_3$	0.1 ∿ 0.5%
Fe_2O_3	0.1 ∿ 0.4%
CO_2	0.4 ∿ 1.5%

5. Caustic soda

Component	Extent
$NaOH$	45%
Na_2CO_3	1% or less
$NaC\ell$	1.3% or less
Fe_2O_3	0.02% or less

5-1-4 Characteristics of Utilities

1. Electric power

Electric power is to be 50 Hz and voltage is to be 6.6 KV.

2. Water

It is assumed that water will be obtained from the Dok Krai reservoir and to have characteristics as given in Table V-2.

3. Fuel oil

Fuel oil shall have the heat value of 10,300 Kcal/kg, and specific gravity of 0.95 ton/m^3.

5-1-5 Characteristics of Products

(1) Soda ash (Dense ash)

Purity:

T. Na_2CO_3:	99.0% or more
NaCl:	0.5% or less
Fe_2O_3:	0.01% or less

Apparent specific gravity:	1.0 or more
True specific gravity:	2.53
Angle of repose:	40°

Particle distribution (reference values)

16 mesh on	0.5%
16–32 mesh	6.0%
32–60 mesh	48.0%
60–100 mesh	38.5%
100 mesh under	7.0%

(2) Ammonium chloride

Purity, Ammoniacal nitrogen:	25.0% or more
Apparent specific gravity:	0.76
True specific gravity:	1.53
Angle of repose:	43°

Particle distribution (reference values)

5 mesh on	1.0%
5–8 mesh	69.5%
8–14%	29.0%
14 mesh under	0.5%

5-2 CIVIL CONSTRUCTION WORK CONDITIONS

5-2-1 Construction Site Preparation Plan

Earthmoving for preparation of the construction site is to be planned in light of soil conditions and so as to require moving of the minimal quantity of earth.

Assumptions for study of the site preparation plan are:

1. Cut and fill will be balanced.

2. The finished grade will be MSL+3.50 m, so as to prevent any possible effects of high waves.

3. The entire site will be made to have the same finished grade.

5-2-2 Plant Foundation

Considering that the bearing stratum is MSL-12.00 m, the foundation for the plant which is to contain heavy and vibrating machinery is to be a 17-meter pile foundation.

Table V-2 ASSUMED ANALYSIS OF DOK KRAI RESERVOIR WATER

	Range
pH	6.7–7.8
Electrical Conductivity @25°C (micro Ω/cm)	100.0–130.0
Ca (ppm)	10.0–17.0
Mg (ppm)	2.0–3.0
Na (ppm)	5.0–7.0
HCO_3 (ppm)	44.0–59.0
Cℓ (ppm)	8.0
SO_4 (ppm)	0.0–2.0
Soluble Sodium Percentage	23.0–32.0
Sodium Absorption Ratio	0.4–0.5
Residual Sodium Carbonate (meg/l)	0.0–0.15
Turbidity (ppm)	25.0

Source: Ministry of Industry.

5-3 PROCESS UNIT FOR SODA ASH PRODUCTION

5-3-1 Process Description

The following description is not of any particular process but is intended only to give a typical example of the Full AC Process (see Figure V-4).

The Full AC Process can be divided into following sections:

1. Crude salt purification
2. Ammonium chloride crystallization
3. Carbonation
4. Calcination and densification
5. Ammonium chloride drying
6. Ammonia recovery

The general features of each section are described below.

(1) Crude salt purification section

Crude salt – rock salt in this Project – contains a higher level of sulfates than crude salt generally used, and because presence of a high level of sulfates could result in a lowering of soda ash quality, sulfates are removed as the first step.

Rock salt which has been received from the mine is conveyed to the Crusher from storage. Crushed salt is fed to the Slurry Tank, where sulfates in the rock salt are dissolved by the saturated salt solution. Then slurry is fed to a Centrifuge, where purified salt and sulfates-containing salt solution are separated.

The purified salt is then fed to the Ammonium Chloride Crystallizer. The separated salt solution is then clarified through reaction with quicklime and carbon dioxide gas in a Brine Tank. Clarified salt solution is recycled to a Slurry Tank. Deposited slurry is filtered through a Filter Press, and the filtrate is recycled to the Brine Tank and filter cake is removed from the process to the Waste Treatment System.

(2) Ammonium chloride crystallization section

Purified salt in the above section is fed to the Salt Slurry Tank, where it is mixed with the liquid from the first Ammonia Absorber and the mother liquor from Ammonium Chloride Separator. This mixture is fed to the First Ammonium Chloride Crystallizer, Second Ammonium Chloride Crystallizer, and then to the AC Thickener.

In the First and Second AC Crystallizer, ammonium chloride (AC) is cooled using the latent heat of evaporation of liquid ammonia. In due course of this cooling process, AC is crystallized to form a slurry. The slurry with suspended AC crystal is sent to the AC Thickener, where AC crystal is settled. Most of the vaporized ammonia in AC Crystallizers is sent to Ammonia Absorbers, and the balance is recycled to the Ammonia Refrigerator, where ammonia is liquefied to be mixed with fresh feed ammonia to be fed to AC Crystallizers.

Settled AC crystal in the AC Thickener is then separated by the AC Centrifuge. AC crystal is sent to the AC Drier, and the part of the mother liquor and the top liquor of AC Thickener are fed to the Salt Slurry Tank and the balance of the mother liquor is fed to the Second Ammonia Absorber. The solution from the Second Ammonia Absorber is sent to the Carbonation Section.

(3) Carbonation section

The solution from the Second Ammonia Absorber is fed to a Reacting Tank, where the solution is reacted with quicklime. Reacted solution is then sent to the Ammoniated Brine Thickener, where the impurities from rock salt are settled. Top solution of Ammoniated Brine Thickener is then reacted with carbon dioxide gas in the cleaning Tower and then in the Making Tower. Unreacted off-gas from these towers is scrubbed with treated water in the Carbonator Scrubber in order to recover carbon dioxide.

The solution from the Making Tower is fed to a centrifuge (Sodium Bicarbonate Separator) to separate crude sodium bicarbonate in crystal form. The major part of mother liquor from Bicarbonate Separator is sent to the AC Crystallization Section and the residual mother liquor is sent to the Ammonia Recovery Tower.

(4) Calcination and Densification Section

Crude sodium bicarbonate from the carbonation section contains moisture and ammonium biocarbonate. In order to achieve a higher yield of ammonia and carbon dioxide and to avoid scaling in the Calciner, crude sodium bicarbonate is mixed with recycled soda ash before it is fed to the Calciner. In the Calciner, sodium bicarbonate is decomposed by indirect heat from steam to form light ash. Off-gas from the Calciner is mainly carbon dioxide containing a small amount of ammonia and is washed by treated water in the Calciner Gas Washer. Washed gas is sent to the Carbonator and bottom liquid of the Calciner Gas Washer is fed to the Bicarbonate Separator as rinsing water.

Light ash from the Calciner is a dusty fine crystal form which is unconvenient for use, so it is converted into dense ash. Dense ash is mixed with water containing about 20% of sodium bicarbonate in the Monohydrate Crystallizer and then is dehydrated in a steam tube drier (Dense Ash Drier) to obtain soda ash as a final product. Gaseous effluent from the Dense Ash Drier is washed in a Drier Gas Washer, of which bottom solution is fed to the Monohydrate Crystallizer.

(5) Ammonium chloride drying section

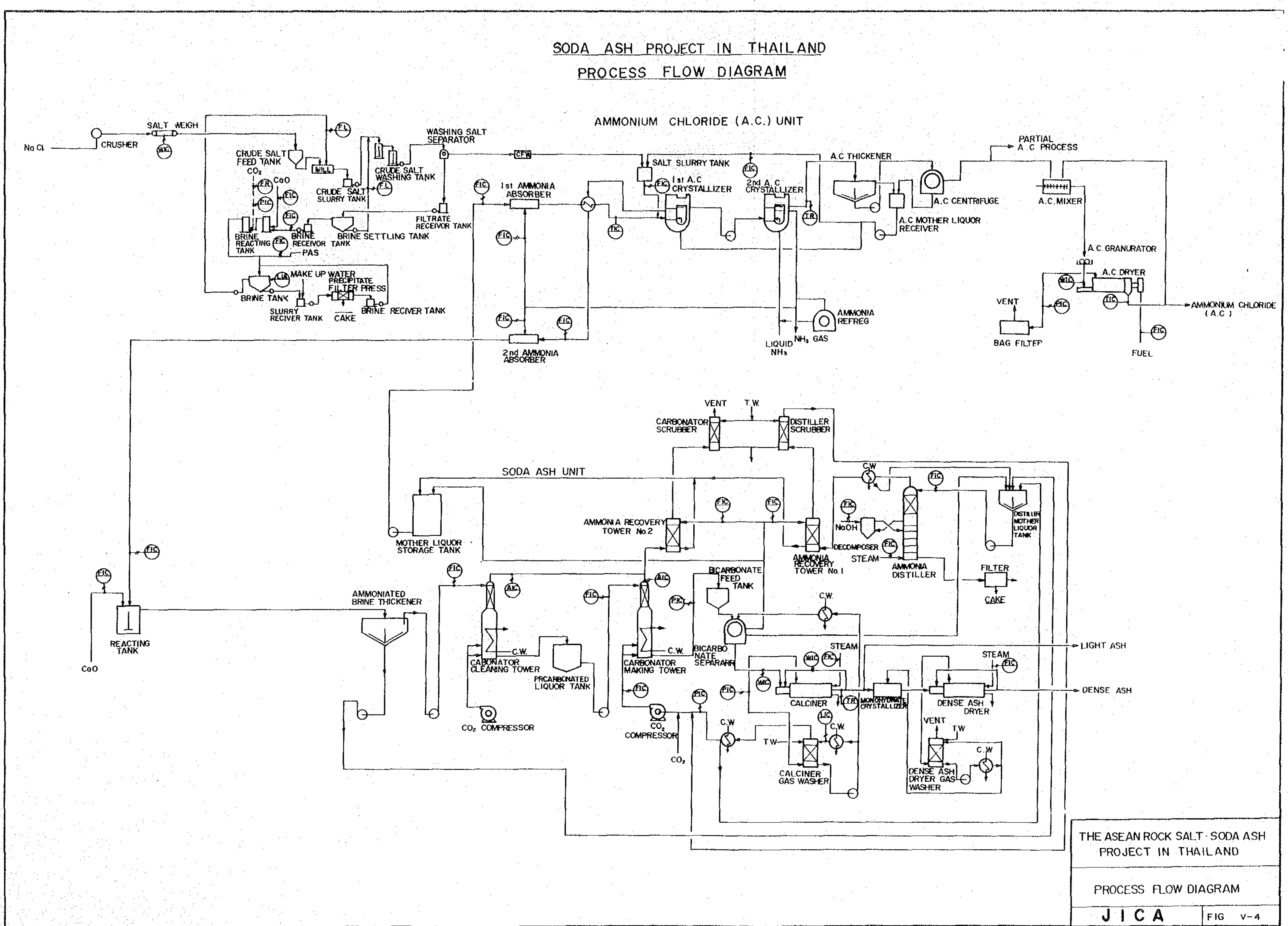
Crude AC crystal from the AC Crystallization section is mixed with off-grades AC at the AC Mixer before these are fed to the AC Granulator. In the AC Granulator, crystal AC is prilled and then prilled AC is fed to the AC Drier, where prilled AC is dehydrated by hot air. After the AC Drier, prilled AC is screened to cut over sizes (off-grades) which are recycled to the AC Mixer.

(6) Ammonia recovery section

In the Full AC Process, impurities in the rock salt are accumulated in the recycle solution so that the solution is continuously blown down in order to remove the impurities. This blow down solution is mixed with sludge from the Ammoniated Brine Thickener in order to separate ammonia and carbon dioxide in the Ammonia Distiller, where the mixture is reacted with caustic soda under indirect heat of steam.

Separated ammonia from the Ammonia Distiller is then absorbed by recycling mother liquor from the Sodium Bicarbonate Separator in the Ammonia Recovery Tower. Top gas from the Ammonia Recovery Tower, containing mainly carbon dioxide, is fed to the Distiller Scrubber, where the gas is washed by treated water in order to recycle carbon dioxide gas to Carbonator.

Bottom solution of Ammonia Distiller is fed to the Filter Press, from which filter cake is disposed as a process waste and filtrated is sent back to the process.


SODA ASH PROJECT IN THAILAND
PROCESS FLOW DIAGRAM
AMMONIUM CHLORIDE (A.C.) UNIT
NaCl
CRUSHER
SALT WEIGH
CRUDE SALT FEED TANK
MILL
CRUDE SALT SLURRY TANK
CRUDE SALT WASHING TANK
WASHING SALT SEPARATOR
FILTRATE RECEIVOR TANK
BRINE REACTING TANK
BRINE RECEIVOR TANK
BRINE SETTLING TANK
PAS
MAKE UP WATER
PRECIPITATE FILTER PRESS
BRINE TANK
SLURRY RECIVER TANK
CAKE
BRINE RECIVER TANK
1st AMMONIA ABSORBER
2nd AMMONIA ABSORBER
SALT SLURRY TANK
1st A.C CRYSTALLIZER
2nd A.C CRYSTALLIZER
LIQUID NH_3
NH_3 GAS
AMMONIA REFREG
A.C THICKENER
A.C CENTRIFUGE
A.C MOTHER LIQUOR RECEIVER
PARTIAL A.C PROCESS
A.C MIXER
A.C GRANURATOR
A.C DRYER
VENT
BAG FILTER
FUEL
AMMONIUM CHLORIDE (A.C)
SODA ASH UNIT
VENT
T.W.
CARBONATOR SCRUBBER
DISTILLER SCRUBBER
MOTHER LIQUOR STORAGE TANK
AMMONIA RECOVERY TOWER No.2
AMMONIA RECOVERY TOWER No.1
NaOH
DECOMPOSER
STEAM
AMMONIA DISTILLER
DISTILLER MOTHER LIQUOR TANK
FILTER
CAKE
REACTING TANK
CaO
AMMONIATED BRINE THICKENER
CARBONATOR CLEANING TOWER
PRCARBONATED LIQUOR TANK
CO_2 COMPRESSOR
CARBONATOR MAKING TOWER
CO_2 COMPRESSOR
CO_2
BICARBONATE FEED TANK
BICARBONATE SEPARATOR
CALCINER
CALCINER GAS WASHER
MONOHYDRATE CRYSTALLIZER
DENSE ASH DRYER
DENSE ASH DRYER GAS WASHER
LIGHT ASH
DENSE ASH
C.W.
T.W.
THE ASEAN ROCK SALT · SODA ASH PROJECT IN THAILAND
PROCESS FLOW DIAGRAM
JICA
FIG V-4

5-3-2 Raw materials and utilities requirements

The process unit for soda ash production requires the following raw materials and utilities.

Raw Material	Unit Consumption (per ton soda ash)
Rock salt	1,413 kg
Ammonia	320 kg
Quicklime	46 kg
Caustic soda (or soda ash)	42 kg (60 kg)

Utility	Unit Consumption (per ton soda ash)
Electric power	391 KWH
Steam	1,800 kg
Cooling circulation water	148 m^3
Process water	5 m^3
Fuel oil	20 ℓ

The utility items in the above listing which can be acquired from outside the plant are electric power, industrial water and fuel oil. Steam, cooling water and process water must be made within the plant. Therefore, the utilities requirements in terms of utility items to be purchased from outside (i.e., electric power, water, and fuel oil) which have been calculated by including the utility requirements not only for the process unit but also other facilities in the plant are:

Utility	Unit Consumption (per ton soda ash)
Electric power	496 KWH
Water	25.6 m^3
Fuel oil	0.208 m^3

5-4 UTILITIES FACILITIES

The following are the major utilities facilities, including those required for the supply of utilities within the plant.

1. Power receiving facilities and distribution facilities

2. Emergency power generation facilities

3. Water treatment facilities

4. Cooling water facilities

5. Boilers

6. Instrument and air facilities

7. Effluent treatment facilities

5-4-1 Electricity Receiving Facilities and Distribution Facilities

For the soda ash plant, electricity will be supplied at the IEAT transformer station, in which IEAT receives the power from EGAT/PEA and steps it down prior to distribution. The plan is to string a 6.6 KV cable a distance of 2 km from the IEAT transformer station to the main transformer of the plant. The plant is also required to have facilities with electricity receiving capacity of 20 MW (25,000 KVA) as well as facilities for distribution of the power. Voltage is to be regulated and controlled by the receiving facilities, and the required power is to be supplied to the production facilities, utility facilities, product storage facilities as well as shipment facilities and ancillary facilities at the site.

5-4-2 Emergency Electricity Generation Facilities

In the event of an interruption in the supply of electricity from EGAT/PEA, plant operation would cease completely; for emergency use at such time as when there is an interruption in electricity supply and for maintenance work, a diesel generator (capacity, 750 KW) is to be provided.

5-4-3 Water Treatment Facilities

Water required by the soda ash plant will be supplied by IEAT at a reservoir which IEAT is to construct within the Laem Chabang area, and it is planned that the soda ash plant shall install a set of pumps at the IEAT reservoir and 2 km of pipeline at the expense of the Project.

The quality of the water supplied as noted above (assuming water from Dok Krai reservoir is used) is such that primary treatment will be required. The primary treatment facilities to be installed in the plant are to include sterilization, sedimentation and filtration equipment. Water treated at these facilities will be supplied for cooling tower make-up water and miscellaneous uses; for use as process water and boiler feed water, water will undergo further treatment in softening and purification equipment. Steam condensate formed within the plant will be treated by the purification equipment and circulated as boiler feed water.

5-4-4 Boiler Facilities

Boiler facilities will be installed in order to generate steam as required by the process unit and utility plant of the soda ash plant. Specifications of the steam are 31 kg/cm^{2}G and 360°C.

5-4-5 Instrument and Plant Air Facilities

Instrument and plant air facilities including an air compressor and regulator are to be installed in the plant.

5-4-6 Waste Water Treatment Facilit'es

Effluent from the process unit of the soda ash plant will contain low quantities of calcium carbonate, gypsum and salt. The effluent will be fed into a settling pond installed within the plant in which solid matter is caused to settle out and only the water remaining after the settlement of solid matter is discharged by diluting so as to be within acceptable environmental standards (Thai standards) before discharge. Analysis of the effluent from the soda ash plant and measures to be taken for its treatment are described in more details below.

(1) Projection of waste production from the soda ash plant of this project

As noted earlier, the raw materials used at the soda ash plant of this Project are salt, ammonia, carbon dioxide, quicklime and caustic soda, and the produced products are soda ash and ammonium chloride. Therefore, unless extraordinary conditions arise, no organic matter is expected to be discharged from the plant. It is expected that the effluent from the plant will be as follows.

1. Solutions	1 m^3 for each ton of soda ash produced (NaCℓ concentration, 60 g/ℓ
2. Solids	(a) Distillation residue per ton Total volume 100 kg; of which water is 40 kg and solids are 60 kg (primarily calcium carbonate)

(b) Disposal from salt purification section per ton of soda ash
Total volume, 260 kg; of which water is 100 kg and solids are 160 kg (mostly gypsum and calcium carbonate)

(2) Comparison with permissible levels for industrial effluent in Thailand

The permissible levels for industrial effluent in Thailand are as shown in Table AV-2-3. These are very strict in comparison to the levels adopted in other countries.

In view of the process of manufacturing soda ash by the Full AC Process, as noted above, there is no reason for there being any organic matter in the plant effluent. Further, there is no reason to expect that heavy metal ions, oxides, cyan compounds and the like, designated as harmful materials, will be present in the effluent, in view of the nature of salt and quicklime used as raw materials, as well as the materials of the equipment and machinery used in the plant. The solution is discharged from the ammonia recovery section, and it will have a pH of 7-8 and salt concentration of 60 g/ℓ.

Although no standard is specified for salt (NaCℓ) concentration, as is shown in Table AV-2-3, the limit for dissolved solids is 2,000 mg/ℓ (by way of comparison, the salt concentration in seawater is 28 g/ℓ), and it is possible to control the concentration by means of diluting the discharged solution with fresh water to the extent necessary. With regard to temperature, color, odor, etc., in view of the conditions prevailing at similar plants now in operation, it is thought that there will be no difficulty with regard to observing the legally set requirements.

5-5 OFFSITE FACILITIES

5-5-1 Raw Materials Receiving and Storage Facilities

(1) Carbon dioxide

PTT is now constructing a natural gas processing plant in the Rayong district. It is planned to discharge the carbon dioxide which is separated from the natural gas, but as part of the Rock Salt - Soda Ash Project, it is proposed to use that carbon dioxide. The facilities required for it to be used are as follows.

1. Carbon dioxide compressor
2. Compressor-related equipment

(items 1 and 2: Within the PTT Rayong plant)

3. Carbon dioxide pipeline; length, 61 km

4. Carbon dioxide holder

If the fertilizer complex which is being planned by the GOT is realized and the carbon dioxide is supplied from this complex of these four requirements, the carbon dioxide holder can be eliminated and the specification of other facilities can be revised so that investment costs can be reduced.

(2) Ammonia

The plan is drawn on the basis of using imported ammonia. Therefore, it is planned to install an unloading arm on the pier at Laem Chabang Deep Sea Port and also to lay a pipeline of 2 km distance from the unloading arm to the plant. The ammonia transported by the tanker will be unloaded by using the shipboard pump and then be transported as a liquid through the 2 km pipeline to the plant. A 5,000 t ammonia reservoir will be installed within the plant. If the fertilizer complex is constructed and ammonia is supplied from the complex, however, the ammonia reservoir will not be needed.

(3) Rock salt

Rock salt is to be dumped from the hopper cars used to transport it from the mine (see Part IV), into an underground hopper (capacity, two cars) from which it is to be moved to the rock salt storage by means of a belt conveyor. The soda ash plant will have these facilities. The capacity of the rock salt storage facility, which is to be an outdoor structure, is to be 70,000 t, in view of the requirements for export shipping of rock salt as well as the rock salt requirements in the soda ash plant. The shipping facilities shall include hoppers and belt conveyors, one set for export and the other for soda ash plant.

5-5-2 Product Storage and Shipment Facilities

The product warehouses shall be of sufficient capacity to hold 1.5 months' production output, as follows:

1.	Soda ash bulk warehouse	36,000 t
2.	Ammonium chloride bulk warehouse	36,000 t
3.	Bagged products warehouse (soda ash and ammonium chloride storage, combined)	36,000 t

The soda ash bulk storage facility shall be of the silo type while the ammonium chloride bulk storage facility and the bagged products warehouse shall be sealed, steel-reinforced concrete warehouses. The soda ash plant and bulk storage facilities shall be linked by belt conveyors, which shall transport the produced soda ash and ammonium chloride directly to their storage points.

Most of the produced ammonium chloride will be bagged in large sacks to be returned after delivery, and will be carried by freight car or truck, so that other than portable conveyors and forklifts no special equipment is installed.

For the shipments of bulk soda ash and ammonium chloride, it is planned to install an extensible ship loader (700 t/h) on the pier and also a belt conveyor system to the pier as described in 3-5 above.

5-5-3 Other Auxiliary Facilities

In addition to the facilities and equipment enumerated above, the following will be required for the safe operation of the plant.

Maintenance equipment: The plant will be required to be furnished with tools and machinery, instruments and electric maintenance equipment, for annual turn-around, routine preventive maintenance, and performance of minor repair work. Repair of large equipment in the plant, however, will be performed by the equipment maker, and the plant personnel will only be expected to undertake relatively small repair jobs on their own. Welding equipment, metalworking machines, winders for electric motors repair, as well as calibrators and other testers for instrument repair will be installed.

Offices and related buildings: An office building, laboratory, cafeteria, garage, gatehouse and various other structures will be required to be constructed at the site. These are described in Table V-3. In addition, firefighting equipment and a communication system for use within the plant are to be established.

5-6 HOUSING FACILITIES

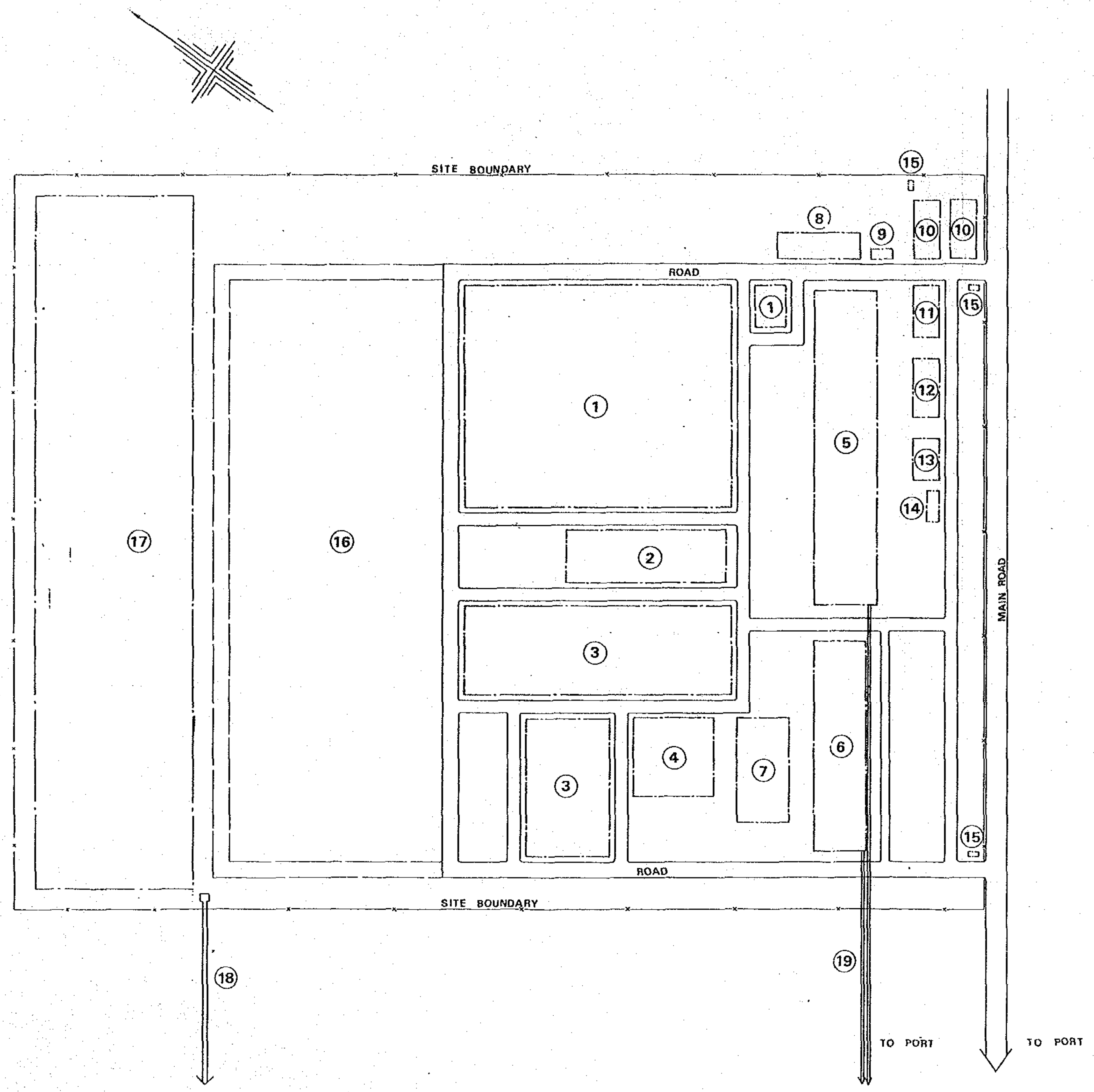
The Laem Chabang area is the location of farming and fishing activities and there are few technical persons available from among the local population. It will be necessary to bring most of the operators, maintenance personnel and management personnel from other parts of Thailand. Therefore, in order to attract good quality engineers and managers to work in Laem Chabang, it will be necessary not only to set salaries at suitable levels but also to provide attractive housing and related (e.g., health and welfare) facilities. As the minimum requirement for employee housing, a total of 360 units of staff and nonstaff housing should be planned. The housing should be constructed on a site to the west of Route 3 where land is relatively level. Water for drinking and other uses is to be supplied from the plant, and electricity is to be supplied to the housing from PEA lines.

5-7 PLANT LOCATION AND PLANT LAYOUT

The layout of the plant can only be finalized after the location of the rail spur for transporting rock salt as well as layout of port and harbor facilities in Laem Chabang Deep Sea Port, which are to be used for shipment of the plant's products, are determined. At the present time the master plan of the port and harbor project is as is shown by Figure V-1. A preliminary plant layout is shown in Figure V-5.

Table V-3 FACILITIES INCLUDED IN THE PROJECT SCOPE

Facilities			Rated Capacity
1.	Process Plants	Soda Ash	1,200 t/d
		Ammonium Chloride	1,200 t/d
2.	Utilities Plants		
1)	Demineralizer		880 m^3/h
2)	Main substation		20,000 KW (25,000 KVA)
3)	Cooling Tower		8,000 m^3/h
4)	Steam boilers		55 t/d x 2 sets
5)	Instrument and plant air		960 Nm^3/h
6)	Emergency diesel generator		750 KW
7)	Effluent treatment		refer to Part V, 5
8)	Utilities distribution		as required
3.	Offsite Facilities		
3-1	Carbon dioxide supply station and pipeline		20,000 Nm^3/h (61,000 mL)
3-2	Raw materials and products storage & loading		
1)	Ammonia storage		5,000 t (−33°C, atmos.)
2)	Rock salt storage		70,000 t
3)	Soda ash storage	Bulk	36,000 t
		Bagged	36,000 t
4)	Ammonium chloride storage	Bulk	36,000 t
5)	Bulk rock salt/soda ash handling & shipping		700 t/h
6)	Conveyor way for rock salt		1,875 mL
7)	Conveyor way for bulk salt		1,410 mL
3-3	Common Facilities		
1)	Equipment and machines for maintenance and workshops		
2)	Equipment for laboratories		
3)	Drinking water & fire-fighting system		
4)	Intercommunication system		
5)	Lighting and lightning system		
6)	Miscellaneous equipment & machines for common facilities		
3-4	Offsite Building & Structures		
			Total Floor Area
1)	Maintenance shop		1,680 m^2
2)	Laboratory		360 m^2
3)	Local laboratories		30 m^2 x 5
4)	Gatehouses		50 m^2 x 2
5)	Garage		150 m^2
6)	Administration office		1,250 m^2
7)	Cafeteria & locker room		1,400 m^2
8)	Warehouses		1,400 m^2 x 2
9)	Workshop		2,000 m^2
10)	First aid house		200 m^2
11)	Maintenance & engineering office		1,000 m^2
12)	Fencing		as required
3-5	Housing and utilities during construction		as required



NO	DESCRIPTION
①	PROCESS PLANT
②	SILO
③	UTILITY AREA
④	LIQUID AMMONIA TANK
⑤	ROCK SALT STORAGE YARD
⑥	PRODUCT STORAGE & BAGGING FACILITY
⑦	PRODUCT STORAGE FACILITY (BULK)
⑧	WORK SHOP
⑨	FIRST AID & FIRE FIGHTING
⑩	WAREHOUSE
⑪	GENERAL OFFICE
⑫	CANTEEN LOCKER
⑬	MAINTENANCE & ENGINEERING OFFICE
⑭	LABORATRY
⑮	GATE HOUSE
⑯	FUTURE & TEMPORARY AREA
⑰	WASTE WATER POND
⑱	DISCHARGE CHANNEL
⑲	CONVEYOR WAYS

0 50 100 150 200M

THE ASEAN ROCK SALT · SODA ASH PROJECT IN THAILAND

PLANT LAYOUT (PROCESS)

JICA | FIG. V-5

CHAPTER 6 PROJECT IMPLEMENTATION AND PLANT OPERATION

6-1 ORGANIZATION FOR IMPLEMENTATION OF THIS PROJECT

The company which will implement the Project and operate the Complex will be established in the near future as a Thai company with the equity provided jointly by the ASEAN countries, and at the present time preparations are being made for the Project by the Ministry of Industry, GOT.

As the Thai shareholding company which is to participate in the joint venture, the Rock Salt and Soda Ash Holding Co. has been established with one-third contribution by the GOT and two-thirds contribution by 10 Thai private companies, but at the present time this company is a pilot company and does not possess the managerial organization needed to function for implementation of the Project.

Although the new joint venture, once established, will of course assume the responsibility for carrying out the required work, in order to obtain maximum assurance of success, the Evaluation Study Team emphasizes that it is necessary to further strengthen the present project team so that when the Project enters the implementation stage the basis for project management will already have been established. It is essential, further, that engineers who will later work for the joint venture, and will have assignments during the construction of the plant as well as operation and maintenance assignments after the start of Complex opeation, be assigned to the project team, so that they will continuously execute their tasks for successful implementation of the Project even after the joint venture company has been established. This will be the first instance of construction of large-scale chemical plant in Thailand. Therefore it is recommended that suitable efforts to train and develop project staff be undertaken.

6-2 CONSTRUCTION PLAN OF THE SODA ASH PLANT

6-2-1 Method of Procurement and Construction of Facilities

The machinery and equipment which will be included in the Complex are exceedingly diverse in nature, and in many cases are technologically sophisticated. Only a few are presenly being made in Thailand, and therefore it will be necessary to rely on imports for the most of the machinery and equipment for the plant. In addition, the construction of the Complex involves a far-ranging and complex assortment of tasks, such as design and engineering of various facilities including process design of the soda ash plant; procurement, shipping and forwarding to the site of equipment, supplies and materials; civil work; erection and installation work; inspection and other relevant activities.

In view of the characteristics and complexity of the Project, it is desirable to use a turn-key lump-sum arrangement for construction, and have the work performed by a qualified, internationally-experienced contractor. Contractor selection will be by means of competitive bidding. Under such form of arrangement, the contract would require the contractor, in a fixed project budget, to perform the design and engineering, procure and supply equipment, supplies and materials, complete the civil, erection and construction work, train operators and other key personnel of the joint venture and to provide assistance for and supervision of start-up and commissioning of the Plants. Further, the contractor should be responsible to complete the construction, including test runs to prove guaranteed performance of plants and facilities, within a certain period.

This manner of constructing the plant is believed to be the safest and most realistic which can be used in instances of constructing projects as large as this one, because it provides assurance of the extent of the total construction cost at the time of signing of the contract, and also because the contractor assumes total responsibility, including the responsibility for completing his work according to a schedule previously approved by the joint venture. Therefore, the subsequent discussions are made on the assumption that construction will be done by an internationally-experienced contractor in the above manner.

6-2-2 Major Tasks which must be Performed by Joint Venture up to the Time of Completion of Construction

On the assumption that procurement and construction of the Project as described above, will be performed by a foreign contractor on a turn-key lump-sum basis, the major tasks which the joint venture must accomplish up to the time of completion of construction, and the manner in which is should proceed, are as described below.

(1) Necessary tasks to be performed by the Project sponsor

The following are the major preparations which must be made by the joint venture prior to issuance of the Invitation to Bid for the engineering and construction contract:

1. Completion of site investigations, and final decision on use of the selected site

2. Detailed examination of the design criteria

3. Preparation of general terms and conditions of contract with regard to the design, engineering, procurement and construction

4. Preparation of tender specifications for contractor's bids on the basis of the above

5. Pre-qualification and short-listing of bidders to be invited

These are described in further detail in the following paragraphs.

(a) Completion of site investigations, and final decision on use of the selected site

It is of urgent necessity that full rights to use of the site be obtained as early as possible, in order that subsequent steps may be taken without hindrance. Then, a further detailed survey of the site conditions must be made, so that the site plans can be drawn. It is advised that as soon as the boring tests and soil investigations are completed, decision on use of the proposed site be made and then design bases be developed.

(b) Detailed examination of the design criteria

It is necessary that based on the concept of plants and facilities which have already been defined in the feasibility study and also on site conditions which have been clarified as the result of the above-mentioned detailed site survey, conceptual design of the plant and facilities be more precisely made in order to finalize the design criteria. Of course, it is not possible at this stage to precisely define the specifications of equipment involved in the process plant, because the processes to be employed can be decided only after the contractor is selected through bidding. However, design criteria for plants and facilities should be determined by the joint venture, to the most detailed extent possible, to enable all bidders to design such plants and facilities on an identical concept, with their budget estimations to be made on the basis of proposed manufacturing processes. Further, at the same time the engineering standards to be followed by the contractor for design and engineering should be identified.

(c) Preparation of general terms and conditions for contract

To satisfy the requirement of financing agencies, it is required for the joint venture to prepare general terms and conditions of contract and to furnish them, as the standard contract form, to bidders as a part of the tender documents.

(d) Preparation of tender specifications

The contractor will be selected by competitive bidding by the pre-qualified firms. The services and supplies to be performed or provided by the contractor broadly comprise the following items:

1. Preparation, and then management, of the overall construction program for the Project (the detailed construction schedule, and the detailed construction budget; coordination and reporting procedures)

2. Procurement, inspection and forwarding to the site (including arrangements for transportation, custom clearance and landing) of equipment, supplies and materials for the Project

3. Construction and erection work

4. Training of operation and maintenance personnel

5. Assistance and supervision for start-up and test-run

To the most detailed extent possible, on the above, there must be determination and preparation of the scope of work to be required of the contractor, his responsibilities, items to be guaranteed (such as plant performance, mechanical performance, construction workmanship, material standards, completion time, etc.), design bases, design criteria, costing and cost estimate form and items of information which bidders are requested to submit with their bids, etc.

(e) Pre-qualification and short-listing of firms to be invited for bids

It is required for the joint venture to carry out pre-qualification and short-listing of firms to be invited for contractor's bids.

(f) Establishment of bid evaluation criteria

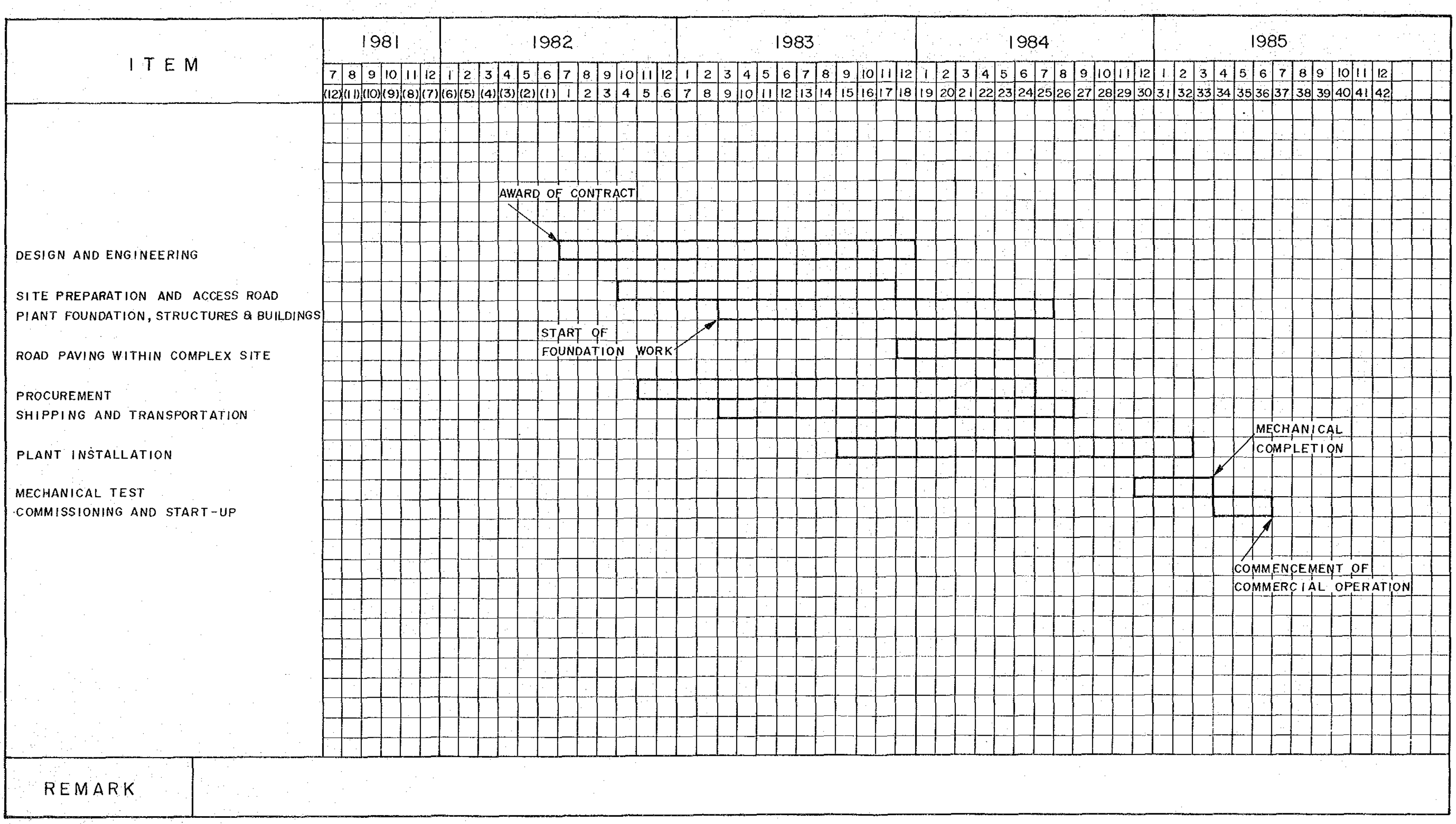
In order to conduct fair evaluation of bids, the bid evaluation criteria must be established in advance.

SCHEDULE

Fig. V-6 PROJECT IMPLEMENTATION SCHEDULE

DATE: DEC 8, '80
BY: M.U.
REV:

PROJECT: 405 THAI RS/SA



(2) Contractor selection

After the above-described preparations for the tender are completed, an invitation to bid is issued to the qualified contractors, and the technical proposal and commercial proposal submitted by each contractor are compared and evaluated according to the predetermined evaluation criteria and, following technical clarifications which may be necessary, a successful bidder is selected. After negotiations with the successful bidder, the contract is executed.

(3) Tasks to be performed by the Project sponsor after the award of contract

Once the contractor has been employed as has been stated above, responsibility for almost all aspects of construction is borne by the contractor. Nevertheless the joint venture may need to review the critical part of the basic design and detailed design prepared by the contractor, and the major pieces of critical equipment selected by the contractor, in order to insure that the plants will meet the requirements of the joint venture and satisfy its desire. It is essential for the joint venture to establish coordination procedures with the contractor and also to organize a project management team so that the joint venture can carry out these tasks in efficient manner.

Further, in order to be assured that after the completion of construction, there will be a smooth start-up of the plant and facilities, it is important for the joint venture, during the construction period, to plan, recruit, organize and train engineers and operators. Another task to be performed by the joint venture will be the contracting and supervision for work outside the scope of the contractor's responsibility; securing of the supply of feedstock, auxiliary materials, utilities and supplies; coordination with relevant authorities or institutions; project budget and schedule control and other necessary overall project management.

6-2-3 Implemention Schedule

The construction schedule was reviewed through referring to actual achievement in similar projects and taking the site conditions into consideration. As the result, it is projected that from the time that the main contract becomes effective to the time of mechanical completion of the Plant, 33 months will be required, and from start-up to acceptance of the Plant by the Project sponsor an additional 3 months will be required so that in all 36 months are needed (see Figure V-6). Therefore, assuming that the contract becomes effective in July, 1982, it is expected that commercial operation could be begun in July, 1985.

6-3 ORGANIZATION FOR PLANT OPERATION AND FOR ADMINISTRATIVE WORK

6-3-1 Organization for Plant Operation, and Manpower Planning

The organization for management and operation of the plant was studied in consideration of the scale of the plant and inherent features of the region of the site. The thus-formulated organization and manpower plan is shown in Table V-4. It is proposed that the head office of the joint venture company will be set up in Bangkok, where a staff of 35 persons will be needed. For operation, management and maintenance of the production facilities and loading of product for shipment, 833 persons will be required.

Operation of the Plant after the completion of construction will be the responsibility of the joint venture company, as owner, but because it is believed that in Thailand it will be extremely difficult to recruit engineers and technicians who are experienced in operating a large chemical plant such as this one, it is of particularly high importance to insure that all goes well in the training activities undertaken during the time that the plant is being constructed, and in the necessary on-the-job training to be carried outduring the initial stages of plant operation. The number of employees presently contemplated is somewhat more than those directly needed, but in view of the above conditions the Evaluation Study Team believes that this number is necessary in order for the joint venture company to maintain required levels of technical personnel even if there are some resignations after start-up.

With regard to the organization of the joint venture company, there would be six departments under a board of directors: Finance and Accounting, General Affairs, Personnel, Marketing, Operations and Complex departments. The Plant Manager, would be in charge of Production, Plant Engineering and Product Storage/Shipping as the direct departments, and General Affairs and Technical Control and Engineering Services as the indirect departments. The total number of employees of the joint venture company, including five executives, would thus be 873. These figures do not include the rock salt mine personnel.

6-3-2 Technical Assistance Services Required to be Provided by Foreign Firms

It is observed that in connection with implementation of this Project the joint venture may need to retain technical assistance services by internationally experienced consultants with regard to preparation of tenders for contractors as well as the following aspects:

1. Necessary technical assistance at the project preparation stage

   Assistance should be acquired for the items given in 6-2-2(1).

2. Necessary technical assistance at the stage of construction

As is stated earlier, there are very many tasks which must be accomplished as part of the work of project management during the construction phase. It will be most effective to contract for the services of an internationally-experienced consulting firm for supply of technical assistance services, to assist the joint venture company in areas where it needs additional experience and expertise. The services which would be required are as follows:

a. Review and checking of the basic and detailed designs submitted by the contractor for owner's approval, and provision of instruction to the contractor in regard to any revision of the designs.

b. Participation in inspection of major pieces of equipment, which will primarily be made by the contractor's inspectors.

c. Assistance to the owner's engineers at times of inspections at the site in the course of erection, installation and piping work.

d. Assistance to the owner in preparation and implementation of training programs (for training other than provided by the contractor).

e. Assistance to the owner's engineers in establishing systems for procurement and inventory control of spare parts and plant supplies.

f. Assistance to the owner in establishing an organization for the start-up and for subsequent operation and maintenance system.

g. Assistance to the owner regarding monitoring and controlling the progress of work and the total project budget, and assistance in reporting to financial institutions and stockholders

3. Technical assistance required to be provided after test-runs and during the initial stage of commercial operation

In order to establish an operation system for the plant and undertake on-the-job training of employees, in parallel with the transition from test to commercial operation, it will be highly efficacious to obtain the systematically organized technical assistance services of an internationally-experienced firm. By means of forming teams of foreign experts and Thai counterparts, and carrying out a thorough on-the-job training program for two to three years, it will be possible to firmly establish a sound plant management organization and method of functioning. The major services which would be required are as follows:

a. Operational assistance at the time of start-up

b. Assistance in establishing a routine operation and maintenance system

c. Assistance in determining job descriptions and arrangements for assignment responsibility, as well as in establishing standard operating procedures

d. Implementation of routine tasks through on-the-job training

e. Assistance for routine plant operation, and periodic and maintenance inspections

f. Assistance in emergency shut-down, start-up, and trouble-shooting

g. Assistance in establishing and implementing production control systems.

6-3-3 Human Resources Development

As stated above, one of the keys to success for this Project lies in the recruiting and then intensive training of personnel during the construction stage.Training provided by the contractor is that which is limited to matters related to the licensed process, and moreover is limited in terms of the number of persons trained and the training period, as well as the content of the training. It is therefore necessary, as noted in the above paragraph, to plan and carry out a comprehensive training program. Need therefore exists to make budgetary provisions for such training, in addition to provision for technical assistance services to be rendered by foreign firms during the construction stage and the initial operation stage.

Table V-4 ORGANIZATION TABLE FOR SODA ASH PLANT

	Level					
	Director General Manager	Manager	Supervisor	Foreman	Worker	Total
Board of Director	(5)					(5)
Head Office BKK	(1)	(6)	(8)	(11)	(9)	(35)
– General Manager's Office	1	1	1	1	1	5
– General Affairs Dept.		1	1	2	1	5
Finance/Accounting Dept.		1	2	2	2	7
Personnel Dept.		1	1	2	1	5
Procurement Dept.		1	1	2	1	5
Sales Dept.		1	2	2	3	8
Soda Ash Plant	(1)	(31)	(77)	(165)	(559)	(833)
– Plant Manager's Office and Factory Adm.	1	1	2	2	2	8
– Production Dept.		(4)	(6)	(32)	(330)	(372)
Carbonation		1	1	4	52	58
Calcining & Dense Ash			1	4	104	109
AC Separation & Drying		1	2	8	128	139
Utility Facilities		1	1	12	40	54
Waste Treatment		1	1	4	6	12
– Maintenance and Inventory Control Dept.		(6)	(18)	(46)	(92)	(162)
Maintenance		4	12	36	72	124
Inventory Control		2	6	10	20	38
– Technical Control & Eng. Service Dept. Service Dept.		(6)	(24)	(41)	(22)	(93)
Production Management		2	10	15	5	32
Engineering Service		2	10	10	5	27
Analytical Lab.		2	4	16	12	34
– Product Storage and Shipping Dept.		(4)	(8)	(8)	(24)	(44)
Product Storage		2	4	4	12	22
Product Shipping		2	4	4	12	22
– General Affairs Dept.	(0)	(10)	(19)	(36)	(89)	(154)
General Affairs		1	2	4	4	11
Personnel		1	2	4	4	11
Payroll		1	3	3	2	9
Accounting		1	2	2	2	7
Community Relations		1	3	3	1	8
Security, Safety and Fire-fighting		3	3	12	48	66
Clinic		1	2	4	8	15
Canteens		1	2	4	20	27

PART VI

CAPITAL REQUIREMENTS AND FINANCING PLAN

PART VI CAPITAL REQUIREMENTS AND FINANCING PLAN

CHAPTER 1 CAPITAL REQUIREMENT

On the basis of technical requirements, conceptual design of facilities and implementation plan for this Project which were stated in Part III and V, the total capital requirements for the Project was estimated. The projected capital requirement is shown in Table VI-1 for the rock salt mine and Table VI-2 for the soda ash plant.

Because the source of financing for the Project is not yet determined, some of the basic conditions for estimation of capital requirements are yet unknown. Nevertheless, the following conditions have been assumed as the bases for the estimation, on the basis of past conditions in Thailand and other relevant matters:

1. Type of contract

   - Turn-key, lump-sum contract, with a single responsibility of each contractor to be separately engaged in the undertaking of construction of the rock salt mine and the soda ash plant.

2. Procedure for the award of contract

   Presumed to be by competitive bidding,

3. Basis for prices

   By application of suitable escalation rates to September, 1980 base prices, up to the time of expenditure for each item.

4. Escalation

   For the foreign exchange portion, 9% p.a.; for the portion to be procured within Thailand 12% p.a.

5. Exchange rates for cost estimation

   Local currency portion is calculated in Bahts, and converted to U.S. dollars at the rate of US\$1 = B20.5. The foreign exchange portion is calculated in U.S. dollars and Japanese yen, and the yen portion is converted to dollars at the rate of US\$1 = ¥210.

Table VI-1 ESTIMATED CAPITAL REQUIREMENTS

ROCK SALT MINE

(US$000)

		Foreign	Local	Total
A.	Land Acquisition	0	970	970
B.	Site Preparation	0	53	53
C.	Facilities Direct Cost	9,769	8,246	18,015
D.	Railway Spur	829	1,347	2,176
E.	Housing Colony	0	2,017	2,017
F.	Construction Equipment	313	2,777	3,090
G.	Ocean Freight, Insurance & Local Handling	715	263	978
H.	Indirect Field Expenses	234	220	454
I.	Services	2,203	3,166	5,369
J.	Project Management	2,481	0	2,481
	Base Project Cost (B/C) (in Sept. End-1980 Prices)	16,544	19,059	35,603
K.	Physical Contingency (% of B/C)	835 (5.0%)	1,447 (7.6%)	2,282 (6.4%)
L.	Price Contingency (% of B/C)	5,612 (33.9%)	8,715 (45.7%)	14,327 (40.2%)
M.	Initial Working Capital (in Mid.-1985 Prices)	442	1,031	1,473
	Total Project Cost	23,433	30,252	53,685
N.	Interest During Construction			
	Interest Rate: 6%	3,609	0	3,609
	5%	2,975	0	2,975
	4%	2,354	0	2,354
	Total Financing Required			
	6%	27,042	30,252	57,294
	5%	26,408	30,252	56,660
	4%	25,787	30,252	56,039

Table VI-2 ESTIMATED CAPITAL REQUIREMENTS

CASE C: FULL AC 400,000 t/Y

(US$000)

		Foreign	Local	Total
A.	Land Acquisition	0	1,155	1,155
B.	Site Preparation	0	3,567	3,567
C.	Plant Direct Cost	103,510	28,833	132,343
D.	Railway Spur	633	801	1,434
E.	Housing Colony	2,842	7,962	10,804
F.	Construction Equipment	5,108	2,778	7,886
G.	Ocean Freight, Insurance & Local Handling	15,350	4,142	19,492
H.	Indirect Field Expenses	1,070	4,237	5,307
I.	Services	30,337	2,671	33,008
J.	Project Management	4,672	1,051	5,723
K.	Pre-Operation Expenses	4,213	3,756	7,969
	Base Project Cost (B/C) ((in Sept. End-1980 Prices)	167,735	60,953	228,688
L.	Physical Contingency	13,962	4,243	18,205
	(% of B/C)	(8.3%)	(7.0%)	(8.0%)
M.	Price Contingency	52,407	26,135	78,542
	(% of B/C)	(31.2%)	(42.9%)	(34.3%)
N.	Initial Working Capital (in Mid.-1985 Prices)	12,787	12,787	25,574
	Total Project Cost	246,891	104,118	351,009
O.	Interest During Construction			
	Interest Rate: 6%	23,600	0	23,600
	5%	19,449	0	19,449
	4%	15,389	0	15,389
	Total Financing Required			
	6%	270,491	104,118	374,609
	5%	266,340	104,118	370,458
	4%	262,280	104,118	366,398

6. Import duty

Assumed to be exempted.

1-1 PROJECT CAPITAL REQUIREMENTS

The breakdown of the projected total capital requirements is shown in Table VI-1 for the rock salt mine and Table VI-2 for the soda ash plant. Because the source of financing is not determined at the present time, the interest rate is not known but for present purposes it is presumed that the interest rate will be 6–4% p.a. Using these rates, and including interest during construction, the capital requirements for the Project would be as follows:

Total Capital Requirements (US$'000)

	Foreign currency portion	Thai currency portion	Total capital requirements
(A) Rock Salt Mine			
At 6% p.a. interest:	27,042	30,252	57,294
	(47.20%)	(52.80%)	(100%)
At 5% p.a. interest:	26,408	30,252	56,660
	(46.61%)	(53.39%)	(100%)
At 4% p.a. interest:	25,787	30,252	56,039
	(46.02%)	(53.98%)	(100%)
(B) Soda Ash Plant			
At 6% p.a. interest:	270,491	104,118	374,609
	(72.21%)	(27.79%)	(100%)
At 5% p.a. interest:	266,340	104,118	370,458
	(71.89%)	(28.11%)	(100%)
At 4% p.a. interest:	262,280	104,118	366,398
	(71.58%)	(28.42%)	(100%)
(C) Total (A + B)			
At 6% p.a. interest:	297,533	134,370	431,903
	(68.89%)	(31.11%)	(100%)
At 5% p.a. interest:	292,748	134,370	427,118
	(68.54%)	(31.46%)	(100%)
At 4% p.a. interest:	288,067	134,370	422,437
	(68.19%)	(31.81%)	(100%)

The capital requirements cited above are for the rock salt mine which is capable to produce 1.2 million t/y of rock salt by two shift operation and to produce 1.8 million t/y by three shift operation, and also for the soda ash plant which is to adopt a Full AC Process and to have the capacity of 400,000 t/y each of soda ash and ammonium chloride. With regard to the mining level of the rock salt mine, it was assumed to be 140 m below the ground surface. For a hypothetical case that a deeper layer, say 200 m below the ground surface, is mined in anticipation that a higher quality of rock salt can be produced, separate estimates of the capital requirements were made on the rock salt mine, as shown in Table VI-3.

1-2 INCREMENT IN CAPITAL REQUIREMENTS DUE TO DELAY IN COMMENCEMENT OF CONSTRUCTION

According to the construction schedule of the rock salt mine and the soda ash plant, it is assumed that operation of this project is to begin in July, 1985. It is anticipated that in the event of a delay in the commencement of construction, whatever the cause, there will be need for increased capital expenditure due to the influence of inflation.

It is herein presumed that the escalation of the foreign exchange cost will be 9% p.a., and that of the Thai currency cost will be 12% p.a., and moreover that the capital requirement is approximately US$430 million, which may be taken as being composed of 69% foreign exchange component and 31% Thai currency component. Under such circumstances, the following increment in the total capital requirements is to be expected in the event of a delay in the commencement of construction:

6 months delay:	approximately US$21.3 million increase (4.9%)
12 months delay:	approximately US$42.7 million increase (9.9%)

Table VI-3 ESTIMATED CAPITAL REQUIREMENTS

ROCK SALT MINE (Deep Mining *)

(US$000)

		Foreign	Local	Total
A.	Land Acquisition	0	970	970
B.	Site Preparation	0	53	53
C.	Facilities Direct Cost	10,932	9,664	20,596
D.	Railway Spur	829	1,347	2,176
E.	Housing Colony	0	2,017	2,017
F.	Construction Equipment	313	2,777	3,090
G.	Ocean Freight, Insurance & Local Handling	715	263	978
H.	Indirect Field Expenses	234	220	454
I.	Services	2,203	3,166	5,369
J.	Project Management	2,481	0	2,481
	Base Project Cost (B/D) (in Sept. End-1980 Prices)	17,707	20,477	38,184
K.	Physical Contingency (% of B/C)	924 (5.0%)	1,588 (7.6%)	2,512 (6.4%)
L.	Price Contingency (% of B/C)	6,047 (33.9%)	9,115 (45.7%)	15,162 (40.2%)
M.	Initial Working Capital (in Mid.-1985 Prices)	442	1,031	1,473
	Total Project Cost	25,120	32,211	57,331
N.	Interest During Construction			
	Interest Rate: 6%	3,855	0	3,855
	5%	3,177	0	3,177
	4%	2,513	0	2,513
	Total Financing Required			
	6%	28,975	32,211	61,186
	5%	28,297	32,211	60,508
	4%	27,633	32,211	59,844

(Note) * Assuming the case where Declining Shaft and Conveying Equipment are extended to the depth of 200 meters.

1-3 ASSUMPTIONS FOR CAPITAL COST ESTIMATE OF EACH COMPONENT

The breakdown of the projected capital requirements is given in Table VI-1 and VI-2, and the bases of estimation of each cost component shown in those tables are provided as the Attachment to Tables VI-1 and VI-2. Explained below are major assumptions taken for the estimation. (Reference is made to each item of cost component shown in those tables.)

1-3-1 Rock Salt Mine

(1) Construction of the mine

It is assumed that the construction of the mine, particularly shaft excavation and the mining facilities construction, will be commissioned to an experienced foreign contractor.

(2) Cost for land acquisition

Land requirements for the mine and related facilities comprise 159 ha. (994 Rai) of land. The land acquisition cost accounts for the costs for acquiring this area of land.

(3) Site preparation cost

The site preparation cost accounts for the costs for grading work of the town site. The scope of this work is limited to such an extent that a local contractor undertaking this job can proceed with execution of work prior to the award of contract for the mine construction, and does not include the work for construction of roads and drainage etc. located inside the boundary of the mine site.

It must be noted that this work should be controlled by the foreign contractor in order to insure the completion of the mine as scheduled.

(4) Facilities direct cost

In the facilities direct cost is included equipment and materials, spare parts, including materials and construction labor cost. It is presumed that all of this equipment and materials except the civil materials are provided. The estimated costs are FOB costs. It is assumed that an initial stock of spare parts needed for two years' operation will be procured at the initial stage. The estimated cost is 7% of the cost of the above-noted equipment and materials. Civil materials for local procurement are listed in the Attachment to Table VI-1. It is assumed that materials not available for procurement in Thailand will be imported.

(5) Construction equipment

It is assumed that crushing equipment for temporary use will be imported and used for crushing rock salt which is excavated during the construction of the mine, and after the completion of the mine this equipment will be sold to others at a price 30% less than the FOB purchase price. Regarding other construction equipment, it is assumed that procurement will be made by means of leasing from local sources.

(6) Ocean freight, marine insurance, and landing and inland transportation costs

It is assumed that unloading of heavy equipment will be done by using heavy-duty derrick cranes. Packing cost, stevedoring costs and other costs and expenses incurred for exports after delivery to export yards are separately estimated. The landing and inland transportation costs are estimated on the assumption that imported equipment and materials are landed at Sattahip port and transported to the mine by rail or roads. It is assumed that the foreign contractor will purchase marine insurance to cover all imported equipment and materials and the premium paid for that insurance will be reimbursed by the owner. The cost of marine insurance premium is estimated at the rate of 0.3% of C&F cost for imported equipment and materials, and is appropriated in the foreign exchange portion.

(7) Contingency

Refer to item (K, L) of the Attachment to Table VI-1.

(a) Physical contingency

The physical contingency is provided in order to cover any costs which may occur in excess of those estimated here due to such factors as the degree of precision of the conceptual design, meteorological conditions in the site area, soil conditions and other matters. The results of this estimate is shown in Table VI-1. It is noted that the physical contingency for the railway spur cost is the equivalent of 10% of the Base Cost in the foreign exchange portion, 9.7% of the Base Cost in the local exchange portion, and 9.8% of the total Base Cost of this item.

(b) Price contingency

Price contingency is that provision for price increases in the future due to inflation. The escalation rates used for the estimates are 9% per annum for the foreign exchange portion and 12% per annum for the local currency portion. The contingency was estimated on compound basis by using these rates and for the period from the time of estimation of the Base Project Cost (as of the end of September in 1980) up to the time of disbursement on each cost component. The results are shown in Table VI-1. It is noted in particular that the price contingency of the railway spur given as D in that table is the equivalent of 39.8% of the Base Cost in the foreign exchange portion, 53.7% of the Base Cost in the local currency portion, and 48.4% of the total Base Cost of this item.

(8) Interest during construction

Interest during construction is estimated on the following assumptions: (a) 70% of the total capital requirement will be financed through loans, (b) disbursement of loans will be made at 30% of the total loan amount in the first year, 40% in the second year and 30% in the third year, and (c) the interest rate (not yet determined) is 6–4% per annum.

(9) Railway spur cost

The railway spur cost accounts for the cost for construction of a railway spur of 5.7 km, including the costs for land acquisition and preparation of right-of-way. The breakdown of these costs is shown in the Attachment to Table VI-1.

(10) Other expenses

The owner's cost incurred for the development is not included in the estimates assuming that these costs will be covered by the royalty, but other costs are included as required.

1-3-2 Soda Ash Plant

(1) Cost for acquisition of land

Land requirements for the soda ash plant and its related facilities comprise 68 ha. (425 Rai) for the plant site and 19 ha. (121 Rai) for the housing colony. The cost for land acquisition was estimated on this basis.

(2) Site preparation cost

The following are the major assumptions taken for the estimation of site preparation cost:

1. Site preparation work would be commissioned to local contractors in accordance with a site preparation plan drawn by a foreign contractor, and

the local contractors undertaking this job would perform contracted work under the supervision of foreign supervisors.

2. The scope of site preparation work to be contracted to the local contractors would be limited to such an extent that they can proceed with execution of work prior to the basic design and engineering (especially the layout of facilities) of the soda ash plant which should be furnished by the general contractor undertaking the design and construction of the plant.

In short, the work included for the estimation of site preparation cost consists of excavation, filling and compacting, grading, the protection of slopes, and forming a drainage ditch around the plant site. Construction of roads and drainage ditch located inside the boundary of the plant site is excluded from this work.

It must be noted, however, that in the event that the site preparation work, as is assumed above, is performed by local contractors, the schedule of their work should be controlled by the general contractor in order to insure the completion of the plant as scheduled, because of the importance of the site preparation work, and the starting date of other construction activities.

(3) Plant direct cost

(a) Plant equipment and materials

Included in this cost component is the equipment and materials except civil and building materials for plant facilities. It is presumed that all of this equipment and materials be met by imports. The estimated costs denote FOB costs.

(b) Spare parts

It is assumed that an initial stock of spare parts needed for operation for two years will be procured at the same time as the plant equipment. On the basis of this assumption, the cost for spare parts to be procured initially is estimated at 3% of the cost of (a) above.

(c) Civil materials

Items of materials for local procurement are listed in the Attachment to Table VI-2. It is assumed here that materials which are not available for local procurement in Thailand will be met by imports.

(d) Construction labor

The costs of this component include only those for local labor. The costs for foreign supervisors are included in the cost component given as item H, "Services" in Table VI-2.

Work volume of local construction workers, including equipment operators, is estimated at 930,000 man-days (at 8 working hours per day) in total, and their costs are estimated at the average rate of US$15 per man-day (B308) including provisions for overtime pay, meals, transportation between work camp and site, lodgings, severance pay, bonus, etc.

(4) Construction equipment

For the estimation of construction equipment costs, there are two alternative methods to be used, as follows.

One method is that of cost estimation on a "Procurement Basis" in which it is assumed that all construction equipment required will be satisfied with the equipment purchased by the contractor at the expenses of plant owners, and this equipment being the owners' property will be retained at the site even after completion of the construction work.

The second method is that of cost estimation on a "Lease Basis" in which it is assumed that all the construction equipment required will be leased by the contractor and will be returned to the leasing company after the construction work.

In the case of the former, the construction equipment costs account for the costs for acquisition of new construction equipment, whereas in the latter the construction equipment costs account for compensation or lease charges for this equipment calculated for the period of using the leased equipment.

The following alternatives for procurement were deemed to be the procurement on the Lease Basis.

1. The contractor is to bring his own construction equipment into the site for use.

2. The contractor will lease equipment.

3. The contractor or the plant owner will purchase new construction equipment, and they will sell this equipment to others after use.

A list of construction equipment needed for construction of the plant is given in item F of the Attachment to Table VI-2, where the equipment to be costed in the foreign exchange portion is distinguished from that to be costed in the local currency portion.

The construction equipment costed in the local currency portion consists mainly of that to be used for civil work. Some of this equipment is to be locally fabricated in Thailand and can be procured with local currency.

As for the equipment not available in Thailand, it is assumed that the local contractors who undertake the civil work for the plant would possibly purchase imported equipment, and, after completion of the construction work, would either use the equipment for other projects or otherwise would sell it as used construction equipment to other local contractors, because there exists large demand for such equipment in Thailand. On this presumption such costs are appropriated in the local currency portion.

The construction equipment of which the cost for use is appropriated in the foreign exchange portion consists of the equipment needed for inland transportation to the site and erection of heavy equipment. This construction equipment is not fabricated in Thailand. Nor could this equipment be expected to be owned by local contractors, because the cost of the equipment seems to be beyond the financial capacity of local contractors for purchasing and, moreover, it is unlikely that there exists demand for it in Thailand.

The costs appropriated in the foreign exchange portion are estimated by means of subtracting the anticipated resale prices from the purchase price of new construction equipment, whereas the costs appropriated in the local currency portion are estimated by means of calculating lease charges based on prevailing lease prices and the anticipated period of use of the leased equipment.

The resale price must be determined separately for each piece of equipment, because the depreciation and charges for use may vary from one to another, depending on the life of equipment and period of its actual use.

However, as an average, the cost for using the construction equipment to be paid by the project owner was estimated at about 45% of the price of new equipment. For the estimation of resale price of construction equipment which was appropriated in the foreign exchange portion, the expenses for reexport after use as well as ocean freight to the origin countries are subtracted from the resale price as estimated in the above manner.

(5) Ocean freight, marine insurance, and local handling costs (in end-September 1980 price)

(a) Ocean freight

The weight of the plant equipment and materials needed to build the plant is estimated at about 100,000 freight tons in total, and that includes many pieces of heavy equipment. In view of this fact, for the estimation of freight charges, it is assumed that chartered vessels having heavy-duty derrick cranes will be used for sea transportation of the equipment and materials. This estimate uses a freight rate of US$90.9 per freight ton in average. Packing costs, stevedoring costs and other costs and expenses incurred for exports after delivery to export yards are separately estimated.

(b) Landing and inland transportation cost

It is presumed that the equipment and materials for construction of the plant will be landed at Sattahip Port and transported to the plant site by roads, because it is anticipated that the Laem Chabang Deep Sea Port will not be completed in time for use.

The cost of this portion is estimated as US$75 per freight ton for heavy cargoes and US$50 per freight ton for other items of cargoes.

(c) Marine insurance

It is assumed that the general contractor will purchase marine insurance to cover all imported equipment and materials for the plant, and the premium paid for that insurance will be reimbursed by the plant owner.

The cost of marine insurance premium is estimated at the rate of 0.3% of C & F cost for imported equipment and materials, and is appropriated in the foreign exchange portion.

(6) Contingencies

For the rates used for estimation of the cost contingency, refer to items (K, L) and (L, M) of the Attachment to Table VI-2.

(a) Physical contingency

The physical contingency is provided in order to cover any costs which may occur in excess of those estimated here; this additional cost, which is unforeseeable at present, may arise from such factors as the degree of precision of the conceptual design, meteorological conditions in the site area, soil conditions and other matters encountered at the time of construction. The contingency rates were estimated individually for each cost item. The physical contingency thus estimated by means of applying the contingency rates, as is shown in Table VI-2, is the equivalent of 8.3% of the Base Project Cost in the foreign exchange portion, 7.0% of the Base Project Cost in the local currency portion, and 8.0% of the total amount of Base Project Cost. It is noted that the total contingency rates for the rail spur cost shown in item D of Table VI-2 is the equivalent of 10% of the Base Cost in the foreign exchange portion, 9.5% of the Base Cost in the local currency portion, and 9.8% of the total Base Cost in this item.

(b) Price contingency

Cost increases due to inflation are anticipated in the future. The rate of escalation (A) is estimated at 9% per annum for the costs of the foreign exchange portion and 12% per annum for the costs of the local currency portion, which are annual compound rates, and the period (B) from the time of estimation of the Base Project Cost (as of the end of September, 1980) up to the time of disbursement was projected on each cost component. The amount of price contingency is estimated by accumulating the amount of escalation on each cost component which is calculated by applying the formula of (A) x (B) in compound. The thus-estimated price contingency, as is shown in Table VI-2, is the equivalent of 31.2% of the Base Project Cost in the foreign exchange portion, 42.9% of the Base Project Cost in the local currency portion, and 34.3% of the Base Project Cost in total. It is noted here that the price contingency for the rail spur given as D in Table VI-2 is the equivalent of 39.7% of the Base Cost in the foreign exchange portion, 53.4% of the Base Cost in the local currency portion and 47% of the total Base Cost of this item.

(7) Interest during construction

Interest during construction is estimated on the following assumption: (a) 70% of the total capital requirements will be financed through loans, (b) disbursement of loans will be made at 30% of the total loan amount in the first year, 40% in the second year, and 30% in the third year, and (c) the interest rate (not yet determined) is 6–4% per annum.

(8) Railway spur

The railway spur cost accounts for the cost for construction of a railway spur of 3.2km, including the costs for land acquisition and preparation of right-of-way. The breakdown of these costs is shown in the Attachment to Table VI-2.

(9) Housing colony

The costs for housing facilities to be constructed for purposes of accommodating the plants employees are estimated separately from those for offsite facilities. Assuming that utilities for the housing colony and related facilities will be supplied by the authorities, such costs are excluded from the estimates.

CHAPTER 2 FINANCING PLAN

As was agreed at the ASEAN Economic Ministers Meeting, of the capital requirements for the Project, 30% would be financed from the equity capital of the joint venture company which is to be established and the remaining 70% would be financed through long-term loans. It has already been decided that the ownership of the company would be in the following ratios, and that the company's shares would be paid up in U.S. dollars:

Thailand	60%
Indonesia	13%
Malaysia	13%
Philippines	13%
Singapore	10%

About 70% of the capital requirements is projected for foreign exchange requirements and the remaining portion is projected for local currency requirements. Therefore, it is anticipated that loans would be sufficient to cover the requirements of foreign exchange funds.

At the present time, since the source of financing for this Project has not yet been determined, the terms and conditions necessarily are not known. When Thailand submitted a proposal for this project to the ASEAN Economic Ministers, the terms and conditions used as the basis of financial planning were the interest rate on loans of 5% p.a., and repayment in 15 years (including a three-year grace period). The same terms and conditions were used for this study, with the additional use of interest rates of 6% p.a. and 4% p.a.

The schedule for disbursement, as mentioned in the item on interest during construction in the preceding chapter of this Part, has been assumed to be as follows:

First year	30%
Second year	40%
Third year	30%
Total	100%

EXPLANATORY NOTES

ON

THE CAPITAL COST ESTIMATE

ROCK SALT MINE

A. Land Acquisition

Mine Site and Town Site

(1)	Area:	159 ha (994 Rai)
(2)	Cost:	20,000 Baht/Rai

B. Site Preparation

1. Design Basis [1]

(1)	Area to be improved	66,770 m^2
(2)	Soil excavation	28,000 m^3
(3)	Soil filling and compaction	28,000 m^3
(4)	Soil disposal	0 m^3

2. Scope of the Site Preparation Works

Grading of the Town Site [2]

3. Estimated Construction Cost

(End Sept. -1980 Price: US$1,000)

a)	Materials [1]	48,000
b)	Labor [2]	5,000

1) Construction Equipment (lease base), fuel and lube oil and consumables.

2) Laborers and operators: 490 man-days

(Note) 1), 2) Details are stated in Part III, 5-1-1.

C. Facilities Direct Cost

(a) Equipment and Materials

Facilities equipment and materials include the following items:

Crushing and Screening Equipment [1]

Grizzly, primary and secondary screen, impeller-breaker.

Conveying and loading equipment [1]

Hopper, belt feeder, belt conveyor.

Mining Equipment [2]

Undercutter, excavation; jumbo, small crusher for scaling and others.

Maintenance and Service Equipment [3]

Motor grader, vibrating roller, welding machine and others.

Electric Equipment

Transformer, power distribution, switchgear and others.

Electric Equipment

Transformer, power distribution, switchgear and others.

Communication System

(Note)
1) Refer to Table III-7
2) Refer to Table III-5
3) Refer to Table III-6

(b) Spare Parts

7% of the equipment and materials cost is allowed for two years supply of spare parts.

(c) Civil Materials include materials for:

Civil materials include materials for site improvement, road pavement, foundations, drainages, concrete structures, steel structures, architectural buildings.

Main items to be locally produced:

Cement, river sand, aggregate, crusher run, crushed stone, asphalt, primer, timber, brick, plywood, reinforced concrete pile, precast concrete pipe, earthenware pipe, rubble stone, gasoline, fuel oil, kerosene.

(d) Construction Labor

- Unit labor cost
  US$10.2/man-day
- Man-hour requirements:

	Man-day	Man-hour
Mine Site	70,000	0.56 million
Town Site except for Housing	60,800	0.49 million
Underground and Equipment Installation	13,000	0.10 million

D. Railway Spur

(US$ 1,000)

		Foreign	Local	Total
1.	Land Acquisition (30,000 Bahts/Rai x 33.4 Rai or 5.4 ha)	0	49 [1)]	49
2.	Facilities Direct Cost	717	697	1,414 [2)]
	(1) Materials [1)]			
	(2) Construction Labor [2)]	0	296	296 [3)]
	Facilities Direct Cost Total	717	993	1,710
3.	Construction Equipment	0	263	263
4.	Ocean Freight Insurance & Local Handling [3)]	112	42	154 [4)]
	Total	829	1,347	2,176

1) – Materials to be imported: Rail, fish plate, tie plate, turnout and others

– Materials locally available: Sleeper, ballast and others

2) – Man-hour requirements
34,800 man-days

– Average labor wage (Sept. End-1980)
US$8.5/man-day (= Baht 174/man-day)

3) – Total freight tons: 798 t

– Average cost: US$196 t

E. Housing Colony

	(US$1,000)
Materials	1,412
Labor (US$10.2/man-day x 59,300 man-day)	605
Total	2,017

F. Construction Equipment

Foreign Portion	(US$ 1,000)
Temporary Crushing Equipment	313
Local Portion	
(1) Equipment Lease for Decline Shaft	2,099
(2) Equipment Lease for Excavation for Plant	772
(3) Used Temporary Crushing Equipment	△ 94
Total	2,777

G. Ocean Freight, Insurance & Local Handling

(1) Total freight tons of imported materials	4,990 t
(2) Average Cost	US$196 /t

H. Indirect Field Expenses [1]

(a) Temporary field buildings [2]
(b) Temporary houses for expatriates
(c) Temporary houses for local laborers
(d) Utility supply facilities for the camps [3]
(e) Construction supplies [4]
(f) Field office expenses
(g) Insurance [5] and miscellaneous

(Notes) 1) Expenses incurred during the plant construction period at the construction site.
Expenses for the site preparation work are separately estimated in item B of this attachment.
2) Administration offices and workshops.
3) Includes drinking water & power supply facilities.
4) Fuel & lubricant oil for the construction equipment, tools for safety and miscellaneous consumables.
5) Insurance on construction works.

I. Services

Foreign portion

(1)	Engineering Fee		US$ 605,000
(2)	General Contractor's expatriates (US$82/man-day)		
	i) Decline Shaft	(13,400 man-days)	US$ 1,099,000
	ii) Excavation for Plant	(6,090 man-days)	US$ 499,000

Local portion US$ 3,166,000

(1) Local Contractor's Supervision

(2) Local Staff Supervision

J. Project Management

1. Technical Advisor for Implementation Stage
   Unit cost: US$ 9,740/man-month
   Required man-months: 3 men x 36 months = 108 man-month
2. Production Management
   Unit cost: US$ 7,440/man-month
   Required man-months: 4 men x 48 months = 192 man-month

The above capital cost estimate is based upon a mine with the decline shaft to the depth of 160 m under the surface. Capital cost of an alternative, in which the decline shaft and the conveying equipment are extended to the depth of 200 m under the ground surface is stated in Table VI-3.

SODA ASH PLANT

A. Land Acquisition

1. Plant Site

   (1) Area: 68 ha (425 Rai)
   (2) Cost: 50,000 Baht/Rai

2. Housing Colony

(1) Area: 19.3 ha (121 Rai)
(2) Cost: 20,000 Baht/Rai

B. Site Preparation

1. Design Basis

(1)	Plant site area	136 ha
(2)	Area to be improved	51 ha
(3)	Finished grade	5 m above Mean Sea Level
(4)	Soil excavation	831×10^3 m^3
(5)	Soil filling and compaction:	598×10^3 m^3
(6)	Soil disposal	66×10^3 m^3

2. Scope of the Site Preparation Works

(1) Clearing and grubbing
(2) Soil excavation
(3) Soil filling and compaction
(4) Slope protection
(5) Drainage on the slope

3. Estimated Construction Cost [1)]

(Mid-1980 US$1,000)

		Components	
		Foreign	Local
a)	Civil materials	0	2
b)	Construction labor [2)]	0	644
c)	Construction equipment [3)]	0	2,921
	Total	0	3,567

Notes: 1) Field expenses are included. Services are included in Section H, Services, below
2) Laborers and operators: 45,000 man-days
3) See Section E, Construction Equipment, below.

C. Plant Direct Cost

(a) Plant Equipment and Materials

Plant Equipment includes the following items;

Dryers, heat exchangers, reactors, towers, drums & tanks, pumps with drivers, compressors with drivers, special equipment & machines, utility equipment, transportation & conveying equipment, fire & safety equipment.

Plant Materials include following items;

Piping, electrical instruments, insulation, painting.

(b) Spare Parts

3% of the plant equipment and materials cost is allowed for two years supply of spare parts.

(c) Civil Materials include materials for:

Piling, site improvement, road pavement, foundations, drainages, concrete structures, steel structures, architectural buildings.

Main items to be locally procured:

Cement, river sand, aggregate, crusher run, crushed stone, asphalt, primer, timber, brick, plywood, precast concrete pipe, reinforced concrete pipe, earthenware pipe, rubble stone, gasoline, fuel oil, kerosene.

(d) Construction Labor

- Unit labor cost comprises the basic salary, overtime, leave, and allowances (meal, medical, retirement pay, etc.) at the end of September, 1980 in the Laem Chabang.

Grade [1]		Baht/day [2]	US$/day
A	General foreman	520	25.4
B	Foreman	416	20.3
C	Heavy machine operator	390	19.0
D	Office clerk, accountant, typist	364	17.8
E	Skilled laborers: Carpenter, bar bender, rigger, plaster, mechanic, driver, welder, electrician, plumber, mason, painter	325	15.9
	Office boy, cook (female)		
F	House boy	182	8.9
G	Unskilled laborers	156	7.6
H	At 8 hours per working day	78	3.8

– Man-hour requirements (See item B, as to man-hours required for the site preparation work)

	Man-days	Man-hours
Civil work	500,000	4.0 million
Erection work	430,000	3.44 million
Total	930,000	7.44 million

– Average labor wage (Sept. End-1980)

US$13,500,000/930,000 man-days = US$15/man-day
(= Baht308/man-day)

D. Railway Spur

		Foreign	Local	Total
1.	Land Acquisition (30,000 Baht/Rai x 23.8 Rai or 3.8 ha)	0	35	35
2.	Facilities Direct Cost			
	(1) Materials [1]	546	392	938
	(2) Construction Labor [2]	0	149	149
	Facilities Direct Cost Total	546	541	1,087
3.	Construction Equipment	0	193	193
4.	Ocean Freight, Insurance & Local Handling [3]	87	32	119
	Total	633	801	1,434

1) – Materials to be imported: Rail, fish plate, tie plate, turnout and others.

– Materials locally available: Sleeper, ballast and others.

2) – Man-hour requirements

17,500 man-days (= 0.14 million man-hour)

– Average labor wage (Sept. End-1980)

US$8.5/man-day (= Baht 174/man-day)

3) – Total freight tons: 602 t

– Average cost: US$196/t

E. Housing Colony

(1) Number of housing units

Type A	5
Type B	15
Type C	100
Type D	130
Type E	110
Total	360 houses

(2) Total cost [1] (Materials and labor cost)

US$ 10,804,000

(3) Land acquisition cost (US$118,000) is included in Section A, Land Acquisition.

F. Construction Equipment [1]

(a) Main Construction Equipment List

(Imported from overseas) [2]		(Locally available) [3]	
Erection & Transportation [4]		Civil Works [5]	
Truck crane (45–180 ton)	4	Bulldozer (BD-2, D-6 D-7, D-8)	12
Hydraulic crane (20 ton, 35 ton)	7	Pay loader (2.1 M^3, 3.1 M^3)	7
Trailer truck (30 ton)	2	Dump truck (11 ton)	26
		Compactor (BW-210)	2
		Back hoe (0.6 M^3)	2
Common Use			
Hydraulic crane (15-35 ton)	5	Erection & Transportation	
Air compressor (100 PS)	3	Trailer truck (200 ton)	1
Engine generator (125 KVA)	2		
Welder (400A)	2		
Welder (300A)	5		
Truck (4 ton, 8 ton)	8		

(b) Common and Miscellaneous Use [6]

Welder, compressor, pump, belt conveyor and others	1 set
Tools for repairing	1 set
Miscellaneous equipment and machines	1 set

(Notes) Assumptions and bases used for the cost estimate

1) All the equipment is estimated on a rental or lease basis.
2) Shall be re-exported to overseas after the completion of erection.
3) Shall be removed by local contractors or equipment suppliers after the completion of erection.
4) A part of the equipment shall be kept at the plant for the plant maintenance even after the completion of erection.

5) Includes equipment for the site preparation use (item B) and for the plant civil works. Most of the site preparation works shall be undertaken using locally available equipment.

6) Assumed that some of equipment shall be locally available.

G. Ocean Freight, Insurance & Local Handling

(1) Total freight ton:	99,400 Ft.
(2) Ocean freight, local handling and marine insurance:	US$19,492,000
(3) Average cost:	US$196/Ft.

H. Indirect Field Expenses [1)]

(a) Temporary field buildings [2)]
(b) Temporary houses for expatriates
(c) Temporary houses for local laborers
(d) Utilities supply facilities for the camps [3)]
(e) Construction supplies [4)]
(f) Field office expenses
(g) Insurance [5)] and miscellaneous

E. Services

(a) General contractor's Fee
- License and know-how fee
- Basic design fee
- Detail engineering fee
- Procurement services
- Inspection
- Documentation services
- Provision for bonus

(Notes) 1) Expenses incurred during the plant construction period at the construction site.
Expenses for the site preparation work are separately estimated in item B of this attachment.
2) Administration offices and workshops
3) Includes drinking water & power supply facilities.
4) Fuel & lubricant oil for the construction equipment, tools for safety and miscellaneous consumables.
5) Insurance on construction works.

(b) Expatriates and Supervision
   - General contractor's expatriates (construction & start-up)
   - Vendor's servicemen
   - Local staff supervision

I. Project Management

(a) Technical Advisor (Implementation stage)
(b) Management Contractor (Operation advisor)
(c) Marketing Advisor

(K., L.) CONTINGENCY SCHEDULE (PHYSICAL & PRICE)

ROCK SALT MINE

(Unit: %)

	Physical Contingency		Price Contingency to Mid. 1985			Combined Contingency	
	(Foreign)	(Local)	Months to Expend Date	(Foreign)	(Local)	(Foreign)	(Local)
A. Land Acquisition	–	–	18	–	23.3	–	23.3
B. Site Preparation	–	5	32	–	35.3	–	42.1
C. Facilities Direct Cost							
(a) Equipment & Materials	5	5	41	34.2	47.3	40.9	54.7
(b) Spare Parts	5	5	41	34.2	–	40.9	–
(c) Civil Materials	10	10	F 39 / L 33	32.3	36.6	45.5	50.3
(d) Construction Labor	10	10	43	36.2	50.1	49.8	65.1
D. Housing Colony	7.5	7.5	38	38.2	43.2	48.6	53.9
E. Construction Equipment	10	10	33	26.7	36.6	39.4	40.3
F. Ocean Freight, Insurance Local Handling	10	10	35	28.6	39.2	41.5	53.1
G. Indirect Field Expenses	10	10	30	24.0	32.8	36.4	46.1
H. Services	5	5	42	35.2	48.7	42.0	56.1
I. Project Management	0	0	52	23.5	23.5	23.5	23.5

(Remarks) : Price Contingency (Escalation in compound rate)

– Foreign exchange; 9% per annum
– Local currency; 12% per annum

(L., M.) CONTINGENCY SCHEDULE (PHYSICAL & PRICE)

SODA ASH PLANT

(Unit: %)

	Physical Contingency		Price Contingency to Mid. 1985			Combined Contingency	
	(Foreign)	(Local)	Months to Expend Date	(Foreign)	(Local)	(Foreign)	(Local)
A. Land Acquisition	–	–	18	–	23.3	–	23.3
B. Site Preparation	–	–	31	–	34.0	–	40.7
C. Plant Direct Cost							
(a) Plant Equipment & Materials	10	10	35	28.6	39.2	41.2	53.1
(b) Spare Parts	10	–	35	28.6	–	41.5	–
(c) Civil Materials	5	5	35	28.6	39.2	35.0	46.2
(d) Construction Labor	–	10	45	–	53.0	–	68.3
D. Housing Colony	7.5	7.5	38	38.2	43.2	48.6	53.9
E. Construction Equipment	10	10	24	18.8	25.4	30.7	37.9
F. Ocean Freight, Insurance & Local Handling	10	10	30	24.0	32.8	36.4	46.1
G. Indirect Field Expenses	10	10	24	18.8	25.4	30.7	37.9
H. Services	5	5	40	33.3	45.9	40.0	53.2
I. Project Management	0	0	52	23.5	23.5	23.5	23.5
J. Pre-Operation Expenses	0	0	52	34.1	34.1	34.1	34.1

(Remarks) : Price Contingency (Escalation in compound rate)

– Foreign exchange; 9% per annum

– Local currency; 12% per annum

(D., D.) CONTINGENCY SCHEDULE (PHYSICAL & PRICE)

SIDING

(Unit: %)

			Physical Contingency		Price Contingency to Mid. 1985			Combined Contingency	
			(Foreign)	(Local)	Months to Expend Date	(Foreign)	(Local)	(Foreign)	(Local)
A.	Land Acquisition		–	–	18	–	23.3	–	23.3
B.	Facilities Direct Cost								
	(a) Equipment & Materials	Locomotive & Covered Cars	0	0	45	38.2	53.0	38.2	53.0
		Rails, Signal, etc.	10	10	44	37.2	51.5	50.9	66.7
	(b) Spare Parts		5	5	45	38.2	53.0	45.1	60.7
	(c) Civil Materials		10	10	42	35.2	48.7	48.7	63.6
	(d) Construction Labor		–	10	42	35.2	48.7	–	63.6
C.	Construction Equipment		10	10	42	35.2	48.7	48.7	63.6
D.	Ocean Freight, Insurance & Local Handling		10	10	36	29.5	40.5	42.5	54.6

(Remarks) : Price Contingency (Escalation in compound rate)

– Foreign exchange; 9% per annum
– Local currency: 12% per annum