7.2 Strategic Plan

7.2.1 Framework of Target Populations

(1) Calculation Procedure

The target populations for the years of 1987 and 2000 are anticipated on the basis of the calculation procedure as shown in Fig. 7.2-1.

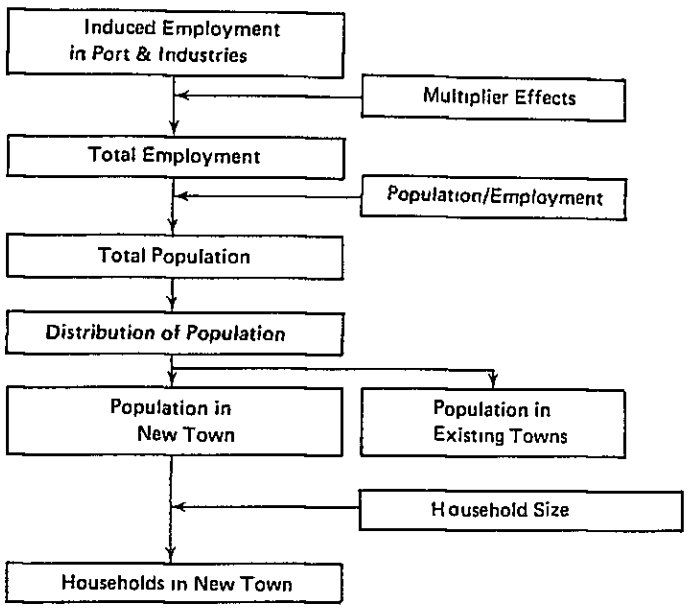


Fig. 7.2-1 Calculation Procedure of Population

In this study, calculation is based on the number of induced employment in Port and Industrial Complex. The basic employment induced by the industries and port operation is directly derived from the Industrial and Port Planning as described in previous chapters. In addition to this, certain secondary employment is inevitably generated from forward and backward linked activities required for human settlement. The secondary employment attributable to this is collectively defined as multiplier effects. From the calculation above, a total number of employment can be obtained.

The total population can be obtained by assuming the ratio of population/employment based on the data available. Then the population is distributed among the New Town and the existing nearby towns with due consideration given to the directions of the future development in the existing towns described in the Basic Policy in the previous paragraph. The number of households in the New Town is obtained by dividing its population by the future household size.

(2) Premises for Population Estimates

The population estimates were based on the following premises:

(a) The number of employees is obtained from the following:

(i) Heavy Industries: from Industrial Planning

(ii) Port: from Port Planning

(iii) Downstream Industries: 20% of Heavy Industries (1st Phase and 2nd Phase)

(iv) Supporting Industries: Assumed by Team based on this study

(b) The following figures are used for multiplier effects.

(i) Multiplier effects set out by ESS

– Heavy Industries including steel & port	0.6
– Downstream Industries	1.0
– Supporting Industries	0.75

(ii) Multiplier effects by construction for development

The number of employment by these effects has been considered 3,000 for 1st Phase and additional 3,000 for 2nd Phase. Construction workers have not been taken into account.

(c) The following figures set out by ESS are used for household size:

– 4.2 persons for 1st Phase

– 4.1 persons for Master Plan

Although natural growth of migrants at the 1st Pahse is to be made during the Master Plan the household size described above is assumed to absorb this growth.

(d) Population/employment is assumed as 2.5 based on the data on the Report of Labor Force Survey (National Statistical Office).

(3) Concepts of Distribution of Population to the Existing Towns

The total population calculated in (2) above has been distributed to the surrounding towns. i.e. Ban Chang, Map Ta Phut, Rayong, etc. based on the following consideration:

(a) Ban Chang Town

Urban fabric including commercial facilities and educational facilities has comparatively been accumulated in Ban Chang, where some parts of these facilities are not in full use at present after withdrawal of American forces. In this study, based on the intentional assumptions made by the Thai side that Ban Chang town should be reactivated through this industrial development, a large number of people have been distributed to this town mainly at the 1st Phase, so that these facilities in pause can be used as efficiently as possible. This will also contribute to elimination of the investment costs for necessary urban facilities in the New Town.

A scale of the distribution of the population to Ban Chang has been determined based on its accommodation capacity estimated from the existing urban fabric and facilities The following show some details of the existing facilities in Ban Chang:

(i) School

There are 6 primary schools and 1 secondary school in Ban Chang. By estimating the

capacity of pupils from the number of classes, the accommodation capacity is presumed as described in Table 7.2-1.

Table 7.2-1 Estimated Accommodation Capacity of Schools in Ban Chang

Level	Number of Classes	Capacity of Pupils	Population
Primary School	78	3,900	27,900
Secondary School	23	1,150	16,400

(ii) Commercial Facilities

There are about 240 stores in Ban Chang, and the shopping area is estimated about 3.5 ha according to a 1/25000 scale map. Accommodation capacity is estimated from the number of stores as follows:

$$P = \frac{240 \text{ (stores)} \times 48 \text{ (m}^2\text{/store)}}{0.36 \text{ (m}^2\text{/person)}} = 32{,}000 \text{ (persons)}$$

where, 48 m^2/store: standard size of store in Thailand
0.36 m^2/person: the area of store per population in urban area

(iii) Houses

There are 2,300 houses in Ban Chang at present.

Assuming that the house hold size is 6 persons/house, the accommodation capacity is estimated as follows:

P = 2,300(houses) x 6(persons/house) = 13,800(persons)

Since there are 14,357 dwellers (1981) in Ban Chang, it can be said that there is no empty house.

(iv) Hospital

There exist 3 hospitals in Ban Chang as shown in the table below. Ban Chang Hospital is a district hospital with 30 beds which can serve some increased population, although the number of beds is not directly related to the accommodation capacity.

Table 7.2-2 Hospitals in Ban Chang

Name of Hospital	Area (rai)
Ban Chang Hospital	19
Ban Chang Hospital (Private)	–
Ban Chang Local Public Health Center	2

(v) Water Supply

According to the information by Town and Country Planning, water supply system in Ban Chang is as shown in Fig. 7.2-2 below. Consequently sufficient water supply is not schemed.

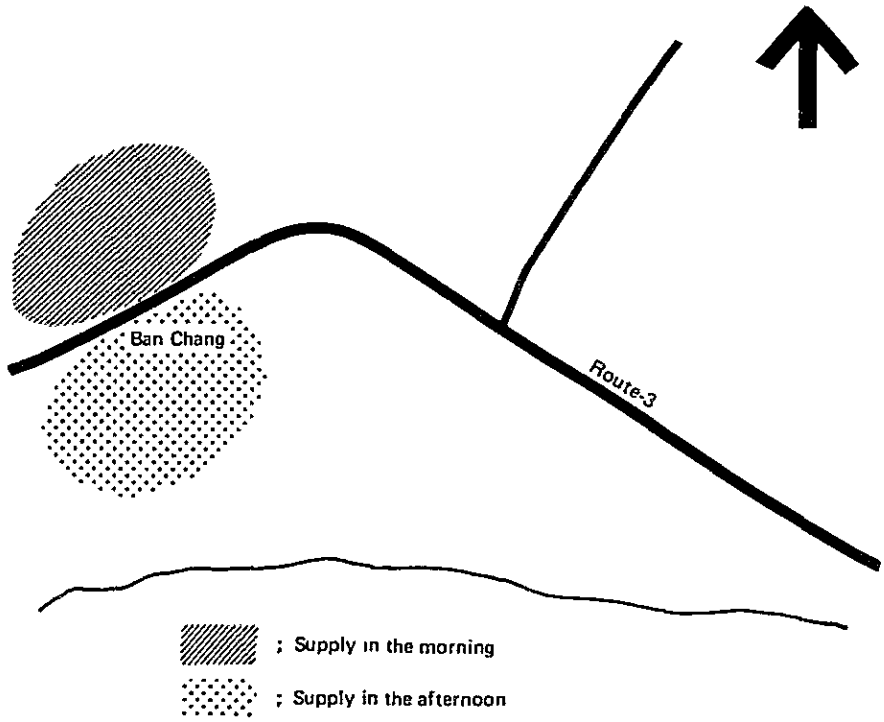


Fig. 7.2-2 Water Supply in Ban Chang

Based on the studies on the existing arrangements of the urban facilities in Ban Chang as described above, the following can be concluded:

The arrangements of such basic urban facilities as water supply and housing are insufficient at present. Furthermore, roads, sewerage systems, stormwater drainage systems, electricity, telecommunications, etc. should be improved. From this viewpoint, it will be difficult to say that the town will have more accommodation capacity than it has at present.

On the other hand, commercial facilities have been highly accumulated and can afford to serve for about 32,000 persons. Referring to the intention given by the Thai side that Ban Chang town be reactivated through full use of the existing commercial facilities, the target population in Ban Chang has been estimated at around 32,000.

In order to avoid adverse effects due to sudden increase in population, the population at the 1st Phase is set up at 22,000.

(b) Map Ta Phut

Map Ta Phut town, the nearest built-up area for urbanization in small scale, lies on the leeward of the proposed Industrial Complex where some environmental problems may occur. According to the recent information, land speculation which makes urban development difficult is often seen in the surrounding area of the town. In these circumstances, the principle has been established that sudden inducement of migrants in this town should be avoided, although it is considered impossible to thoroughly freeze the growth of population. Therefore, based on the discussions with the Town and Country Planning, the population increase in Map Ta Phut was anticipated to be 3,000 at the 1st Phase and additional 1,000 at the 2nd Phase.

(c) Rayong and Other Towns

The other towns including Rayong Municipality, which are rather far distant from the planning area compared with Ban Chang and Map Ta Phut, are considered to have less repercussion effects of the industrial development than the two towns. Therefore, the populations of 1,600 at the 1st Phase and additional 1,000 at the 2nd Phase were distributed to these towns.

(d) New Town

The workers who will be induced by the industrial development usually wish to live in the palce near the Industrial Complex where commuting is convenient for them and where urban fabric necessary for daily life is complete. The place should be provided with comfortable residential environment and amenities with sufficient infrastructures and urban facilities. With this consideration, all the employees and their families are anticipated to live in the New Town. In addition, the migrants by multiplier effects, who will be engaged in service industries such as stores, schools, etc. will be induced in the New Town for serving the inhabitants.

At the 1st Phase, the number of such migrants will be such that the inhabitants can live their daily lives without hindrance. Thus, the investment on the urban infrastructures can be reduced to the minimum. At the 2nd Phase, with the increase of industrial workers, more accommodation capacity will be needed.

The existing town of Ban Chang will not be able to accommodate excessive population as previously described. Therefore, most of the migrants induced by the multiplier effects as well as all the industrial workers with their dependents will live in the New Town, which is expected to play an important role as a hub in this area covering Ban Chang and Map Ta Phut.

(4) Framework of Target Population

Based on the calculation procedure, the premises for population estimates and the concept of population distribution as described above, the framework of the target populations for Short Term Plan and Master Plan was set up as follows:

Table 7.2-3 Number of Employment

	Short Term Plan	Master Plan
Heavy Industries		
Soda Ash	840	1,410
Petrochemical	1,550	2,600
Fertilizer	1,050	1,800
Steel	–	7,010
Port	500	1,000
Downstream Industries	–	2,560
Supporting Industries	1,500	1,500
Induced Industries Sub-total	5,440	17,880
Multiplier Effects	6,490	17,980
Total	11,930	35,860

Table 7.2-4 Population

		Short Term Plan	Master Plan
Induced Industries	Employees	5,440	17,880
	Population	13,600	44,700
Multiplier Effects	Employees	6,490	17,980
	Population	16,230	44,950
Total	Employees	11,930	35,860
	Population	29,830	89,650

Table 7.2-5 Anticipated Population in Each Area for Short Term Plan and Master Plan

Short Term Plan

	New Town	Ban Chang	Map Ta Phut	Rayong, etc.
Existing Residents (1981) + Natural Growth (until 1987)	–	15,500**	7,800**	–
Population by Induced Industries	13,600	–	–	–
Population by Multiplier Effects	4,700	6,900	3,000	1,630
Total	18,300	22,400	10,800	–

Master Plan

	New Town	Ban Chang	Map Ta Phut	Rayong, etc.
Existing Residents (1981) + Natural Growth (until 2000)	–	20,000*	10,750**	–
Population by Induced Industries	44,700	–	–	–
Population by Multiplier Effects	26,800	11,500	4,050	2,600
Total	71,500	31,500	14,800	–

* Based on the data given by the Town and Country Planning, including natural growth. 14,357 residents (1981) in Ban Chang.

** Based on ESS, including natural growth. 7,400 residents (1981) in Map Ta Phut.

Table 7.2-6 Households in New Town

	Population	No. of Households
1st Phase	18,300	4,360
Master Plan	71,500	17,340

7.2.2 Development Strategy

(1) New Town Development Strategy

(a) Establishment of Development Area

Based on the result of site selection, New Town area is established as shown in Fig. 7.2-3. The size of the New Town has a close relationship with the employment opportunity induced by industrial development and has to be established taking the relationships with the adjacent existing towns into consideration. The area, occupying some 575 ha (3,600 rai) of land, is bordered north by the transmission line. The southern boundary is set about 1 km north to the proposed bypass. The western boundary lies about 1,400 m apart from the easternmost boundary of the military security zone. The eastern boundary is set about 1,400 m west to the gas pipeline, whose eastern part is developed as Industrial Complex. This location is to secure the amenity of New Town, to exclude the land owned by Social Welfare Department and to avoid including upper-stream catchment area.

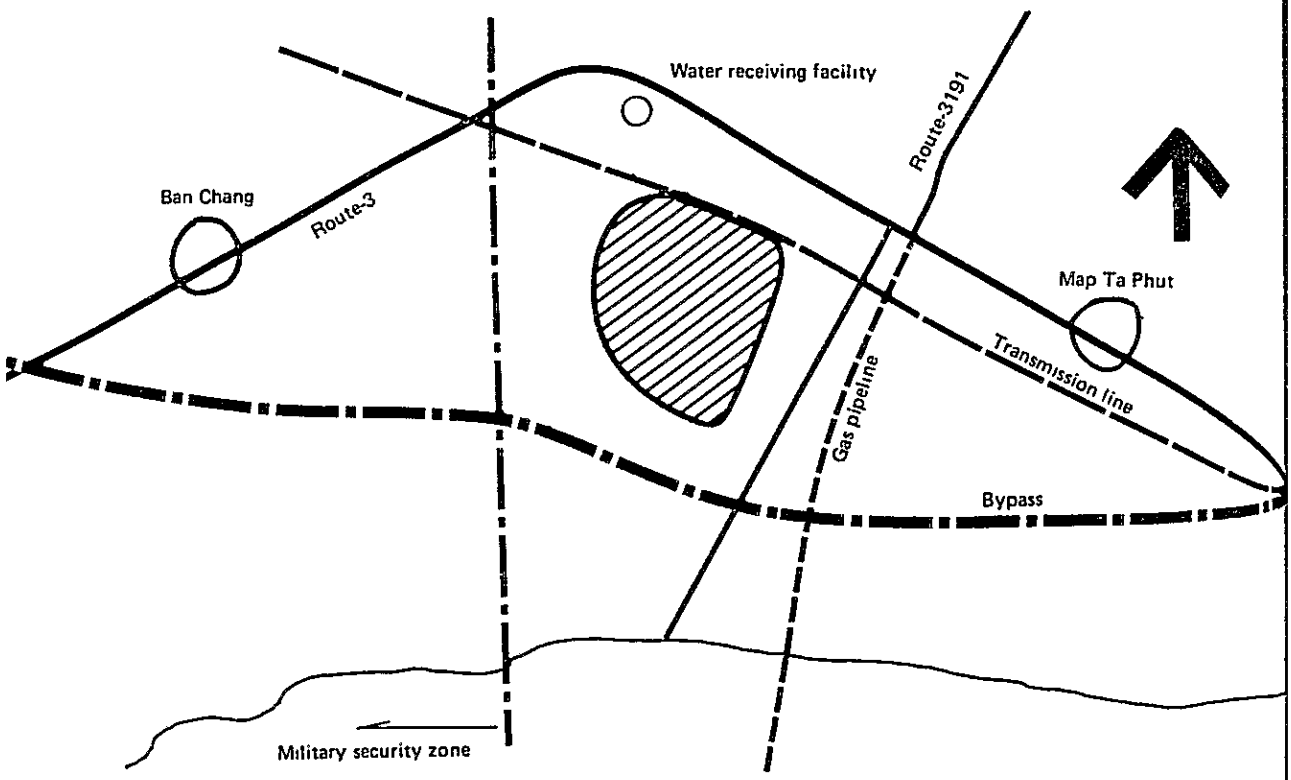


Fig. 7.2-3 Establishment of Development Area

(b) Phased Development

The New Town will be developed to be compatible with the phased development of Industrial Complex. At 1st Phase (target year of 1987) one neighborhood unit will be developed to accommodate a population of 18,300. A part of Town Center and Central Park will also be provided at the same time to foster core facilities in this area. However, these areas will be minimized to such extent that the inhibitants in the New Town can live without hindrance and inconvenience, thus avoiding excessive investment for infrastructures at 1st Phase.

At 2nd Phase (target year of 2000), additional migrants of 53,200 will live there and require four neighborhood units. It is anticipated that the New Town will be well developed to have complete streets and active Town Center at the end of this target year.

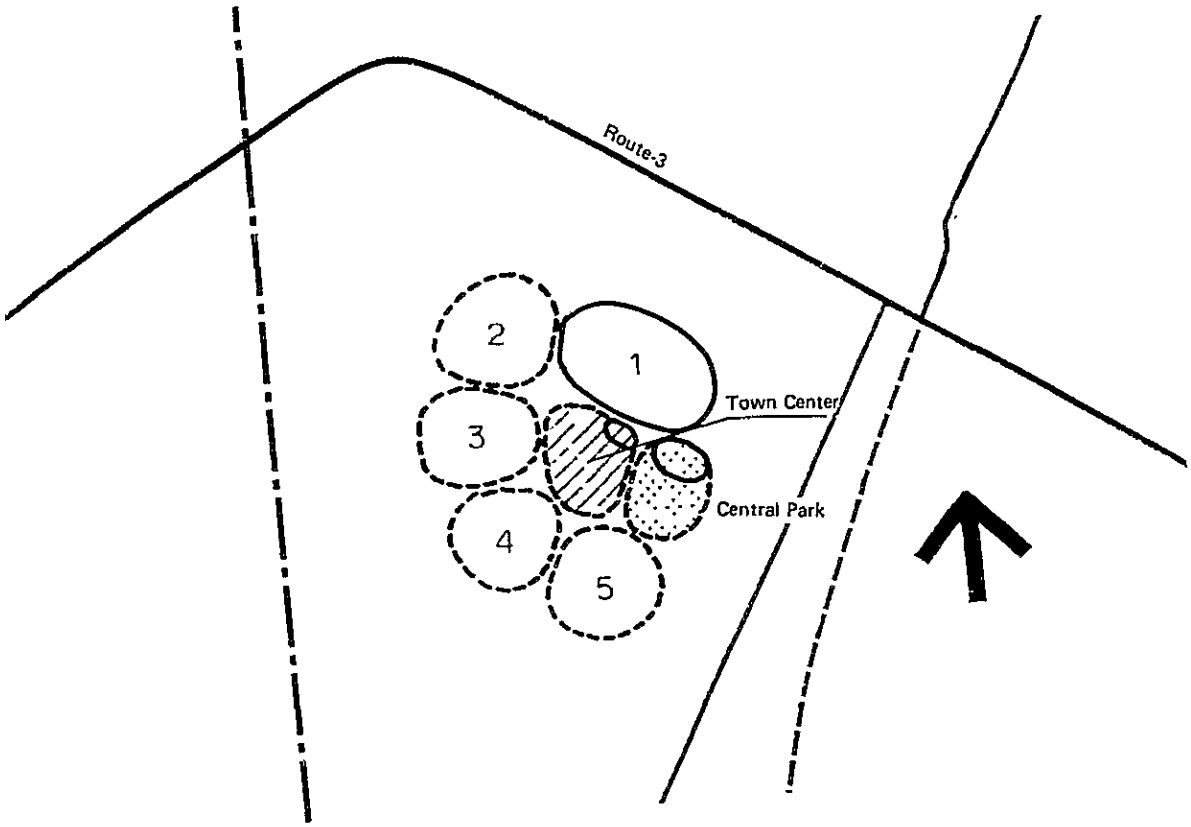


Fig. 7.2-4 Phased Development

(c) Flexibility

The New Town project is a large scale and long range development and involves many indefinite factors. Therefore, flexibility to cope with the future changes in demand for land of the New Town will be inevitable, and it is vital to propose a grown-up direction of the New Town which will make it possible to develop the New Town step by step.

Fig. 7.2-5 illustrates the proposed direction of the New Town development.

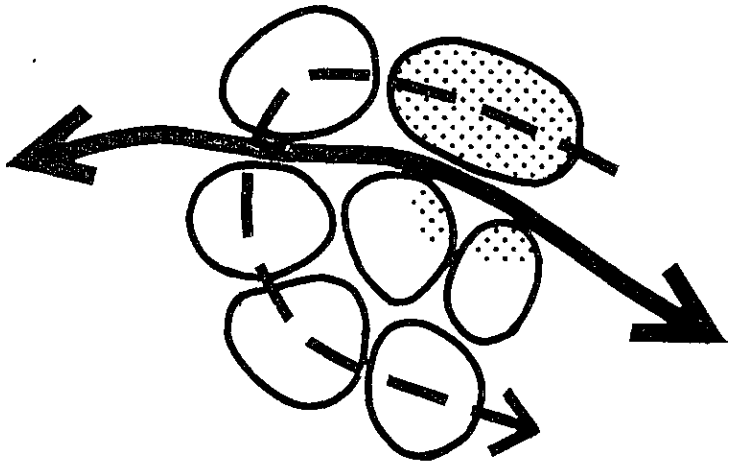


Fig. 7.2-5 Proposed Direction of the New Town Development

(d) Trunk Road Development

There are three national highways passing through and connecting the study area with other areas. Route 3 connects Rayong and Sattahip. Route 3191 connects Route 3 to Route 36 which is a short-cut to Bangkok Area. Alongside Route 3191 run underground two pipelines for water transmission from Dok Krai Reservoir and for gas transportation. In future another gas pipeline will be laid in this right-of-way. This will cause difficulty in widening the width for serving as trunk road to deal with heavy traffic to be generated from the Industrial Complex to Bangkok Area.

Route 3 is anticipated to have a future through-traffic volume of more than 10,000 vehicles/day for Rayong-Sattahip according to ESS. If upon development a new road paralled to Route 3191 is required for connection to Route 36, Route 3 will deal a total traffic volume of some 50,000 vehicles/day, which will cause a public nuisance such as traffic noise and exhaust gas and separation in the study area. Therefore, a bypass providing direct access to the Industrial Complex from Pattaya direction is proposed south to the New Town for diverted through-traffic. The bypass alignment is desired to be arranged south to Ban Chang town as illustrated in Fig. 7.2-6.

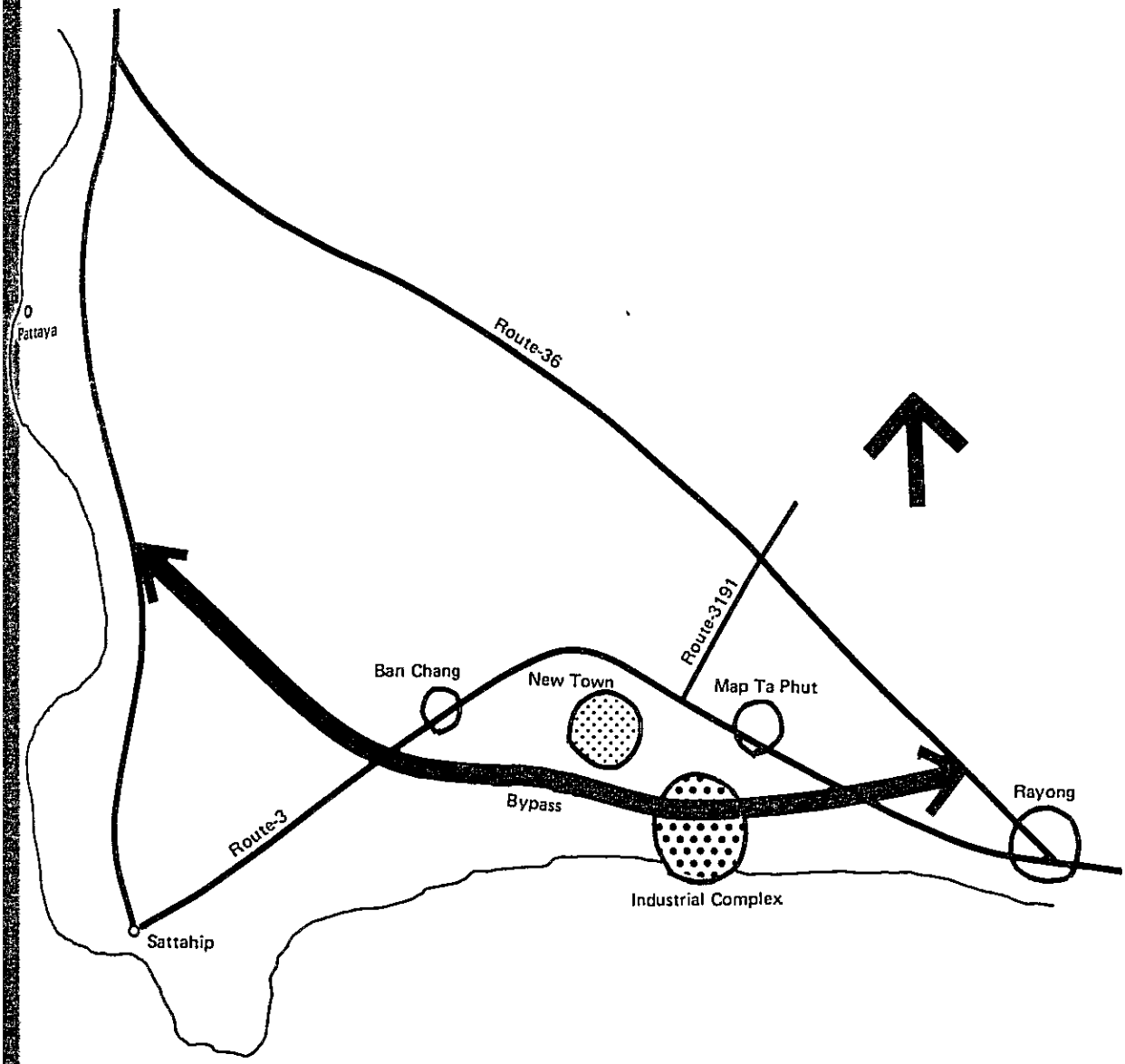


Fig. 7.2-6 Trunk Roads and New Bypass

(e) Buffer Zone

Buffer zone will be provided between the New Town and the Industrial Complex; and between Map Ta Phut and the Industrial Complex to secure such residential environment and amenities as described below:

(i) Providing landscaped view along the boundary of the Industrial Complex
(ii) Intercepting the spread of fire to the residential area
(iii) Preventing industrial area and the residential area from sprawl
(iv) Providing a place of refuge in case of an emergency

For this purpose, a 1 km width of buffer zone would be desirable to be preserved

between the residential area and Industrial Complex.

It may sometimes be difficult to secure sufficient buffer zone from the viewpoint of profitability but even in that case, public, recreational or agricultural utilization should be introduced by controling and regulating the land use within this area.

In this study, therefore, a 200 m width of buffer zone is proposed to be purchased by IEAT, taking the difficulty in land expropriation into consideration. The width is standardized in Japan where similar cases are often seen.

In addition, the land adjacent to the land purchased by IEAT should be preserved as a part of buffer zone by regulating the land use as described above.

(f) Rivers and Site Developments

Rivers running through the Development Area cover a stormwater catchment area of some 1,500 ha or 9,300 rai outside the area. In the land use planning for the New Town, stormwater runoff in these areas will mainly be discharged through the rivers. For this purpose, the rivers will be improved with maximum use of the existing locations and be so arranged as to flow at the center of each residential area for effective layout in collection systems of stormwater. In view of open space and breathing area arrangement, watercourses as well as green belts are one of the most enjoyable and attractive factors for human settlement. Therefore, river banks at both sides will be developed as malls which will be a part of green network as illustrated in Fig. 7.2-7. This is also one of the reasons why the rivers flow at the center of each residential area.

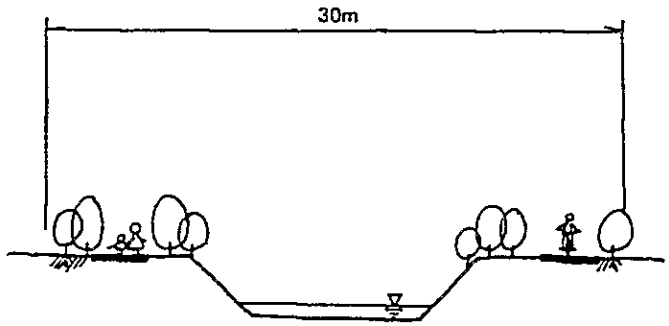


Fig. 7.2-7 Mall at River Banks

The existing terrain of a proposed site is gradually sloped with a gradiant of about 1–2%. Taking this advantage, graded levels will be contoured to minimize soil volume to be cut or filled, thus resulting in minimized cost for site preparation. In the meantime, stormwater darinage and sewerage systems will also be arranged alongside road network to discharge by gravity flow, being compatible with the site grading, which will contribute to easy maintenance. Fig. 7.2-8 shows a schematic plan and section of stormwater collection system.

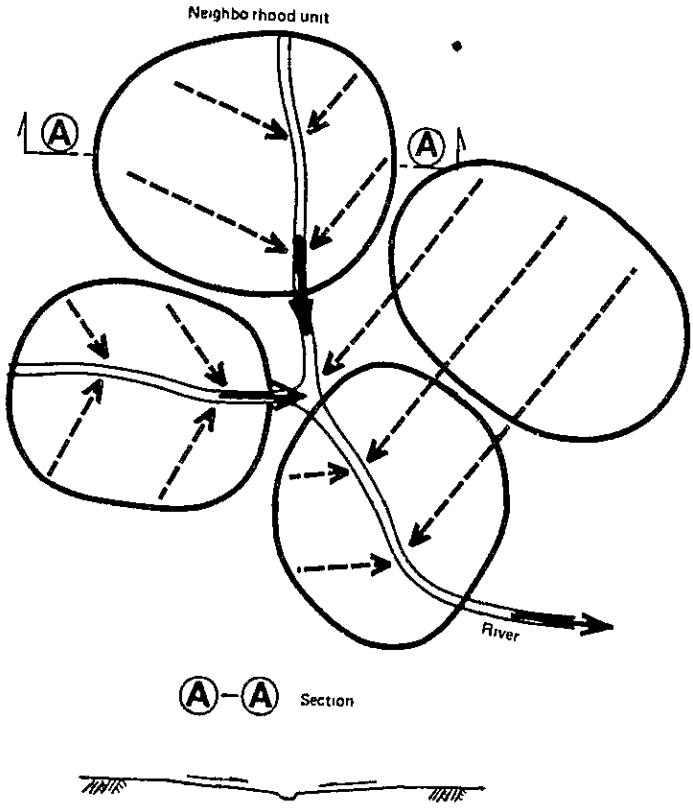


Fig. 7.2-8 Schematic Plan and Section of Stormwater Collection System

(2) Relationships among the New Town and the Existing Towns, and Anticipated Development of Ban Chang

(a) Relationships among the New Town and the Existing Towns

The towns influenced directly or indirectly by the industrial development will be Bang Chang and Map Ta Phut. As previously described in this report, the intentional assumptions were given by the Thai side for these towns; Ban Chang should be reactivated by making full use of the existing urban facilities, while excessive growth in population should be avoided in Map Ta Phut.

Under these circumstances, the relationships among the New Town and the existing towns backed up by the development policy can be summarized as follows:

(i) At the 1st Phase, besides the industrial workers with their families, only some part of migrants by multiplier effects will live in the New Town, where initial investment will be reduced to the minimum. Therefore, the New Town will be provided with minimum service facilities necessary for daily life of the inhabitants, thus largely depending on Ban Chang for higher urban facilities including recreational facilities, shopping facilities for durable consumer goods and high-priced goods, medical facilities, etc..

However, at the 2nd Phase, the population in the New Town is anticipated to be far

bigger than that in Ban Chang, which lies in the military security zone. Establishment of a town center serving the target population in this area will not be suited in Ban Chang, because of the building construction guidelines applied to this zone. Therefore, a sizable sum of such urban facilities as a town center and a central park for high-grade amenities should be accumulated in the New Town, which will play an important role as a core in this area, while Ban Chang can enjoy these attractive facilities in the nearby New Town.

(ii) It is important that the new facilities in the New Town should also be used by the residents in Map Ta Phut, and thereby they can enjoy the amenities, since no improvement will be planned for facilities in this existing town. Even at the 1st Phase, the facilities arranged for the New Town, though they will still be of minimum provisions required for daily life, will be very fundamental ones for urbanized development, and will also serve for Map Ta Phut. Therefore, it should be essential at all events that the residents in Map Ta Phut can enjoy benefits from the establishment of the New Town which is anticipated to be a hub for future development in this region.

In this viewpoint, such a method of management and operation that they can use the facilities in the New Town should be employed to lead to desirable urbanization for consolidated development.

For this purpose, the following are proposed:

- o Arterial roads should be arranged as axes of the urban area development to link these three regions each other.
- o A site facing the above stated arterial roads should be intentionally reserved for the proposed Town Center in the New Town to cope with the future demand.

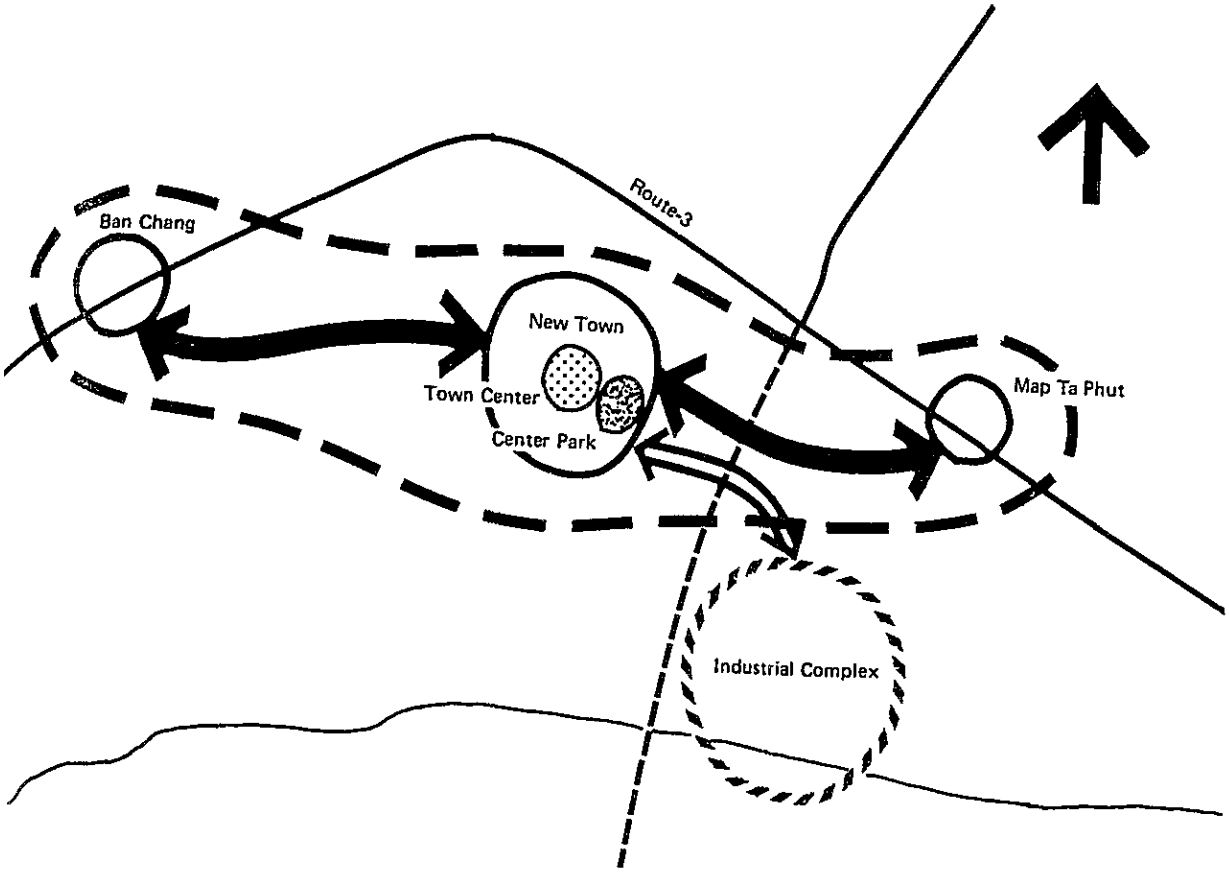


Fig. 7.2-9 Relationships among New Town and Existing Towns

(b) Anticipated Development of Ban Chan

The present population of Ban Chang is about 14,000. It will go up to about 22,400 at the 1st Phase (1987) and about 31,500 at 2000.

This sudden growth in population will give the existing town a big impact. Therefore, it is indispensable to scheme an intentional arrangement for infrastructures at its initial stage in order to lead it to a desirable direction, although it is quite difficult to arrange infrastructures in the region which has been densely populated to some extent. Without this arrangement, the town could not be grown up properly, resulting in causing sprawl and slums. In order to prevent such situation, the increased population will be distributed to a proposed neighborhood unit at each phase.

The population increase in Ban Chang is anticipated to be about 8,000 at the 1st Phase (1981–1987) and additional about 9,000 at the 2nd Phase (2000). A population of 8,000 to 9,000 can be considered to form a small neighborhood. So, two neighborgood units, for which community facilities and infrastructures will be required, should be arranged in Ban Chan in future. As a future problem at implementation stage, detailed investigation should be done as to where and how to arrange them specially in relation to the highly accumulated urban area, with the data on the existing distribution of various facilities, land ownership and so on.

The basic concept related to the community facilities and infrastractures in a neighborhood unit is described as follows:

(i) Community Facilities

Table 7.2-7 shows typical community facilities required for a neighborhood unit Among them, neighborhood shopping center, secondary and primary schools which have been already accumulated in Ban Chang should be further studied for their improvement, even if they can be utilized.

Table 7.2-7 Community Facilities

Facilities	Size	Remarks
Neighborhood Shopping Center	*	Using the existing facilities
Community Center	1.5 ha (9 rai)	
Neighborhood Park Playground	3 ha (18 rai) 4 units (2 ha) (12 rai)	
Secondary School Primary School Kindergarten	* * 4 units (1 ha) (6 rai)	Using the existing facilities

(ii) Infrastructures

As for urban infrastructures, relevant authorities of public sectors should take actions for a road network in earlier stage of development. At the same time, such public utilities as water supply, drainage and sewerage systems, electricity and telecommunications should be provided beforehand to meet the future demand, and these arrangements will be essential to facilitate and lead to the future development of the communities as desired. Fig. 7.2-10 shows an example for the road network to be provided in the area.

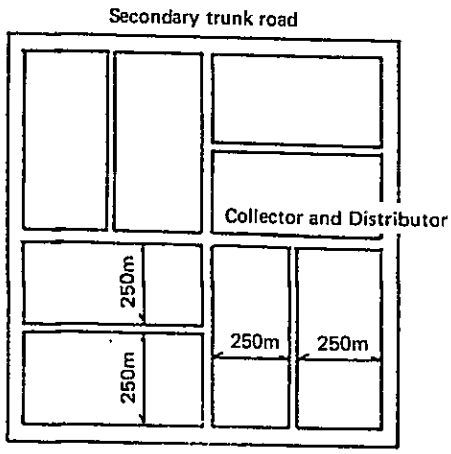


Fig. 7.2-10 Example Road Network

In the year of 2000, future demands for public utilities are estimated as shown in Table 7.2-8.

Table 7.2-8 Future Demand

Public Utilities	Future Demand	
	1st Phase	Master Plan
Portable water	2,450,000 m^3/year	3,450,000 m^3/year
Sewerage Discharge	6,700 m^3/day	9,500 m^3/day
Electricity	6,000 KW	8,500 KW
Telephones	1,500 Line	3,000 Line

(iii) Development Methodology

Since the existing built-up area shows rather high density in land utilization and land cost is comparatively high, it would be very difficult to purchase the land as a whole. Although it is very essential that the area should be further studied by relevant authorities who will be in charge of implementation, it is proposed in this study that "land readjustment method" be employed as one of practical solutions for expediting the development in this area. The procedure has been widely adopted in Japan and West Germany and gained fruitful results in the development of the area where many land owners who will not want to sell their land exist.

(3) Relocation of Inhabitants within Development Area

There are at present about 400 residents in the Development Area. The required land within the Area should be purchased in time to expedite the Industrial Complex and Urban Area Development on schedule. For this purpose, some residents may inevitablly be expropriated if necessary.

If the inhabitants forced to move by such expropriation desire to live in the New Town, they should be given a priority to acquire a suitable location for their new residences.

The same procedure must be taken to the dwellers in the buffer zones proposed in this study.

7.3 Land Use Plan

7.3.1 Fundamental Structure of Land Use

(1) Basic Concept

Based on the basic policy of urban development and strategic plan, the following basic concept of land use has been adopted, synthesizing factors to be solved or added for the development of the New Town in harmony with the existing land use of the surrounding towns and Industrial Complex.

(a) The site area for residential use to accommodate the estimated number of housing units classified in each income group for the target population in the year of 2000 will be provided within the New Town, divided into five neighborhood units.

(b) Town Center, which will be basically composed of the commercial block, institutional block and cultural block, will be located at the center of gravity to serve equally for the New Town, existing towns of Ban Chang and Map Ta Phut and Industrial Complex, and be a new core of the integrated Map Ta Phut Area.

(c) Central Park will be located adjacent to the Town Center to give attractiveness for the New Town. It also provides an athletic field which is intended for use by inhabitants and workers not only in the New Town but in the outside area.

(d) Buffer zone will be needed between the New Town and Industrial Complex; and between the existing Map Ta Phut Town and Industrial Complex to keep safety and health of inhabitants. Any building should be regulated there, except facilities for the public, recreational or agricultural use which have to be studied to keep buffer zone by land use control in case that land acquisition is difficult from the viewpoint of profitability.

(2) Land Use Plan

The area allotment by land use is as indicated in Table 7.3-2, which is settled to meet the anticipated demand for land for respective purposes under the following consideration.

(a) Area required for residential use will be estimated by classifing the inhabitants into some income groups and assuming each plot size for these groups. As a result of this, a total of 245 ha or 1,530 rai will be allotted for net housing area (Described in Section 7.4 in detail).

(b) Area for Town Center will be gained by using the following unit of commercial area per capita. Since the New Town has a characteristics of industrial town as well as residential town, the average value (8 m^2/person) for these two towns has been adopted in this study. About 54 ha or 337 rai is proposed to be reserved for Town Center.

Table 7.3-1 Commercial Area per Capita Required

Classification of Town	Commercial Area per Capita Required
Commercial Town	15 – 30 m/person
Industrial Town	5 – 15
Light Industrial Town	10 – 15
Residential Town	5 – 8

Neighborhood shopping center will be located in each neighborhood unit bordered by the major roads to meet the daily shopping demand. The size required for each nieghborhood shopping center is about 1 ha.

(c) The community facilities such as community center and schools will be provided in each neighborhood unit, taking the planning criteria and way of life in Thailand into consideration (Described in Sub-Section 7.3.3 in detail).

(d) Breathing areas such as parks and malls will be provided in the New Town in the ratio of not less than 13% of the total area which is one of planning criteria in Thailand. Area for buffer zone between New Town and Industrial Complex is not included in Table 7.3-2.

(e) Area for right-of-way includes all roads and streets — even minor access roads, except Route 3 Bypass. Utility facilities such as sewage treatment facilities, electric sub-station, bus depots and so on will be located adjacent to the New Town site and area for them is about 1% of the total area.

Table 7.3-2 Area Allotment by Land Use

	Area (ha)	Ratio (%)
Residential Use (Net)	245	43
Town Center	54	9
Neighborhood Shopping Center	5	1
Community Center	10	2
Secondary School	24	4
Primary School	12	2
Kindergarten	5	1
Sub-total	41	7
Central Part	45	8
Neighborhood Park	13	2
Playground	5	1
Pedestrian Way	9	2
River and Mall	21	4
Sub-total	93	16
Road	119	21
Sewage Treatment and Others	8	1
Total	575	100

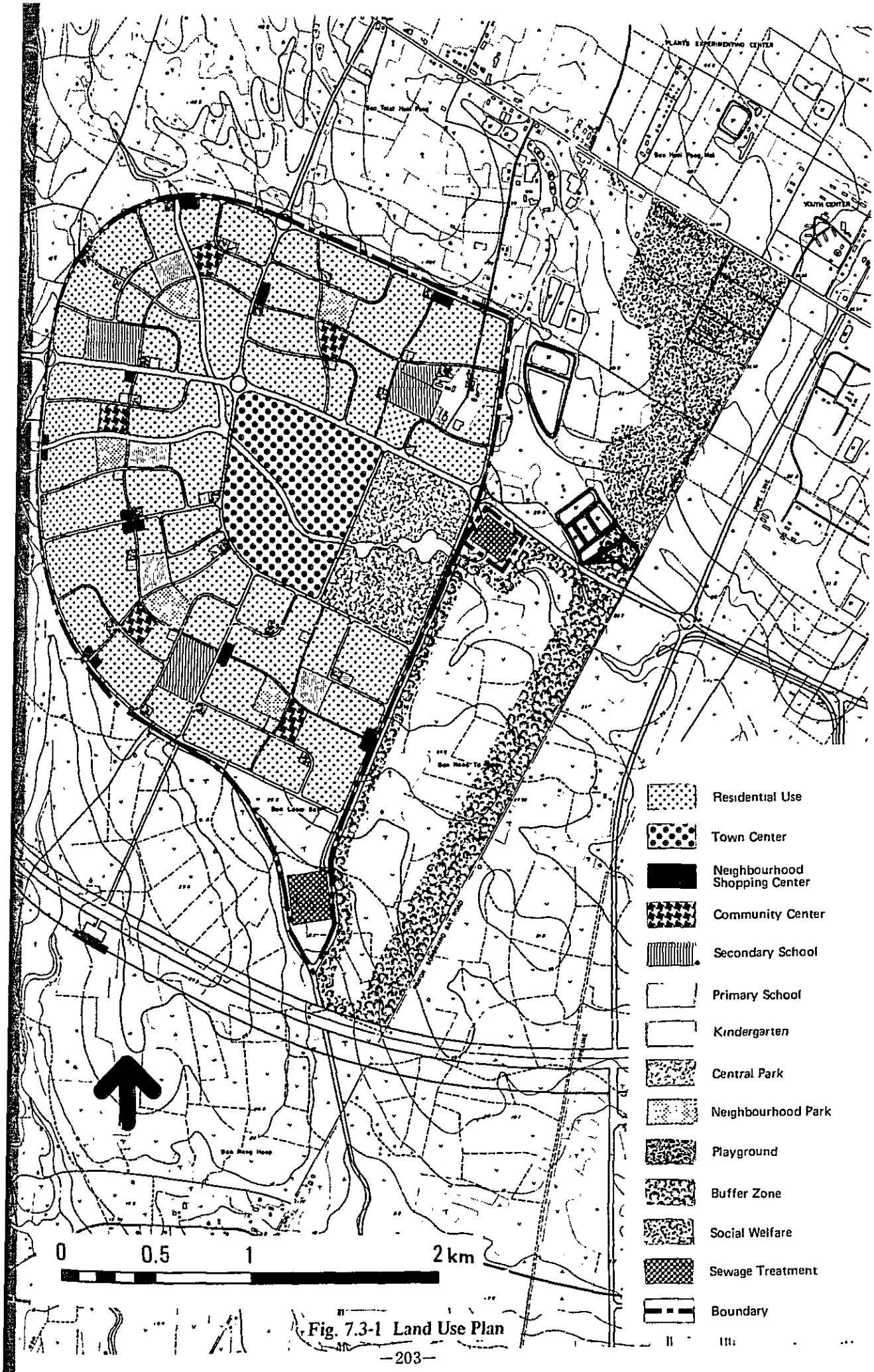


Fig. 7.3-1 Land Use Plan

7.3.2 Green Network

Green network comprises Central Park, neighborhood parks, playgrounds and malls; and furthermore, buffer zone should be added to keep environment and safety for inhabitants.

The green network is intended to have a unified and continuous space, thereby creating a symbolic spot of the New Town and providing recreational and sports facilities serving for inhabitants and workers in and outside the New Town.

(1) Central Park

Central Park will mainly consist of two types of facilities; one is for taking a rest, strolling or indulging oneself in the natural atmosphere and another is for regional sports activities.

Scenic green stretch with trees, plants and lawn, resting facilities such as pergolas and benches, ponds, botanical garden and so on will be useful for the former purpose. Sports facilities of high-grade such as a stadium, gymnasium, soccer ground, swimming pool, sports club, youth hostel, etc. will be expected to be planned for the latter purpose.

The realization of these facilities will be supposed to contribute to the formation of the unified regional community.

(2) Neighborhood Park and Playground

A neighborhood park will be provided in each neighborhood unit. The location will be determined with due consideration given to the optimum walking distance of the residents. The size will be large enough to make it available for soccer and other outdoor sports events. Site area of 2.5 ha will be required to meet such functional demand.

In addition to the neighborhood park, four playgrounds will be provided in each of the neighborhood units, mainly for use by infants and children, where some facilities for taking a rest such as benches with trees will be installed so that aged people can also make free use of them. The walking distance to playground does not exceed 250 m from the farthest residence and the site area of one playground is taken as 0.25 ha.

(3) Mall

For keeping the safety and comfort of foot and cycle traffic, malls for exclusive use of pedestrians and bicyclists should be provided in the New Town, in addition to roads and streets.

Malls will connect such community facilities as schools, parks, community centers and neighborhood shopping centers, and furthermore the adjoining neighborhood units, Town Center and Central Park will be linked by the malls, enabling the pedestrians to move in wider area of the New Town.

Thus, a network for malls with footways and cycle tracks will create smooth circulation lines for trips to and from work, school, shopping, etc., by forming the primary skeleton of the New Town.

In Thailand, river water is a very important factor in the daily life, so that malls along the river are laid out within the New Town.

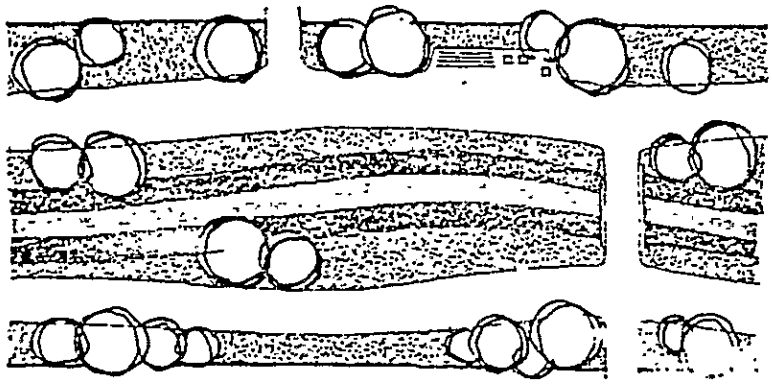


Fig. 7.3-2 Conceptual Image of Mall

(4) Buffer Zone

The role of buffer zone is particularly important to keep the safety, health and comfort of inhabitants, protecting them from public nuisances and emergent disasters including fire and explosion which may happen in the Industrial Complex. Buffer zone will be provided between the New Town and the Industrial Complex; and between Map Ta Phut and the Industrial Complex. The former buffer zone will be arranged to have a width of about 800 m against possible explosion accidents in Petrochemical Industries. A 200 m width of land along the existing Pakon Songkhrorat Road will be purchased by IEAT and the land within the remaining width of about 600 m should be preserved by regulating the land use. The latter buffer zone will be secured on the south of the right-of-way (40 m width) of the transmission line and on the east of the dew point control plant with the same width of 200 m.

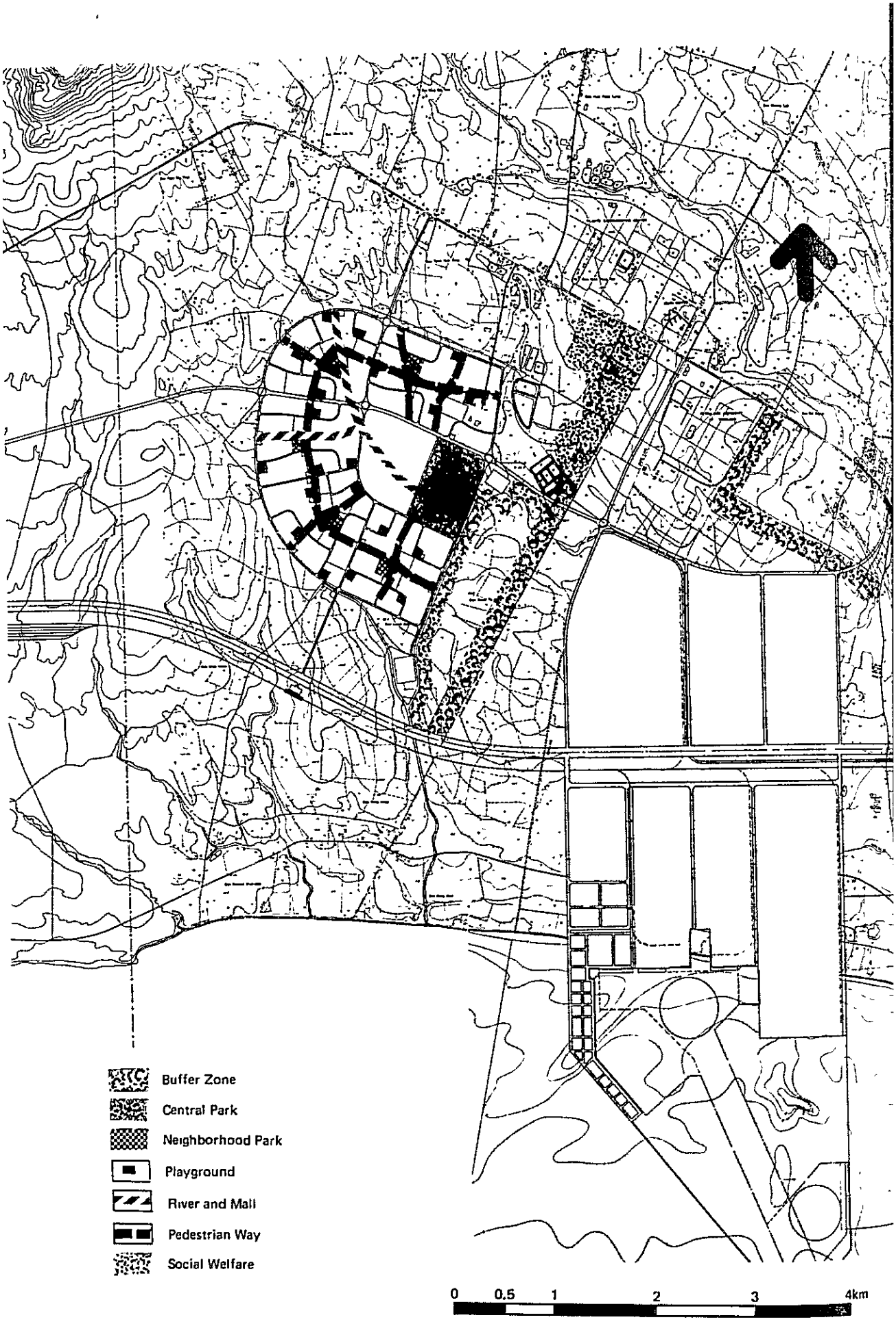


Fig. 7.3-3 Green Network

7.3.3 Community Facilities

In line with the basic policy established for urban development, the New Town should have attractiveness and comfortable environment with advanced urban fabric. The major parts of such social developments as institutional, educational, medical and welfare, recreational facilities will be made by relevant authorities of public bodies, while commercial facilities will be mostly developed under private investments. In this section, some major items of social facilities involved in urban development are briefly discussed, though further studies should be made at implementation stage by relevant authorities concerned.

(1) Neighborhood Community Facilities

At the 1st Phase, taking the effective investment on urban development into account, one neighborhood unit with a population of about 18,300 will be established.

There will be five neighborhood units for residential use in the New Town in the target year of 2000. Each neighborhood with an average population of about 13,000 will be provided with such community facilities as schools, a shopping center, a community center, parks and recreational facilities in reasonable plots within close proximity to dwellers.

(a) Educational Facilities

The educational system in each level in Thailand comprises the following:

Table 7.3-3 Main Characteristics of the Education System in Thailand

Level	Appropriate Age of Students	Years of School	Enrollment Ratio	
			1982	1986
Pre-primary School	4–5	2 or 1	14.8	35.4
Primary School	6–11	6	108.1	111.5
Secondary School	12–17	6	28.6	37.1
Lower	(12–14)	(3)	32.5	44.0
Upper	(15–17)	(3)	24.6	30.3
University	18–23	4–6	4.5	4.8

The attendance rate at each level is rapidly increasing year by year by the efforts made in accordance with the National Development Plans established since 1961. It is anticipated that this increase will more or less continue for the whole study period. In order to give equal educational opportunity, sufficient number of educational facilities should be provided in the New Town. Table 7.3-4 shows comparative figures for planning criteria for educational facilities obtained from relevant authorities concerned. In this study, the educational facilities required in each neighborhood will be calculated on the students ratio per population as set out by National Housing Authority as described below:

Table 7.3-4 Planning Criteria for Educational Facilities

		M.O.E	N.E.C.	NHA (Lad Krabang)	NHA (Bang Plee)	E.S.S
KINDERGARTEN/DAY-CARE	Students/pop.	-	-	0.065/pop.	0.056/pop.	-
	No. of students/ school	-	120 - 150	300	240	-
	No. of classes	-	4	-	-	-
	No. of students/ class	-	30 - 35	-	30	-
	Plot size	-	5 rai	1.23 rai	1 rai	-
	Other requirements			Within radius of 400 m from the farthest dwelling		
PRIMARY SCHOOL	Students/pop.	1/house'd	-	0.140/pop	0.130/pop. 0.8/house'd	0.140/pop.
	No. of students/ school	2,000	500 - 800	2,681	2,000	-
	No. of classes	40 - 45	20	-	36	-
	No. of students/ class	45 - 50	30	-	55	25 - 30
	Plot size	5 - 8 rai	8 - 12 rai	12 rai	10 rai	6 rai or 40 m^2/student
	Other requirements	Within radius of 3 km for rural area	Within radius of 2 km	Within 30 min. walking distance from the farthest dwelling	-	The nearest existing school is at least 6 km distance from the proposed location
SECONDARY SCHOOL	Students/pop.	-	-	0.125/pop.	0.092/pop	Lower 0.073/pop x 74.5% = 0.054 Upper 0.070/pop x 30% = 0.021
	No. of students/ school	1,200 - 1,900	1,200 - 1,500	2,400	2,750	-
	No. of classes	30 - 42	40 - 50	-	-	-
	No. of students/ class	40 - 45	30	-	-	40
	Plot size	35 rai	Lower 25 rai Upper 50 rai	21 rai	25 rai	35 rai
	Other requirements			Adjacent to the public space		The nearest existing school is at least 20-25 km distance from the proposed location

M.O.E. Ministry of Education
N.E.C. National Education Commission
N.H.A. National Housing Authority

(i) Pre-primary Education

Pre-primary education for the age group of 4–5 is usually given at a kindergarten or day-care center with two-year course for urban area or one-year course for rural area. The students ratio per population is anticipated as 0.070 with due consideration given to the increased ratio of enrollment in future.

Therefore, each neighborhood will have applicants for pre-primary education of 910 students. A reasonable size of kindergarten or day-care center is considered to be 240–300 students per unit, then three units will be required for each neighborhood. The standard size of plot area will be about 1.5 rai to accommodate the said number of students in each unit. Each unit will be located at reasonable site within the radius of 300 m from the farthest dwelling from viewpoint of walking distance of students.

(ii) Primary School

Primary school education is compulsory in Thailand and is considered to be attended by all children of this age group. Considering average walk distance of students, one primary school should be established in each neighborhood. The students ratio per population is assumed as 0.14. According to this, each neighborhood will have 1,820 students in its community. This size of primary school is considered rational in the light of the examples planned by NHA, although it is advisable that the number of enrollment be reduced to some extent from the viewpoint of upgrading educational standards and making good use of facilities. Each school occupies about 16 rai or 2.5 ha and locates within the radius of walking distance of 500 m which will be rather convenient access in comparison with the existing school in this area. At the 1st Phase, the existing primary school near the proposed neighborhood area can be utilized.

(iii) Secondary School

At present the enrollment ratio of secondary school is about 40% of this age-group in whole Thailand.

However, in future this ratio will considerably go up in keeping pace with increased economic growth.

Particularly in this region, it is anticipated that the migrants of high educational background will live there, resulting in increased demand of higher education for their dependents.

Therefore, in view of this, the students ratio per population is taken as 0.10. Three secondary schools of both lower and upper grades will be provided in the New Town, with an average capacity of 2,400 students. The plot size of each school will be about 50 rai or 8 ha.

(b) Neighborhood Shopping Center

Each neighborhood will be provided with a shopping center which comprises shophouses, supermarkets, gas stations and other commercial facilities to serve daily life for dwellers. Neighborhood shopping center should preferably group a certain number of similar shops so that shoppers can have a wide range of choice and more than one shop of the same kind will compete to refine their service.

This center will be mainly developed by private sectors, therefore, in this study a suitable size of land (1 ha or 6.25 rai in total) is reserved in each neighborhood unit for this purpose.

(c) Community Center

It is desirable that each neighborhood have a community center, which constitutes a core of the community. The following will be the major facilities and be grouped together:

- Health clinic
- Community hall together with small library
- Post office
- Police depot
- Telephone booth
- Restaurants
- Parking lot

The land required for the center is about 12.5 rai or 2 ha.

(2) Town Center

Town Center is one of the most important factors to be taken into account in order to build up an image of the New Town. Town Center is expected to provide those people living in the New Town and its surrounding area and working at the Industrial Complex with diversified daily services. Therefore, it is planned so as to have the pivotal functions for such large area and concurrently to stand in such environment as will suit the functions. Adequate transport media will also be provided for underpinning such functions.

The major activities to be expected of Town Center is to serve as central organ in the commerce and business, governmental/municipal service, and cultural affairs. Also, commercial and business facilities to be provided in the center will give job opportunities to a considerable number of people, thus playing an important role in this respect.

(a) Accessibility

The accessibility from residential area can be made by the use of the proposed major road network and malls. Access not only from the residential area, but from Ban Chang Map Ta Phut and the Industrial Complex will be facilitated.

(b) Composition

The composition of Town Center is arranged to give it flexibility for phased development and to make it attractive. Town Center will be basically composed of the commercial zone, the public institution zone and the cultural zone as shown in Fig. 7 3-4 The facilities to be established in each zone should greatly contribute to the economic and social growth and be practically feasible. For this end, careful and thorough studies should be carried out at the later stage to cover a number of items including types, sizes floor areas, layouts, etc. to be compatible with their functions and activities. Table 7 3-5 shows plot areas of each zone in the Town Center roughly allotted on the basis of the data on similar projects available in Japan.

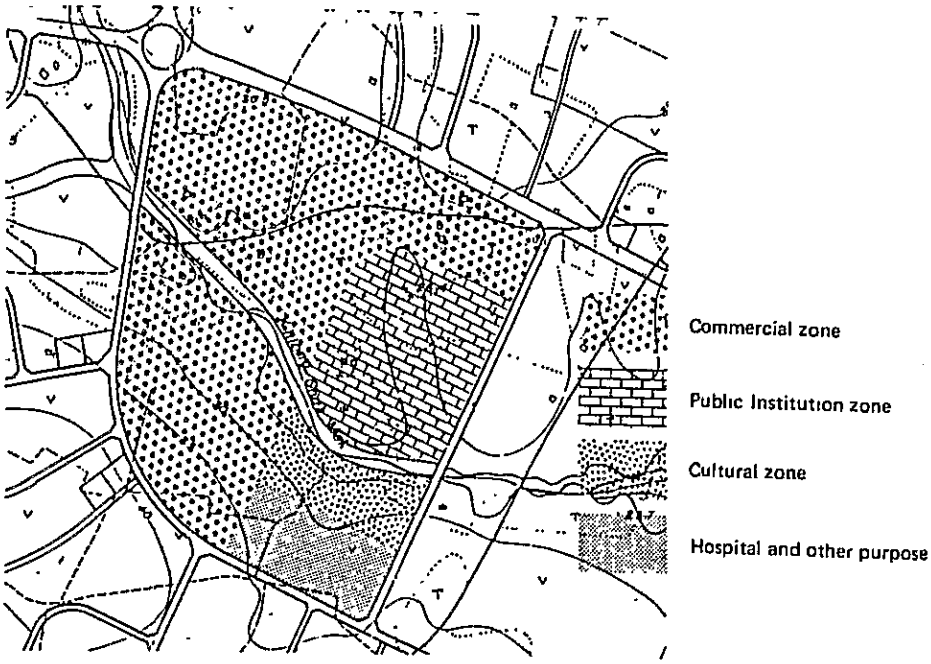


Fig. 7.3-4 Composition of Town Center

(i) Commercial Zone

Commercial zone will provide high-grade merchandize and services as well as daily necessaries for meeting the requirements of dwellers. The facilities include the following:

- Shopping complex comprising almost all types of retail shops, supermarkets and department stores
- Catering facilities collectively referred to restaurants, eating houses, coffee houses, etc.
- Banks and other business offices
- Amusement facilities
- Exhibition hall
- Hotels and high-grade condominia
- Car parks

This commercial zone, mainly developed by private investors, should be arranged in such a form as to create most lively space in the entire Town Center. Therefore, it is essential that the managerial aspects and phasing of construction should be thoroughly studied by the developers at the implementation stage.

(ii) Public institution zone

As for the governmental agencies, institutional bodies and other public organizations, it is difficult to discuss at this stage in detail because they are governed by the factors specific to the locality. The facilities needed in this area will include government offices, police station, fire station, central post office, telephone office,

etc.. Therefore, some lots will be reserved for this purpose with allowance for future expansion.

(iii) Cultural Zone

This zone will be reserved for civic center, auditorium, museum, public library and religious facilities which will provide the inhabitants with breathing places in a relaxed atomosphere.

Table 7.3-5 Plot Area Allotment in Each Zone in Town Center

Zone and Major Facilities	Plot Area (ha)
Commercial Zone - Shopping complex - Restaurants - Banks and offices - Amusement facilities - Exhibition hall - Hotels and condominia - Car Parks, etc.	34
Public Institution Zone - Government offices - Police station - Fire station - Central post office - Telephone office, etc.	10
Cultural Zone - Civic center - Auditorium - Museum - Public Library - Religious facilities, etc.	5
Hospital and other purpose	5
Total	54

(3) Other Social Facilities

(a) Hospital

Medical services for the inhabitants in the New Town will primarily be provided in health clinics to be established in each community center. However, it will not be sufficient for medical care of higher level or inpatients facilities. There exists a provincial hospital with a capacity of 350 beds in Rayong Municipality and a district hospital with 30 beds in Ban Chang. According to the standard in Thailand, a new public hospital can not be established in this study area. However, taking workers' accidents at factories in the Industrial Complex and emergency cases for inhabitants into consideration, a new hospital of higher level will be essential for upgrading medical services in this area Therefore, space for a private hospital with 100 beds will be reserved at a location close

to the Central Park.

(b) Higher Education

It is advisable that vocational or technical high schools be established in this region to meet the increased demand for educational opportunity of higher level.

In addition to this, it is also recommendable to establish a research center of high technology in close relation to the induced industries in order to expedite manpower development and contribute to further industrialization in this region. For establishment of the center, thorough studies should be made at the implementation stage to determine the location, site area, layout, etc. of the facilities compatible with the required functions and activities.

7.4 Housing Scheme

7.4.1 Housing Development

(1) Housing Demand

In estimating the housing demand from the population of the New Town, two factors have to be considered; i.e., the number of households and their sizes. The average houlehold size is assumed to 4.2 persons for the Short Term Plan and 4.1 persons for the Master Plan according to the Eastern Seaboard Study (Reffer to Table 7.4-1).

Table 7.4-1 Projection of Population and Households in New Town

Phase	Population	Households	Average size
Short Term Plan	18,300	4,360	4.2
Master Plan	71,500	17,340	4.1

The housing demand, affected by the program of industrial investment in Map Ta Phut area should correspond to each development phase. At the implementation stage of this project, it is anticipated that a number of construction workers will be employed. Those workers will also require housing units. In this study, however, this housing demand is not taken into account on the assumption that they will live in a camp on the construction sites or around Ban Chang or Map Ta Phut. In this regard, it is advisable that this camp should be properly controlled to avoid generating slums in this development area.

(2) Classification of Household

In order to estimate the housing demand of different types, household structures will be clarified by occupation and income. The occupational composition can be predicted on the basis of the jobs available at the Industrial Complex and its related income level, being classified into three categories as described below:

Group I: employers, managers, doctors, professional and equivalent workers

Group II: technical, clerical and skilled workers and foremen

Group III: semi-skilled and unskilled workers, service workers

Based on this classification, the itemized percentage of households in the New Town can be assumed as shown in Table 7.4-2.

Table 7.4-2 Percentage of Households by Income Group

Income Group		Income per month	Percentage
Group I	High Income	More than 9,000 ฿	7%
Group II	Middle Income	5,500 – 9,000 ฿	21.1%
Group III	Low Income	Less than 5,500 ฿	71.9%

Notes: Income as of 1983.
Income includes basic salary, bonus, pension fund and fringe benefits.
Income excludes any allowance such as over-time allowance, up-country fee, accommodation fee and so on.
(Refer to Appendix 2)

(3) Type and Number of Housing Unit

Individual persons have a wide variety of desires when they buy or rent houses. Housing units should be supplied to meet their respective requirements as much as possible. In this study, however, the housing units are classified into the following four types for simplifying the land use planning:

Table 7.4-3 Type of Housing

Type of Housing	Range of Residential Unit Size	Ave. of Unit Size
1. Detached House	250 m^2/plot – 800 m^2/plot (60 wah^2/plot – 200 wah^2/plot)	400 m^2/plot (125 wah^2/plot)
2. Semi-Detached House	150 m^2/plot – 250 m^2/plot (40 wah^2/plot – 60 wah^2/plot)	180 m^2/plot (50 wah^2/plot)
3. Town House	80 m^2/plot – 150 m^2/plot (20 wah^2/plot – 40 wah^2/plot)	100 m^2/plot (25 wah^2/plot)
4. Flat or Row House		80 m^2/plot

In this study, a larger size than average unit size in Bangkok is adopted for each type of housings, mainly because the land cost is low compared with that in Bangkok and the fesidential environment of high quality should be created and preserved in future. The percentages of houses by type which corresponds to income distribution are assumed as shown in Table 7.4-4.

Table 7.4-4 Housing Distribution by Type

Income Group	Housing Distribution		Housing Type
Group I High Income Group (7%)	100%	10%	Detached house
Group II Middle Income Group (21.1%)	15%		
	85%	20%	Semi-detached house
Group III Low Income Group (71.9%)	60%	40%	Town house
	40%	30%	Flat or Row house

From Table 7.4-1 and Table 7.4-4, a total number of housing units within the New Town are calculated below.

Table 7.4-5 Number of Housing Units by Type

	Ratio	Number of housing	
		Short Term Plan	Master Plan
Detached house	10%	440 Units	1,730 Units
Semi-detached house	20%	870 Units	3,470 Units
Town house	40%	1,740 Units	6,940 Units
Flat or Row house	30%	1,310 Units	5,200 Units
Total:	100%	4,360 Units	17,340 Units

(4) Housing Supply

Housing units should be sufficiently supplied in keeping pace with the constant increase of industrial workers for a long term. In this country, there are two ways of housing development. One is development by public sectors and the other is by private sectors. Public sectors mean such government authorities as National Housing Authority and Local Housing Authorities. Private sectors mean individuals, enterprises of major industries and speculative builders. To create well balanced community in the New Town, cooperative work by these sectors will be necessary. NHA will mainly take part in providing low cost houses for sale or rent for the income level of below 50th percentile, while private sectors will provide a greater number of houses for the middle and high income groups.

It is predicted that there will be potential needs for low and middle income groups as the

Industrial Complex grows up constantly. To cope with this, it is proposed to establish certain corporation, a kind of semi-public body, which will play an important role for the supply of new houses for these groups. This establishment may also be an effective measure to eliminate slum occurrence to be caused by poor developers. It can also be considered that the housing development for these low and middle income groups would be made under a financial support by induced industries as welfare programs of their employees.

It is also proposed that a pre-fabrication system be introduced to the low cost houses within this development area. By introducing this system, standards of the quality for housing units will be elevated and kept. The utmost benefit will be gained if the pre-fabrication system is applied to high. or middle-rise housing complex. For this end, arrangement of standard modules, cost analysis, technical know-how etc. should be further studied.

7.4.2 Housing Distribution Plan

(1) Land requirement for residential areas

Houses for workers are consistently provided during the long periods. The problem is that company-owned houses are often provided on the industrial sites. But this Industrial Complex is not suitable to live in, because the heavy industries and the large scaled plants will be induced there. Therefore, all houses should be planned within the residential area.

Fig. 7.4-1 shows the calculation procedure of residential area adopted in this study and Table 7.4-6 shows the total net residential area required for housing units as described in 7.4.1.

In this project, net residential area occupies more than 40% of the whole area in the New Town.

Table 7.4-6 Total net residential area

Housing type	Residential Area (ha)		Rate of each type
	Short Term Plan	Master Plan	
I	17.5	69.4	28.6%
II	15.7	62.4	25.7%
III	17.5	69.4	28.6%
IV	10.5	41.6	17.1%
Total:	61.2	242.8	100%

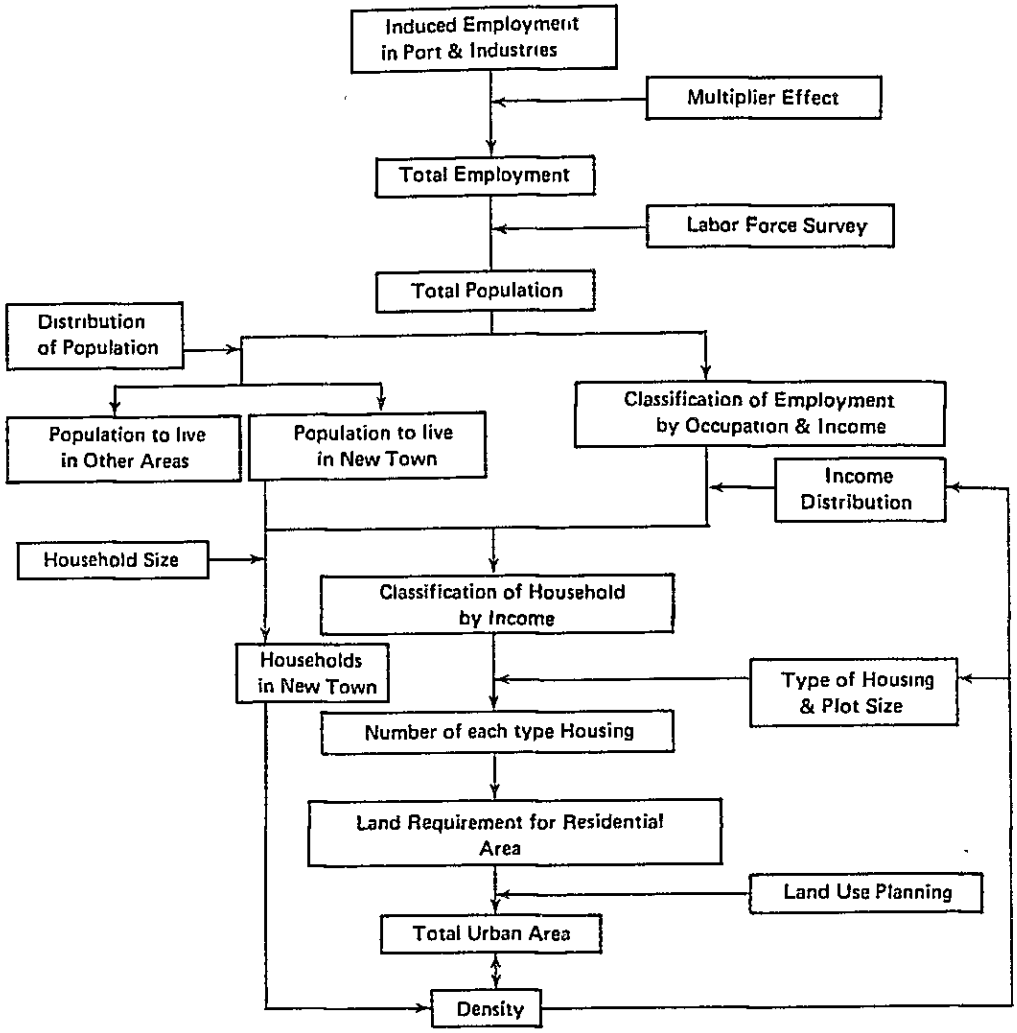


Fig. 7.4-1 Calculation Procedure of Residential Area

(2) Density of Residential Area

The question of density is a basic factor in determining the acreage of the development area. It will require large area to build houses at very low density. On the other hand, the amount of land can be saved by high densed buildings, although it is carefully weighed against possible loss of flexibility and various amenities.

The density of residential area will also justify the sufficient amenity of life. However, sometimes it was not considered from a viewpoint of profit. The good amenity of life in the New Town will be taken into consideration.

It is the most important point in planning to clarify the reasonable density. "Net residential density" will be given by referring to the population and housing area covering dwellings, gardens, incidental open space and local roads and footpaths. "Gross residential density" will be given by including schools, local shops and community facilities within the residential area besides the area described above.

Net density can be classified into three categories; low density (30 – 100 persons/ha), medium density (100 – 250 persons/ha) and high density (250 – 650 persons/ha). Average net density in new towns is generally in a range of medium density of 75 – 200 persons/ha.

Based on the average net density, it will be possible to provide a variety of dwelling types and amenity of city life. Net density in this New Town is assumed as follows:

Average net density	213	persons/ha	52	dwellings/ha
Low net density	74	persons/ha	18	dwellings/ha (Detached house)
Medium net density	164	persons/ha	40	dwellings/ha (Semi-detached house)
High net density	266–328	persons/ha	65–80	dwellings/ha (Town house, Flat)

Many examples of new towns in foreign countries indicate that a gross density ranges from 30 to 150 persons/ha in most cases, while the following data are available in Thailand:

- o Lad Krabang New Community
  gross density: 166.5 persons/ha (5 persons/household)
  33.3 dwellings/ha
- o Bang Plee New Town
  gross density: 161.3 persons/ha (6 persons/household)
  26.9 dwellings/ha
- o Assumption by ESS
  gross density: 125 persons/ha (4.1 persons/household)
  31.3 dwellings/ha

Taking soundness of living environment into consideration, the gross density in this New Town is planned at 125 persons/ha and 30 dwellings/ha.

(3) Housing Distribution

For the planning of housing distribution, the balance of the low and high densities' area should be considered. The mixture of all types of dwellings in the housing area is important in housing distribution.

The location of houses which will be provided by public sectors must be carefully arranged since it is of most importance in shaping the pattern of growth of urban area. In general, peak density area will appear around Town Center and the density will slowly decrease toward outer area. But this distribution pattern should be arranged in a flexible manner to secure amenity of the town.

Fig. 7.4-2 shows the diagram of housing distribution by density.

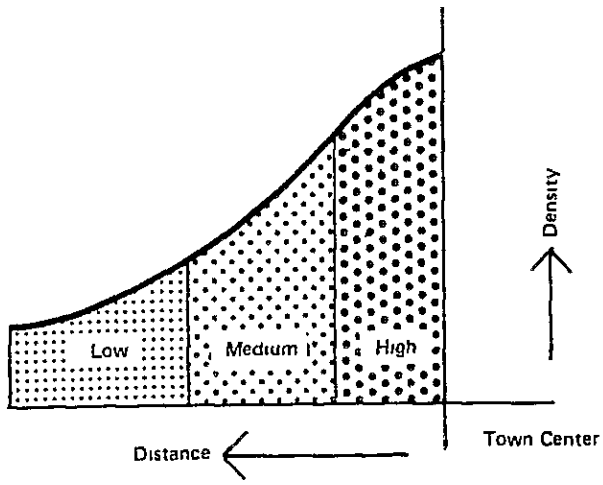


Fig. 7.4-2 Diagram of Housing Distribution by Density

The structure of each residential unit (micro-structure) should be distributed as shown in Fig 7.4-3.

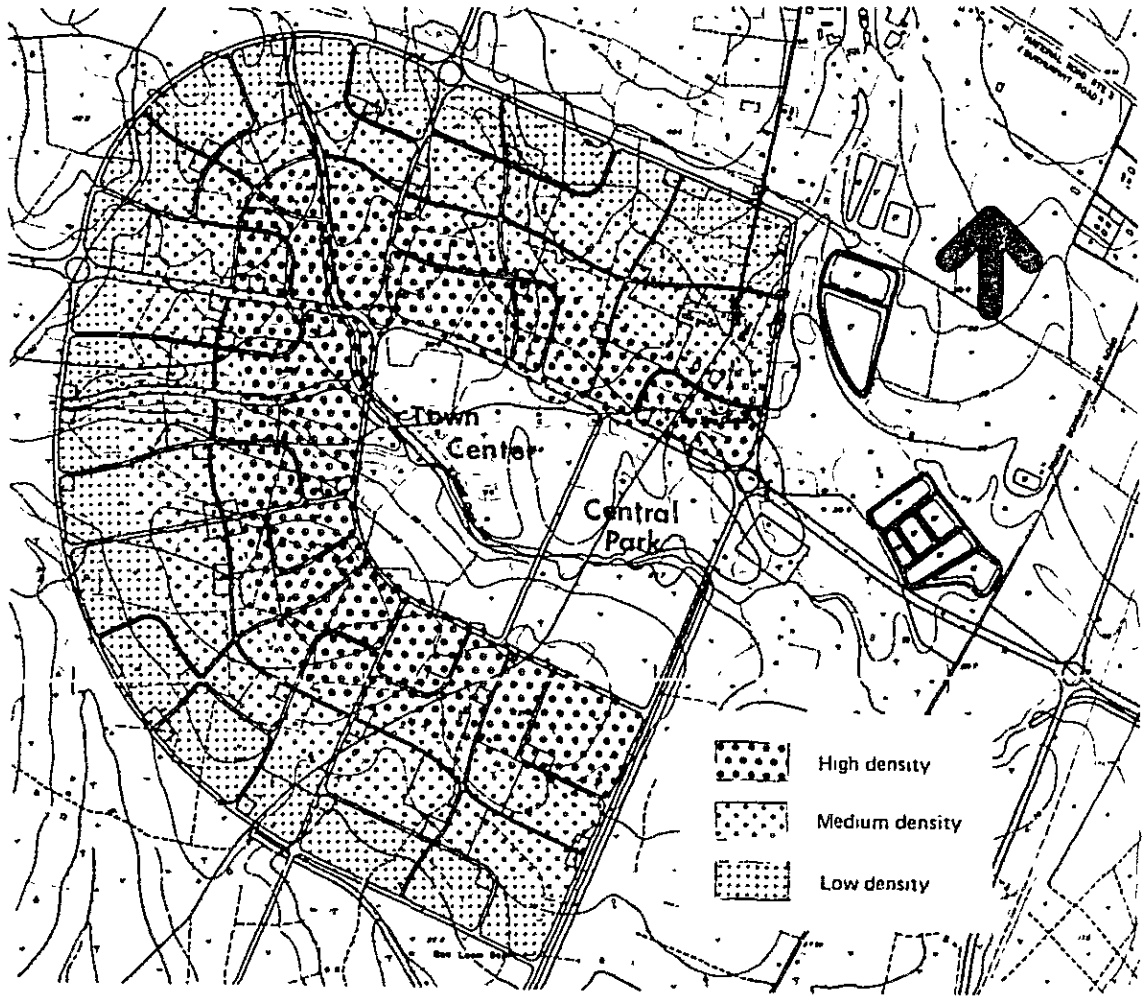


Fig. 7.4-3 Distribution of Density in Residential Area

7.4.3 Typical Zoning of Housing Estate

(1) Neighborhood Units and Community Structure

In the New Town, a basic unit of neighborhood is planned in an area of about 100 ha to accommodate 13,000 people or 3,000 households with variations in density. A primary school, community facilities, neighborhood shopping center and parks and playgrounds to be served for dwellers are planned as basic elements in community structure.

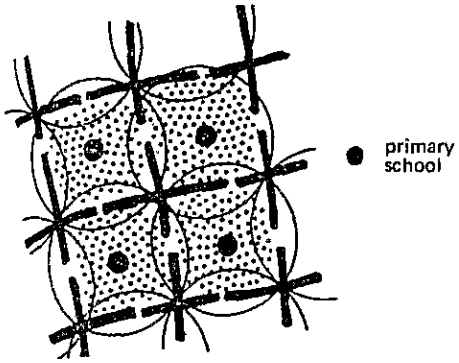


Fig. 7.4-4 Neighborhood unit related to primary school

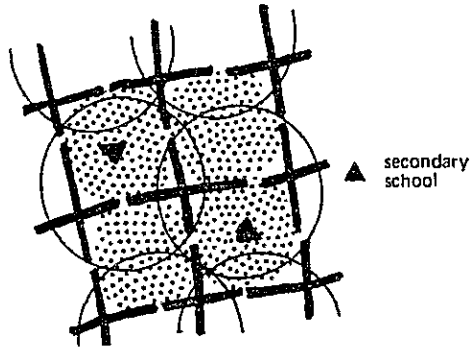


Fig. 7.4-5 Neighborhood unit related to secondary school

The dominant theme concerned with neighborhood unit planning is to balance in age structure, family structure, house tenure and socio-economic grouping. There are many advantages to be gained from mixed development of dwellings in neighborhood units, which will be one of the most useful methods for the well balanced community. From many samples of new towns, hierarchy of grouping of dwellings in relation to the residential unit is considered as follows:

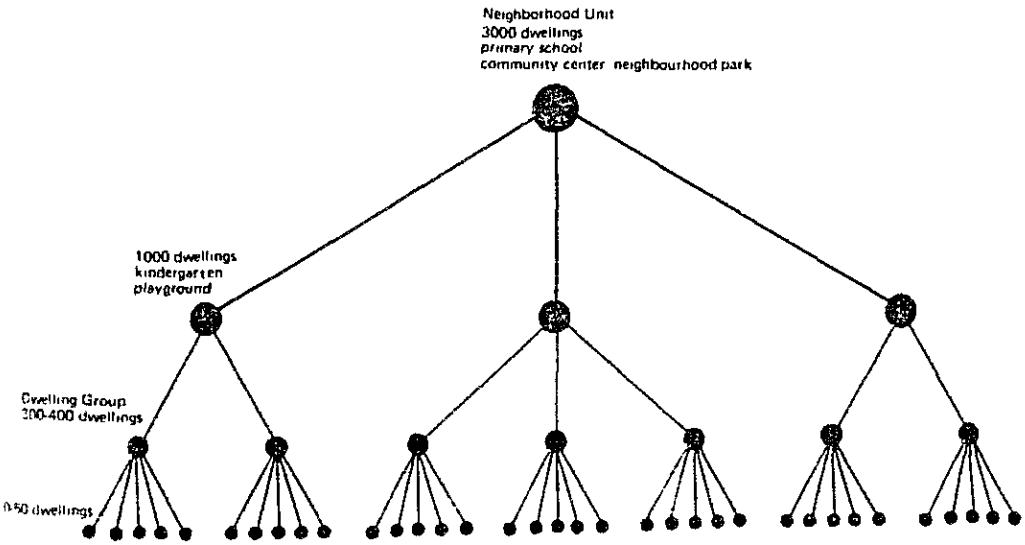


Fig. 7.4-6 Hierarchy of Grouping of Dwellings Related to the Residential Unit

The physical layout of a residential area should be planned with three main requirements in mind, i.e., accessibility, adequate space and environmental quality. By keeping the traffic volume down to levels sufficient to ensure safety, it is possible to eliminate the potential danger of traffic accidents on peripheral roads in a neighborhood. This will also control noise and air pollution.

Within a residential area all roads will be access roads with a few traffic volume. Access roads are planned to allow cross movements in all directions but not to give short-cuts for through-routes.

To secure comfortable residential environment, opportunities for children's play in residential area will be provided in a range of places beginning with nearby small lot through larger space for organized sports, football ground and adventure playgrounds. All play spaces should be sited along pedestrian movements and should become a network of open space in the whole New Town

In process of forming community the structures of residential unit (micro-structure) which involve one of the most important factors among the social development have a great influence upon the structure of urban area (macro-structure). However, in Thailand development of a large scale new town has just started and not yet given any available data on social survey. Therefore, in order to develop this New Town with a reasonable form of community, social research, including population growth, household structure, age/sex structure, occupation, income, academic career, religion, political ideas, etc. of inhabitants should be further made by relevent authorities.

Fig. 7.4-7 shows a model of typical residential unit.

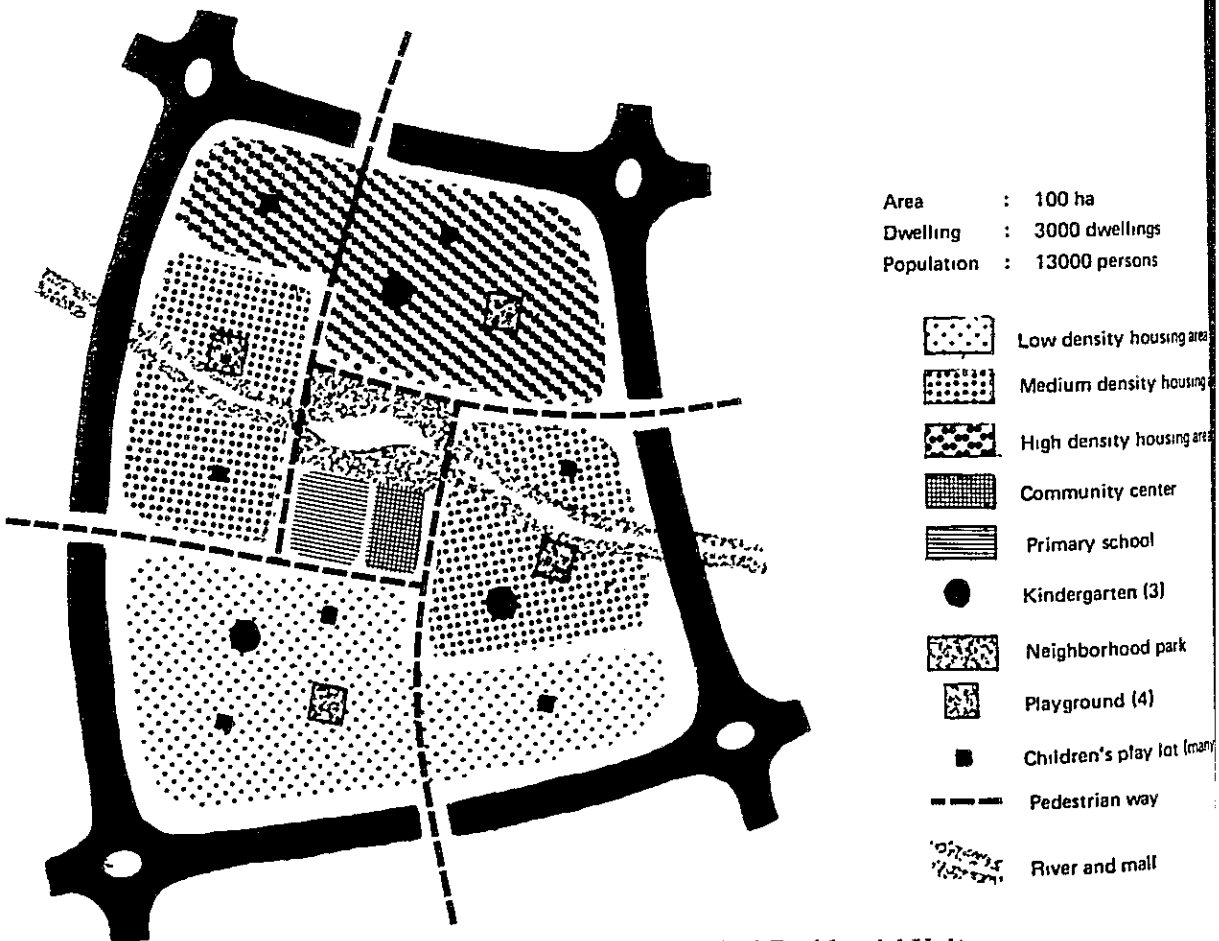


Fig. 7.4-7 Model of Typical Residential Unit

(2) Residential Area Layout

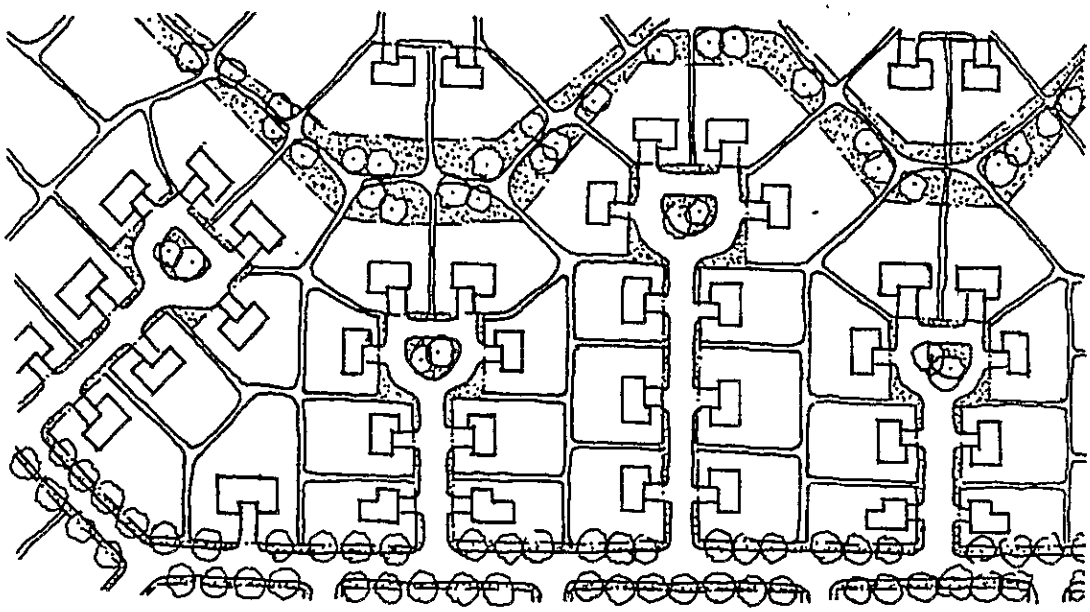
Residential area should be laid out to create residential environment of good quality. Besides high standard of buildings and ample living space which are two important aspects to build residential environment, the following physical and social aspects should be taken into consideration at the detailed planning and designing stage:

- Natural features in urban area must be utilized to the maximum extent for residential layout avoiding the large scale site preparation. This site is not too rough and wild to be developed for residential purpose.
- Specific natural characters such as the existing forests, khlongs, dikes and ditches should be introduced into the landscaping design so as to create more attractive pedestrian mall, children's play lot and playground.
- Tropical climate conditions should be taken into consideration. In a housing units must be sited to be naturally ventilated and, at the same time, to avoid direct exposure to the sun.
- The major function of access roads is to serve the residential area and, therefore, care should be taken in designing so as not to give short circuit to the major grid. The access roads will be arranged to have T-junctions at grid road pattern. Generally a cul-de-sac arrangement is one of the most useful methods in order to separate pedestrains from vehicles; however, it is not economical or realistic in this New Town where traffic volumes on the access roads will be low.
- All of detached houses and some part of semi-detached houses will be provided with garages in their own plots, and parking spaces for some part of semi-detached houses, town houses and flats will be centralized at some lots.
- Pedestrain malls will be designed to connect the residential area with each other and to be put to practical use.
- Trees and grass will be planted as many as possible in order to give shade and landscaping on the land after site proparation.

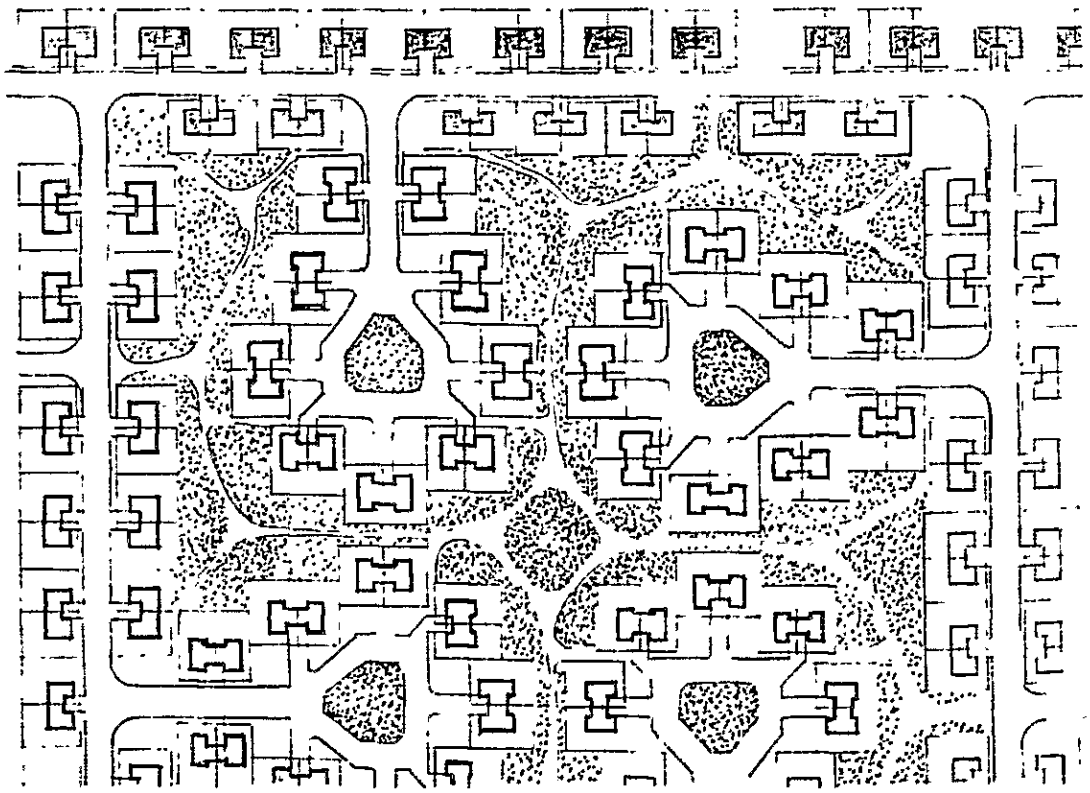
For reference, residential layouts of each housing type are shown on the following pages.

Fig. 7.4-8 Idea of Residential Layouts

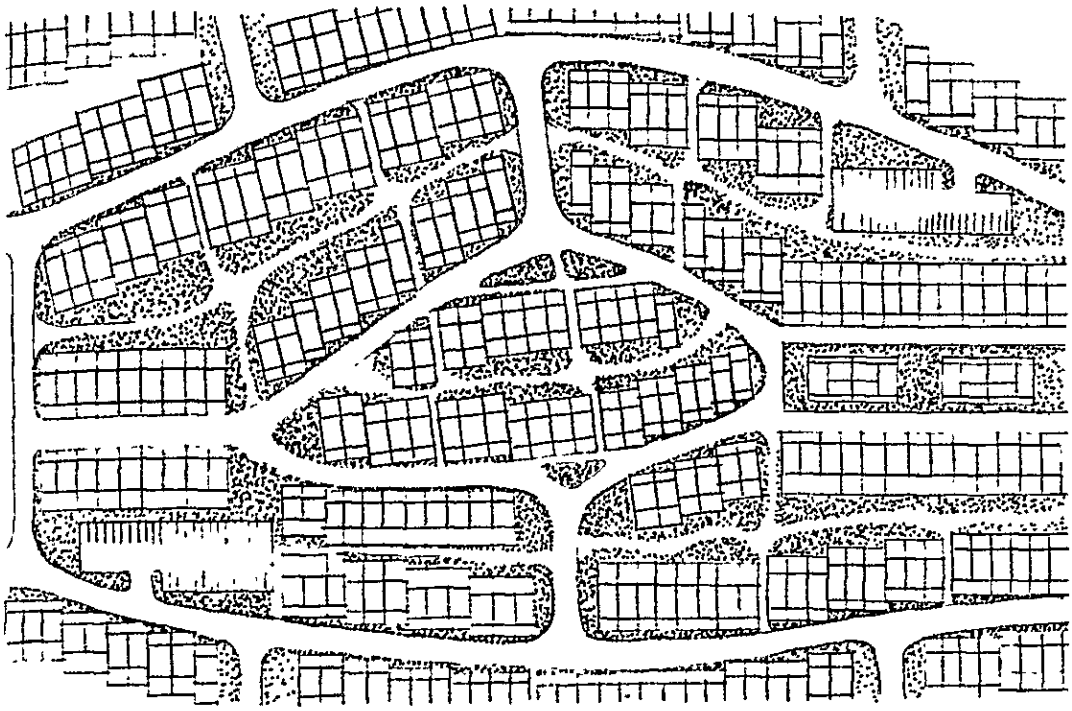
Detached house layout



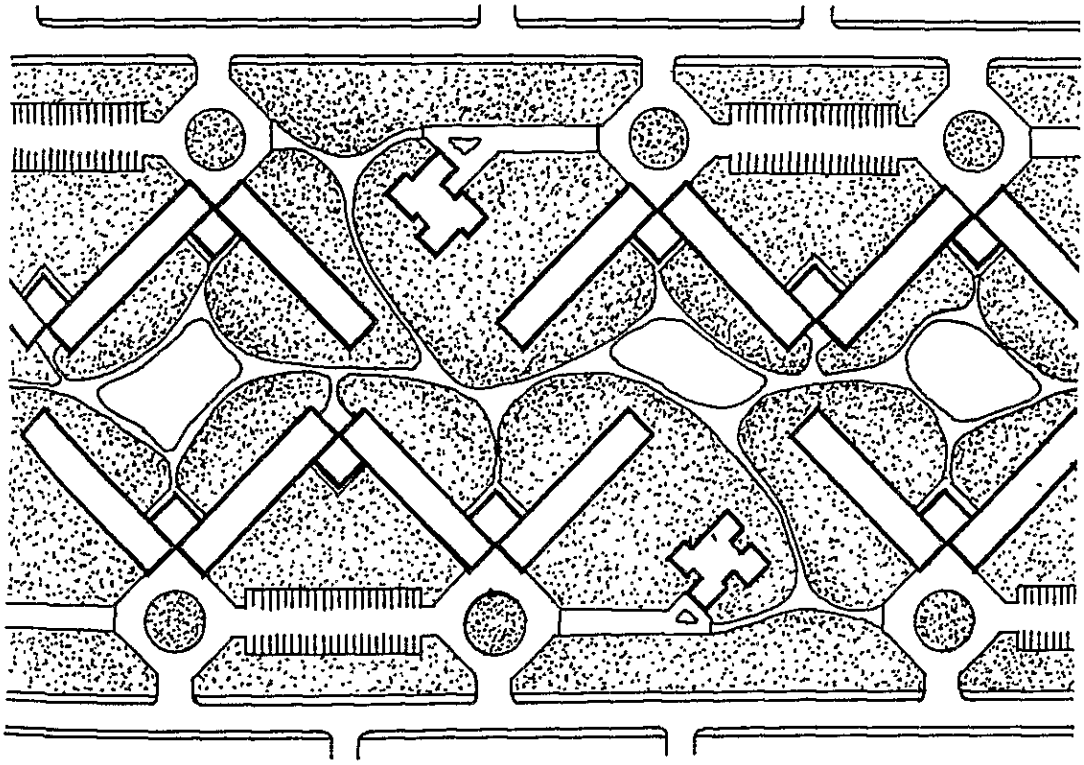
Semi-detached house layout

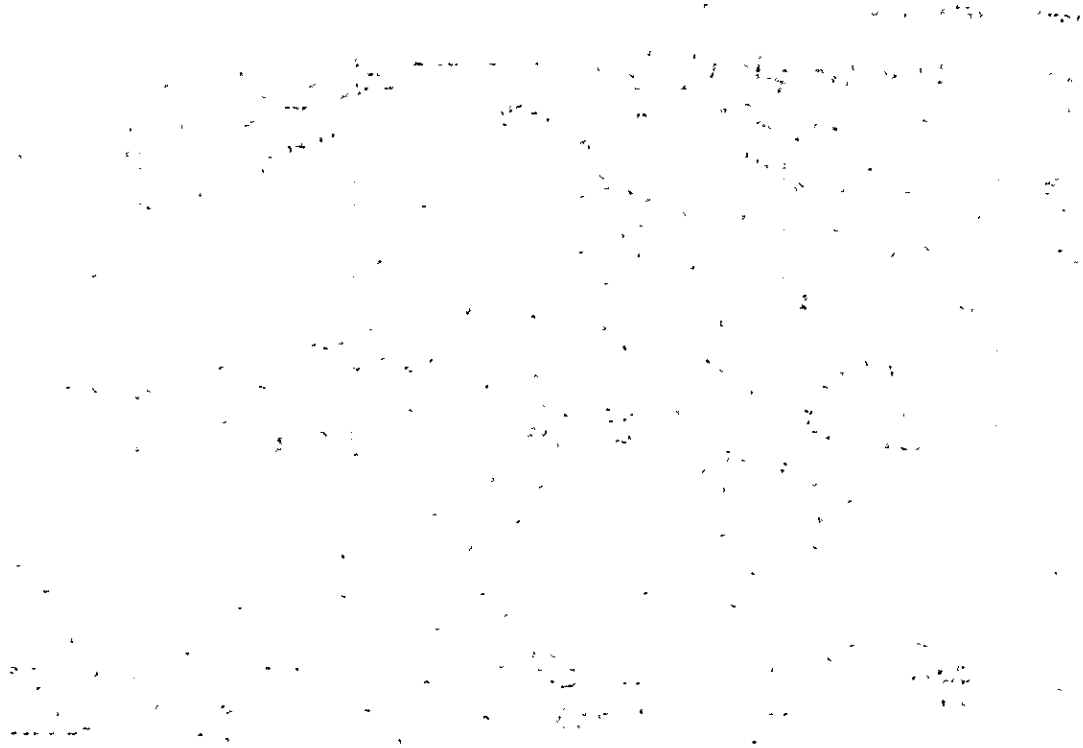


Town house layout



Flat (midium rise) layout





CHAPTER 8

PLAN FOR RELATED INFRASTRUCTURES

CHAPTER 8. PLAN FOR RELATED INFRASTRUCTURE

8.1 Transportation Network

8.1.1 Forecast of Road Traffic

(1) Purpose and process of Traffic Forecast and Planning

The Road network, public transport network and pedestrian network must be proposed so as to create improved accessibility to and from the Industrial Complex, residential area and Town Center, and also assure smooth and efficient traffic flow in and outside the area.

Therefore, it is important to study to attain the following:

(i) Road hierarchy should be clearly established and road network should be arranged so as to be capable of meeting the traffic requirements, thereby avoiding heavy traffic generated from the Industrial Complex and through-traffic in the residential area.

(ii) Improvement of inter-regional highway should be studied to cope with the future cargo traffic demand.

(iii) Road sections have to be determined to suit the future traffic volume without giving rise to a traffic jam.

(iv) Zone bus system will be desirable to provide dense transportation service block by block within the residential area, Town Center and Industrial Complex. In that case, Ban Chang – Map Ta Phut – Rayong will be the axis of zone bus system, connecting each other by express bus operation. Railway may be difficult to be used as intra-city transportation means for commuting for the time being. It will mainly be used for cargo and in future for inter-city traffic means for passengers, taking the town scale into consideration.

However since no reliable data are available at the Eastern Seaboard, quantitative analysis based on the future traffic demand prediction must be made in order to establish such comprehensive transportation system plan. Fig. 8.1-1 shows the process of the future travel demand estimate and facility planning adopted under the limited data sources.

(2) Person Trip and Passenger Vehicle Trip Generation

(a) Person Trip Generation

The trip rate per person excluding foot trips in the year 1987 and 2000 was determined at 1.5, referring to the increase rate of the number of trips per person in Greater Bangkok Area. The number of trips by truck is excluded from the above trip rate. The control total of person trip generation from the New Town, the existing Map Ta Phut and Ban Chang Town will be estimated as follows, multiplying the population by the number of trips per person.

	1987	2000
New Town	27,450 trips/day	107,250 trips/day
Map Ta Phut Town	16,200	22,200
Ban Chang Town	33,600	47,250
Total:	77,250	176,700

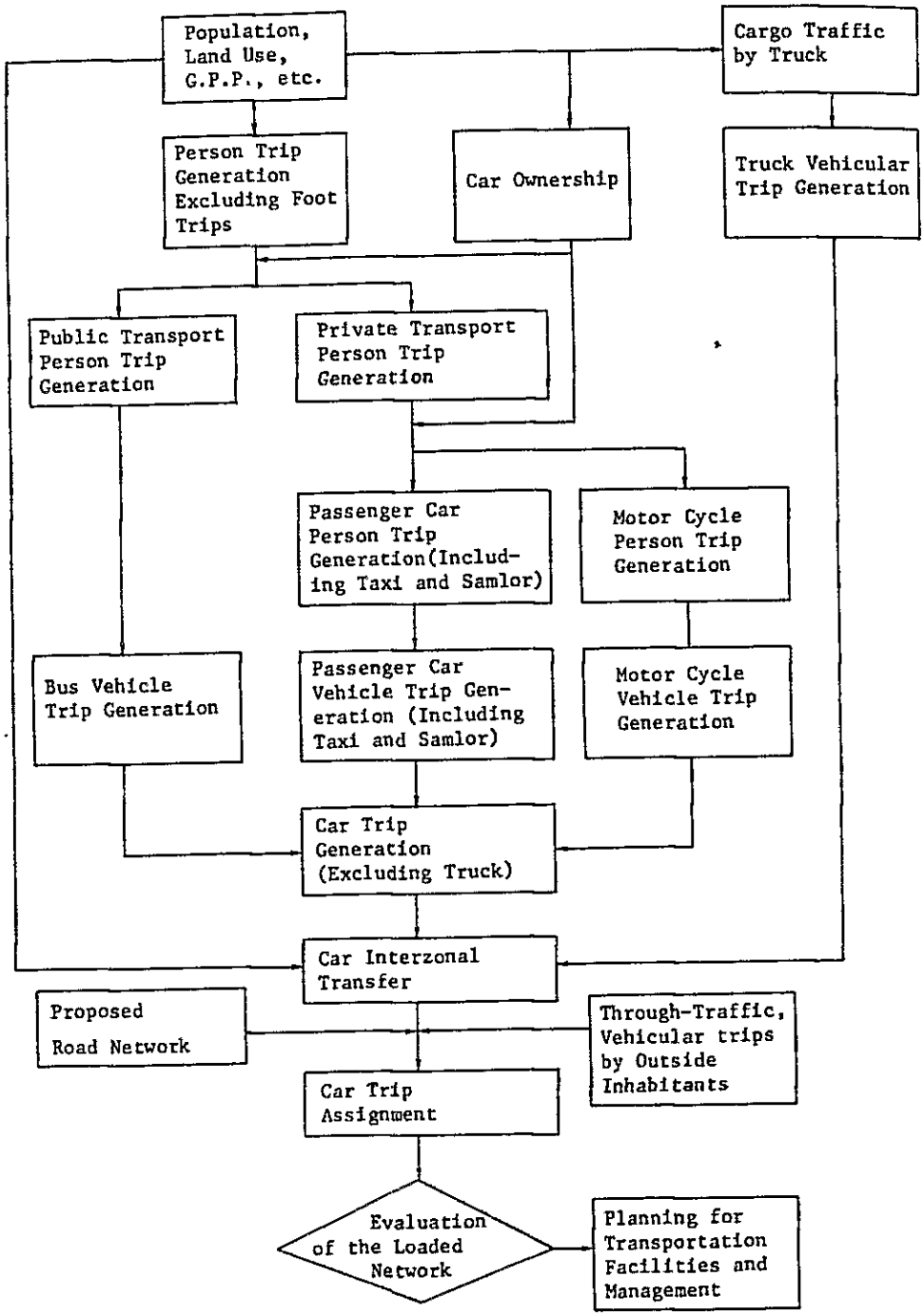


Fig. 8.1-1 Process of Transportation Planning

(b) Modal Split

Public transport/private transport rate in the total person trips will be estimated, based on the number of vehicles registered. The number of vehicles in the region will be affected by Gross Provincial Product; therefore, future G.P.P. in the planning site has been assumed same as that in Greater Bangkok Area in the year 2000, where "Feasibility Study on the Second Stage Expressway System in the Greater Bangkok" is now in process under the aegis of JICA and the basic data are being provided. Referring to that study, it has determined by extending the present conditions in the Greater Bangkok Area that the car ownership rate is 80 vehicles/1,000 persons in the year 2000 and that the percent share of private transport users in the total person trips in 2000 is 40% while the share is 35% in 1982.

As next step, private transport users will be split by passenger car users and motorcycle users. Passenger car includes taxi and samlor. It is known that increase in the passenger car ownership will be accompanied with decrease in the motorcycle ownership when income rises above a certain level. So the share of motorcycle users in private transport users has been determined at 15% in the year 2000 while 19% in 1982.

Thus, the rate of each traffic means in the total person trips in the year 2000 will be estimated as follows:

	Composition	
Passenger Car	34%	
Motorcycle	6%	40%
Public Transport (Bus)	60%	

(c) Passenger Vehicle Trip Generation

Conversion from person trips to vehicle trips will be made by applying the following future passenger occupancy rate which was studied in the aforesaid JICA Study. With regard to the rate, the reason why each rate in 2000 is smaller than that in 1982 is that standard of living and service level of public transport is supposed to be improved in future.

Table 8.1-1 shows the estimated future person trip and passenger vehicle trip generation. The figures in 1987 are estimated by interpolation on the linear line between 1982 and 2000.

	1982	2000
Passenger Car	1.65 persons/vehicle	1.50 persons/vehicle
Motorcyle	1.24	1.20
Bus	47.00	30.00

(3) Truck Generation

Based on the cargo traffic forecast described in Chapter 4, the number of truck trips will be anticipated by the following equation.

$$T = A \times \frac{1}{W} \times \frac{\alpha}{12} \times \frac{\beta}{30} \times \frac{1+\delta}{E}$$

T: Number of truck trips (trips/day)

A: Annual volume of cargoes handled (1,000 tons)

Where, W: Truck actual load (ton/truck)

α: Monthly variation rate (peak month/average month)

β: Daily variation rate (peak day/average day)

δ: Rate of related vehicles (related vehicles/total number of trucks)

E: Loaded truck rate (trucks loaded with cargoes/total number of trucks)

Table 8.1-1 Number of Trips by Mode

			New Town		Map Ta Phut Existing Town		Ban Chang Existing Town		Total	
			Perosn Trips	Passen-ger Vehicle Trips	Person Trips	Passen-ger Vehicle Trips	Person Trips	Passen-ger Vehicle Trips	Person Trips	Passen-ger Vehicle Trips
1987	PVT	Passenger Car	8,230	5,110	4,850	3,010	10,070	6,250	23,150	14,370
		Motorcycle	1,790	1,460	1,060	860	2,190	1,780	5,040	4,100
		Sub-Total:	10,020	6,570	5,910	3,870	12,260	8,030	28,190	18,470
		Bus	17,430	420	10,290	240	21,340	510	49,060	1,170
		Total:	27,450	6,990	16,200	4,110	33,600	8,540	77,250	19,640
2000	PVT	Passenger Car	36,470	24,310	7,550	5,030	16,070	10,710	60,090	40,050
		Motorcycle	6,430	5,360	1,330	1,110	2,830	2,360	10,590	8,830
		Sub-Total:	42,900	29,670	8,880	6,140	18,900	13,070	70,680	48,880
		Bus	64,350	2,150	13,320	440	28,350	950	106,020	3,540
		Total:	107,250	31,820	22,200	6,580	47,250	14,020	176,700	52,420

Note / PVT : Private Transport

In determining the value of W x E, truck loading volumes in a 1979 survey as shown in Table 8.1-2 are referred. These figures include trucks travelling empty. As for another coefficient, the following values have been adopted:

$\alpha = 1.0, \qquad \beta = 1.5, \qquad \delta = 1.5$

Estimated numbers of truck trips are summarized in Table 8.1-3 and 4 by type of industry.

Table 8.1-2 Load/Veh. and Composition

Classification	Composition	Load/Veh
4 wheel truck	35.3%	0.9 t/veh
6 wheel truck	46.7%	2.6 t/veh
10 wheel truck	18.0%	6.2 t/veh

Source: DLT

Table 8.1-3 Truck Cargo Volume and Number of Truck Trips 1987

(Unit: Ton/year, Veh/Day)

	From Industrial Complex				Into Industrial Complex				Total			
	Truck Cargo Volume (A)		Number of Truck Trips (T)		Truck Cargo Volume (A)		Number of Truck Trips (T)		Truck Cargo Volume (A)		Number of Truck Trips (T)	
1. Fertilizer Center		Destination		Destination		Origin		Origin		O & D		O & D
	350,000 14,000	whole W → N	2,625 105	whole W → N					350,000 14,000	whole W → N	2,625 105	whole W → N
2. Soda Ash Center	70,000 140,000	W → N Whole	525 1,050	W → N whole	-		-		70,000 140,000	W → N whole	525 1,050	W → N whole
3. Petrochemical Center	158,340	W → N	1,188	W → N	-		-		158,340	W → N	1,188	W → N
4. Iron & Steel Center	-		-		-		-		-		-	
5. Down Stream & Supporting Industry	136,000	W → N	1,020	W → N	149,000	North	1,118	North	136,000 149,000	W → N North	1,020 1,118	W → N North
6. Commercial Center	280,000	W & E	2,100	W & E	760,000	East	5,700	East	280,000 760,000	W & E East	2,100 5,700	W & E East
Total	490,000 378,340 280,000	Whole W → N W & E	3,675 2,838 2,100	whole W → N W & E	149,000 760,000	North East	1,118 5,700	North East	490,000 378,340 280,000 149,000 760,000	whole W → N W & E North East	3,675 2,838 2,100 1,118 5,700	whole W → N W & E North East

Total 15,431

Table 8.1-4 Truck Cargo Volume and Number of Truck Trips 2000

(Unit: Ton/year, Veh/Day)

	From Industrial Complex				Into Industrial Complex				Total			
	Truck Cargo Volume (A)		Number of Truck Trips (T)		Truck Cargo Volume (A)		Number of Truck Trips (A)		Truck Cargo Volume (A)		Number of Truck Trips (T)	
		Destination		Destination		Origin		Origin		O & D		O & D
1. Fertilizer Center	595,000 7,000	whole W → N	4,463 53	whole W → N					595,000 7,000	whole W → N	4,463 53	whole W → N
2. Soda Ash Center	112,000 280,000	W → N whole	840 2,100	W → N whole					112,000 280,000	W → N whole	840 2,100	W → N whole
3. Petrochemical Center	347,480	W → N	2,606	W → N					347,480	W → N	2,606	W → N
4. Iron & Steel Center	1,502,830	W → N	11,271	W → N	334,460	North	2,508	North	1,502,830 334,460	W → N North	11,271 2,508	W → N North
5. Down Steam & Supporting Industry	320,498	W → N	2,404	W → N	323,856	North	2,429	North	320,498 323,856	W → N North	2,404 2,429	W → N North
6. Commercial Center	560,000	W & E	4,200	W & E	760,000	East	5,700	East	560,000 760,000	W & E East	4,200 5,700	W & E East
Total	875,000 2,289,808 560,000	whole W → N W & E	6,563 17,174 4,200	whole W → N W & E	658,316 760,000	North East	4,937 5,700	North East	875,000 2,289,808 560,000 658,316 760,000	whole W → N W & E North East	6,563 17,174 4,200 4,937 5,700	whole W → N W & E North East
										Total	38,574	

(4) Interzonal Transfer

(a) Passenger Vehicles

Future interzonal trip generation will be estimated in various mathematical procedures. However, there are no O–D data surveyed at the eastern seaboard, the trip distribution of passenger vehicles has been studied based on the population, number of workers and land use of each town by trip purpose.

The interzonal trip rates for each town have been estimated on the analogy of the size and compactness of each town; – New Town at 50%, Ban Chang and Map Ta Phut at 40%.

The interzonal trip distribution in the year 2000 was quantitatively and qualitatively studied as shown in Table 8.1-5, based on the following index by trip purpose and proportion of trips by purpose.

Trip Purpose	Index (Trip Generation)	Index (Trip Attraction)	Proportion
1) Commuting	Population	worker	25%
2) School	Population	Student	5%
3) Business	Worker	Worker	15%
4) Shopping, recreation, etc.	Population	Service worker, Land Use	15%
5) Going home	Trip Attraction of 1) + 2) + 4)	Trip Generation of 1) + 2) + 4)	40%
All purpose			100%

Table 8.1-5 Interzonal Transfer

By Residents in New Town		
Intra-Zone (Inside New Town)	15,910 veh/day	(50%)
New Town – Industrial & Port Area	7,960	(25%)
New Town – Map Ta Phut	1,590	(5%)
New Town – Ban Chang	3,180	(10%)
New Town – Other Towns	1,590	(5%)
Industrial & Port Area Based	1,590	(5%)
Total:	31,820 veh/day	(100%)
By Residents in Ban Chang		
Intra-Zone (Inside Ban Chang)	5,620 veh/day	(40%)
Ban Chang – Industrial & Port Area	3,500	(25%)
Ban Chang – New Town	3,500	(25%)
Ban Chang – Other Towns	700	(5%)
Industrial & Port Area Based	700	(5%)
Total:	14,020 veh/day	(100%)
By Residents in Map Ta Phut		
Intra-Zone (Inside Map Ta Phut)	2,620 veh/day	(40%)
Map Ta Phut – Industrial & Port Area	1,650	(25%)
Map Ta Phut – New Town	1,650	(25%)
Map Ta Phut – Other Towns	330	(5%)
Industrial & Port Area Based	330	(5%)
Total:	6,580 veh/day	(100%)

(b) Truck

Interzonal transfer of trucks will be estimated by the distribution rate of each cargo's origin and destination described in Chapter 4. Table 8.1-3 and 4. show the results.

(c) Related Trips by Outside Residents

Related trips by outside residents from outside to the planning site are assumed equal to the number of inside resident's trips by Passenger Vehicle from the planning site to outside. The number is estimated at about 3,000 veh/day.

(d) Through-Traffic

Through-traffic data are taken from Travel Demand 2000 in Eastern Seaboard Study. According to the data, through-traffic volume is estimated at about 10,000 veh/day between Sattahip and Rayong.

(5) Car Traffic Assignment

For the purpose of assigning the car trips to the proposed road network, the car trip generation and attraction are broken down to match each block of the Industrial Complex, residential area and Town Center. Then, the car trips are assigned onto minimum pass by using the directional assignment factors pertinent to the interzonal transfers to estimate the traffic demand for each road.

Fig. 8.1-2 shows the result of traffic assignment in the year 2000. The truck traffic volumes on main roads are as follows.

Route 3 Bypass for Sattahip	34,556 Veh/Day
Route 3 Bypass for Rayong	2,878 Veh/Day
Route 3191	1,140 Veh/Day

Most of the truck traffic will be supposed to go to and from the north by using Route 3 Bypass. Through-traffic will be assigned on existing Route 3 and Route 3 Bypass.

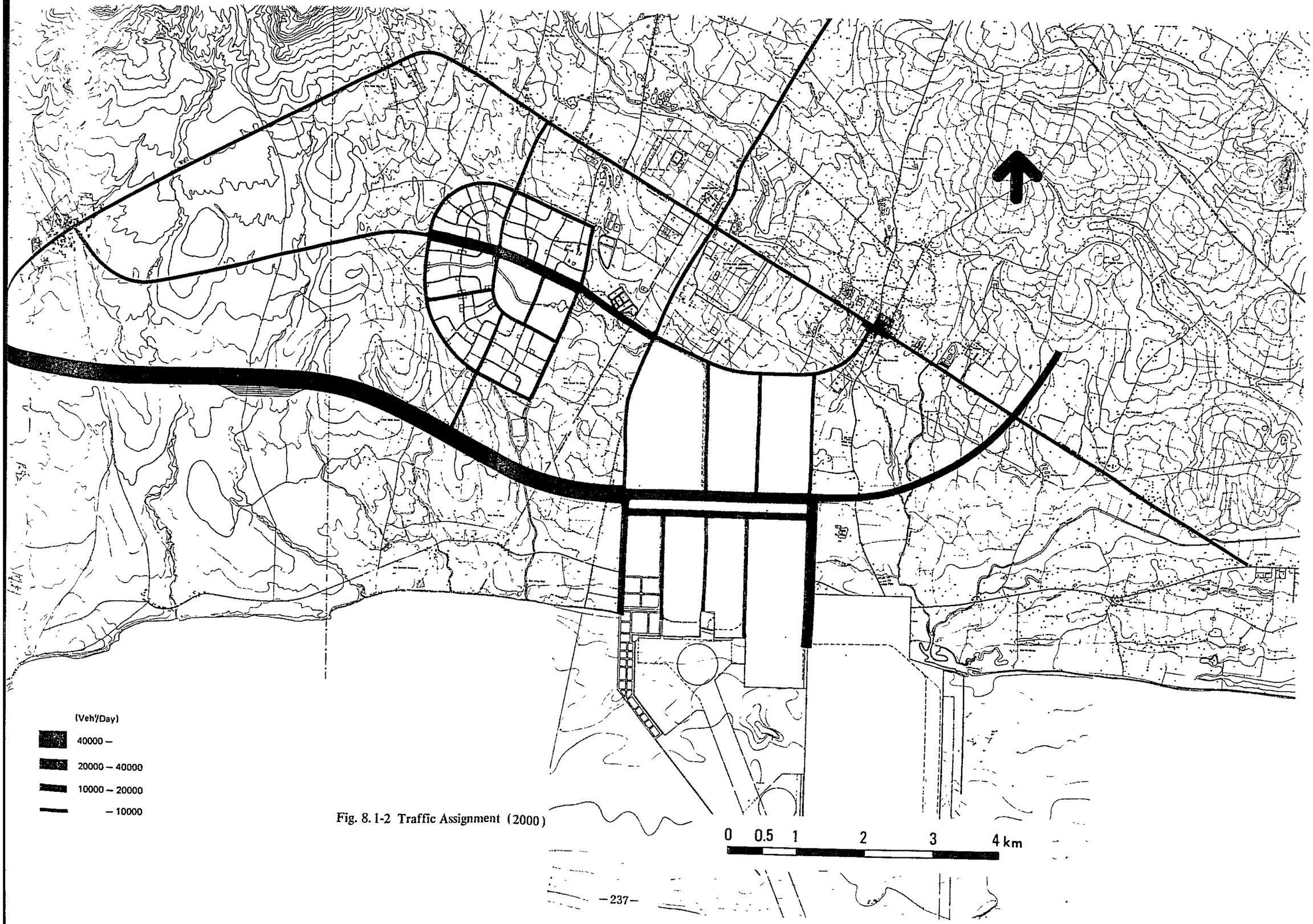


Fig. 8.1-2 Traffic Assignment (2000)

8.1.2 Road Facilities Planning

(1) Road Network and Cross Section

The following road hierarchy was established, based on the evaluation of the loaded network by car traffic assignment and furthermore on the basis of the qualitative and quantitative analysis of the traffic flow on each road.

Road Hierarchy	Right-of-way	Number of Lanes
1. Bypass	100 m	6 Lanes + 4 lanes (frontage road)
2. Primary trunk road	40 m, 30 m	4 Lanes
3. Secondary trunk road	25 m, 16 m	2 Lanes
4. Collector and Distributor	15 m, 12 m	2 Lanes
5. Minor Access Road	6.5 m	2 Lanes

Road hierarchy in the Development Area is as shown in Fig. 8.1-3, and the cross sections of the roads in Fig. 8.1-4 as established on the basis of the road capacities taking the ratio of truck traffic volume on each road into consideration.

The primary trunk road connecting Map Ta Phut, Ban Chang and the New Town is the main route axis among these towns and is desirable to have four lanes. The Route 3 Bypass is required to have six lanes for heavy traffic.

Table 8.1-6 shows the practical capacities of two-way urban roads. Here, the peak factor is assumed as Ca. 10%.

In the cross sections of the roads, pavement construction, drainage system, location of utility lines, etc. are also shown.

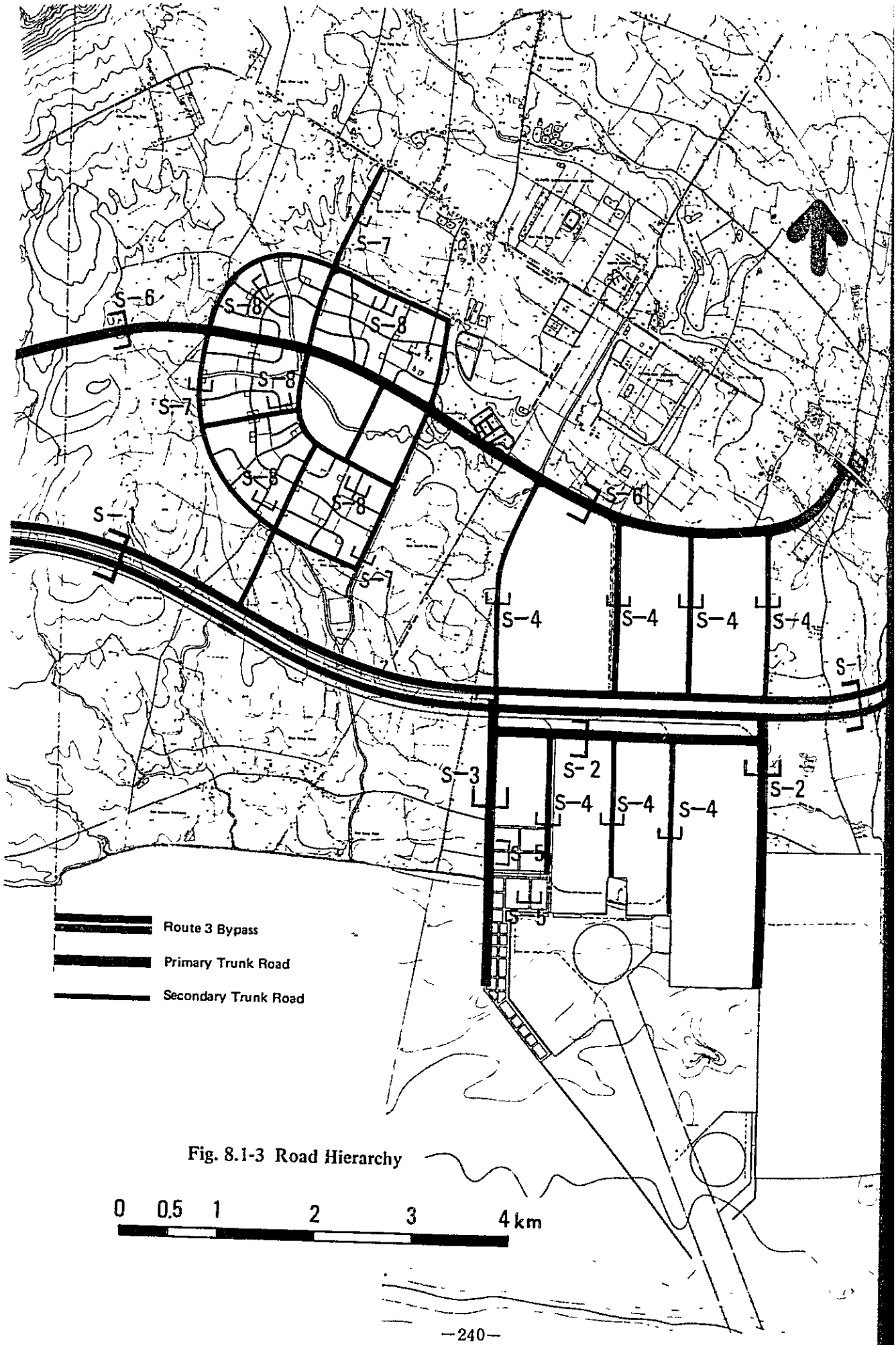
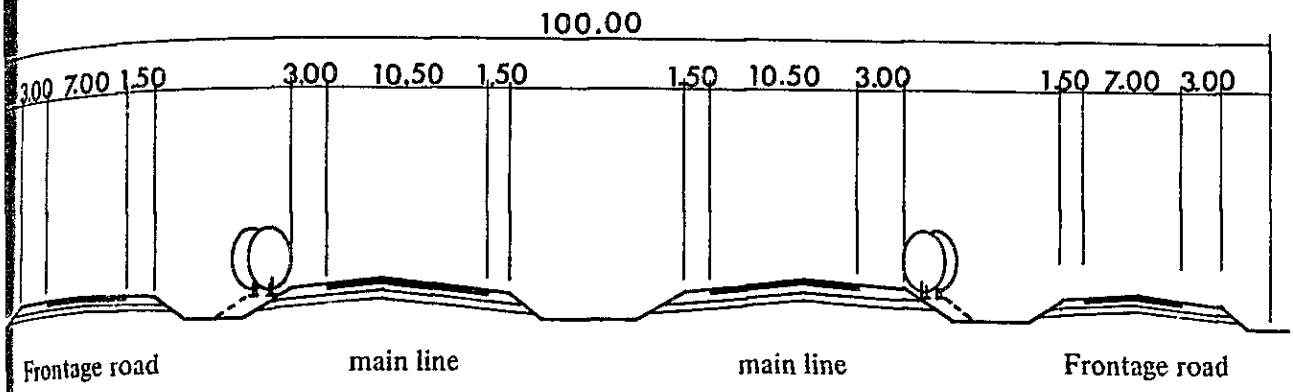
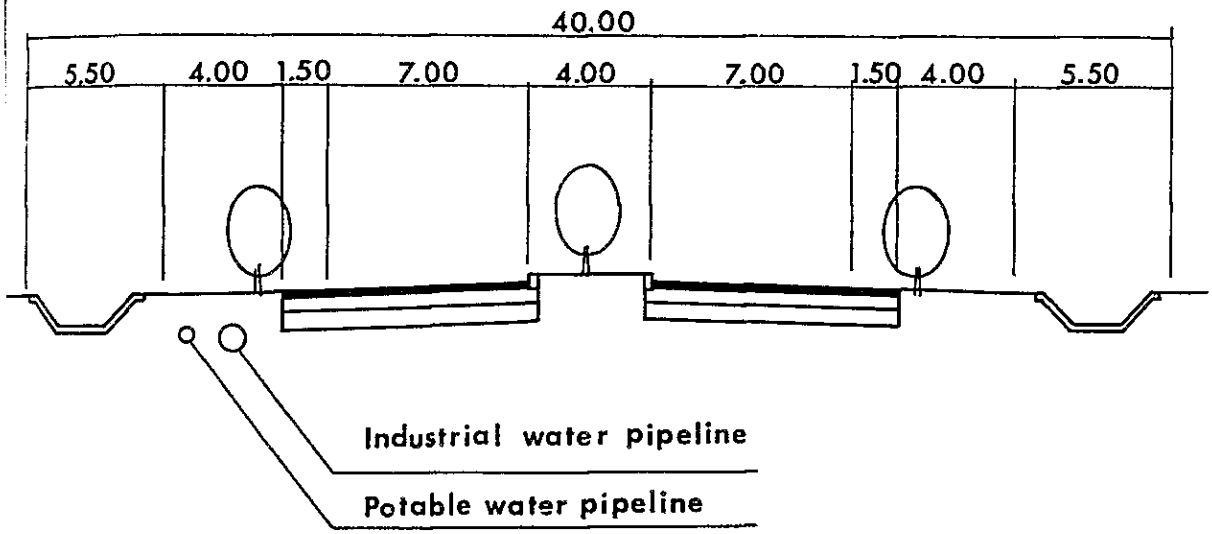


Fig. 8.1-3 Road Hierarchy

S-1 Highway (Route 3 By-pass)



S-2 Primary Trunk Road - 1 (For Industrial Complex)



S-3 Primary Trunk Road - 2 (--do--)

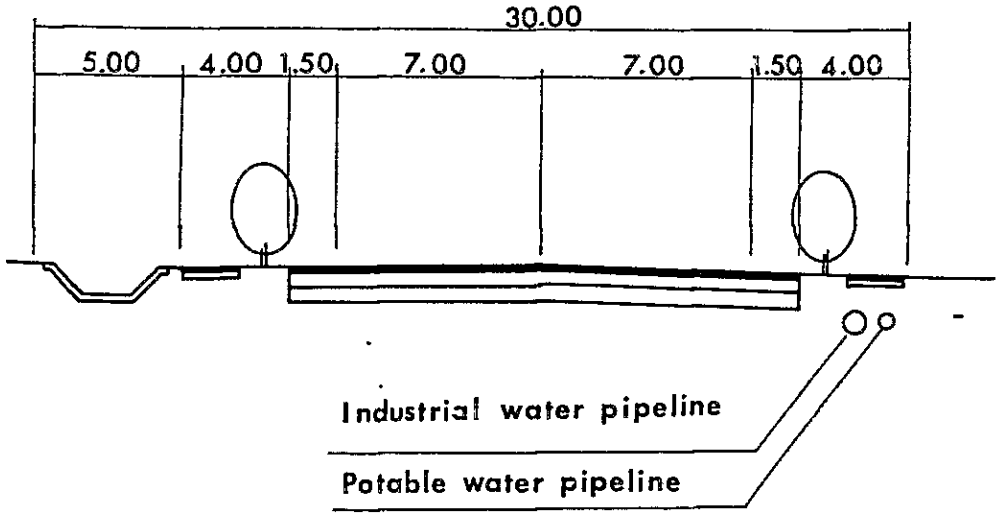
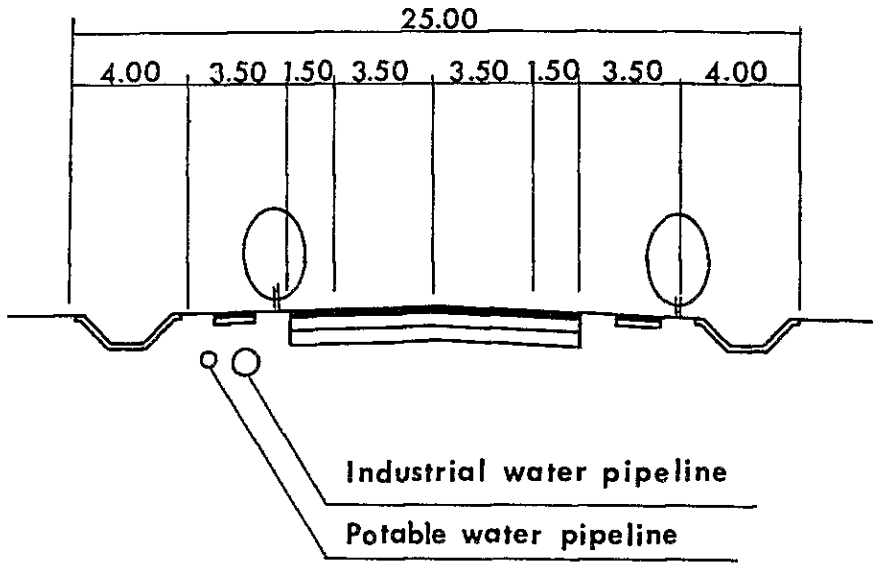
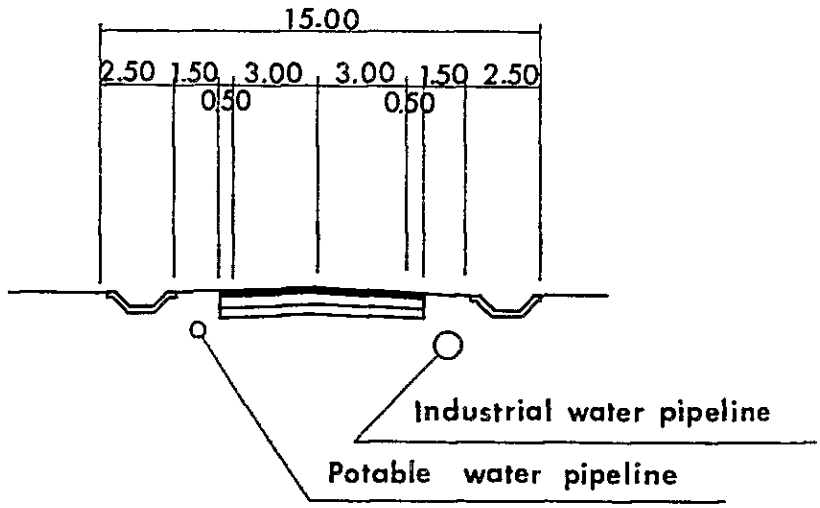


Fig. 8.1-4 Cross Section of Roads

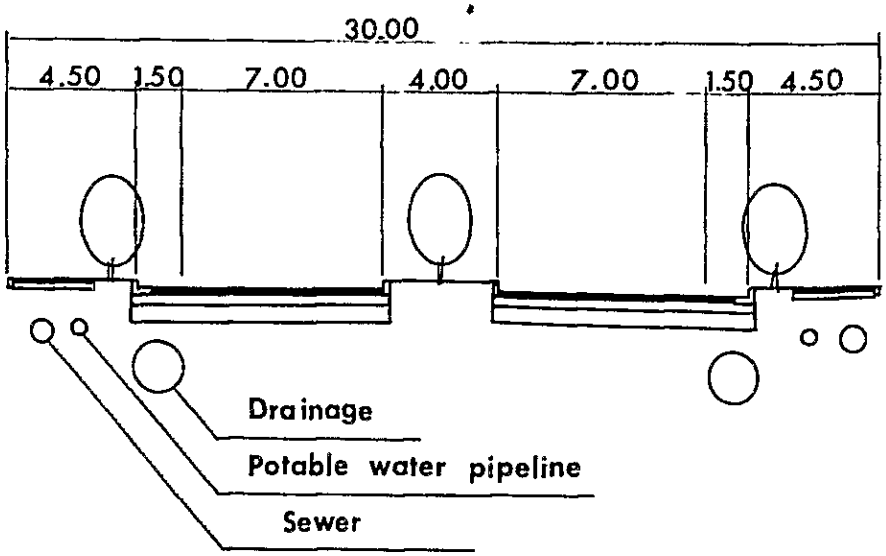
S−4 Secondary Trunk Road (--do--)



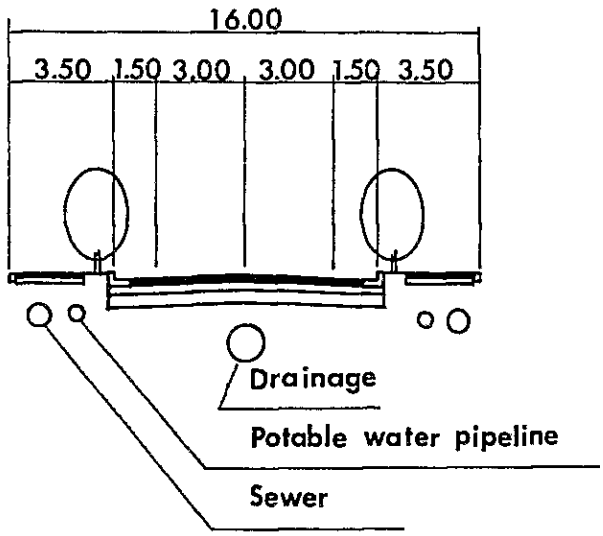
S−5 Collector and Distributor (--do--)



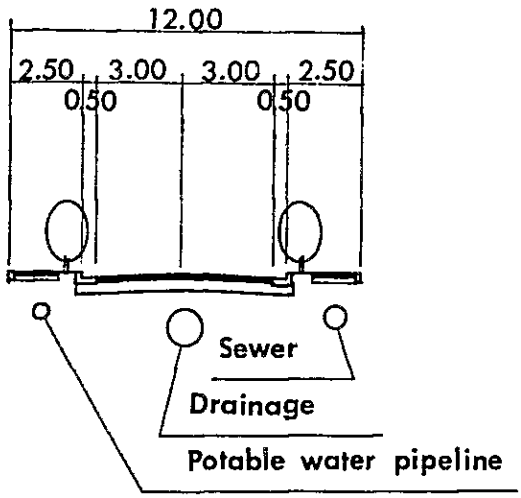
S−6 Primary Trunk Road (For New Town)



S-7 Secondary Trunk Road (--do--)



S-8 Collector and Distributor (--do--)



S-9 Minor Access Road (--do--)

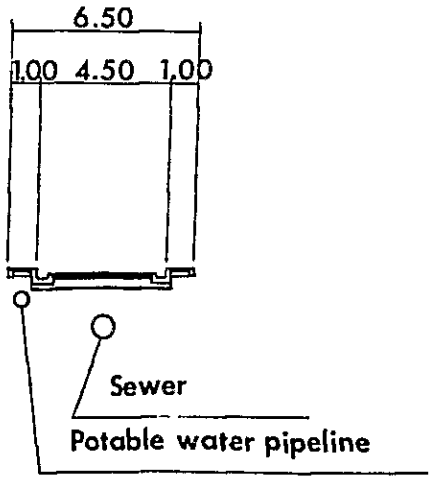


Table 8.1-6

PRACTICAL CAPACITIES OF TWO-WAY URBAN ROADS

Effective width of carriageway in feet (excluding refuges or central reserve)	2-lane			3-lane		4-lane			6-lane			Remarks
	20'	22'	24'	30'	33'	40'	44'	48'	60'	66'	72'	
Description	Capacity in pcu's per hour for BOTH directions of flow					Capacity in pcu's per hour for ONE direction of flow						(for definitions of road types)
Urban motorway with grade separation and no frontage access								3,000			4,500	Applicable to the highest category of distributor
All-purpose road with no frontage access, no standing vehicles permitted and negligible cross-traffic	1,200	1,350	1,500	2,000	2,200	2,000	2,200	2,400	3,000	3,300	3,600	Appropriate for all-purpose distributors
All-purpose street with high-capacity junctions and "No Waiting" restrictions	800	1,000	1,200	1,600	1,800	1,200	1,350	1,500	2,000 2,200 for dual carriageways	2,250 2,450	2,500 2,700	Applicable to those distributors and access roads where access to development is frequent but capacity is not unduly restricted by junctions
All-purpose street with capacity restricted by waiting vehicles and junctions	300 to 500	450 to 600	600 to 750	900 to 1,100	1,100 to 1,300	800 to 900	900 to 1,000	1,000 to 1,200	1,300 to 1,700	1,500 to 2,000	1,600 to 2,200	Typical of existing roads where waiting vehicles and junctions with heavy cross traffic severely limit capacity

(2) Improvement of Existing Road and Street System

As a result of evaluation for the loaded roads, it was clarified that the following improvement of the existing road and street system would be required.

(a) Improvement of the Existing Roads

(i) New alignment of Route 3 Bypass will be required since the heavy cargo traffic will be generated from the Industrial Complex. Route 3 Bypass is proposed to be connected with Route 3 at the northwest part of the Development Area to cope with the cargo traffic demand to northward. Thereby, no improvement for Route 3 will be required.

(ii) To widen Route 3191 may be difficult because the gas pipeline is underlying along the road. However, Route 3191 will take an important role to cope with the cargo traffic demand during the 1st Phase, although the traffic volume will decrease at the 2nd phase by the construction of Route 3 Bypass. Therefore the standard of the road should be upgraded by widening the width of carriageway to some extent while it will remain to be 2-lane road.

(b) Provision of Route 3 Bypass

Although a slight improvement of existing road system can meet the cargo traffic demand at the 1st Phase by 1987, the traffic capacity of Route 3191 and Route 36 will not be sufficient to cope with the heavy traffic demand for the northeastward in Bangkok direction at the 2nd Phase by 2000, thus it will be inevitable to investigate the alignment of Route 3 Bypass.

Although a thorough feasibility study should be made for provision of Route 3 Bypass,

its necessity was proposed in the present study and basically approved by the Thai side based on quantitative analysis made for future demand in a simple way due to lack of reliable data.

The Bypass has been aligned to be connected with Route 3 between Pattaya and Sattahip and with Route 36 between Rayong and the Industrial Complex, respectively as shown in Fig. 7.2-6.

The function, the future traffic volume, the alignment and type of junctions within the study area for Route 3 Bypass are as follows.

(i) Function

The functions of Route 3 Bypass are as follows, mainly composed of the element to cope with the heavy traffic demand which will be generated from the Industrial Complex.

- o To cope with the heavy cargo traffic demand and through-traffic by the clarification of road hierarchy.
- o Activation of existing industries in the surrounding area, introduction of new industries to the Eastern Seaboard, increase of employment opportunity and decentralization of population in Bangkok.
- o Environmental protection against the public nuisance by the rectification of the heavy traffic flow.
- o To make it possible to utilize the most of the social and natural resources in the surrounding area.

(ii) Future Traffic Volume

The traffic demand for Route 3 Bypass is estimated at more than 40,000 veh/day in Bangkok direction. This figure includes the major part of 39,000 veh/day trucks generated and attracted from and to the Industrial Complex, a half of 10,000 veh/day through-traffic between Sattahip and Rayong, and some part of the related trips from the study area.

One-third of the total number of trucks is related to Iron & Steel Center, one-fourth is related to Commercial Center (within the Industrial Complex) and these two figures come up to 60% of the total truck generation and attraction.

Since the most part of truck demand is in Bangkok direction, it is vitally important to improve the traffic capacity in the northeastward by the provision of Route 3 Bypass.

(iii) Alignment and Type of Junction within Study Area

The alignment of Route 3 Bypass within the study area is set as shown in this report, with due consideration given to the functions of highway, future land use pattern of new urban area and the existing nearby towns and so on. However, as a result of discussions with the Thai side, the alignment of the Bypass should have an allowance to be shifted by 500m at either side of the present plan for final determination given after further studies.

The grade of Route 3 Bypass should be a highway, taking its functions into consideration, and 200m width of right-of-way is planned to be kept for both Route 3 Bypass and railway which is aligned along Route 3 Bypass.

The rough sketch of the Bypass and railway section is illustrated in Fig. 8.1-5.

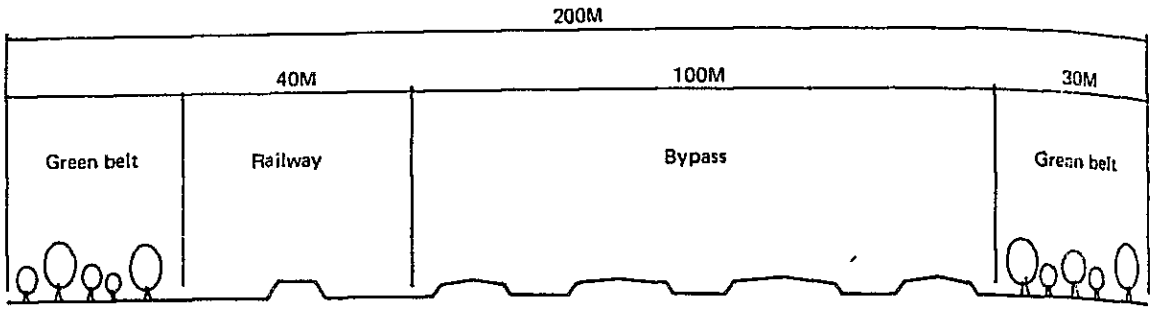


Fig. 8.1-5 Right of Way for By-pass and Railway

The junction of main line of Route 3 Bypass should be provided as shown in Fig. 8.1-6 only at an intersection where it meets the main approaches of the Industrial Complex and the New Town, and a diamond type or signal-controlled type junction is desirable to be used to insure traffic in all directions as freely as possible. The other minor access roads for the Industrial Complex are interconnected only with the frontage road of highway as shown in Fig. 8.1-4.

In planning the junction or access road, the following items should be taken into consideration.

- Although the frontage road of highway is one way traffic, the access from the road side to this sub-line should be free.
- The interval between each junction on the highway should be more than 1 km.

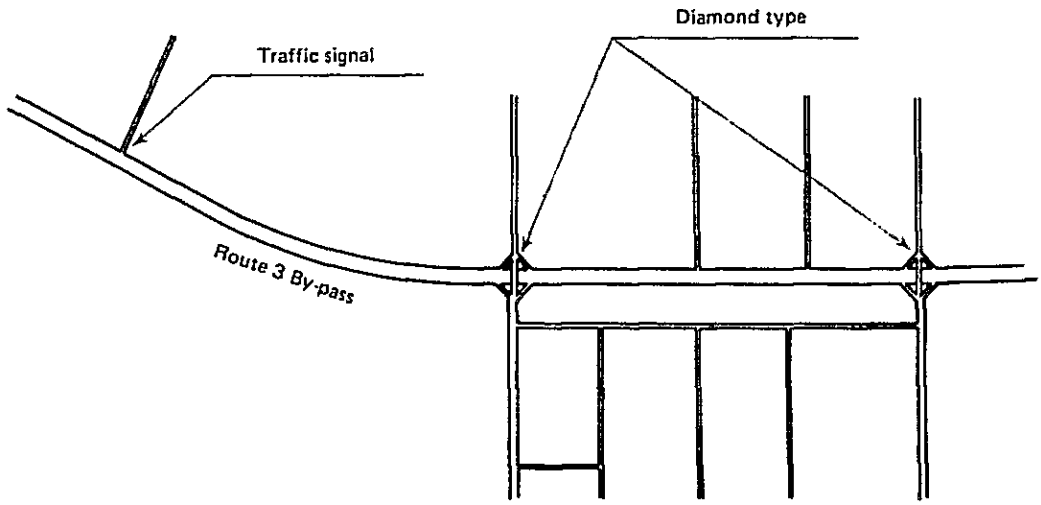


Fig. 8.1-6 Type of Main Junction

(3) Proposed Public Transportation System

(a) Bus Circulation System

The main public transportation system in the planning site will be buses, which will be widely used for travels to work and school and also for shopping. The bus service network must therefore be established following as closely as possible the desirable lines for these respective trip purposes.

Bus trip generation in the New Town, the existing Map Ta Phut town and Ban Chang town is estimated at 106,020 person-trips/day in total of which 25% will be assigned to trips to and from Industrial Complex, 40% to 50% within the intra-zone, and 15% among the towns. Zone Bus System is proposed to be adopted to meet such traffic demand. Zone Bus System means that each block of the New Town will be served intensively by some zone bus routes which will connect the main bus route. The bus network thus organized is considered most rational.

Fig. 8.1-7 shows the proposed bus network in the planning site. In this network, Ban Chang – Map Ta Phut – Rayong route is taken as the main axis of the bus network and each zone bus is connected with the main lines at the Traffic Terminal in Town Center of the New Town.

(b) Traffic Terminal

Within the Traffic Terminal, bus terminal, taxi boarding and alighting berths, taxi parking space, private car stopping space, environmental facilities suitable for the town's gateway, concourse, etc. will be provided. Therefore a land of 1 ha should be secured for Traffic Terminal along the trunk road of Town Center. Traffic Terminal will be a crowded place with people who visit Town Center, which coincides with the pivot of Town Center where a large number of bus passengers and taxi and car users begin or terminate their trips or seek for transfer.

In addition to Traffic Terminal, a bus depot should be provided elsewhere outside the town for shedding and overhauling.

(c) Bus Service Level

Average distance between bus stops should be taken as 500 m with the intension of guaranteeing dense services, and an attractive cruising speed of the buses. And the bus route and stops should be laid out to cover all the residents and workers in the planning site by 5 to 10 minutes walking distance. In each route, bus service should be operated at intervals of max five minutes at a peak period and 10 to 20 minutes at an off-peak period.

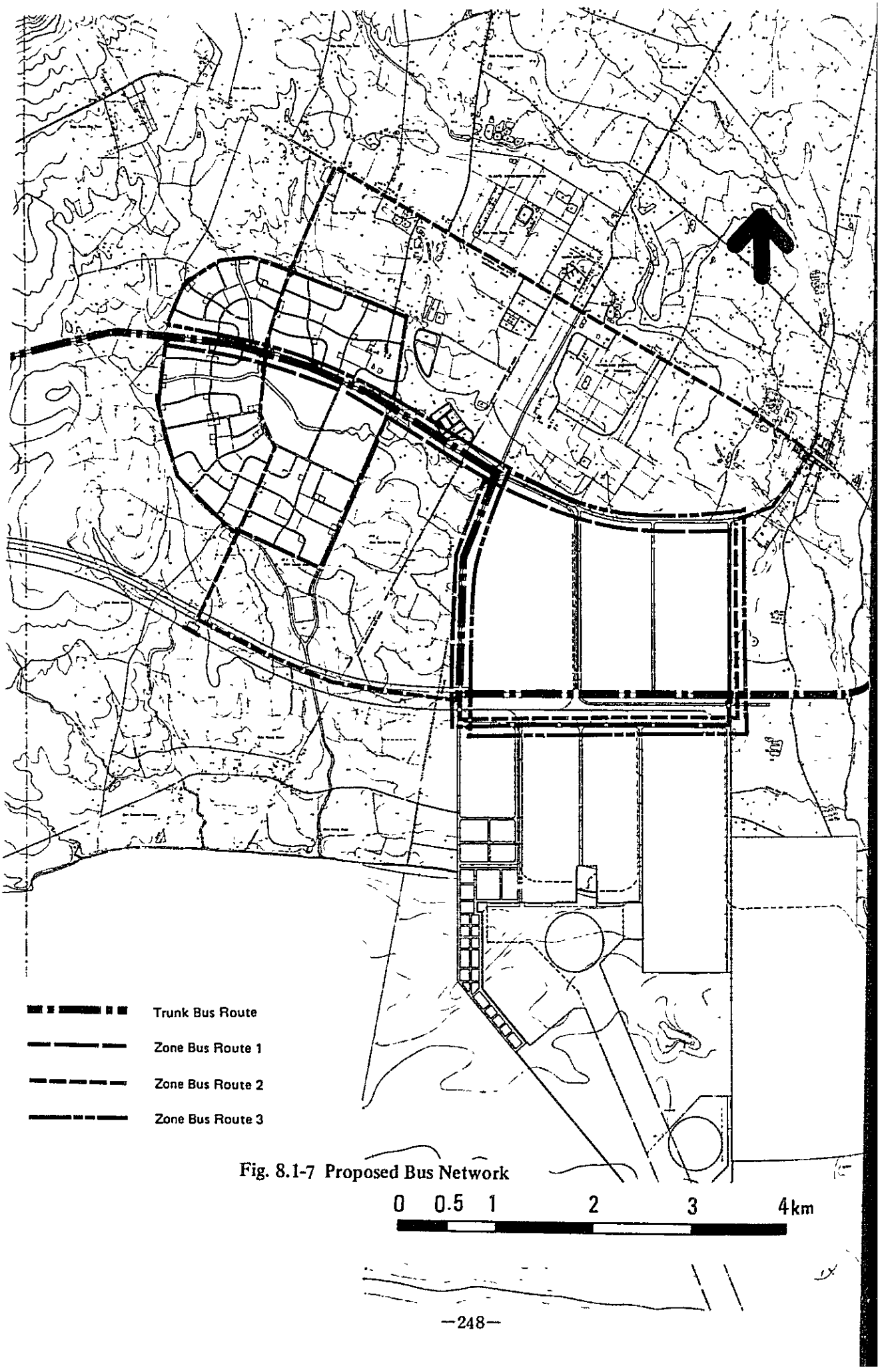


Fig. 8.1-7 Proposed Bus Network

8.1.3 Railway

(1) Design Traffic Volume

(a) Cargo Volume

The Cargo Volume generated by the Map Ta Phut Industrial Complex and the cargo volume of raw materials to be supplied from outside are shown in Table 8.1-7. Table 8.1-8 shows the railway cargo volume generated in each industrial center.

Table 8.1-7 Cargo Volume by Railway

(Unit: ton/year)

Name of Each Center	1st Phase		2nd Phase	
	From	Into	From	Into
Fertilizer Center	156,000	315,000	258,000	650,000
Soda Ash Center	90,000	562,200	168,000	1,122,000
Petrochemical Center	67,860	91,200	148,920	182,400
Iron and Steel Center	3,000	0	644,070	143,340
Down & Supporting Industries	0	0	27,123	6,017
Commercial Center	0	685,000	0	350,000
Total	316,860	1,653,400	1,246,113	2,453,757

The destination of cargo generated in the Industrial Complex lies to north and the origin of the raw materials is from north. The planned railway should transport 5,398 tons per day at 1st Phase and 10,137 tons per day at 2nd Phase assuming full operation.

Table 8.1-8 The Cargo Volume (Railway)

Name of Centers	Item of Commodities	1st Phase				2nd Phase				Remarks (Type of Trains)
		From		Into		From		Into		
		Cargo Volume	Trains	Cargo Volume	Trains	Cargo Volume	Trains	Cargo Volume	Trains	
1. Fertilizer Center	Urea	60,000	-	-	-	120,000	-	-	-	General
	Fertilizer	90,000	-	-	-	135,000	-	-	-	General
	Phosphate Acid	6,000	-	-	-	3,000	-	-	-	Special (L)
	Sulfer	-	-	-	-	-	-	-	-	-
	Phosphate Ore	-	-	-	-	-	-	-	-	-
	Potash Ore	-	-	315,000	-	-	-	650,000	-	Special (B)
2. Soda Ash Center	Soda Ash	30,000	-	-	-	48,000	-	-	-	General
	Ammonium Chloride	60,000	-	-	-	120,000	-	-	-	General
	Rock Salt	-	-	562,200	-	-	-	1,122,000	-	General (H)
3. Petro-chemical Center	LDPE	-	-	-	-	24,000	-	-	-	General
	HDPE	33,000	-	-	-	59,400	-	-	-	General
	PP	21,000	-	-	-	37,800	-	-	-	General
	MEG	3,000	-	-	-	6,000	-	-	-	Special (L)
	VCM	4,800	-	-	-	9,600	-	-	-	Special (L)
	Caustic Soda	6,060	-	-	-	12,120	-	-	-	Special (L)
	Rock Salt	-	-	91,200	-	-	-	182,400	-	Special (H)
4. Iron & Steel Center	Steel Products	-	-	-	-	341,400	-	-	-	Special (B)
	Iron Ore									
	Scrap									
	Burnt Lime							140,280		Special (B)
	Ferro-Manganese									
	Ferro-Silicon									
	Aluminum									
	Fluorite							3,060		Special (B)
	Carburizing									
	Fly Ash					74,700				General
	Fine Lime					3,870				General
	Sludge					192,000				Special (B)
	Scale					32,100				Special (B)
5. Down Stream & Supporting Industries	Products	3,000	-	-	-	27,123	-	-	-	General
	Raw Materials							6,017		General
6. Commercial Center	Potash Ore	-	-	685,000	-	-	-	350,000	-	Special (B)
Total		316,860		1,653,400		1,246,113		2,453,757		

(2) The necessity of the spur to Map Ta Phut Industrial Complex

The Chachoengsao – Sattahip line will be constructed by 1984 by State Railway of Thailand. One of main reasons for this line is to transport raw materials such as rock salt and potash ore to the Map Ta Phut Industrial Complex from Northeast Thailand. Table 8.1-9 shows the cargo volume by commodity type.

Table 8.1-9 The Cargo Volume by Commodity Type

(unit: ton/year)

Cargo Format	1st Phase		2nd Phase	
	From	Into	From	Into
Bag	294,000	0	622,770	0
Liquid	19,860	0	30,720	0
Bulk	3,000	1,653,400	592,623	2,453,757
Total	316,860	1,653,400	1,246,113	2,453,757

If the spur to Map Ta Phut is not planned, the above mentioned cargo must be transported by truck. The results of the cost-comparison study between the cost by truck and the cost by railway are shown in Table 8.1-10. (See Appendix 5)

Table 8.1-10 The Results of Cost-Comparison Study

Case	The Cost of Transportation	
	1st Phase	2nd Phase
Case-1	34,569,426 ฿	135,950,928 ฿
Case2	81,609,000 ฿	311,871,570 ฿
Case-3	116,178,426 ฿	447,822,498 ฿

Note Case 1: Transport by Railway from Map Ta Phut to Bangkok
Case 2: Transport by Truck
Case 3: Transport by Truck and Railway with the interchange at Ban Phu Ta Luang

These results show the advantage of selecting the railway mode, as compared with the truck mode. The cost of handling and transportation by truck is 2–3 times higher than that by railway. And also, it is anticipated that the land acquisition cost of R.O.W. for the railway will be low, based upon the premises of SRT's responsibility for construction work.

40 m (width) x 30 km (length) ÷ 1,600 m^2 x 50,000 ฿/Rai = 37.500,000 ฿

Therefore, the spur from near Ban Phu Ta Luang Station to the industrial complex will be needed.

The reasons to build the spur are summarised below.

(i) The transportation cost would be 2–3 times higher without the spur.

(ii) Rock Salt and Potash Ore from Northeast Thailand can be transported without double handling, and the intensity of the vehicles on the highway will be able to be kept the lower level.

(iii) In future, this spur will be able to use the main line to Southeast Thailand.

(3) Train Composition Plan

(a) Train Type

(i) Locomotives

Due to the advantages in operation, inspection and maintenance it is assumed that the existing locomotions, owned by the State Railway of Thailand for common use, can be used for this project. As the Alsthom Type Locomotions, the largest presently used by SRT can be used there is no need to provide new locomotives exclusively for transportation to and from Map Ta Phut.

The specification of the premised locomotive is shown below.

Type of Locomotive	Alsthom Type
Horsepower/R.P.M.	2,400 Hp/1,500 RPM
Max. Length	16,258 mm
Max. Width	2,800 mm
Max. Height (above the rail)	3,880 mm
Capacity of Load Axcels	13.75 ton
Number of Load Axcels	6
Total Weight	82.5 ton
Traction Weight	1,398 ton

(ii) Rolling Stock

In accordance with the commodity type generated in the industrial complex, Hopper type, General type, Bulk type and Liquid type of freight cars are required. Hopper and Liquid types of cars will have to be purchased by the individual companies, by the 1987. Therefore, Hopper and Liquid types are not included in the investment cost of this project.

The specifications of each rolling stock type is shown below:

(unit: Million Ton)

	Hopper Type	General Type	Bulk Type	Liquid Type
1. Max. Axle Load on Rail	15.0	15.0	10.5	13.0
2. Tare Weight	16.3	17.4	14.0	20.5
3. Max. Pay Load	43.7	38.6	28.0	(42,300 ℓ) 31.5
4. Total Weight	60.0	56.0	42.0	52.0

(b) Train composition Plan

The allowable axial load of the railway from Chachoengsao to Sattahip is 20 tons, but the allowable axial load of other railways is 15 tons. Therefore, the allowable axial load of the freight cars is assumed to 15 tons.

The maximum number of cars is assumed to be 23 in accordance with the following premises.

(1,398 ton – 10 ton) ÷ 60 ton = 23.1 = 23 cars

where,

Traction weight	: 1,398 ton
Caboose weight	: 10 ton
The weight of one freight car	: 60 ton

If the loading limit of one car is assumed to be 43.7 tons, the total transported volume of one composed train is 1,005.1 tons (=43.7 tons x 23 cars). Therefore, the length of one composed train is 399 m.

Length of one locomotive	: 16,258 m
Length of 23 cars	: 372.6 m
Length of one caboose	: 10 m
Total	: 399 m

(c) Railway Traffic Forecast

Table 8.1-11 shows the result of the railway traffic forecast in accordance with the traffic forecast estimation equation as shown below:

$$GT = Z \div (Cp \times Rg \times R) \div nW$$

where,

GT: Number of freight cars
Z: Cargo Volume in freight ton per year
Cp: Loading capacity of a car (43.7 ton)
Rg: Loading efficiency of a car (365 days)
R: Loaded car ratio (1.0)
NW: Number of cars in a train (23)

Table 8.1-11 The Results of Railway Traffic Forecast

	1st Phase		2nd Phase	
	From	Into	From	Into
Cargo Volume per year	ton/y 316,860	ton/y 1,653,400	ton/y 1,246,113	ton/y 2,453,757
Cargo Volume per a day	ton/d 868.1	ton/d 4,529.9	ton/d 3,414	ton/d 6,722.7
Number of Trains per day	trains/d 0.87	trains/d 4.6	trains/d 3.4	trains/d 6.7

(d) The required number of composed trains

(i) The transport cycle times

The transport cycle time for Rock Salt from Bammet Narong to Map Ta Phut is assumed to 30 hours in accordance with the Soda Ash and Rock Salt Project report written by JICA.

Loading time at the site	2 hours
From the site of Bammet Narong	30 minutes
From Bammet Narong to Map Ta Phut Yard	12 hours
From Map Ta Phut Yard to the Plants	30 minutes
(Unloading time at the plants	2 hours)
Total	15 hours
1 cycle	30 hours

(ii) The required number of composed trains

Maximum number of trains per day is 4.6 trains for the first phase and 6.7 trains for the second phase. The average time between trains at any point in the cycle is 5.2 hours for the first phase and 3.5 hours for the second phase.

24 hours ÷ 4.6 trains/d = 5.2 hours (1st phase)
24 hours ÷ 6.7 trains/d = 3.5 hours (2nd phase)

Considering the 30 hour cycle time, we calculate the number of trains needed to run at the frequency, as follows:

30 hours ÷ 5.2 hours = 5.77 = 6 (1st phase)
30 hours ÷ 3.5 hours = 8.57 = 9 (2nd phase)

Hence, the required number of cargo trains, including a spare composed train, comes to:

7 trains x 23 wagons = 161 cars (1st phase)
10 trains x 23 wagons = 230 cars (2nd phase)

(4) Alignment Planning

(a) The Route Alignment Selection Study.

Four alternative plans for the route alignment, between the branch off point on the Chachangsao – Sattahip line and the city of Rayong, where already recommended to the Eastern Seaboard Development Sub-committee on July 6th 1981. These four alternative plans are shown in F g. 8.1-8 to Fig. 8.1-11

The basic premises of these recommended alignments are described below:

(i) The alignment should be selected either along the sea side or to run near the mountains.

(ii) The branch off point should be selected so that it only crosses Route 331 once.

However any alignment meeting these criterion must also be compatable with the land use plan for the new industrial urban complex, and take into consideration the technical feasibility of the branch out point and of the connecting to spur from industrial complex, as well as its environmental effects.

The land use policy of this area is that the new town and the industrial complex should be developed to the south of Route 3. Since the center this new development will be located to the south of Route 3, the basic route alignment between the branch off point on the Chachoengsao – Sattahip Line and the city of Rayong should be along the sea-side.

The branch off point will be selected for technical reasons. If the branch off point is selected to be near the station of Ban Phu Ta Luang, the alignment will problem at the crossing with Route 331 and the provincial road. Therefore, the branch out point should be located to the north of the station of Ban Phu Ta Luang.

The alignment should be selected considering the environmental aspects. If the alignment ruins through the existing town and the developed new urban area, life within the town might suffer greatly, as has been experienced in Japan.

Finally, the construction cost of each alingment (Alt. 1 and Alt. 2) is shown in Table 8.1-13. The cost of Alt. 1 is 1.6 times that for Alt. 2.

Following these considerations, the second alignment alternative between Chachoengsao-Sattahip Line and the City of Rayong should be selected.

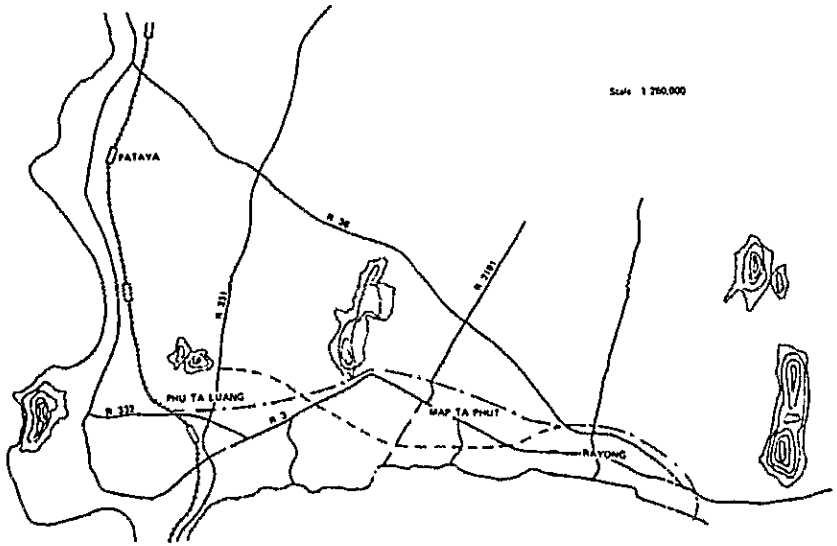


Fig. 8.1-8 Railway Alignment – Alt. 1

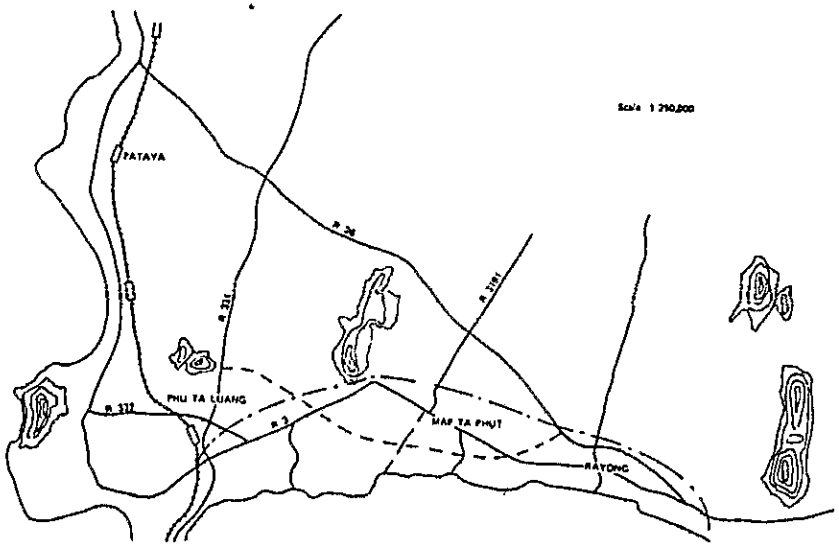


Fig. 8.1-10 Railway Alignment – Alt. 3

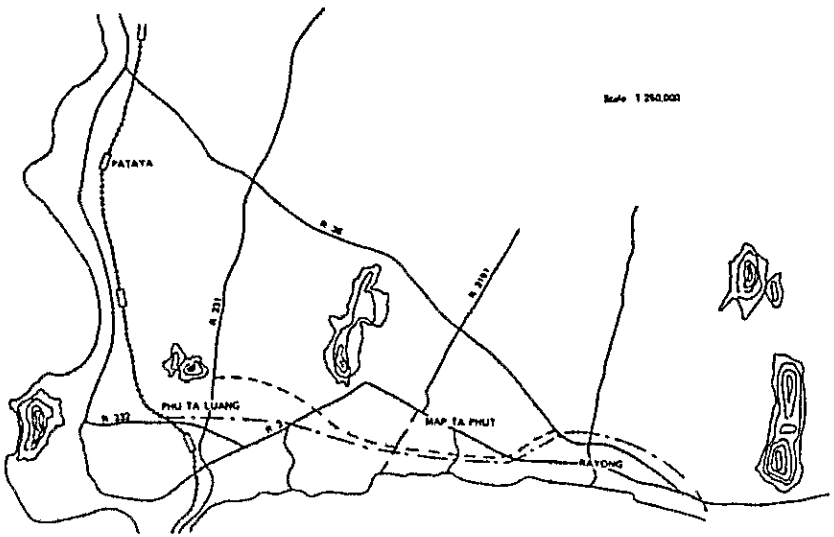


Fig. 8.1-9 Railway Alignment – Alt. 2

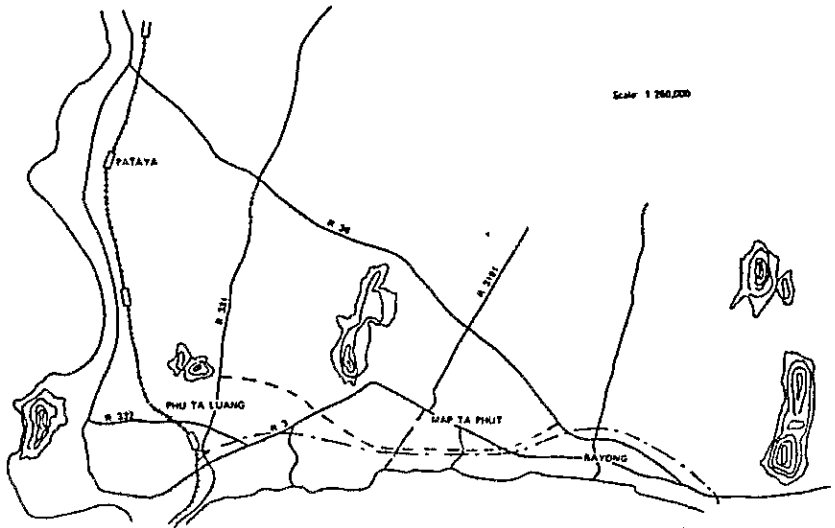


Fig. 8.1-11 Railway Alignment – Alt. 4

Table 8.1-12 The Result of Assessment of Alignment Alternatives

Item for Assessment	Alt-1	Alt.-2	Alt.-3	Alt.-4
1. The number of Junction across the trunk road (include the By – pass Road)	4	5	5	6
2. The difficulty of constructing the marshalling yard. (O: Easy X: Difficult)	X	O	X	O
3. The difficulty of the spur construction (O: Easy X: Difficult)	X	O	X	O
4. The railway length (including the spur)	30 km	27 km	30 km	27 km
5. Land Acquisition cost (H: High L: Low)	L	H	L	H
6. Technical Feasibility of the branch off point on on the main line*	O	O	X	X
7. Technical Feasibility of the longitudiual curve. (F: Flat U: Undulating)	U	F (partly) U	U	F (partly) U
8. The consistency with future land use including the industrial estate and the urban Area. (F: Fit E: Existing town U: Un-fit)	U	F	U	F
9. Assessment (over all)	2	1	–	–

Note: The main line means the Chanchoengsao – Sattahip Line.

Table 8.1-13 Comparison of Railway Construction Cost

Item	Unit	Alt. 2				Alt. 1				Remarks
		Quantity	Amount (Thousand ¥)			Quantity	Amount (Thousand ¥)			
			Total	Local Currency	Forein Currency		Total	Local Currency	Forein Currency	
1. Land Acquisition		(127.4ha)	(37,250)	(37,250)	(0)	(153.4ha)	(37,000)	(37,000)	(0)	
Within Promalgated Area	ha	79.4	24,810	24,810	0	72.2	23,340	23,340	0	
Outside Promalgated Area	ha	48.0	12,440	12,440	0	81.2	13,660	13,660	0	
2. Trunk Line			(167,200)	(105,010)	(62,190)		(250,250)	(166,240)	(84,010)	
(1) Truck Structure			(82,960)	(63,370)	(19,590)		(151,580)	(117,890)	(33,690)	
Preparatory Work	ha	47.2	944	850	94	60.2	1,204	1,084	120	
Embankment	m^3	662,000	55,740	44,592	11,148	1,402,000	114,658	91,731	22,927	
Sodding	m^2	162,000	2,430	2,430	0	354,000	5,310	5,310	0	
Laterite	m^3	47,200	8,968	5,829	3,139	60,200	11,438	7,435	4,003	
Aggregate Base	m^3	42,500	14,875	9,669	5,206	54,200	18,970	12,330	6,640	
(2) Truck Work			(58,740)	(27,610)	(31,130)		(74,770)	(35,200)	(39,570)	
Concrete Sleeper	Unit	36,350	28,353	21,265	7,088	46,360	36,161	27,121	9,040	
Truck (80 lb)	Ton	1,888	24,544	2,454	22,090	2,408	31,304	3,130	28,174	
Shunt (80 lb)	Set	7	1,120	112	1,008	8	1,280	128	1,152	
Truck Installation	km	23.6	4,720	3,776	994	30.1	6,020	4,816	1,204	
(3) Bridge	Unit	11	25,500	14,030	11,470	10	23,900	13,150	10,750	
3. Marshaling Yard			(21,570)	(12,420)	(9,150)		(78,360)	(57,850)	(20,510)	
(1) Truck Structure			(9,070)	(6,550)	(2,520)		(65,860)	(51,980)	(13,880)	
Preparatory Work	ha	25	500	450	50	25	500	450	50	
Embankment	m^3	88,000	3,520	2,817	703	721,000	60,310	48,247	12,063	
Laterite	m^3	10,000	1,900	1,235	665	10,000	1,900	1,235	665	
Aggregate Base	m^3	9,000	3,150	2,048	1,102	9,000	3,150	2,048	1,102	
(2) Truck Work	m	5,000	12,500	5,870	6,630	5,000	12,500	5,870	6,630	
4. Communication/Signalling	Ls	1	20,000	18,000	2,000	1	20,000	18,000	2,000	
5. Lighting Facilities	Ls	1	3,260	1,880	1,380	1	3,260	1,880	1,380	
6. Maintenance Office	Ls	1	2,900	2,460	440	1	2,900	2,460	440	
Sub-Total			252,180	177,020	75,160		391,770	283,430	108,340	
Investigation/Engineering	Ls	1	28,860	11,500	17,360	10	35,480	14,190	21,290	
Phisical Contingency	Ls	1	32,260	20,980	11,280	15	53,250	36,980	16,270	
Total			313,300	209,500	103,800		480,500	334,600	145,900	
Truck Length	km	23.6	313,300/23.6 = 13,275 ¥/m			30.1	480,500/30.1 = 15,963 ¥/m			

(b) The standard truck structure

The annual total cargo tonnage of the spur which will be constructed a point near the Ban Phu Ta Luang Station to the Map Ta Phut Industrial Complex is shown in Table 8.1-15

According to these results this line will by the 2nd Phase, rank in the 1st class of SRT's standard's for rall lines. Therefore, the standard trock structure is shown in Fig. 8.1-12

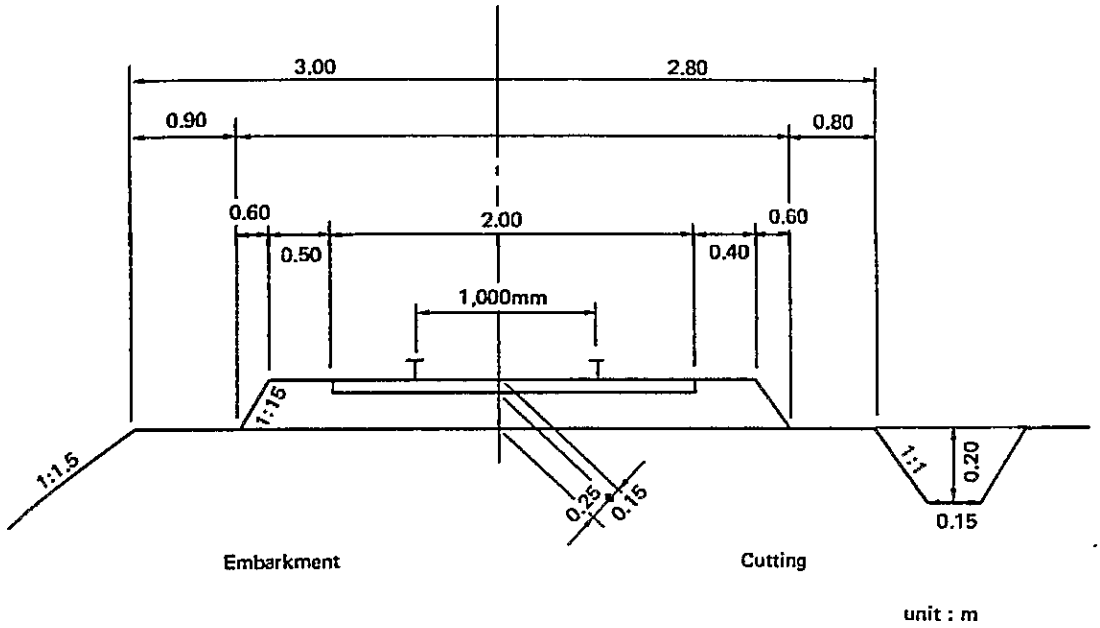


Fig. 8.1-12 The Standard Track Structure

Table 8.1-14

Weight of rail	:	80 lb/yd
Type of fastening	:	Elastic fastening
Sleeper type	:	PS concrete or concrete
Spacing	:	60 cm
Min depth of ballast below sleeper	:	25 cm
Maximum train speed allowed	:	100 km/hr

(c) Alignment of Railway

The premises of alignment of rãilway shown below:

(i) This new route will start at a junction north of the Ban Phu Ta Luang Station of line from Chachoengsao to Sattahip, which is presenth being constructed.

(ii) The route alignment crosses Route 3 at the North-east end of the U-Taphao airfield.

Table 8.1-15 The Annual Total Cargo Tonnage of the Spur

	Annual Cargo Volume	Cargo Volume per day	Total Cargo Tonnage per day	Total Cargo Tonnage per year
	(out of) t/y 316,860	t/d 868.1		
	(into) t/y 1,653,11	t/d 4,529.9		
	(total) t/y 1,970,260	t/d 5,398.0	t/d 12,409	t/y 4,529,285
	(out of) t/y 1,246,113	t/d 3,414		
	(into) t/y 2,453,757	t/d 6,722.7		
	(total) t/y 3,699,870	t/d 10,136.7	t/d 19,017.3	t/y 6,941,314.5

where,

Total Cargo Tonnage per day: T_1 (1st Phase), T_2 (2nd Phase)

T_1 = (Cargo Volume per day + 467.4 ton x 7 trains) + (Cargo Volume per day + 467.4 ton x (7 + 1))

(out of) (Into)

T_2 = (Cargo Volume per day + 467.4 ton x 9 trains) + (Cargo Volume per day + 467.4 ton x (9 + 1))

(out of) (Into)

The weight of locomotive : 82.5 ton

The weight of all cars and one caboose : 384.9 ton

Total : 467.4 ton

(iii) In the future, a new station should be located in a convenient position near the new urban area in correspondence with future commuter demand.

(iv) The spur line should service the Petrochemical complex, Port area, Fertilizer complex and Iron & Steel complex.

(v) In correspondence with the future plan of the city of Rayong, the Rayong Station should be located in the northern part of the city.

Fig. 8.1-13 shows the alingment of the railway in accordance with the above premises. The planning policies for the railway routed alignment are presented below.

i) The route alignment to the west of Map Ta Phut Station is planned to lie as far north as possible in accordance with the land use policy that the west seashore area will be used in the future form industrial complex.

ii) Within the industrial complex the route alignment is planned to parallel the main trunk road to conveniently handle the cargo generated there.

iii) The route alignment from the industrial complex to the city of Rayong is planned along the trunk road and so as to cross the southern point of the trunk road junction with Route 3.

(d) The Spur lines within the industrial complex

The type of industries which need spur line are show below.

(i) Fertilizer Complex

The cargo volume generated at the Fertilizer Complex will be 908,000 ton/year in the year 2000. This cargo volume consists of 258,000 ton/year of outward cargo and 650,000 ton/year of inward cargo. The alignment of this spur line will be along the east side of road No. 1. This line will be branch off into the Fertilizer Complex at a point to be decided besed on the layout plan of this center.

(ii) Soda Ash Plant

The cargo volume of the Soda Ash plant will be 1,290,000 ton/year in the year 2000. This cargo volume consists of 168,000 ton/year of outward cargo and 1,122,000 ton/year of inward cargo. The alignment of this spur line will be along the west side of Road No.3.

(iii) Petrochemical Center and Iron & Steel Complex

The cargo volume of the Petrochemical Complex will be 331,320 ton/year in the year 2000. This cargo volume consists of 148,920 ton/year of outward cargo and 182,400 ton/year of inward cargo. The Petrochemical Complex will be built at two locations, one part in Phase 1 and a 2nd part Juring Phase 2.

The alignment of the 1st phase spur will be along the west side of Road No. 5. The 2nd phase's alignment will be along the west side of Road No. 4. This spur also serve the Iron & Steel Complex. The cargo volume of the Iron & Steel Complex will be 787,410 ton/year in the year 2000. This cargo volume will consist of 644,070 ton/year of outward cargo and 143,340 ton/year of inward cargo.

(iv) Port Commercial Complex

The Port Commercial Complex will be located at the west end of the water front. The cargo volume of this area will be 685,000 ton/year in the 1st phase but will decrease to 350,000 ton/year in the 2nd phase in accordance with the increase in production

scale at the Fertilizer Complex, the Soda Ash Plant and the Petrochemical Complex. The alignment of this spur line will be along the east side of Road No. 1. This line will also be used to handle the cargo from the Fertilizer Complex. The only part commercial area cargo carried by this line will be Potash ore.

Therefore, the alignment of this spur within the port-commercial center will determine the system of on-loading. The Hopper car trains will proceed to the storage-yard of Potash ore from the turn out point on main line. The Potash ore cars will be dumped at two points in the stroage-yard. The empty cars will be collected by a locomotive and parkedona side line. Therefore, the spur will need a locomotive for collecting the empty cars.

(v) Down Stream and Supporting Industries.

The cargo volume of the Down Stream and Suppprting Industries will be 33,140 ton/year at 2nd phase. The lot volume is small compared with that of other cargoes. Therefore, this cargo assummed to be taken to the Marshaling Yard by truck. The cars to be loaded with this cargo will be composed together with the other cars.

(e) The longtudinal curve

The longtudinal curve of the main line is decided as below.

(i) To fix the initial junction location, whose elevation is assummed to 50m above the mean sea water level.

(ii) To fix the point where it crosses, R.3. at an elevation which is also assumed to 50m above M.S.L.

(iii) The elevation of the line through the industrial complex is assumed in accordance with the industrial complex and use plan.

Fig. 8.1-14 shows the longtudinal curve between the initial junction and the city of Rayong. A max. grade of 10% occurs between the initial junction and the crossing of R.3, which is compatable with the standard's of S.R.T.

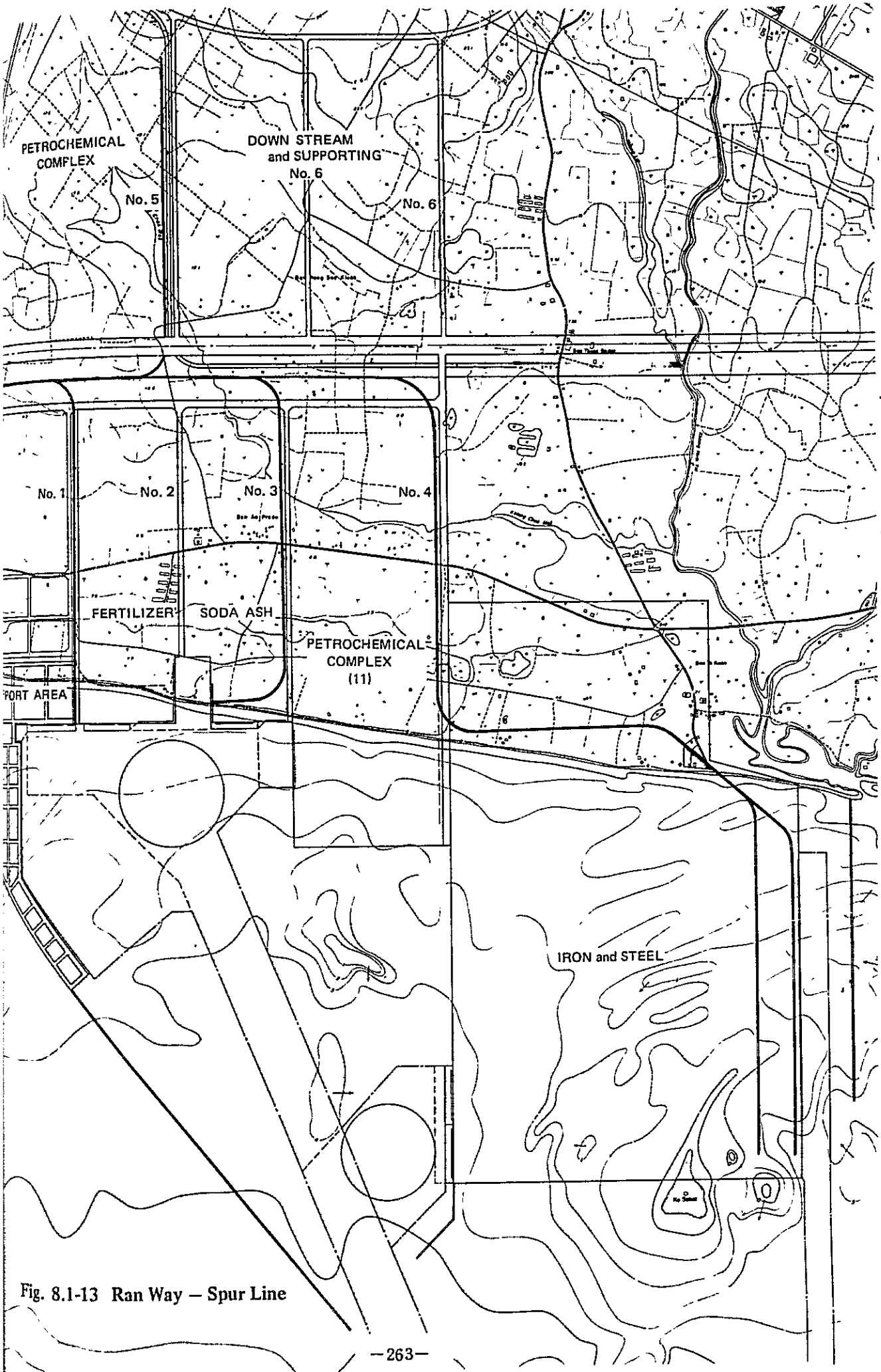


Fig. 8.1-13 Ran Way – Spur Line

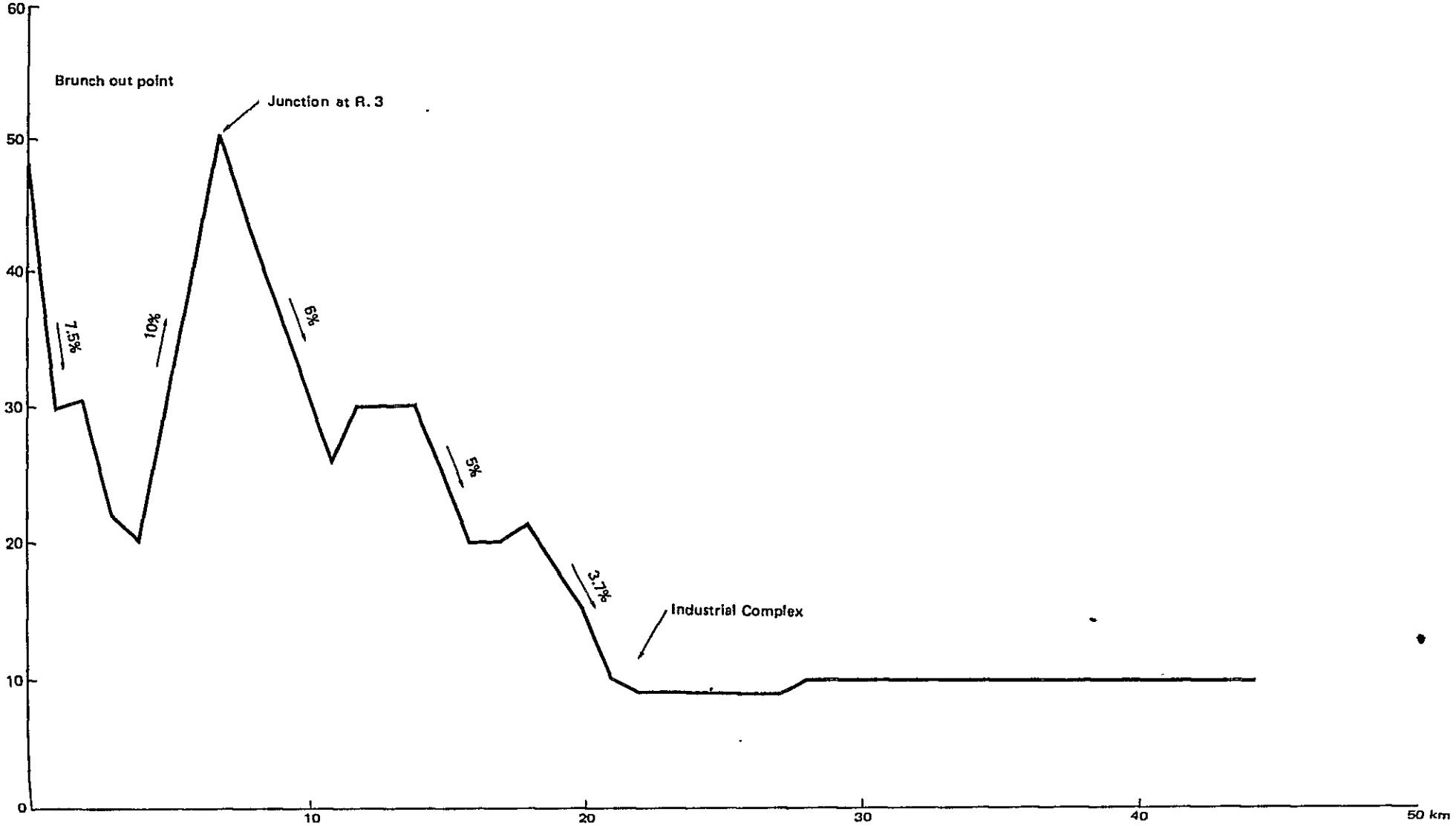


Fig. 8.1-14 The Longtudinal Curve

8.1.4 Gas Pipeline

The supply of natural gas for fuel and feedstock to the industiral complex will be made by means of a pipeline installed from the gas separation plant, under construction at this time, to each of the complex. And also the spot and the right of way for the pipeline, the size and the routing of the pipeline are to be decided in accordance with the demand from the complex.

The expected gas supply lines to the Industrial Complexes for the 1st phase will be comprising the feed gas, i.e. ethane, propane and carbon dioxyde, and the fuel gas to Petrochemical Complex, Soda Ash Plant and Fertilizer Complex. Those pipelines will start at the Gas Separation Plant, run underground along the east side of the west primary trunk road to the complexes area crossing under the bypass and the railway. One culvert box underground the crossing spot will be installed, at the north west of the complex area to protect gases and water pipes from heavy traffic load.

Gas pipelines for the 2nd phase will be installed along the east primary trunk road, crossing under the bypass and railway at the north east of the complexes area. Another culvert box will be provided there to protect pipelines for the three chemical complex expansion and the Iron and Steel Complex.

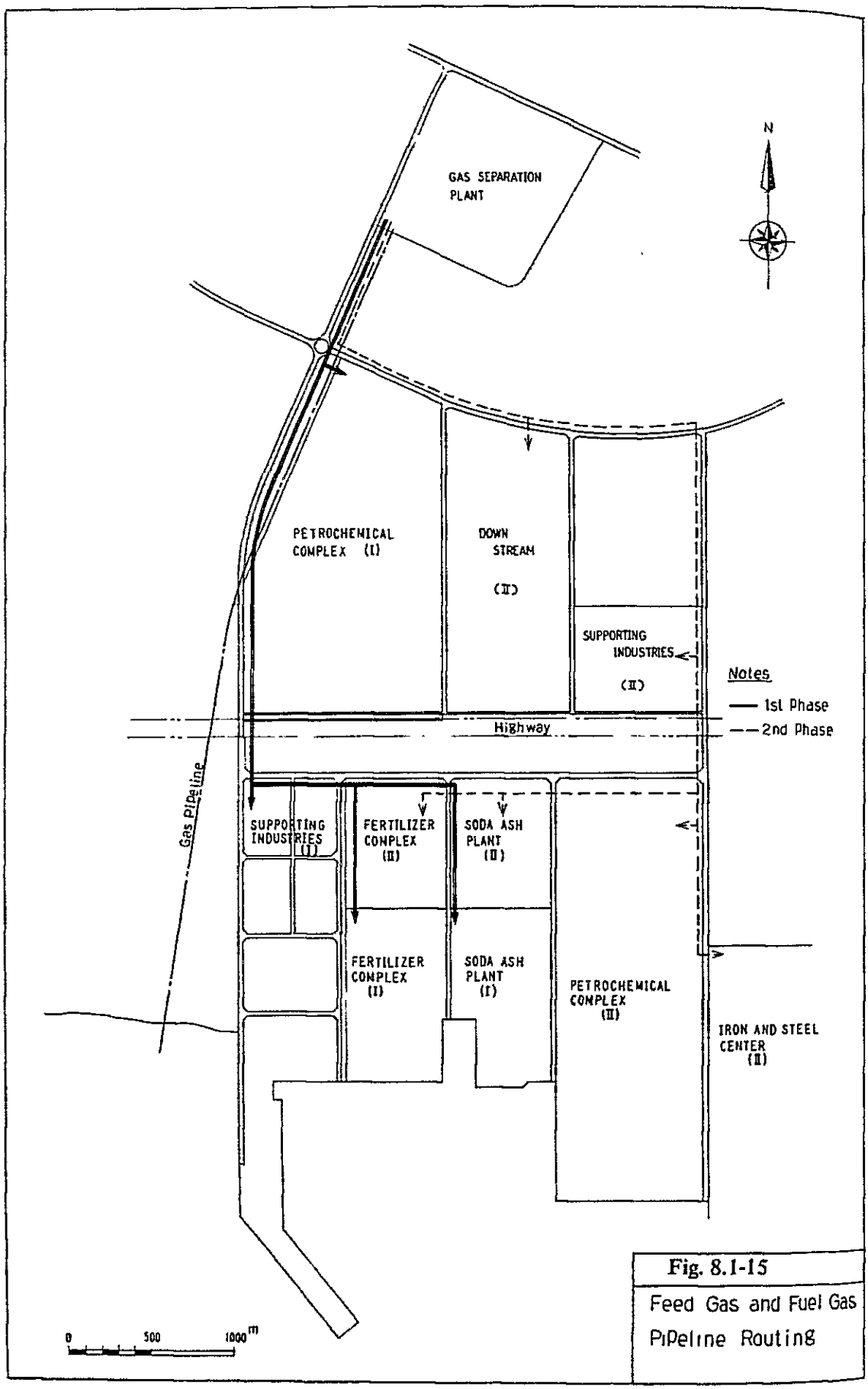


Fig. 8.1-15

Feed Gas and Fuel Gas Pipeline Routing

8.2 Water Supply System

8.2.1 Water Demand

(1) Water Supply Demand

The amount of water required by a municipality, depending on climate, commercial activities and economic consideration, is preferably determined based on the past record of water consumption in various use. In this study, however, water demand is based on an average amount for residential use water.

(a) Residential Water

Appendix 2 shows average daily charged water per capita in cities of North-East Thailand in the past ten years. These figures, which may include water consumed by residents and other customers, show an increasing tendency year by year. The maximum value in the figures is 272 lpcd and the average one in all cities 229 lpcd. On the other hand, according to Private Water Purification Plant Standard by MWWA (1979), 250 lpcd is taken as average water supply for residential area. In view of this, the average amount of residential use water at present is considered 200 – 250 lpcd. Therefore, taking increase into consideration, the amount of residential use water is 250 lpcd for the year 1987 and 300 lpcd for the year 2000.

Table 8.2-1 Amount for Residential Use Water

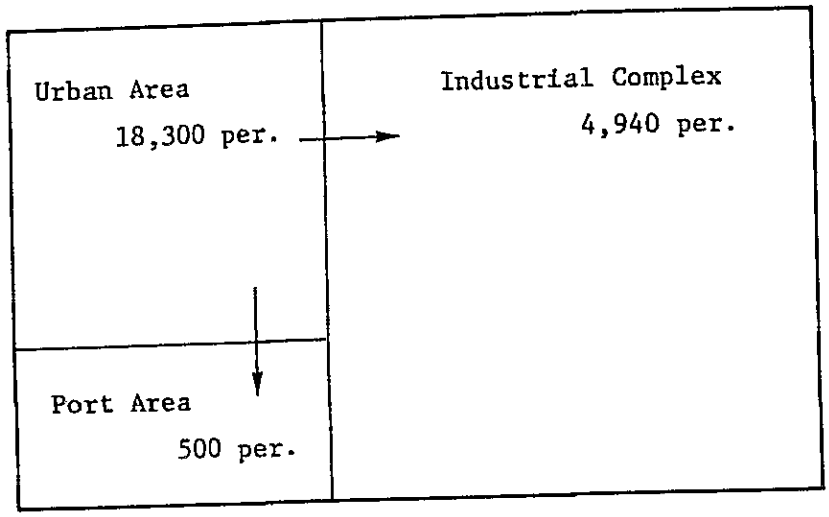
	1st Phase	2nd Phase
Amount for Residential Use Water	250 lpcd	300 lpcd

(b) Water Demand

Potable water demand for the whole Development Area is calculated based on the population as described in Section 7.2.

* lpcd: (l/c·d)

(i) 1st Phase (1987)



Urban Area	18,300 x 250	=	4,575 m^3/day
Industrial Complex	4,940 x 150*1	=	741 m^3/day
Port Area	500 x 150*1 x 1.6*2	=	120 m^3/day
(For Ship Use)			336 m^3/day
	Total:		5,772 m^3/day

*1 Workers in New Town will work at Industrial Complex or Port and consume water of 150 lpcd in working area.

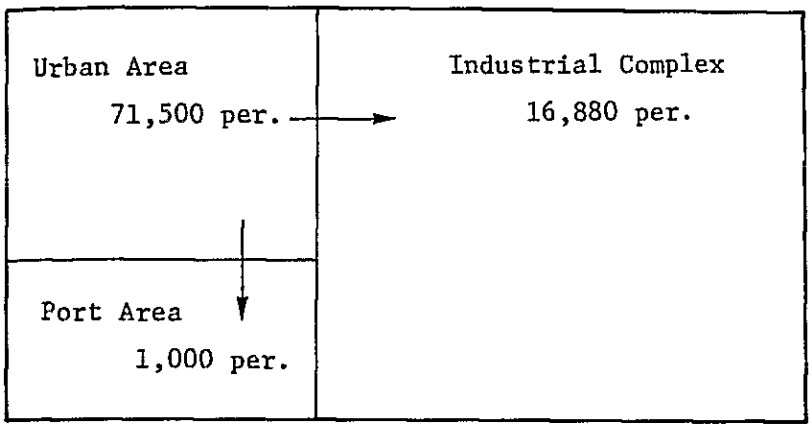
*2 Commercial use factor in Port.

If $\frac{\text{Daily average water supply per capita}}{\text{Daily maximum water supply per capita}} = 0.8$, the following can be obtained:

Table 8.2-2 Water Demand per Capita in Each Zone (1987)

	Urban Area	Port Area	Industrial Complex
Daily Maximum (lpcd)	312.5	300.0	187.5
Daily Average (lpcd)	250.0	240.0	150.0

(ii) 2nd Phase (2000)



Urban Area

71,500 x 300 = 21,450 m^3/day

Industrial Complex

16,880 x 150*1 = 2,532 m^3/day

Port Area

1,000 x 150*1 x 1.6*2 = 240 m^3/day

(For Ship Use) 336 m^3/day

Total: 24,558 m^3/day

*1 Workers in New Town will work at Industrial Complex or Port and consume water of 150 lpcd in working area.

*2 Commercial use factor in Port

If $\frac{\text{Daily average water supply per capita}}{\text{Daily maximum water supply per capita}} = 0.8$, the following can be obtained:

Table 8.2-3 Water Demand per Capita in Each Zone (2000)

	Urban Area	Port Area	Industrial Complex
Daily Maximum (lpcd)	375.0	300.0	187.5
Daily Average (lpcd)	300.0	240.0	150.0

(2) Port-related Water Demand

Water required in Port Area is calculated in (1) above and tabulated as below:

Table 8.2-4 Water Demand in Port Area

	1st Phase	2nd Phase
Population Served (per.)	500.0	1,000.0
Daily Maximum (lpcd)	300.0	300.0
Daily Average (lpcd)	240.0	240.0
Daily Maximum (m^3/day)	150.0	300.0
Daily Average (m^3/day)	120.0	240.0
For Ship Use (m^3/day) Daily Maximum	420.0	420.0
For Ship Use (m^3/day) Daily Average	336.0	336.0

(3) Water Demand for Industrial Complex

The total water requirement for the Industrial Complex in the year of 2,000 will be 339,900 m^3/day or 113.3 million m^3/Y (refer to Table 8.2-5).

Table 8.2-5 Fresh Water Consumption

Item	Industrial Water							Portable Water			Total Demand ($10^3 m^3/Y$)
	Fertilizer (m^3/H)	Soda Ash (m^3/H)	Petrochem (m^3/H)	Gas Sep. (m^3/H)	Support-ing (m^3/H)	Down Stream (m^3/H)	Iron/ Steel (m^3/H)	Industrial Area (m^3/d)	Port Area (m^3/D)	Urban Area (m^3/D)	
1st Phase (1987)											
(1) Industrial Water	1,470	1,280	1,500	220	50	–	–	–	–	–	36,160
(2) Potable Water	(15)*1/	(12)*1/	(25)*1/		(22)*1/	–	–	740*2/	456*6/	4,575*2/	2,430*3/
Total											38,590
2nd Phase (2000)											
(1) Industrial Water											
1st phase	1,470	1,280	1,500	220	50	–	–				
2nd phase	1,176*4/	1,024*4/	1,200*4/	220	–	500	4,500*5/				
Sub Total	2,646	2,304	2,700	440	50	500	4,500				105,120
(2) Potable Water	(27)*1/	(22)*1/	(40)*1/		(22)*1/	(38)*1/	(105)*1/	2,540*2/	576*6/	21,450*2/	8,190*3/
Grand Total											113,310

Notes: *1/ Maximum hourly requirement.
*2/ Normal daily requirement calculated based on 10 hours/day operation at the maximum hourly requirement
*3/ Total annual requirement
*4/ These figures are estimated based on an assumption that 20% of industrial water requirement can be substituted by the use of sea water.
*5/ This figure is estimated based on an assumption that 50% of industrial water requirement can be substituted by the use of sea water.
*6/ Of which, 336 m^3/D will be used for the washing purpose

(4) Water Resource

The demand of water for the Industrial Complex, Port and the New Town for the 1st Phase and Master Plan are shown in Table 8.2-5.

For the Master Plan, the demand of industrial water is calculated based upon the following premises.

(a) For 20 per cent of total demand of the chemical industries such as Fertilizer, Soda Ash and Petrochemical plants, sea water will be utilized.

(b) For 50 per cent of total volume of Iron and STeel Complex, sea water will be utilized.

There are five proposed and existing reservoirs in this surrounding area in accordance with East Coast Resource Development Project reported by JICA. Effective water storage capacity and water collection area of five reservoirs are given below:

Name of Reservoirs	Catchment Area	Storage Cap.
Dok Krai	291 Km	91 MCM
Nomg Pla Lai	426	119
Khlong Yai	223	70
Khlong Bang Phai	113	10
Tup Ma	296	40

For the 1st phase, water demand generated in the Industrial Complex, Port Area and the New Urban Area amounts to 39 MCM per year. The pipeline under construction from Dok Krai reservoirs to Map Ta Phut area will be able to transmit the water of 83 MCM per year.

But the water demand for the 2nd phase will increase to 117 MCM per year.

Therefore, new water resources will have to be developed for supplying to meet water demand for the Master Plan. The above-noted presumes that the water demand for the irrigation in Rayong Valley for the year 2000 is indicated to 136 MCM per year.

Fig. 8.2-1 shows the propsed transmission system for the year 2000.

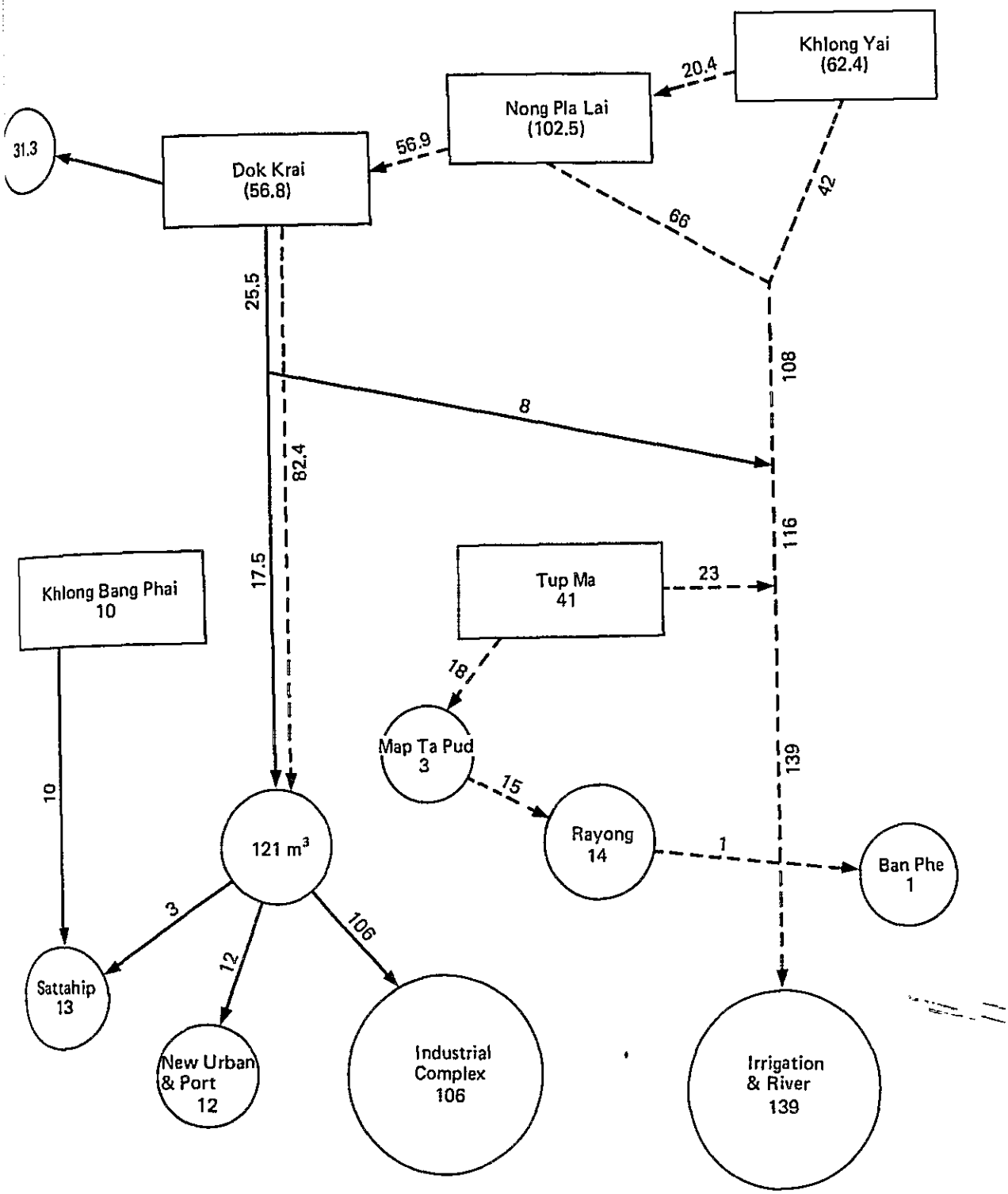


Fig. 8.2-1 Proposed Water Supply System

In accordance with this proposed system, the Industrial Complexes, Port Area and the New Town will be able to be supplied to meet the water demand for the year 2000.

But the existing pipeline system from Dok Krai reservoir to Map Ta Phut area is not sufficent to supply the volume of the water demand for the Master Plan.

Therefore, the double pipeline system will be needed from Dok Krai Reservoir to Map Ta Phut area for the Master Plan. On that time, Dok Krai, Nong Pla Lai and Khlong Yai reservoirs will have to be developed for supplying for the water demand generated in the existing town of Map Ta Phut, Rayong and Ban Phe.

In accordance with the above mentioned a more profound study for the water resources and for the allocation of water from those resources will be needed after the Short Term Devleopment or in the detailed design phase.

8.2.2 Planning Policy

(1) Classification of Water by Usage in the Industrial Complex

In large scale industries, river or well has been generally used as supply source for industrial water. Water is treated at water treatment plants within the battery limit of the industries to meet specific qualitative requirements for the following categories.

Process water and boiler feed water

Potable water

General service water

Requirements for process water vary depending on the characteristics of process. Quality of boiler feeder water should be determined to meet the specifications for boilers and generated steam in accordance with the process requirements. A water treatment system to supply water of the specific quality will call for the investment cost and operating cost proportionate to the quality of the water. Those technical and financial aspects must be involved in planning stage of the water supply system for Industrial Complex.

Potable water should be hygienic and be purified to have a standard quality for drinking and other living use.

Water for general services such as washing and fire-fighting is normally used as the most economical water without treatment, or with simple filtration in some cases, for cooling water make-up and so forth.

Considering the above-mentioned aspects, the fresh water supply scheme is proposed as follows:

(i) Each complex in the Industrial Area is supplied with raw fresh water for industrial use. It will be treated in come amount at its own treatment facilities properly designed for process and boiler use, while the remainder can be utilized for general services.

(ii) Potable water will be supplied to Industrial Area, Port Area and Urban Area by an integrated water supply network after hygienic treatment at a purification plant.

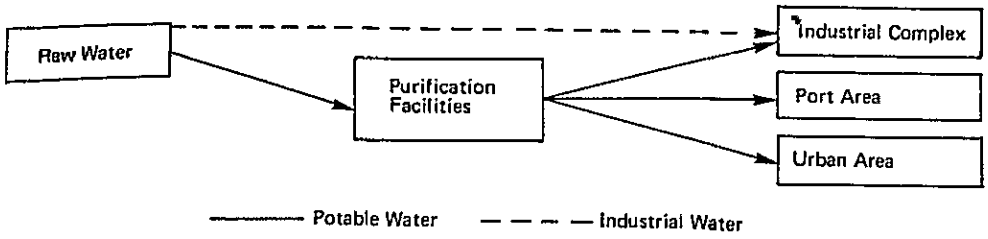


Fig. 8.2-2 Water Flow

(2) Review on the Location of Water Receiving Facilities

Water coming from Dok Krai Reservoir will be received at the Water Receiving Facilities, which will be constructed at the proposed site south to Route 3 at the farthest point of the highway from the coast. In order to establish the water supply system for potable and industrial use, reviewing has been made on the location of the Water Receiving Facilities as follows:

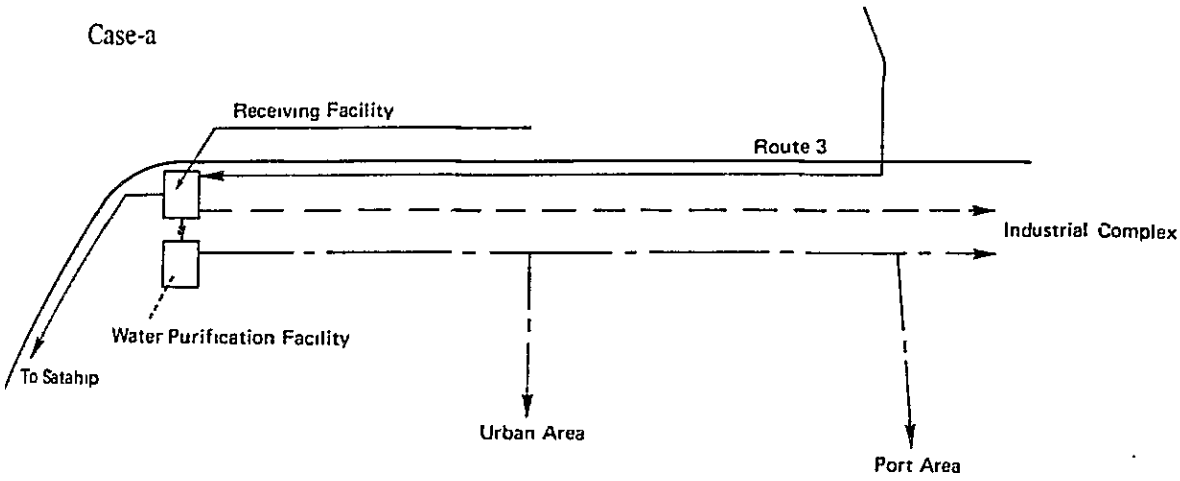


Fig. 8.2-3 Original Location

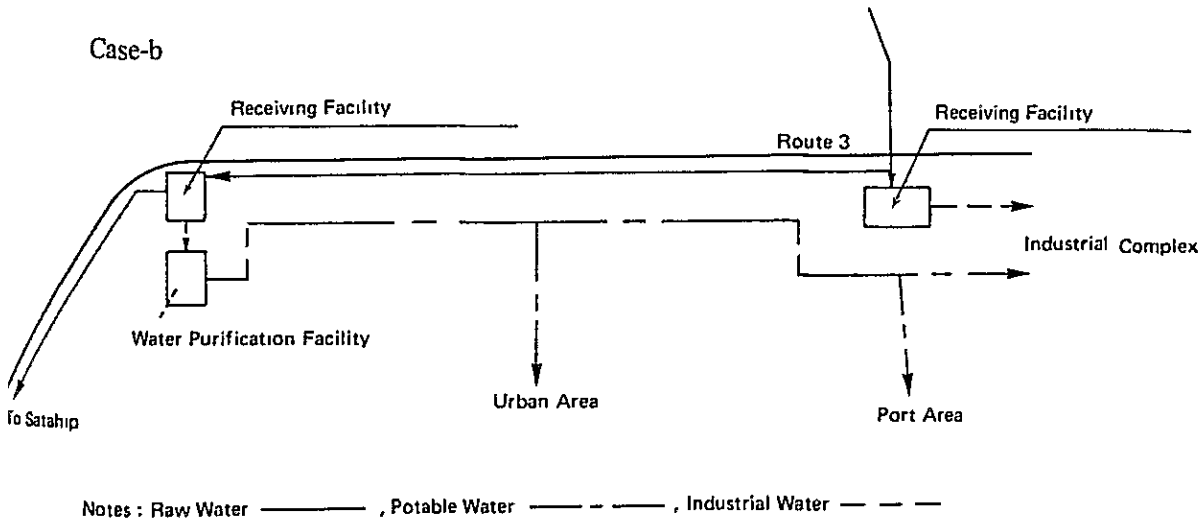


Fig. 8.2-4 Alternative Location

Outline of comparative study is shown as follows:

Table 8.2-6 Comparative Study for Alternatives

	Case- a	Case- b
Potable Water	There is no difference between a and b)	
Industrial Water	Two pipeline; one for transmission from Dok Krai Reservoir to Receiving Facilities and the other for industrial water from Receiving Facilities to Industrial Complex will be needed in parallel between the junction of Route 3 and Route 3191 to Receiving Facilities.	Water for industrial use will be branched from the transmission pipeline from Dok Krai Reservoir. In this case, a receiving facility will be provided to cope with changes in water demand in the Industrial Complex. The transmission pipeline between the junction and Receiving Facilities can be reduced in diameter.
Construction Cost	Case b is somewhat lower than that of Case a *1	

*1 (See Appendix 2)
It may be considered that Case-b is somewhat better than Case-a

8.2.3 Water Supply System

(1) Water Transmission Planning

Water to be used in the study area will be transmitted from Dok Krai Reservoir to the Water Receiving Facilities through underground pipelines which are now underway for construction. Fig. 8.2-5 shows the outline route of the transmission pipelines from the Reservoir to Water Receiving Facilities. Referred to the JICA Report titled "Detailed Design for Dok Krai – Mab Ta Phut Water Pipeline Project," the outline of the transmission pipelines is as follows:

Length: 7.5 km from pumping station at the Reservoir to the head tank 19 km from the head tank to Water Receiving Facilities

Pipes: 1.35 m in diameter, made of steel with the inside lining and outside coating wrapping

Water at the Receiving Facilities will be transmitted to purification facilities for potable water supply in the study area. The transmission pipeline will be 700 mm in diameter, of the same material as described above. The total length will be 100 m.

(2) Potable Water Supply System

Potable water will be treated at purification facilities and distributed to the demand points in the Industrial Complex, the Port Area and the Urban Area, via distribution pond and/or elevated tanks by gravity as follows:

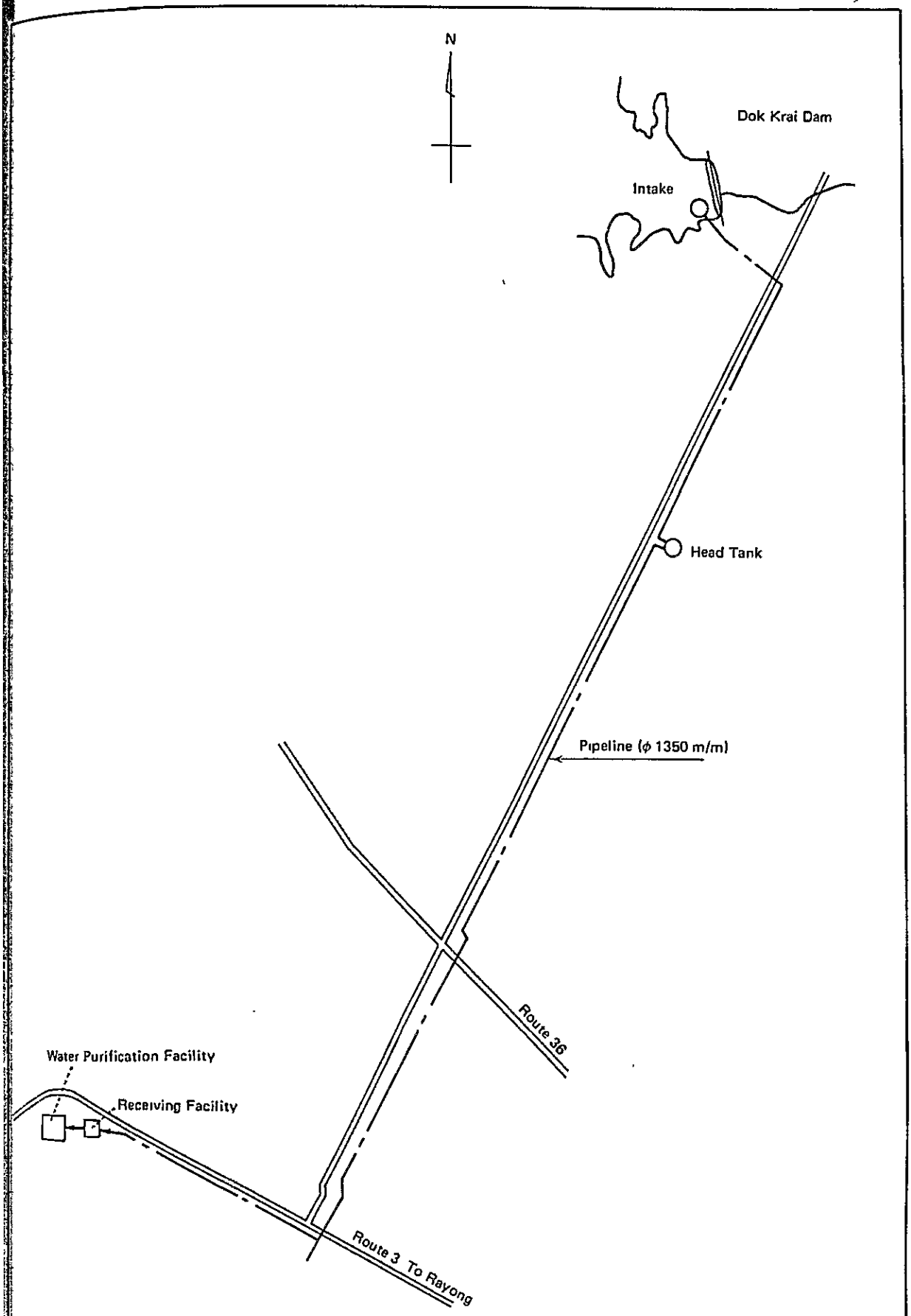


Fig. 8.2-5 Route Map of Pipeline

(3) Industrial Water Supply System

The water supply system for the Industrial Complex is tightly connected with the forecasted demands, availability and development plan of the resources. The water supply system for the 1st Phase, as stated in 8.2.1(4), is to transfer fresh water through a 1.35 m diameter pipeline from Dok Krai Reservoir via Map Ta Phut are to the Industrial Complexes, the New Town and the Port Area. For the 2nd phase Dok Krai reservoir will be connected with Nong Pla Lai and Khlong Yai Reservoirs with water pipeline. Also an additional water pipeline will connect Dok Krai Reservoir and Map Ta Phut area. Those new pipelines will enable an increased water supply to the 2nd phase project as illustrated in Fig. 8.2-6. The sea water will be used in the 2nd phase for industrial uses covering 20% of total water demands for Fertilizer, Soda Ash and Petrochemical Complex, and 50% of one for Iron and Steel Center.

The system of the final stage of the water supply will follow the planning policy stated in paragraph 8.2.2. The fresh water, often called as the raw water, is fed to each complex where the water is treated to the required grades for the process uses and partly used untreated as noted in paragraph 8.2.2. The quality of the fresh (raw) water of Dok Krai is shown in Table 8.2-7.

Table 8.2-7 Assumed Analysis of Dok Krai Reservoir Water

PH Value	6.7 – 7.8
Electric Conductivity at 25°C (micro mno/cm)	100.0 – 130.0
Ca (ppm)	10.0 – 17.0
Mg (ppm)	2.0 – 3.0
Na (ppm)	5.7 – 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
Turbidity (ppm)	25.0

Source : Ministry of Industry

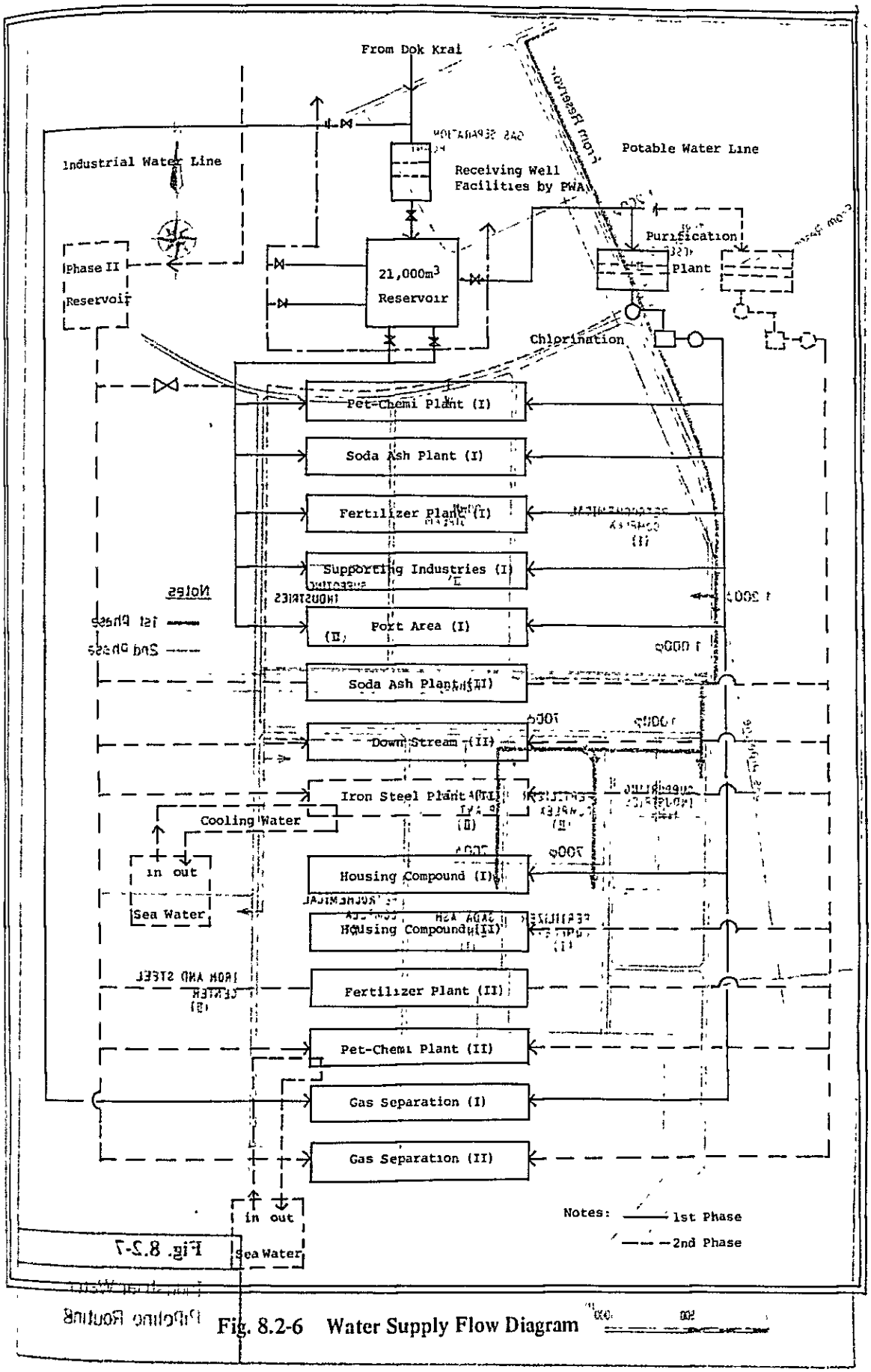


Fig. 8.2-6 Water Supply Flow Diagram

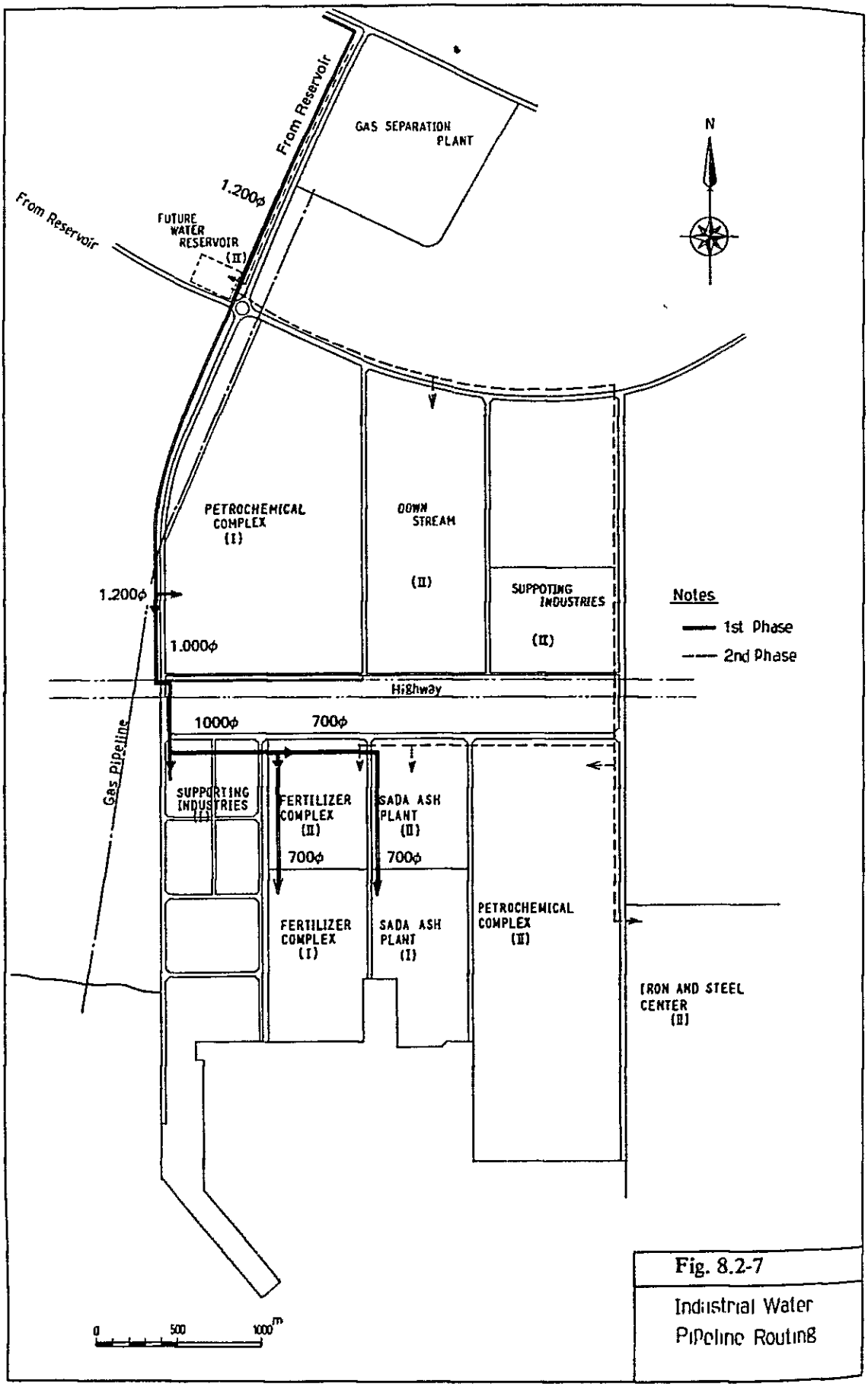


Fig. 8.2-7

Industrial Water Pipeline Routing

8.2.4 Purification Facilities

(1) Location

Water purification facilities will be located west to the Water Receiving Facilities to be constructed near Route 3. The Development Area is gradually sloped down southeastward with a highest altitude of about 47 m at the northwestern part in the Urban Area and a lowest altitude of about 10 m at the Port Area. The proposed location of the purification facilities has an altitude of about 57 m. Purified Water can be distributed to the Urban Area by gravity flow by providing elevated tanks and to the Industrial Complex Area and the Port Area directly from distribution ponds. The site is adjacent to the Water Receiving Facilities, thus resulting in shortening the length of transmission pipelines between them. This site selection is quite reasonablyin view of economy.

(2) Standards of Drinking Water

Appendix 2 shows some quality requirements for drinking water set out by authorities in Thailand, Japan and WHO. In Thailand, relevant authorities have their own standards.

(3) Purification System

Water in Dok Krai Reservoir, though its actual quality data are not available, will increase turbidity depending on season of the year and will contain algae. Therefore, a high rated coagulosedimentation system is employed in this study. Sludges generated from the rapid coagulosedimentation basin will be treated in sludge lagoons and disposed of by landfilling.

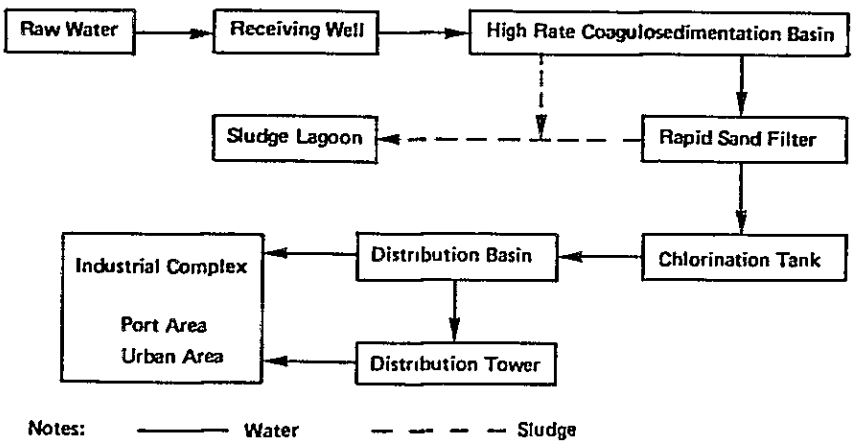


Fig. 8.2-8 Flow Diagram for Purification Facilities

(4) Conceptual Plan

(a) Amount of Water to be purified

The amount of water to be purified is calculated based on the daily maximum water supply for the 2nd Phase with marginal increments of 10% to meet the increased demand for years.

(i) 1st Phase (1987)

	Daily Average	Daily Maximum
Industrial Complex	741 m³/d	926 m³/day
Port Area	120 m³/d	150 m³/day
(For ship use)	336 m³/d	420 m³/day
Urban Area	5,490 m³/d*	6,863 m³/day
Total	6,687 m³/d	8,359 m³/day

8,359 x 1.1 = 9,195

= 9,200 m³/day

*18,300 x 300 x 10^{-3} = 5,490 m³/d

(ii) 2nd Phase (2000)

	Daily Average	Daily Maximum
Industrial Complex	2,532 m³/d	3,165 m³/day
Port Area	240 m³/d	300 m³/day
(For ship use)	336 m³/d	420 m³/day
Urban Area	21,450 m³/d	26,813 m³/day
Total	24,558 m³/d	30,698 m³/day

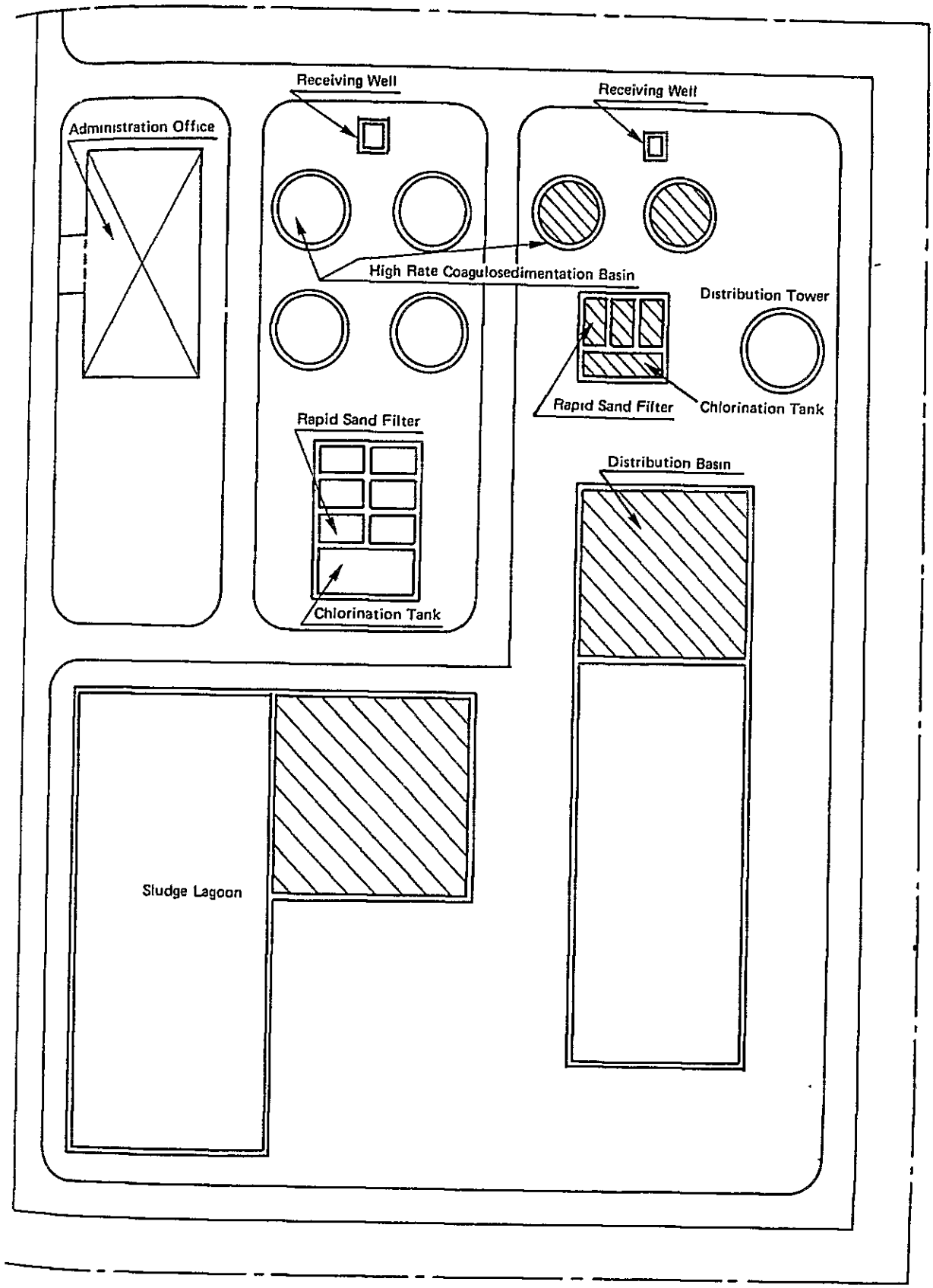
30,698 x 1.1 = 33,769

= 34,000 m³/day

Table 8.2-8 Design Value for Purification Facilities

	1987	1987-2000 (Expansion)	2000 (Total)
Amount of water	9,200 m³/day	24,800 m³/day	34,000 m³/day

Appendix 2 shows the capacity of major facilities of the purification facility and Fig. 8.2-9 illustrates the layout of the plant.



Notes: 1st Phase (1987)

2nd Phase (2000)

Fig. 8.2-9 Layout of Water Purification Facilities

8.2.5 Water Distribution Planning

Water purified at the purification facility will be transmitted to the distribution basin and distribution tower supplying the water to each demand point by gravity flow at the Industrial Complex, Port and Urban Area. Fig. 8.2-10 shows the general layout plan of the water distribution system.

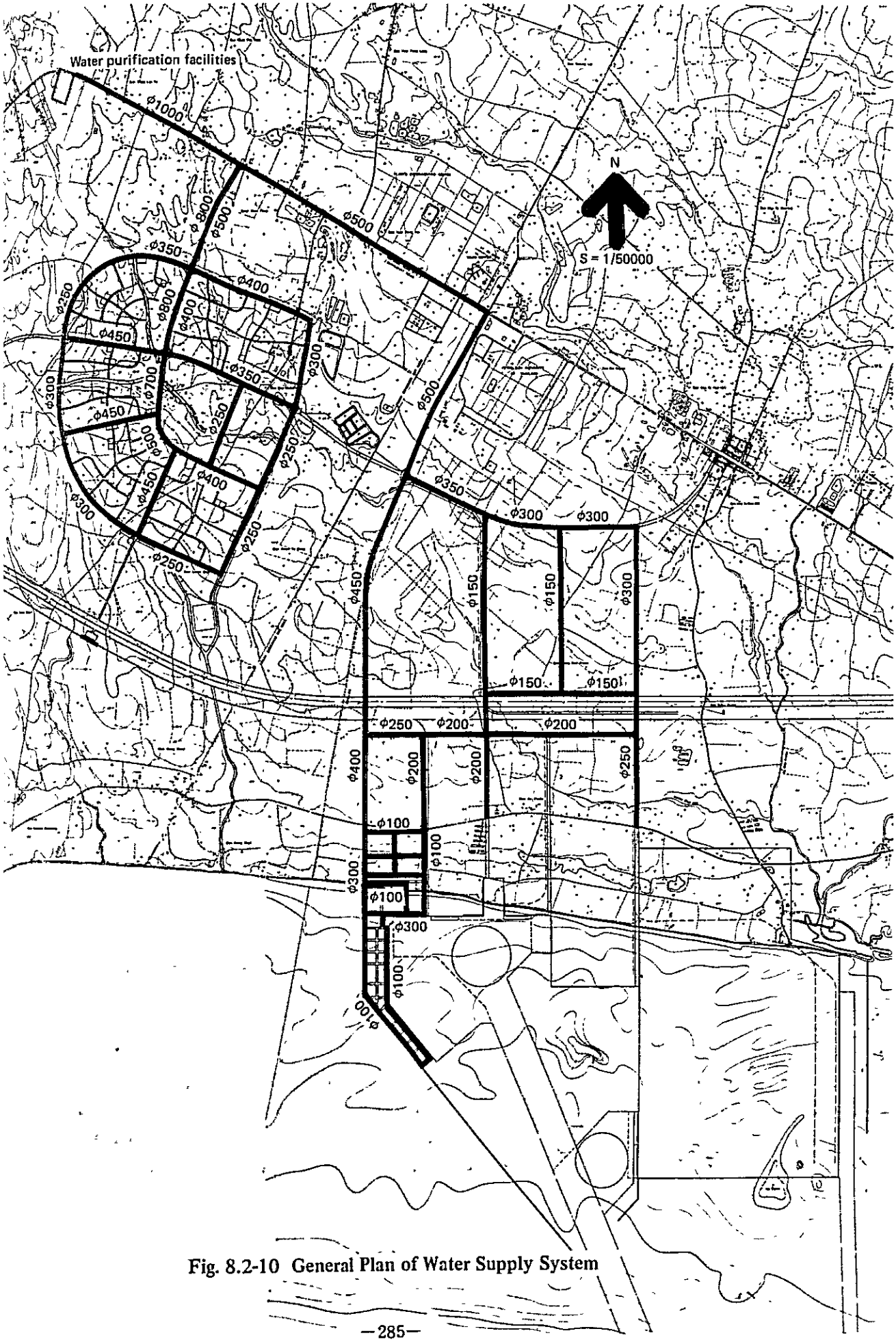


Fig. 8.2-10 General Plan of Water Supply System

8.3 Sewerage and Treatment of Effluents

8.3.1 Future Sewage Effluent and Sewage Waste Load

Waste effluents from the Map Ta Phut Industrial Development Area can be divided into two categories; one is domestic waste or sanitary waste from residences, business buildings, and institutions; and the other is industrial waste from manufacturing plants.

(1) Future Domestic Effluents and Loads

(a) Domestic Wastewater

Domestic wastewater discharge in the study area will mainly be sanitary sewage from kitchens, toilets and shower-rooms and other effluents containing a large amount of organic matter. Daily discharge of domestic wastewater is assumed as equal to daily maximum supply of potable water. Therefore, the same figure as the daily maximum per capita per day of supply water used for this study is adopted for computation of volume of domestic wastewater.

(b) Underground Water

Domestic wastewater from houses and buildings will be collected in treatment facilities by sewers where underground water will often enter due to lack of watertightness at pipe joints. The entrance of water must be eliminated to a minimum extent, but cannot be technically avoided. Though being aften disregarded in a small planning area because of short sewer lengths.

The volume of water entering sewer systems, depending largely on the conditions of soil strata, sub-surface water flow, types of pipe joints and construction techniques, cannot be determined with a fixed figure. Therefore, taking account of an empirical figure in Japan of 10–20% of the daily maximum sewage per capita, the entrance of underground water has been considered as follows:

–Port Area: Not taken into account.
–Urban Area: 10% of daily maximum sewage volume.

From the figure obtained by water supply planning, daily maximum is 26,813 m^3/day The area of urban site is 575 ha in total. Therefore, the total volume of wastewater is shown in Table 8.3-1.

(c) BOD and Suspended Solid Loads

Wastewater loads are estimated by the use of BOD and Suspended Solids contributed to the wastewater per capita in g/cp/d. The unit production of loads, varying in area mainly due to the difference of eating habits and standard of living, have a increasing tendency in future because of better standard of living. Table 8.3-2 indicates some examples of these figures in three countries.

Table 8.3-1 Amount of Sewage in Urban Area

No.	Items	Unit	1st Phase	2nd Phase	Total	Reference
(1)	Target population	per	18,300	53,200	71,500	
(2)	Size of urban area for design of sewage treatment plant	ha	131	444	575	
(3)	Daily maximum	m^3/d	6,863	19,950	26,813	
(4)	Daily maximum	m^3/hr	285.96	831.25	1,117.21	
(5)	Under ground water	m^3/d	686	1,995	2,681	
(6)	Under ground water	m^3/hr	28.58	83.13	111.71	
(7)	Daily maximum (include ground water)	m^3/d	7,549	21,945	29,494	(3) + (5)
(8)	Daily maximum (include ground water)	m^3/hr	314.54	914.38	1,228.92	(4) + (6)
(9)	Hourly maximum (include ground water)	m^3/hr	457.52	1,330.01	1,787.53	(4) × 1.5 + (6)

Table 8.3-2 Examples of BOD and SS Loads (1972)

Unit: g/cp/d

	Japan (Min. of Construction)	West Germany (Imhoff)	United States (Whole Nation)
BOD	44.25	54	76
SS	27.67	–	91

Source: Sewerage Facility Design Criteria and Explanatory Guideline by Japan Sewerage Association

In Thailand, an annual BOD Load of 85 g/cp/d was given in the Report "Master Plan of Sewerage Project in Bangkok Metropolis, JICA (1981)" based on previous studies in Bangkok Metropolitan. However, it can be seen that the figure is considerably high in comparison with the table above. Office of the National Environment Board gave another estimated figure of 50 g/cp/d in its report titled "Environmental Guidelines for Coastal Zone Management in Thailand Inner Gulf Zone".

The average BOD and SS concentration of the wastewater can be calculated by the following formula:

$$C = \frac{M}{Q}$$ where, C: Concentration of BOD or SS (mg/l)
M: BOD or SS Load (g/cp/d)
Q: Sewage volume (m^3/cp/d)

However, the BOD and SS Loads in the study area cannot be defined; therefore; the BOD value has been taken at 200 mg/l based on NHA Design criteria and SS value at 250 mg/l for this planning.

(2) Loads from Industrial Complexes

Sewage from Industrial complexes consists of the waste water generated in the process plants and the domestic wastewater. Those sewages have a wide variaties of qualities and the quantities according to the characteristics of each plant. Sewages will be treated independently within each plant in the same way as being projected for the petrochemical complex by PTT. That way of treatment system is the common practise in other industrial complexes. The effluent after processed in the waste water treatment facilities in each plant will be discharged to sea in accordance with the standard of wastewater.

Table 8.3-3 shows the quantity of the sewages discharged to the waste water treatment facilities within the complex.

Table 8.3-3 Summary of Waste Water (m^3/h)

1st Phase (Short-term Development):	
Soda Ash Plant	450
Petrochemical Complex	540 (Mixture)
Fertilizer Complex	500 (Mixture)
1st & 2nd Phase (Master Plan):	
Soda Ash Plant	810
Petrochemical Complex	970
Fertilizer Complex	900
Iron and Steel Complex	4,050
Total	8,220

8.3.2 Planning Policy

The Map Ta Phut Industrial Development Area will be devided into three different zones; Port Zone, Industrial Complex Zone and Urban Zone. Each zone will be individually located as shown in Fig. 8.3.2-1. Wastewater discharge from each zone will be characterized as follows:

Port and Urban Zones: Mainly domestic waste
Industrial Complex Zone: Mainly industrial waste with little domestic waste

In order to establish the planning policy for sewerage system in the whole area, several alternatives were proposed and studied in each case of the following:

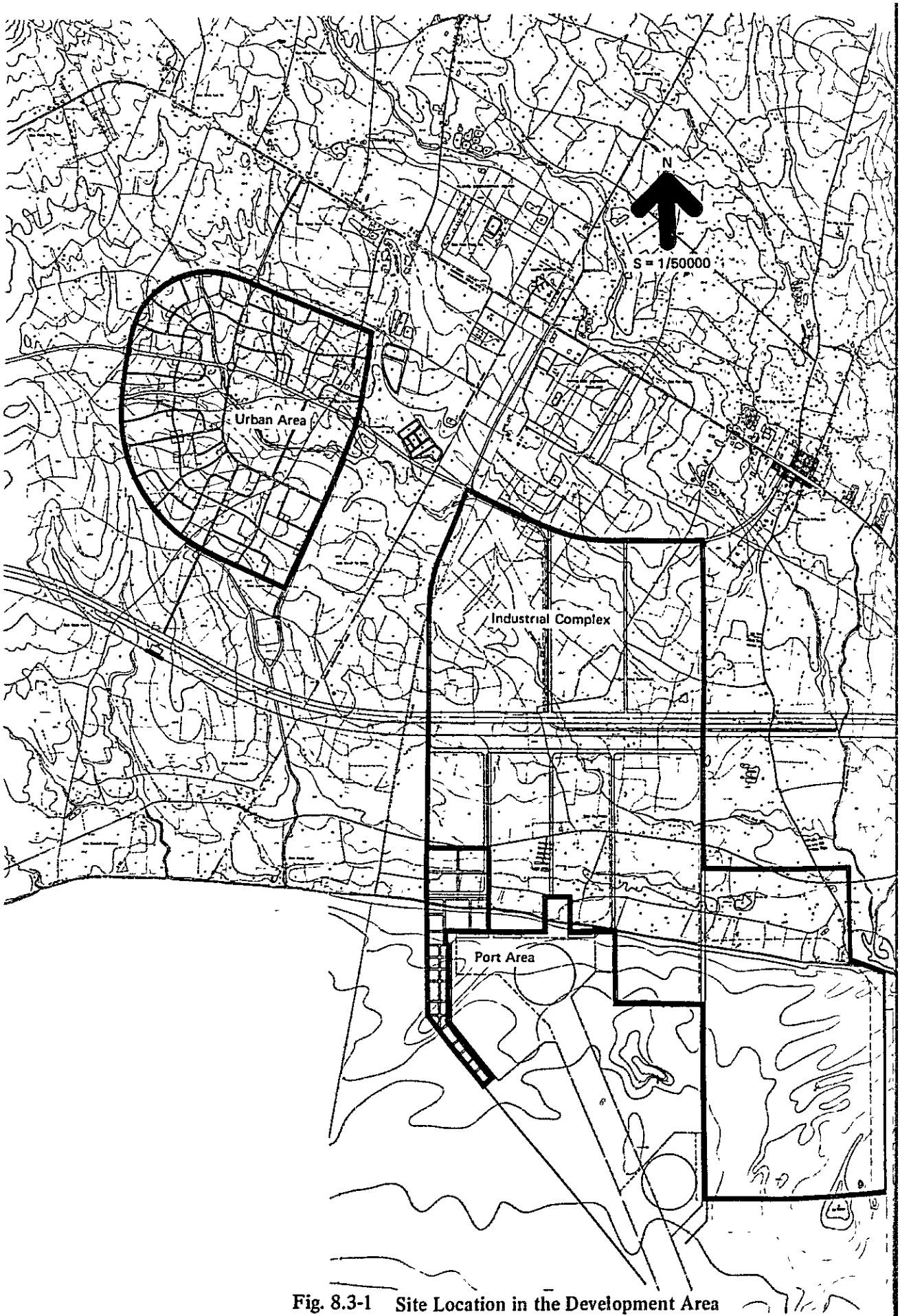


Fig. 8.3-1 Site Location in the Development Area

(1) Joint Treatment of Industrial Waste and Domestic Waste.

Industrial waste discharged from manufacturing plants will have characteristics as follows:

(a) Industrial waste varies in quality and quantity depending on scale and type of actories.

(b) Industrial waste, being different from domestic waste, may contain some harmful or toxic matter.

As for the possibility of joint treatment of industrial waste and domestic waste, industrial waste with those characteristics, even though pre-treated within the plant site, will cause a lot of technical difficulties in planning and implementing sewers and sewage treatment system. The joint treatment facilities, yet possible, would not be easily operated and maintained and may give adverse effects on the environment. Industrial waste in this study area will considerably be more than domestic waste in volume and have unforeseenable factors at this moment because types of factories for downstream and supporting industries are not yet decided. In this view, it will be more advisable to treat industrial waste and domestic waste separately in this study.

(2) Treatment of Domestic Wastewater

There are several alternatives to study treatment methods of domestic wastewater discharged from each zone: wholecombined treatment, partially-combined treatment and individual treatment. The comparative study for each alternative was made qualitatively as described in Table 8.3-4 and revealed that individual treatment at each zone (Alternative 5) would be most advisable.

(3) Conclusion

Based on the study above, it is concluded that sewage generated from Port, Industrial Complex and Urban Area will be individually treated in each zone.

Table 8.3-4 Comparative Study on Domestic Sewage Treatment

Alternative	Technical Points	Operation and Maintenance	General Comments
1 Whole-combined (U + P + I)	Treatment facility will be far from each generating point of domestic waste.	Maintenance of sewers will be costly.	X
2 Partially-combined (U + P, I)	Waste from port should be pumped up.	Pump station must be maintained.	X
3 Partially-combined (U + I, P)	Treatment facility will be far from each generating point of domestic waste.	Maintenance of sewers will be costly	X
4 Partially-combined (U, I + P)	Sewers length will be too long in comparison with the quantity of waste from Port and Industrial Complex.	Maintenance of sewers for Port and Industrial Complex will be costly.	X
5 Individual Treatment (U, P, I)	Most suitable sewerage system will be planned within each zone.	Maintenance can be made easily at each zone.	O

U: Urban Zone
I: Industrial Complex Zone
P: Port Zone