6.2 Infrastructure and Utilities

6.2.1 Sewerage

1) Introduction

(1) Priority Projects

The urgent need for sewerage and sewage treatment facilities for the Na Klua and Jomtien areas is clear. It is also clear that major expansion of the existing (including currently being implemented) sewerage and sewage treatment facilities serving the Phatthaya town area is essential if wastewater pollution problems are to be continued in the future.

Because of the extended nature of the study area, the imbalance and variety of the development and population concentrations and the urgency of the situation, a regional sewerage scheme with a centralized sewage treatment works is not a viable proposition. Such a scheme works take considerable time to fully implement would incur an unnecessarily heavy commitment to sewage pumping and would locally magnify difficulties with safe effluent disposal. The difficulties associated with the assembly and acquisition of a single large site for a centralized sewage treatment works could also be expected to cause further and unacceptable delays to project implementation. Separate sewerage as sewage treatment projects are therefore proposed for end of the three principal catchments. The elements of the accelerated sewerage programme for the area are therefore the Priority Projects of:

- Na Klua Area- Sewerage and Sewage Treatment Project
- Jomtien Area - Sewerage and Sewage treatment Project
- Phatthaya Town - Sewerage and Sewage Treatment Project.

The outlines of these projects presented in Chapter 4 of this report are elaborated and implementation recommendations are made in this Chapter.

(2) Phased Development

The ultimate demand for sewerage and sewage treatment/disposal in each of the three principal catchment areas shall be met through phased implementation of the works required. The priority projects

shall comprise the Phase I works required to achieve the Priority 1 goal of ensuring that unacceptable discharge of wastewaters to natural watercourses and the sea are eliminated and/or avoided. Although phased development of sewage treatment provisions is proposed land acquisition (or reclamation) for the works should be sufficient for the future treatment/disposal capacities required. The future demands for sewage treatment/disposal capacity and the recommended Phase I design capacities (cu m/day average flow) are shown on Fig. 6.2.1. Phase I works designs must be prepared bearing in mind future expansion requirements

(3) Sawage Treatment Works - Site Availability Problems

In the case of the Jomtien Sewerage as Sewage Treatment Project a site for a sewage treatment works has already been acquired. This site is suitably located and the Project proposed utilizes it. No site has yet been acquired for treatment facilities to serve the Na Klua catchment area nor has a site large enough to accommodate treatment facilities to meet the future demands of the Phatthaya town area been allocated. For both of these Projects possible alternative sitings are examined and, recognizing the possible difficulties and delays in assembling and acquiring suitable sites, the option of developing sewage treatment works or headworks to long sea outfalls on reclaimed land are examined. Fig. 6.2.2 shows the sitings for these reclamation works and provisional routings for long sea outfalls from these sites.

Because of the uncertainties of site availability in Na Klua and Phatthaya town and about the legal aspects of coastal land reclamation works in Thailand, each of the alternative solution options are evaluated and ranked by cost and engineering preference. Final scheme selection for each of these two catchments shall, however, be governed by the practicalities of implementation.

2) Na Klua Area Sewerage and Sewage /Treatment Project

(1) General

For sewerage and sanitation purposes the Na Klua catchment area is defined as the area within Phatthaya City boundaries to the north of the line of the watershed between Na Klua and Phatthaya town.
See Fig. 6.2.3.

At present no site for a sewage treatment works has been acquired, although the PWD has identified one suitable location (site A) close to the Na Klua river. This study confirms that suitably sized site approximate to the Na Klua river either within or just outside the city boundary would be generally suitable provided reasonable access and power can be made available. Land costs in this area are amongst the lowest in the Phatthaya area and opportunities to acquire suitable derelict land from abandoned tapioca starch processing factories may arise. Despite the above it is recognized that land acquisition may present problems and unacceptable delays and the possibilities of developing sewage treatment facilities or the headworks required to serve a long sea outfall disposal option or reclaimed land in the south corner of Bang Lamung bay to the east of the Na Klua fishing piers (Site B) is also considered. This area boarders the urbanized area of Na Klua and, although coasted it is not intensely developed as a tourist beach area. Figure 6.2.3 shows the general areas considered for sewage treatment works installation and a potential alignment for a long sea outfall pipeline.

Minimum site requirements for Na Klua area sewage treatment works facilities are 1.9 Ha (12 Rai) (assuming rotating biological contactor process with ultimate capacity of 15,000 cu m/day average flow). Site requirements for the headworks to a long sea outfall of same capacity are 1.5 Ha (9 Rai).

LAND COSTS/VALUES IN ALTERNATIVE TREATMENT WORKS SITE

	Location	Cost / Value - Baht			
		per m^2	per Rai	12 Rai	For 9 Rai
1 a	Alongside Na Klua River General area	410~1000	0.656~1.6Mil.	--	--
b	As per identified site (PWD/this study)	410	0.656Mil.	7.9 Mil.	5.9 Mil.
2 a	By reclamation site	3,400	5.44 Mil.	65.3 Mil.	50 Mil.
b	Reclamation Costs	850	1.36 Mil.	16.3 Mil.	12.25 Mil.

The cost of reclamation 2(b) is the estimated cost, per m^2 or Rai, of the necessary reclamation works based on an overall site requirement of 1.5 - 1.9 Ha (9-12 Rai) for headworks or treatment facilities with an ultimate capacity of 15,000 cu m/day average flow.

(2) Criteria for Sewerage Design

The sewerage system shall be modified or partially combined system, see Chapter 4 Section 4.2.4.9), c), d), e) and f) for system description and basic design criteria.

(3) Scope of Sewerage Provisions for Priority Projects

The project works shall include construction of all major interceptor sewers, connections to them from existing drainage and the necessary overflow and sewage pumping arrangements required to achieve the Priority 1 goal, (see Section 4.2.4.), of eliminating all unacceptable wastewater discharges to natural watercourses and the sea.

(4) Criteria for Sewage Treatment/Disposal Design

The principal criteria for outline design of the Na Klua sewage treatment works are:

Design horizontal year : 2006

Treatment works to be designed
for phased implementation.

Average daily flow in peak season

Phase I (up to 2000)	:	12,500 cu m/day
Phase II (from 2000)	:	15,000 cu m/day

Works will receive pumped flow from modified combined sewage system with estimated characteristics.

BODs influent	:	170~200 mg/ℓ
SS influent	:	135~160 mg/ℓ

Treatment effluent standard

BODs treated effect	:	20 mg/ℓ
SS treated effect	:	30 mg/ℓ

Treated effluent to be chlorinated.

For long sea outfall alternative: -

Design should be for preliminary and primary treatment only together with balancing and pumping facilities for the ultimate requirement of 15,000 cu m/day average flow, to achieve the water quality objectives outlined in Section 4.2.4.9).

(5) Scope of Sewage Treatment/Disposal Provision for Priority Project

For the full sewage treatment works option the project works shall include for all works required to meet the Phase I demand above, designed for expansion to meet the Phase II requirements. For the long sea outfall option the works shall be for the ultimate (2006) demand.

(6) Priority Project - Sewerage and Sewage Treatment Alternatives

Scheme A

Scheme A assumes that a site for a sewage treatment works is acquired alongside the Na Klua River to the east of Sukhumvit Road, that the sewerage system is designed to convey sewage to this site and that treated effluent is disposed to the Na Klua River.

Fig. 6.2.4 shows the assumed site for this sewage treatment works and the Phase I and Phase II trunk sewerage requirements.

The major elements of this sewerage scheme are: -

° Sewers and Interceptor Sewers: -

Diameter mm	Length m Phase I	Phase II
800	700	-
600	2,200	-
500	500	400
400	3,250	-
300	600	1,700
200	2,800	4,300

° Pumping Stations: -	Phase I	Phase II
Submersible Pump type	7 No.	3 No.
Dry Well/Wet Well type	1 No.	-

° Rising Mains: -

Diameter mm	Length m Phase I	Phase II
600	1,100	-
500	600	-
300	800	300
150	2,900	1,600

The estimated costs for these works are summarized in following table.

SUMMARY OF SEWERAGE COSTS
NA KLUA - SCHEME A

Element	Cost in Baht (× 1000)	
	Phase I	Phase II
Trunk Sewers	36,538	20,640
Manholes	5,695	3,621
Pumping Stations	6,362	1,070
Rising Mains	16,366	2,708
Total Costs	64,961	28,039

The sewage treatment works options considered for Scheme A are, oxidation ditches, conventional activated sewage process and process and rotating biological contactors plant. Estimated land acquisition and construction costs for each of these alternate options are summarized in following table. These estimates are for a treatment works with a Phase II capacity of 15,000 cu m/day average flow. The Phase I treatment works capacity requirement is 12,500 cu m/day average flow and some reductions in Phase I costs, typically in the area of 1.0 - 2.0 m, for reduced sewage drying bed requirements etc. could be realized at detail design stage. Soil reduction are however within the order of accuracy of the estimate and the full Phase II estimated cost is therefore used for this .

SEWAGE TREATMENT WORKS OPTIONS SUMMARY OF COSTS
NA KLUA - SCHEME A

Element	Cost in Baht (× 1000)			
	Oxidation Ditch	Activated Sludge	RBC Plant	Long- Sea Outfall
I. Land				
Land Required	3.0 Ha	2.5 Ha	1.9 Ha	-
Land Cost (410 B/m2) (Purchase)	12,300	10,250	7,790	-
II. Treatment Works				
a)Works construction	32,550	37,367	56,982	-
b)E.O. for site filling & flood protection	4,500	3,750	2,850	-
c) Effluent disposal	To river no adiitional costs No pumping			
Total cost sewage treatment works	37,050	41,117	59,832	-
III. Total Cost Sewage Treatment works including land	49,350	51,367	67,622	-

The following table shows the total sewerage and sewage treatment works costs for the Scheme A options.

SEWERAGE AND SEWAGE TREATMENT WORKS
SUMMARY OF TOTALCOSTS
NA KLUA - SCHEME A

Element	Cost in Baht (× 1000)		
	Oxidation Ditch	Activated Sludge	RBC Plant
Phase I			
Land costs	12,300	10,250	7,790
Sewerage costs	64,961	64,961	64,961
Sewage treatment and effluent disposal costs	37,050	41,117	59,832
Total Phase I costs			
a) Excluding land costs	102,011	106,078	124,793
b) Including land costs	114,311	116,328	132,583
Phase II			
Land costs	-	-	-
Sewerage costs	28,039	28,039	28,039
Sewage treatment and effluent disposal costs	-	-	-
Total Phase II costs	28,039	28,039	28,039
Total overall cost including land	142,350	144,367	160,622

Scheme B

Scheme B assumes that a site for a sewage treatment works on long sea outfall headworks is reclaimed in the south eastern corner of Bang Lamung Bay and that the sewerage system is designed to convey sewage to this site. Fig. 6.2.5 shows the proposed site and the Phase I and Phase II trunk sewerage requirements.

The major elements of this sewerage scheme are:

° Sewer and Interceptor Sewer: -

Diameter mm	Length m Phase I	Phase II
600	2,000	-
500	1,150	400
400	3,050	-
300	600	1,700
200	3,150	4,300

° Pumping Station: -

	Phase I	Phase II
Submersible pump type	8 No.	3 No.
Dry will/wet well type	-	-

° Rising Mains: -

Diameter mm	Length m Phase I	Phase II
500	1,000	-
400	450	-
300	500	300
150	2,900	1,600

The estimated costs for these works are summarized as follows.

SUMMARY OF SEWERAGE COSTS
NA KLUA - SCHEME B

Element	Cost in Baht (× 1000)	
	Phase I	Phase II
Trunk Sewers	34,379	20,640
Manholes	5,638	3,621
Pumping Stations	5,260	1,070
Rising Mains	12,643	2,708
Total Costs	57,920	28,039

The sewage treatment works/effluent disposal options considered for Scheme B are, oxidation ditches, conventional activated sludge process, rotating biological contactor plant and headworks with a long sea outfall.

Estimated land reclamation and construction costs for each of these alternate options are summarized in the following table. As for Scheme B these estimates are for a sewage treatment works/effluent disposal scheme with a Phase II capacity of 15,000 cu m/day average flow.

SEWERAGE TREATMENT WORKS OPTIONS SUMMARY OF COSTS
NA KLUA - SCHEME B

Element	Cost in Baht (× 1000)			
	Oxidation Ditch	Activated Sludge	RBC Plant	Long Sea Outfall
I. Land				
Land Required	3.0 Ha	2.5 Ha	1.9 Ha	1.5 Ha
Land Cost				
Reclamation (1,275 B/m²)	38,250	31,875	24,225	19,125
II. Treatment Works				
a) Works construction	32,550	37,367	56,982	14,853
b) Effluent disposal	500	500	500	276,978
c) E.O. for piled founds	9,971	4,619	3,059	1,836
Total cost sewage treatment works	43,021	42,486	60,541	293,667
III. Total Cost Sewage Treatment works including land	81,271	74,361	84,766	312,792

The following table shows the total sewerage and sewage treatment works costs for the Scheme B options: -

SEWERAGE AND SEWAGE TREATMENT WORKS
SUMMARY OF TOTAL COSTS
NA KLUA - SCHEME B

Element	Cost in Baht (× 1000)			
	Oxidation Ditch	Activated Sludge	RBC Plant	Long-Sea Outfall
Phase I				
Land reclamation costs	38,250	31,875	24,225	19,125
Sewerage costs	57,920	57,920	57,920	57,920
Sewage treatment and effluent disposal costs	43,021	42,486	60,541	293,667
Total Phase I costs				
a) Excluding land costs	100,941	100,406	118,461	351,587
b) Including land costs	139,191	132,281	142,686	370,712
Phase II				
Land costs	-	-	-	-
Sewerage costs	28,039	28,039	28,039	28,039
Sewage treatment and effluent disposal costs	-	-	-	-
Total Phase II costs	28,039	28,039	28,039	28,039
Total overall cost including land	167,230	160,320	170,725	398,751

(7) Scheme Selection

From the above analysis, it can be seen that there is little difference between the construction costs for Scheme A and Scheme B. The choice of scheme is therefore governed by the practicalities and costs of land acquisition and land reclamation. If sufficient land can be acquired at or about Site A at a price of less than 1,000 Baht/m^2 Scheme A will be cheaper overall. If a site cannot be acquired (as the price is greater than 1,000 Baht/m^2) Scheme B would be essential (or more attractive). Bearing in mind the urgency of the conditions it is recommended that the government proceed on the basis of Scheme B under which they have control of the land reclamation works and costs.

(8) Treatment Option Assessment

The analysis shows that the long sea outfall is not viable and it is therefore discounted from further consideration. The overall costs (land reclamation plus construction costs) for the three secondary treatment options vary form Baht 74.4 million for the conventional activated sludge process to Baht 84.8 million for the RBC plants. The cost for the oxidation ditch processing costs Baht 81.3 million. Final selection of the treatment option should be made at the feasibility study/detailed design stage, however, this first inspection suggests that an oxidation ditch plant with its lesser commitment to running costs and technical management is economically viable despite its higher land reclamation and foundation costs. An oxidation ditch plant is therefore the initially preferred option.

3) Jomtien Area Sewerage and/Sewage Treatment Project

(1) General

For sewerage and sanitation planning purposes the Jomtien catchment area is defined as the area within Phatthaya City boundaries to the south of the line of the watershed between Phatthaya town and Jomtien and includes the Khao Phatthaya area (See Fig. 6.2.5). A site for a sewage treatment works has already been identified and acquired at Wat Boon road. The site is generally suitably located within the catchment area although a site closer to

the proposed Jomtien Second Road intersection with Wat Boon Road which would require a lesser commitment to sewage and treated effluent pumping would have been preferable. In mitigation the land acquisition costs for the preferred site location would have been approximately five times higher that the cost/opportunity value of the given site. Fig. 6.2.6 shows general details of the catchment and the location of the treatment works site.

(2) Scope of Sewerage Provisions for Priority Project

The Project works shall include construction of all branch, lateral and trunk sewers and sewage pumping stations required to serve all existing and planned coastal developments on Jomtien Beach. Developments fronting Wat Boon road shall be included and provision shall be made for all future sewage flows from the Khao Phatthaya area. The Project shall be aimed at achieving the Priority 1 goal, (See Section 4.2.4 8) of ensuring that the wastewaters arising from these developments are prevented form discharging to natural watercourses or the sea.

(3) Criteria for Sewage Treatment/Disposal Design

The principal criteria for outline design of the Jomtien sewage treatment works are:

Design horizontal year	:	2006
Treatment works to be designed for phased implementation.		
Average daily flow in peak season		
Phase I (up to 2000)	:	15,000 cu m/day
Phase II (from 2000)	:	20,000 cu m/day
Works will receive pumped flow from largely separate sewerage system but with some from modified combined system.		
Estimated characteristics:		
BODs influent	:	170~200 mg/ℓ
SS influent	:	135~160 mg/ℓ

Effluent standard

BODs treated effect	:	20 mg/ℓ
SS treated effect	:	30 mg/ℓ

Treated effluent to be chlorinated.

Phase I effluent disposal shall be via effluent pumps to a gravity outfall in Wat Boon road. The disposal system shall, however, be designed, for future diversion (Phase II) to improve land drainage system required to serve low lying land inland of coastal developments and ultimately to discharge to Khlong Huay Yai.

(4) Scope of Sewage Treatment/Disposal Provision for Priority Project

The Project shall include the works required to meet the Phase I demand above, but shall be designed for expansion to meet the Phase II and III requirements.

(5) Priority Project

It is proposed that sewage treatment functions be developed on the already acquired site at Wat Boon Road and that the sewage system be designed accordingly. Fig. 6.2.7 shows the site location and the Phase I and Phase II trunk sewerage requirements.

The major elements of this sewerage scheme are: -

° Sewers and Interceptor Sewers: -

Diameter	Length m	
mm	Phase I	Phase II
700	500	-
500	900	-
400	2,100	1,000
300	3,000	5,800
200	4,000	3,600

° Pumping Stations: -	Phase I	Phase II
Submersible Pump type	5 No.	5 No.
Dry Well/Wet Well type	1 No.	-

° Rising Mains: -

Diameter mm	Length m Phase I	Phase II
700	1,700	-
500	900	-
400	700	-
300	1,700	600
200	-	1,050
150	1,000	300

The estimated costs for these works are summarized in following table.

SUMMARY OF SEWERAGE COSTS
JOMTIEN

Element	Cost in Baht (× 1000) Phase I	Phase II
Trunk Sewers	37,364	37,818
Manholes	5,950	5,899
Lateral Sewers*	14,520	-
Pumping Stations	6,385	2,265
Rising Mains	27,548	3,825
Total Cost	91,767**	49,807

* Majority of lateral sewers should be installed by developers. This provision of 15 no 300 m length.

** Cost without lateral sewers is 77,072,000 Baht.

The sewage treatment works options considered for this Project are, oxidation ditches, conventional activated sludge process and rotating biological contactor plant.

Estimated construction costs for each of these alternate option are summarized in following table. Estimates for both the Phase I priority project and the Phase II works are compared.

SEWAGE TREATMENT WORKS OPTIONS
SUMMARY OF COSTS
JOMTIEM

Element	Option Costs - Baht (× 1000)		
	Oxidation Ditch	Activated Sludge	RBC Plant
I. Land			
Land Required (Ultimate)	4.2 Ha	3.3 Ha	2.7 Ha
Land Cost	Site already acquired.		
II. Treatment Works			
a)Phase I Works construction	32,550	37,367	56,982
b)Phase II Works construction	10,850	12,456	18,994
c) Effluent disposal	17,983	17,983	17,983
Total cost sewage treatment works	61,383	67,806	93,959
III. Total Cost of Sewage			
Treatment and disposal Phase I	50,533	55,350	74,965

The following table shows the total sewerage and sewage treatment works costs for each of the treatment options.

SEWERAGE AND SEWAGE TREATMENT WORKS
SUMMARY OF TOTAL COSTS
JOMTIEN

Element	Cost - Baht (× 1000)		
	Oxidation Ditch	Activated Sludge	RBC Plant
Phase I			
Sewerage costs	91,767	91,767	91,767
Sewage treatment and effluent disposal costs	50,533	55,350	74,965
Total Phase I costs	142,300	147,117	166,732
Phase II			
Sewerage costs	49,807	49,807	49,807
Sewage treatment and effluent disposal costs	10,850	12,456	18,994
Total Phase II costs	60,657	62,263	68,801
Total overall cost	202,957	209,380	235,533

(6) Priority Project - Treatment Option Assessment

The overall range of treatment works option costs is within the estimating accuracy of this study and the final selection of the treatment works process should be made at feasibility study/detailed design stage. However, the above analysis strongly suggests that an oxidation ditch plant is the first choice secondary treatment works option, and this treatment option is, subject to any site constraints, recommended for the works at Jomtien.

4) Phatthaya town - Sewerage and Sewage Treatment Project

(1) General

For sewerage and sanitation planning purposes the Phatthaya town catchment are is defined as the area within Phatthaya City boundaries, to the south of the Na Klua/Phatthaya town watershed and to the north of the Jomtien/Phatthaya town watershed (See Fig. 6.2.8). Figure also shows outline details of the existing (and currently being implemented) municipal sewerage and sewage treatment works sites at Soi Kazem Suwan and Soi 17, in South Phatthaya and outline details of the existing sewerage system. The most difficult to resolve problem in developing the sewerage and sewage treatment works capacity to a level adequate to meet future demands in the Phatthaya town area is the availability and cost of suitable land for the additional treatment works capacity required. A number of alternative schemes are therefore examined including; expansion of the existing works at Soi Kazem Suwan, establishment of a new inland treatment works to serve the future needs of the whole catchment area and development of either, full sewage treatment facilities or the necessary headworks to serve a long sea outfall on land to be reclaimed under the proposed South Phatthaya Reclamation Project.

Fig. 6.2.8 also shows the alternative sites considered.

The following alternative schemes are therefore analyzed to identify the 'best choice' solution and to make the alternatives.

(2) Outline Criteria for Treatment Works Design

The principal criteria for outline design of the Phatthaya town

sewage treatment works are:

Design horizontal year	:	2006
Treatment works to be designed for phased implementation.		
Average daily flow in peak season		
Phase I (up to 2000)	:	30,000 cu m/day
Phase II (from 2000)	:	40,000 cu m/day
Works will receive pumped flow from modified combined sewage system with estimated characteristics.		
BODs influent	:	170~200 mg/ℓ
SS influent	:	135~160 mg/ℓ
Treatment effluent standard		
BODs treated effect	:	20 mg/ℓ
SS treated effect	:	30 mg/ℓ
Effluent to be chlorinated.		

For long sea outfall alternative: -
Design should be for preliminary and primary treatment only together with balancing and pumping facilities for the ultimate requirement of 15,000 cu m/day average flow, to achieve the water quality objectives outlined in Section 4.2.4.9).

(3) Scope of Sewage Treatment/Disposal Provision for Priority Project

For the full sewage treatment works options the project works shall include for all works required to meet the overall Phase I demand of 30,000 cu m/day average flow. For some options this can be achieved by a combination of existing works and new works capacities.

For the headworks/long sea outfall options the Project shall comprise preliminary and primary treatment facilities to meet the Phase I demand of 30,000 cu m/day average flow (designed for extension to 40,000 cu m/day) together with effluent pumping facilities and outfall

designed for the ultimate requirement of 40,000 cu m/day average flow.

(4) Land Costs for Sewerage Treatment Works/Headworks Option

LAND COSTS/VALUES AT TREATMENT WORKS HEADWORKS SITES

Scheme	Cost/Value - Baht	
	per m^2	per Rai
Scheme/Site A		
- Adjacent to Soi Kazem Suwan Sewage Treatment Works	5,200	8.32 million
Scheme/Site B		2.56 million
- North of South Phatthaya Road	1,600	
Scheme/Site C		
- Reclaimed land in south Phatthaya Bay		
Value:	50,000+	80.0 million+
Cost:	850	1.36 million

Land costs/values for schemes A and B are based on land tax valuation as per Phatthaya City 1987 up-rated to 1989 prices.

Land values for schemes Ca are the estimated opportunity values for the sites based on adjacent coastal land prices.

Land costs for Schemes C are the estimated per m^2 or Rai costs of the reclamation costs for the proposed reclamation project in south Phatthaya Bay.

(5) Sewerage and Sewage Treatment Alternatives

The following alternative schemes are analyzed to identify the 'best choice' solution and to rank the alternatives:-

i) Scheme A

Acquire additional and adjacent to the existing treatment works at Soi Kazem Suwan and progressively improve and expand the sewerage system to convey all sewage in the catchment area to this site. (The Soi 17 sewage works would be abandoned and its site released for other use/redevelopment at appropriate time in the future)

Fig. 6.2.9 shows the Phase I and Phase II trunk sewerage requirements for these options together with treatment works outfall details.

The major elements of this sewerage scheme are:

° Sewer and Interceptor Sewer: -

Diameter mm	Length m Phase I	Phase II
800	-	500
600	500	-
500	2,850	1,600
400	2,500	1,900
300	4,400	4.900
200	300	2,300

° Pumping Station: -

A total of five new pumping stations are proposed, however to deal with rapidly increasing flows it will be necessary to progressive update the existing pumping stations. Five or the existing pumping stations will require re building or expansion and reequipping and the other five shall require reequipping only.

	Phase I	Phase II
Dry will/wet well type	1 No.	-
Submersible pump type	1 No.	3 No.
Submersible pump type existing:		
a) to be expanded and reequipped	3 No.	2 No.

b) to be reequipped only - 5 No.

° Rising Mains: -

Diameter mm	Length m Phase I	Phase II
600	50	-
500	2,700	100
400	-	200
300	-	1,000
150	-	250

The estimated costs for these works are summarized in following table.

SUMMARY OF SEWERAGE COSTS
PHATTHAYA TOWN - SCHEME A

Element	Cost in Baht (× 1000) Phase I	Phase II
Trunk Sewers	38,298	38,818
Manholes	5,967	6,358
Pumping Stations	7,762	5,485
Rising Mains	15,458	4,486
Total Costs	67,485	55,147

The sewage treatment works options considered for Scheme A are, oxidation ditches, conventional activated sewage process, rotating biological contactors plant and preliminary and primary treatment only with effluent pumping facilities discharging through a long sea outfall. Estimates for both the Phase I Priority Project and the Phase II works are compared. The Phase I estimate for the long sea outfall option assumes that the existing treatment facilities at Soi Kazem Suwan and Soi 17 are abandoned. The Phase I estimates for the oxidation ditch, activated sludge and rotating biological contactor options are based on incomponating the existing (and currently being

implemented) facilities at Soi Kazem Suwan within the Phase I treatment works. This maximizes the return on the existing investment.

For the oxidation ditch and activated sludge options it will also be necessary to retain the Soi 17 works in operational condition until the Phase II works and commissioned to ensure sufficient treatment capacity during Phase II construction. Phase II construction would also have to be advanced by one or two years.

For the rotating biological contactor plant option the works at Soi 17 can be abandoned on commissioning of the Phase I works and the 5 no rotating biological contactors salvaged, reconditioned and incorporated in the works.

This saving is incorporated in the Phase I estimate for the option. The Phase II estimate for this option includes the savings from incorporating the existing RBC Plant at Soi Kazem Suwan in the overall works.

Estimated land acquisition and construction costs for each of the above options are summarized in following Table.

SEWAGE TREATMENT WORKS OPTIONS
SUMMARY OF COSTS
PHATTHAYA TOWN - SCHEME A

Element	Option costs - Baht (× 1000) Oxidation Ditch	Activated Sludge	RBC Plant	Long-Sea Outfall
I. Land				
Total land required	5.5Ha (35 Rai)	4.4 Ha (28 Rai)	3.8 Ha (24 Rai)	2.7 Ha (17 Rai)
Existing land holding	0.9 Ha (5.6 Rai)			
Balance required	4.6Ha	3.5 Ha	2.9Ha	1.8Ha
Land cost at 5,200 B/m²	239,200	182,000	150,800	93,600
II. Treatment Works				
a) Phase I -	48,270	50,862	89,786	23,026
Less cost of 5 PRC units (From Soi 17 works)	-	-	(10,000)	-
b) Phase II -	37,866	34,216	53,789	12,508
Existing RBC plant etc.	-	-	(23,850)	-
E.O for demolition of existing works	1,250	1,250	-	1,250
c) Effluent disposal (pumps to river/sea)	28,965	28,965	28,965	274,890
Total cost of sewage treatment works	116,351	115,293	138,690	311,674
III Total Cost of Sewage Treatment works including land	355,551	297,293	289,490	405,274
IV Total Cost for Phase I Development				
a) Without land cost	77,235	79,827	108,751	297,916
b) Including land cost	316,435	261,827	259,551	391,516

The following table shows the total sewage and sewage treatment works/effluent disposal costs for each of the treatment options

SEWERAGE AND SEWAGE TREATMENT WORKS
SUMMARY OF TOTAL COSTS
PHATTHAYA - SCHEME A

Element	Cost in Baht (× 1000)			
	Oxidation Ditch	Activated Sludge	RBC Plant	RBC Plant
Phase I				
Land costs	239,200	182,000	150,800	93,600
Sewerage costs	67,485	67,485	67,485	67,485
Sewage treatment and effluent disposal costs	77,235	79,827	108,751	297,916
Total Phase I costs				
a) Excluding land costs	144,720	147,312	176,236	365,401
b) Including land costs	383,920	329,312	327,036	459,001
Phase II				
Sewerage costs	55,147	55,147	55,147	55,147
Sewage treatment and effluent disposal costs	39,166	35,466	29,939	13,758
Total Phase II costs	94,263	90,613	85,086	68,905
Total overall cost including land	478,183	419,925	412,122	527,906

ii) Scheme B

Assemble and acquire a suitable inland site for a new sewage treatment works to serve all future demands in the catchment. All sewerage would be diverted to this site and both existing treatment works sites would be released for other use/redevelopment at appropriate time in the future. Fig. 6.2.10 shows the assumed site for this sewage treatment works option and the Phase I and Phase II trunk sewerage requirements.

The major elements of this sewerage scheme are:

° Sewer and Interceptor Sewer: -

Diameter mm	Length m Phase I	Phase II
600	1,400	-
500	3,150	300
400	3,150	1,100
300	5,200	2,700
200	300	2,300

° Pumping Station: -

A total of five new pumping stations are proposed, however, to deal with rapidly increasing flows it will be necessary to progressively update the existing pumping stations. Five of the existing pumping station will require re-building or expansion and reequipping and the other five shall require reequipping only.

	Phase I	Phase II
Dry will/wet well type	1 No.	-
Submersible pump type	2 No.	2 No.
Submersible pump type existing:		
a) to be expanded and reequipped	3 No.	2 No.
b)to be reequipped only	-	5 No.

° Rising Mains: -

Diameter mm	Length m Phase I	Phase II
800	1,000	-
600	50	-
500	2,200	100
400	-	200
300	-	300
150	-	250

The estimated costs for these works are summarized as follows

SUMMARY OF SEWERAGE COSTS
PHATTHAYA TOWN - SCHEME B

Element	Cost in Baht (× 1000) Phase I	Phase II
Trunk Sewers	48,793	20,028
Manholes	7,429	3,638
Pumping Stations	12,415	4,805
Rising Mains	21,858	2,648
Total Costs	90,495	31,119

The sewage treatment works options considered for Scheme B are, oxidation ditches, conventional activated sewage process, rotating biological contactors plant.

Estimates for both the Phase I Priority Project and the Phase II works are compared. The Phase I estimate are based on retaining the existing (and currently being implemented) treatment facilities at Soi Kazem Suwan until commissioning of the Phase II works. This maximize the return on the existing investments. The Soi 17 works can, however, be abandoned and the site released or commissioning of the Phase I works.

For the rotating biological contactor plant option it is assumed that the rotating biological contactor at Soi 17 works will be salvaged, reconditioned and installed in the Phase I development and that the contactors at Soi Kazem Suwan will be salvaged, reconditioned and transferred to the new works as part of the Phase II expansion.

Estimated land acquisition and construction costs for each of the above options are summarized in below.

SEWAGE TREATMENT WORKS OPTIONS SUMMARY OF COSTS
PHATTHAYA TOWN - SCHEME B

Element	Option costs - Baht (× 1000)			
	Oxidation Ditch	Activated Sludge	RBC Plant	Long- Sea Outfall
I. Land				
Total land required	5.5Ha	4.4 Ha	3.8 Ha	2.7 Ha
Land cost at 1,600 B/m^2	88,000	70,400	60,800	-
II. Treatment Works				
a) Phase I construction	48,270	50,862	89,786	-
Less cost of 5 PBC units from Soi 17			(10,000)	
b) Phase II - construction	37,866	34,216	53,789	-
Less cost of 6 RBC units from Soi Kazem			(12,000)	
c) Effluent disposal	42,000	42,000	42,000	-
Total cost of sewage treatment works	128,136	127,078	163,575	-
III Total Cost of Sewage Treatment works including land	216,136	197,478	224,375	-
IV Total Cost for Phase I sewage treatment works				
a) Without land cost	90,270	92,862	121,786	-
b) With land cost	178,270	163,262	182,586	-

The following table shows the total sewerage and sewage treatment works/effluent disposal costs for each of the treatment options.

SEWERAGE AND SEWAGE TREATMENT WORKS
SUMMARY OF TOTAL COSTS
PHATTHAYA TOWN - SCHEME B

Element	Cost in Baht (× 1000)		
	Oxidation Ditch	Activated Sludge	RBC Plant
Phase I			
Land costs	88,000	70,400	60,800
Sewerage costs	90,495	90,495	90,495
Sewage treatment and effluent disposal costs	90,270	92,862	121,786
Total Phase I costs			
a) Excluding land costs	180,765	183,357	212,281
b) Including land costs	268,765	253,757	273,081
Phase II			
Sewerage costs	31,119	31,119	31,119
Sewage treatment and effluent disposal costs	37,866	34,216	41,789
Total Phase II costs	68,985	65,335	72,908
Total overall cost including land	337,750	319,092	345,989

iii) Scheme C

Scheme C contemplates to develop either, full sewage treatment works with a short sea outfall, or preliminary and primary treatment works with effluent disposal via a long sea outfall, on part of the proposed land reclamation project in South Phatthaya Bay.

Fig. 6.2.11 shows the Phase I and Phase II trunk sewerage requirements for these options and Fig. 6.2.12 shows approximate site requirements and outfall pipe arrangements in the reclaimed land area in South Phatthaya bay.

The major elements of this sewerage scheme are:

° Sewer and Interceptor Sewer: -

Diameter mm	Length m Phase I	Phase II
800	-	500
600	650	-
500	3,800	1,600
400	1,400	1,900
300	4,400	4,900
200	300	2,300

° Pumping Station: -

A total of four new pumping stations are proposed, however, to deal with rapidly increasing flows it will be necessary to progressively update the existing pumping stations.

	Phase I	Phase II
Dry will/wet well type	1 No.	-
Submersible pump type	-	3 No.
Submersible pump type existing:		
a) to be expanded and reequipped	2 No.	-

b)to be reequipped only	1 No.	3 No.
c) to be reequipped only	-	3 No.

° Rising Mains: -

Diameter mm	Length m Phase I	Phase II
1,000	2,600	-
500	2,050	100
400	-	200
300	-	1,000
150	100	250

The estimated costs for these works are summarized as follows:

SUMMARY OF SEWERAGE COSTS
PHATTHAYA TOWN - SCHEME C

Element	Cost in Baht (× 1000) Phase I	Phase II
Trunk Sewers	38,068	38,818
Manholes	5,967	6,358
Pumping Stations	9,920	5,120
Rising Mains	42,930	4,486
Total Costs	96,885	54,782

The sewage treatment/effluent disposal options considered for Scheme C are oxidation ditches, conventional activated sludge process, rotating biological contactor plant and preliminary and primary treatment only with effluent pumping facilities discharging through a long sea outfall.

Estimates for both the Phase I priority Project and the Phase II future expansion are compared. The Phase I estimate for the long sea outfall assumes that the existing treatment facilities at Soi 17 and Soi Kazem

Suwan are abandoned. The Phase I estimates for the sewage treatment options are based on retaining the treatment facilities at Soi Kazem Suwan until commissioning of the Phase II extension. This maximizes the return on the existing investment.

The Soi 17 works would however be abandoned and the site released on commissioning of the Phase I works. For the rotating biological contactor plant option it is assumed that the contactor at Soi 17 will be salvaged, reconditioned and installed in the Phase I works. It is also assumed that the contactors at the Soi Kazem Suwan works will be salvaged, reconditioned and transferred to the new works during Phase II expansion.

All estimates are adjusted to allow for piled foundations in the reclaimed land and for the provision of a boundary screen wall in lieu of fencing to lessen the visual impact of the works in this tourist active area. A coarse assessment of the additional cost involved in constructing a treatment works 'underground' in the reclaimed land area is also determined.

Estimated land reclamation and construction costs for each of the above options are summarized in following table.

The unit rate (850 Baht/m^2) for land reclamation is based on the costs developed for the proposed south Phatthaya land reclamation project. For the case where this project does not proceed, reclamation is undertaken for the sewage treatment works only. The unit rate for reclamation is 1,275 Baht/m^2.

SEWAGE TREATMENT WORKS OPTIONS SUMMARY OF COSTS
PHATTHAYA TOWN - SCHEME C

Element	Option costs - Baht (× 1000)			
	Oxidation Ditch	Activated Sludge	RBC Plant	Long- Sea Outfall
I. Land				
Total land required	5.5Ha	4.4 Ha	3.8 Ha	2.7 Ha
Reclamation cost (850 B/m²)	46,750	37,400	32,300	22,950
Reclamation cost (1,275 B/m²)	70,125	56,100	48,450	34,425
II. Treatment Works				
a) Phase I - construction	48,270	50,862	89,786	23,026
Less cost of 5 PRC units from Soi 17 works			(10,000)	
E.O. for piled found	14,050	6,333	4,417	3,554
E.O. for wall to site	1,169	1,080	996	861
Effluent disposal (pumps to river/sea)	1,000	1,000	1,000	240,165
b) Phase II - construction	37,866	34,216	53,789	12,508
Less cost of RBC units from Soi 17 works			(12,000)	
E.O. piles foundation	12,478	5,467	3,583	1,379
Total cost of sewage treatment works	114,833	98,958	131,571	281,493
III Total Cost of treatment works including land (Ph. I + Ph. II)				
a) at 850 B/m2	161,583	136,358	163,871	304,443
b) at 1,275 B/m2	184,958	155,058	180,021	315,918
IV Total Cost for Phase I Development				
a) Without land cost	64,489	59,275	86,199	267,606
b) With land at (850 B/m²)	111,239	96,675	118,499	290,556
c) With land at (1,275 B/m²)	134,614	115,375	134,649	302,031
V Ever over for AS/RBC Plant "underground"	-	75,975	75,975	48,350
a) construction cost	-	10,000	10,000	5,000
b) additional men annual ventilation services				
c) mechanical sludge dewatering	-	25,500	25,500	23,000
Total E.O.	-	111,475	111,475	75,350

The following table shows the total sewerage and sewage treatment/effluent disposal costs for each of the treatment options.

SEWERAGE AND SEWAGE TREATMENT WORKS
SUMMARY OF TOTAL COSTS
PHATTHAYA TOWN - SCHEME C

Element	Cost in Baht (× 1000) Oxidation Ditch	Activated Sludge	RBC Plant	Long Sea Outfall
Phase I				
Land costs (a) 850 B/m2	46,750	37,400	32,300	22,950
(b) 1,275 B/m2	70,125	56,100	48,450	34,425
Sewerage costs	96,885	96,855	96,855	96,855
Sewage treatment and effluent disposal costs	64,489	59,275	86,199	267,606
Total Phase I costs				
a) Excluding land costs	161,374	156,130	183,054	364,461
b) Inc. land at 850 B/m2	208,124	193,530	215,394	387,411
c) Inc. land at 1,275 B/m2	231,499	213,230	231,504	398,886
Phase II				
Sewerage costs	54,782	54,782	54,782	54,782
Sewage treatment and effluent disposal costs	50,344	39,683	45,371	13,887
Total Phase II costs	105,126	94,465	100,154	68,669
Total overall cost including land				
(a) 850 B/m2	313,250	287,995	316,508	456,080
(b) 1,275 B/m2	336,625	306,695	331,658	467,555

Recommendation of the Underground Treatment Works

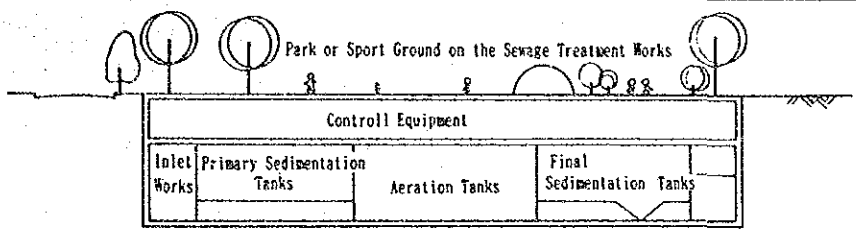
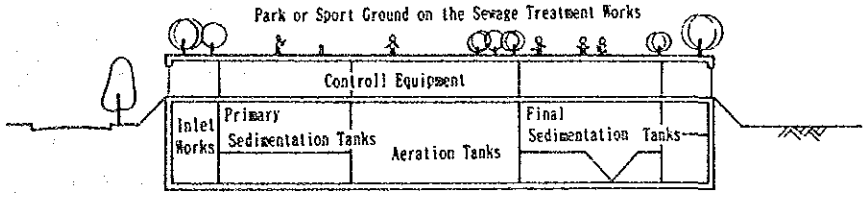
It should be emphasized that the development of an 'underground' sewage treatment works in the reclaimed land could overcome some problems in this area as shown below:

Such a development would be preferable, although, it should carry a cost premium in the area of Baht 110 million (a 30% up on total construction costs) and would require a considerable additional commitment to works operation and maintenance.

① free from the aesthetic objections to the plants;
② easy to equip a countermeasure to the smell problem;
③ valuable land usage of the roof ground of the superstructure.

a) Alternatives of the Underground Treatment Works Structure

Two alternatives of the underground treatment works structure shown below can be proposed in the reclaimed land.

Type	Section
Full Underground Type	
Half Underground Type	

The advantages and disadvantages of each type are presented in the following table.

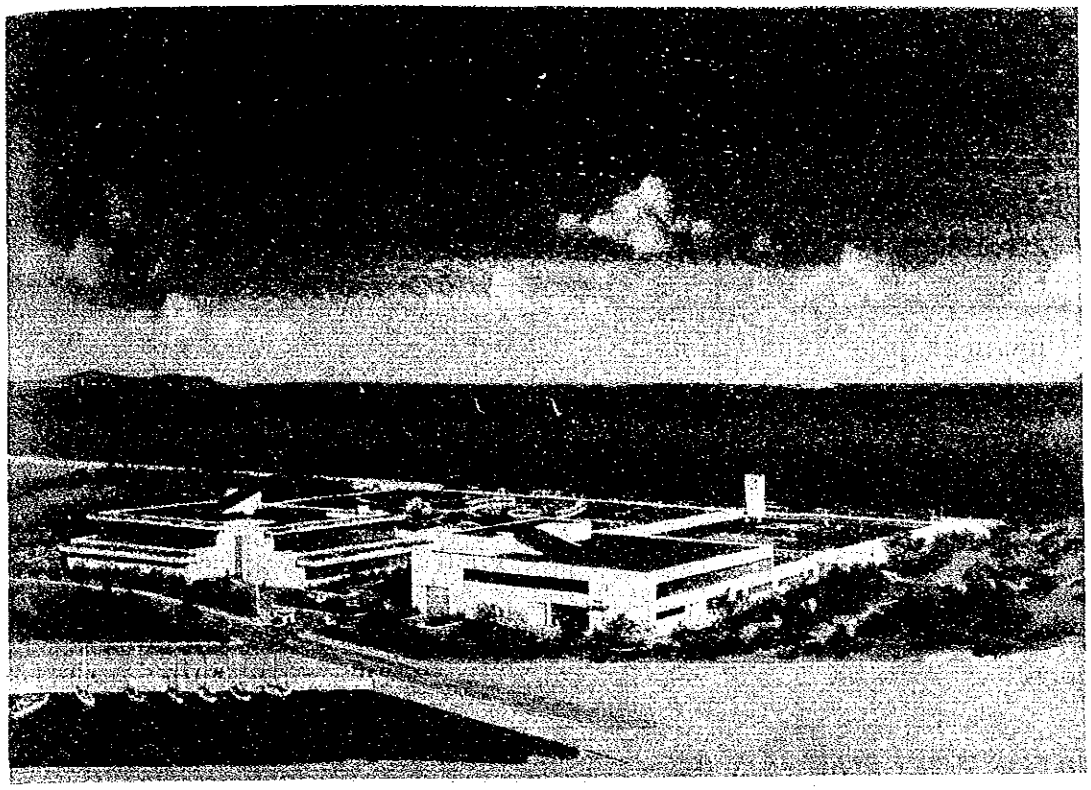
	Advantages	Disadvantages
Full Underground Type	• Perfect solution can be introduced for the aesthetic objections of the treatment works • Most valuable land usage of the roof ground can be realized.	• A thick structure is required to bear the strong earth pressure so that the construction cost raises higher than the normal ground type (a 50% up). • The sufficient air condition and lighting equipment which raise the maintenance cost are required.
Half Underground Type	• The construction cost is less than the full underground type (a 20-30% up on the normal ground type) • Maintenance cost is less than the full underground type because of less air condition and lighting equipment	• Some restriction is inevitable for the land use because the roof level is located 2-3 m higher than the ground level.

Detail study for the choice of alternatives should be made at feasibility study/detailed design stage.

b) Land Use Plan of the Roof Ground

According to the experience in Japan, the roof ground of the sewage treatment works can be utilized as the park, sport facilities (swimming pool, tennis court, etc.), car parking, building of hotel and conference room and so on.

The land use example of the roof of sewage treatment works in Japan is shown in the following figure.



Land Use of the Roof Ground of the Sewage Treatment Works

c) Countermeasure for Smell Problem

Following countermeasures could perfectly remove the unagreeable smell from the sewage treatment works.

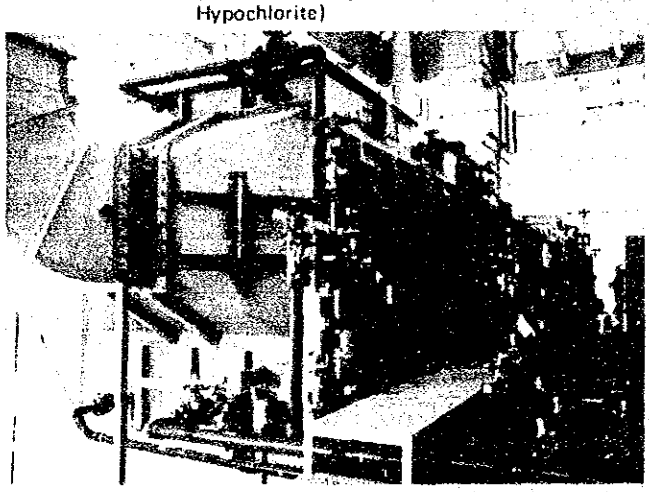
- Chemical flushing method
- Activated carbon method
- Chemical flushing + Activated carbon (Double stage method)

As the comparison among three methods shows in the following table, chemical flushing method is recommendable in Phatthaya mainly because of the maintenance aspect.

COMPARISON OF THE SMELL REMOVAL METHOD

	Construction Cost	Maintenance Cost	Engineering Difficulty	Reliability	Total Evaluation
① Activated carbon	○	△	△	○	△
② Chemical flushing	○	◎	○	○	◎
③ ①+②	△	○	○	◎	○

Legend: ◎ ... excellent ○ ... good △ ... possible



Chemical Flushing Method

The cost of the chemical flushing method is estimated as follows based on the Japanese experience.

- Construction Cost ... 3% of the total construction cost of the sewage treatment works
- Maintenance Cost ..... 1 - 5% of the total maintenance cost of the sewage treatment works

Remarks: In the case of 20,000 cum/day of average daily flow.

(6) Scheme Selection and Treatment Option Assessment

The following table gives a comparison of the leading cost parameters for each of the three schemes.

COMPARISON OF ALTERNATIVE SCHEME COSTS

Element	Cost in Baht (× 1000)			
	Oxidation Ditch	Activated Sludge	RBC Plant	Long sea outfall
Scheme A				
1. Land costs (5,200 B/m2)	239,200	182,000	150,800	93,600
2. Phase I construction costs	144,720	147,312	176,236	365,401
3 Construction costs (Ph. I + Ph. II)	238,983	237,925	261,322	434,306
4. Total Cost incl. Land Cost (Ph. I + Ph. II)	478,183	419,925	412,122	527,906
Scheme B				
1. Land costs (1,600 B/m2)	88,000	70,400	60,800	-
2. Phase I construction costs	180,765	183,357	212,281	-
3 Construction costs (Ph. I + Ph. II)	249,750	248,692	285,189	-
4. Total Cost incl. Land Cost (Ph. I + Ph. II)	337,750	319,092	345,989	-
Scheme C				
1. Land costs (850 B/m2)	46,750	37,400	32,300	22,950
(1,275 B/m2)	70,125	56,100	48,450	34,425
2. Phase I construction costs	161,374	156,130	183,054	364,461
3 Construction costs (Ph. I + Ph. II)	266,500	250,595	283,208	433,130
4. Total Cost incl. Land Cost (Ph. I + Ph. II)				
a) at 850 B/m^2	313,250	287,995	315,508	456,080
b) at 1,275 B/m^2	336,625	306,695	331,658	467,555
5 E.O. for "underground" construction	-	111,475	111,475	76,350

Among the treatment options, long sea outfall option is by far the most costly regardless the scheme. In the case of Scheme A, RBC plant option is the least costly while activated sludge option is the cheapest for Scheme B and Scheme C.

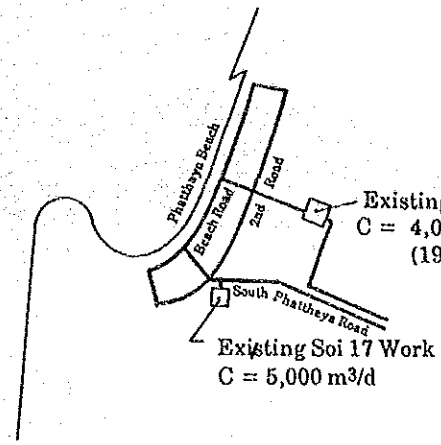
Comparing the three least cost options of the three schemes, Scheme C is the cheapest. Between Scheme B and Scheme C, the difference is rather small, i.e., 319.0 million bahts (Scheme B) vs 306.7 million bahts (Scheme C at 1,275 B/m^2 of of reclamation cost). Possibility of land acquisition is not certain in the case of Scheme B, however, while it is more certain in the case of reclamation at least for the limited-scale reclamation for the purpose of sewage treatment plant construction.

Considering these, it is proposed that Scheme C should be adopted. To solve the problem of unagreeable smell and aesthetic objection in the midst of the tourist and recreational area, it is further recommended to adopt underground type treatment plant. About 111 million bahts of extra cost would be incurred due to extra foundation cost and others. However, this would be more than justified, if the value of the land on the top of the underground treatment plant structure which is in the order of two billion bahts is taken into account.

(7) Alternative Development Scenario for Sewage Treatment Plant

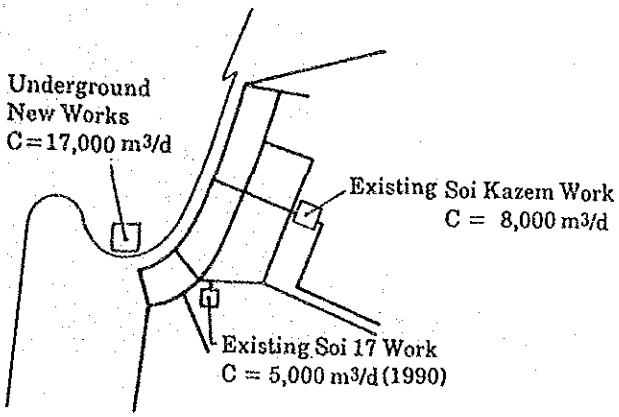
Instead of the development program for the treatment plant construction explained in the foregoing sections, the following alternative program can be conceived. Namely Soi Kazem Suwan would continue to be in operation beyond 2006. Advantage of this alternative is the reduction of investment cost while disadvantage is the loss of the benefit which would be accrued from the development of the Soi Kazem Suwan site for the purpose of commercial, residential or other uses after its abolition. Considering rather short service period of the Soi Kazem Suwan Treatment Plant after installation, extension of its service period beyond 2006 may be more recommendable.

1989



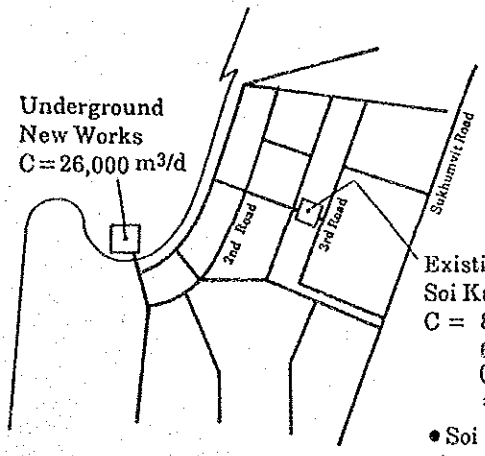
- Waste Water Demand
  12,000 m3/d
- Treatment Capacity
  8,000 + 5,000
  = 13,000 m3/d

1996
(Phase I)



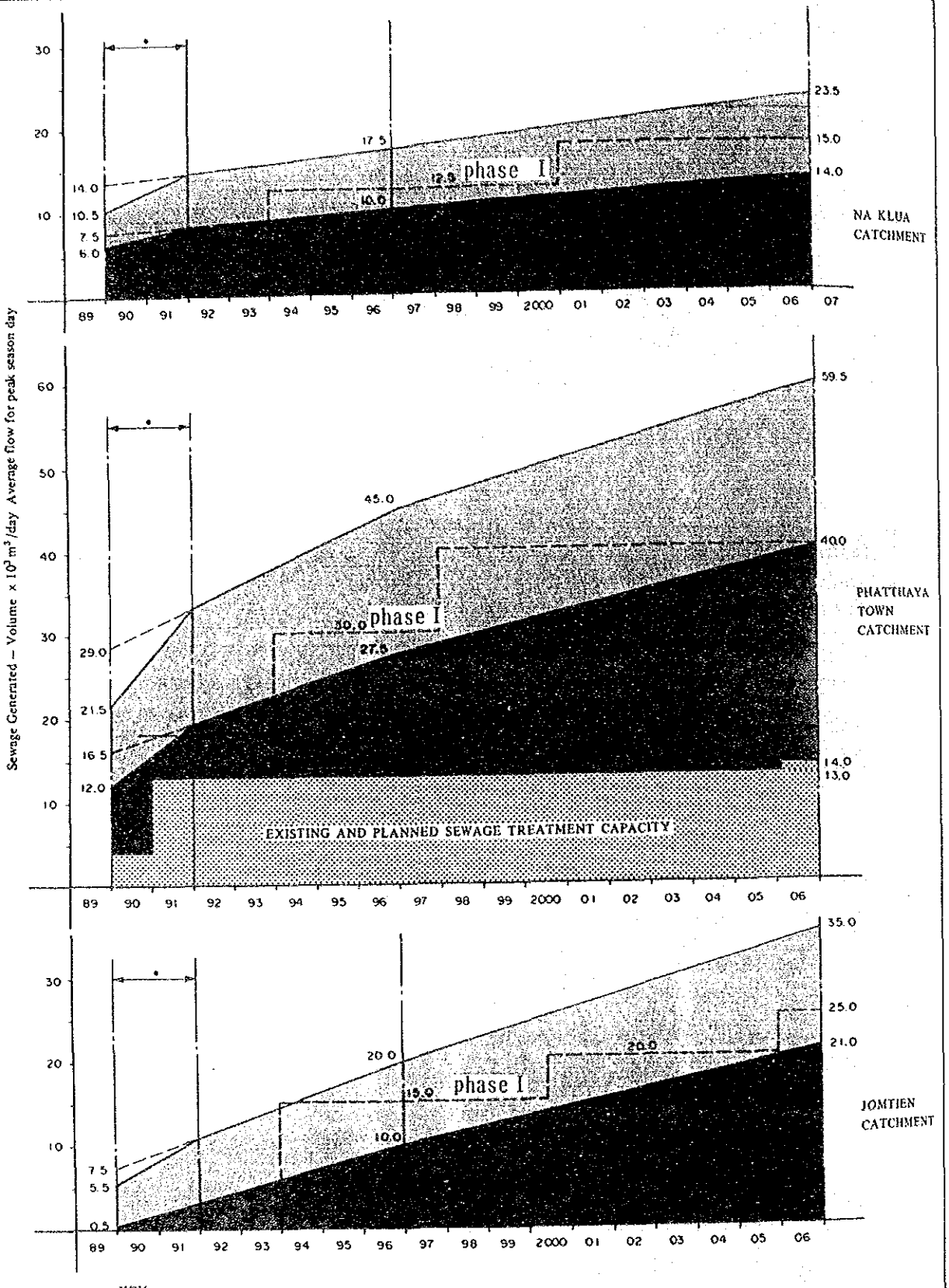
- Waste Water Demand
  27,500 m3/d
- Treatment Capacity
  8,000+5,000+17,000
  = 30,000 m3/d

2006
(Phase II)

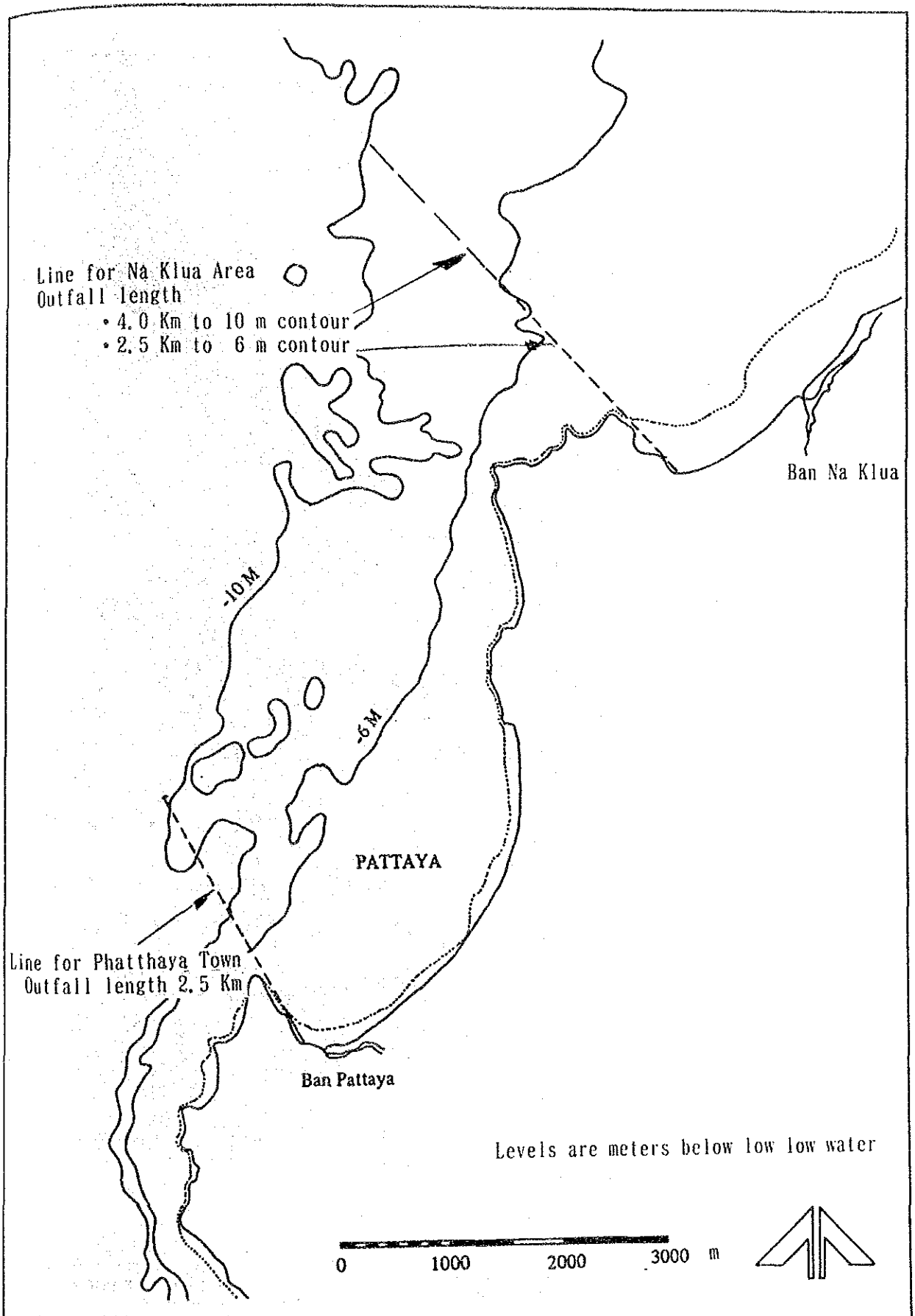


- Waste Water Demand
  40,000 m3/d
- Treatment Capacity
  14,000+26,000
  = 40,000 m3/d

Development Scenario of Sewage Treatment Works
(Phatthaya Town Area)

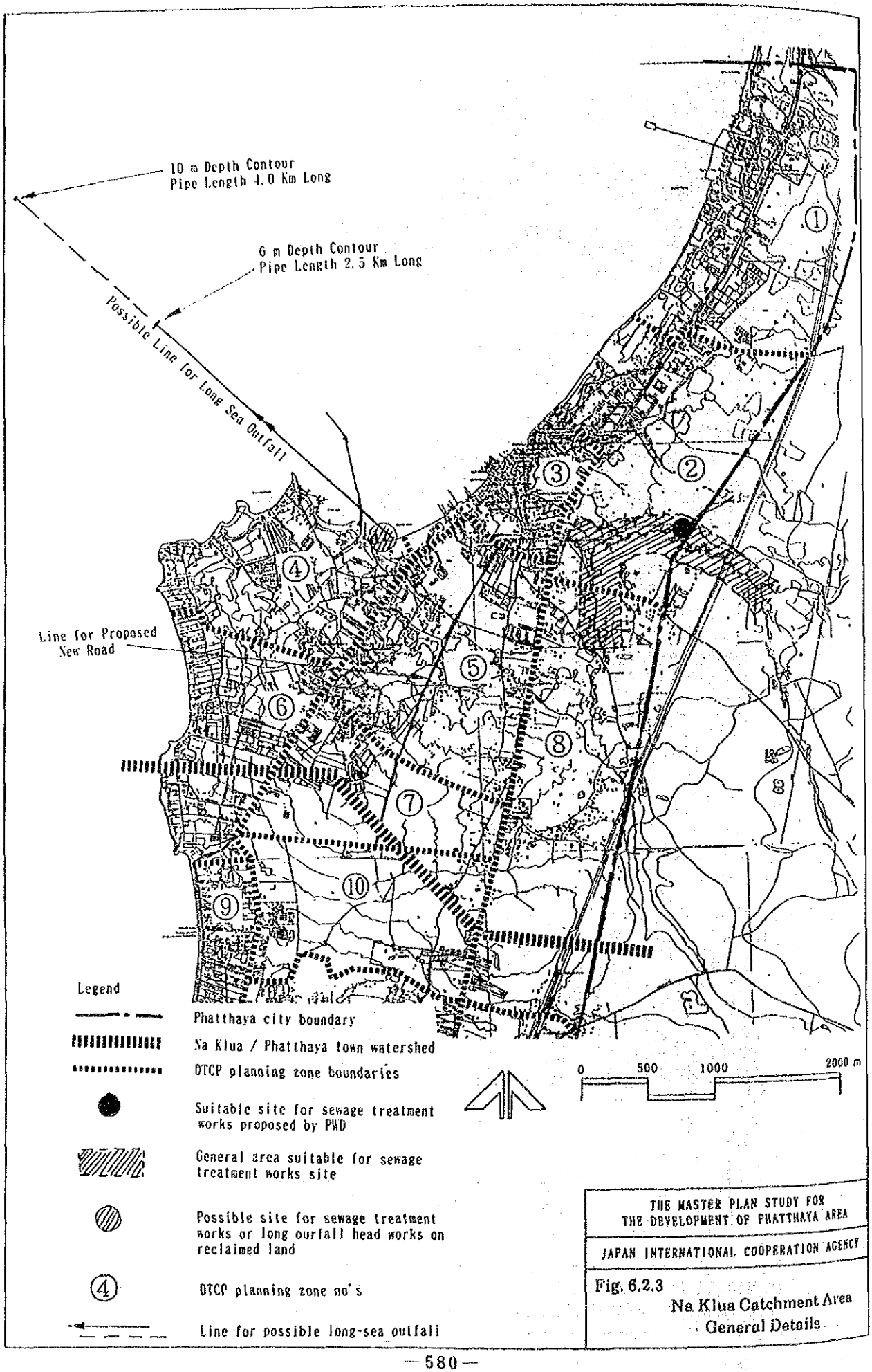


THE MASTER PLAN STUDY FOR THE DEVELOPMENT OF PHATTHAYA AREA	JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 6.2.1 Sewage Treatment Disposal Phased Development



THE MASTER PLAN STUDY FOR
THE DEVELOPMENT OF PHATTHAYA AREA

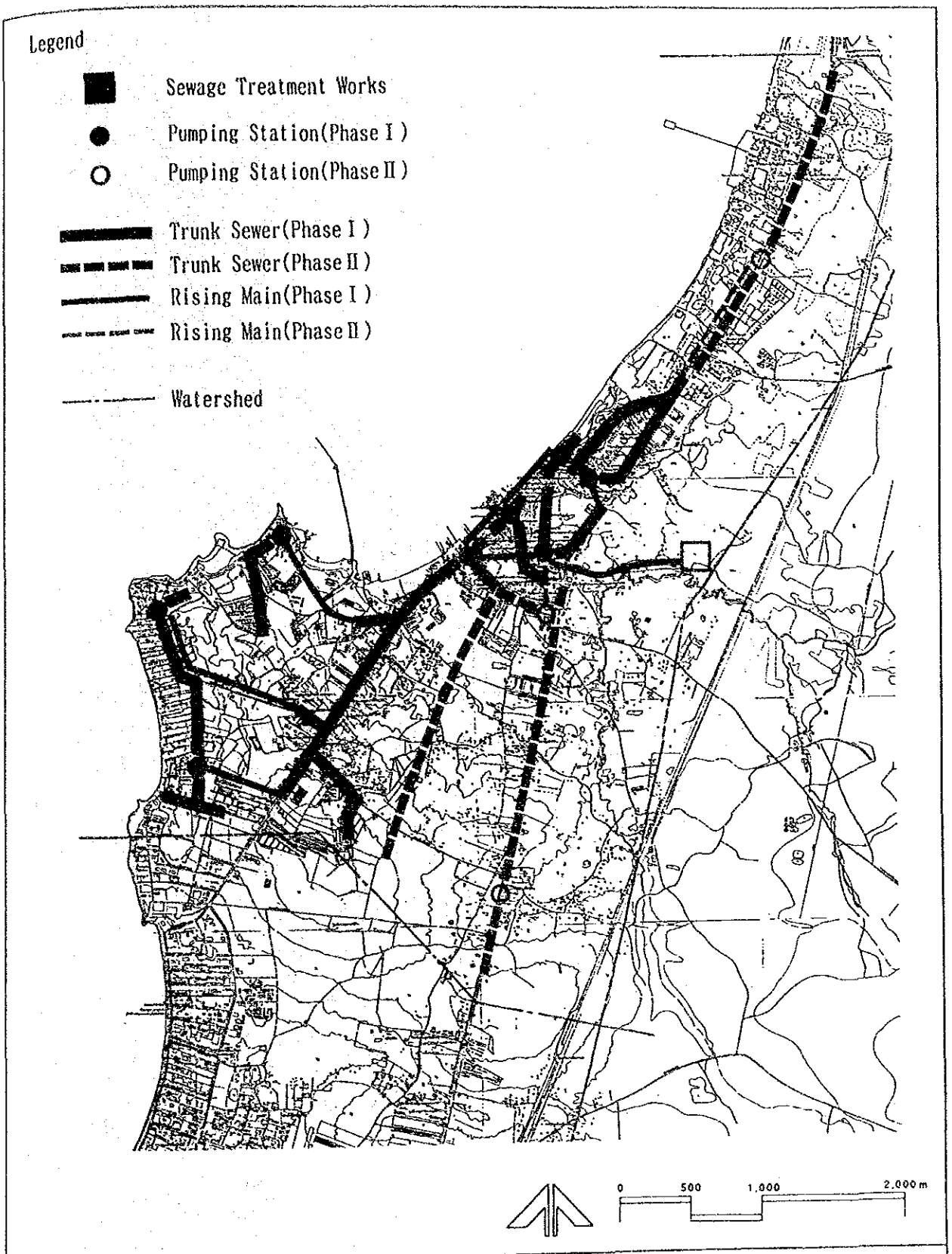
Fig. 6.2.2 Offshore Contours and Lines for Possible Outfall Pipes from Na Klua and Phatthaya Town



THE MASTER PLAN STUDY FOR THE DEVELOPMENT OF PHATTHAYA AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

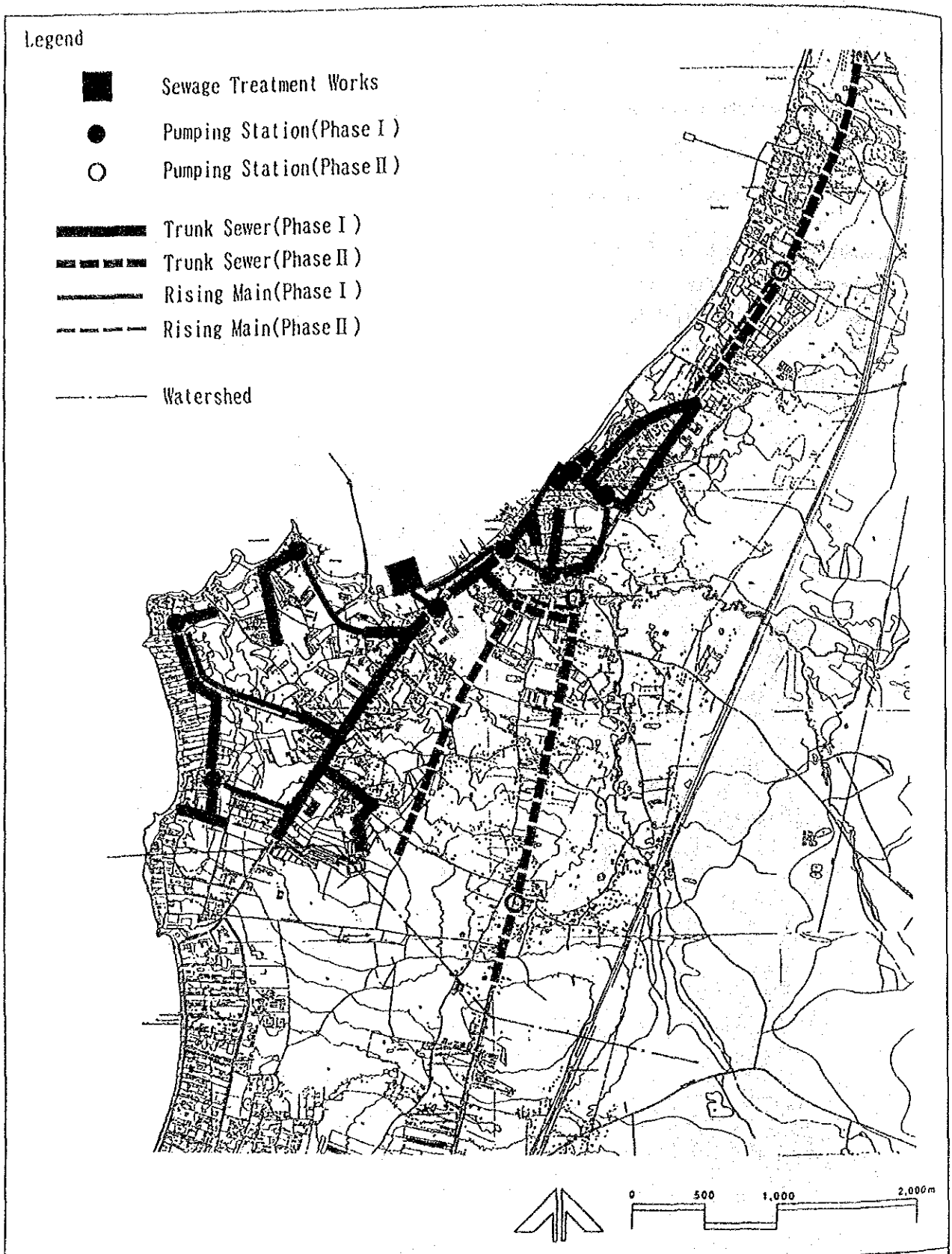
Fig. 6.2.3
Na Klua Catchment Area
General Details



THE MASTER PLAN STUDY FOR
THE DEVELOPMENT OF PHATTHAYA AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

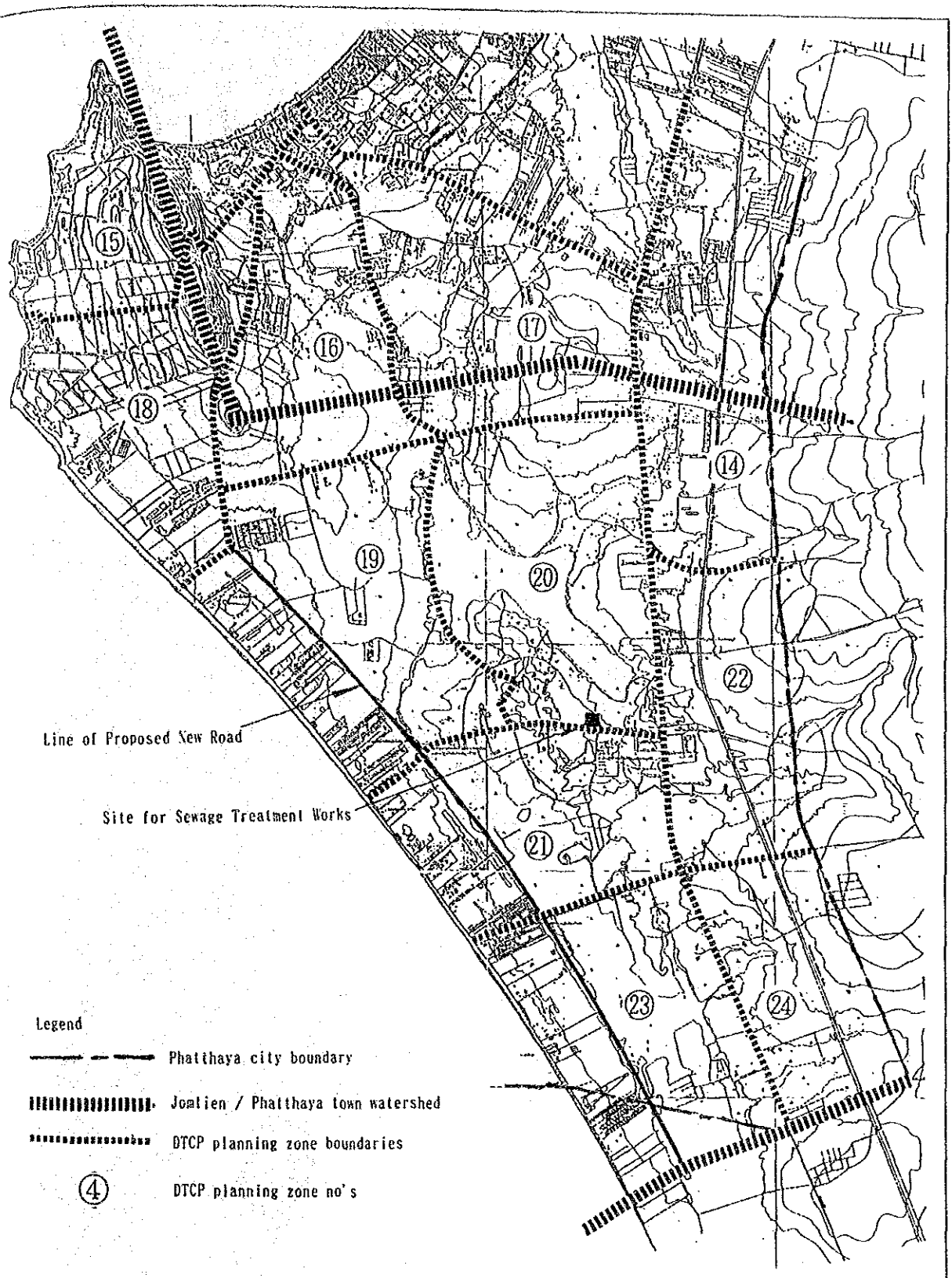
Fig.6.2.5 Na Klua Catchment Area Details for Scheme A



THE MASTER PLAN STUDY FOR
THE DEVELOPMENT OF PHATTHAYA AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

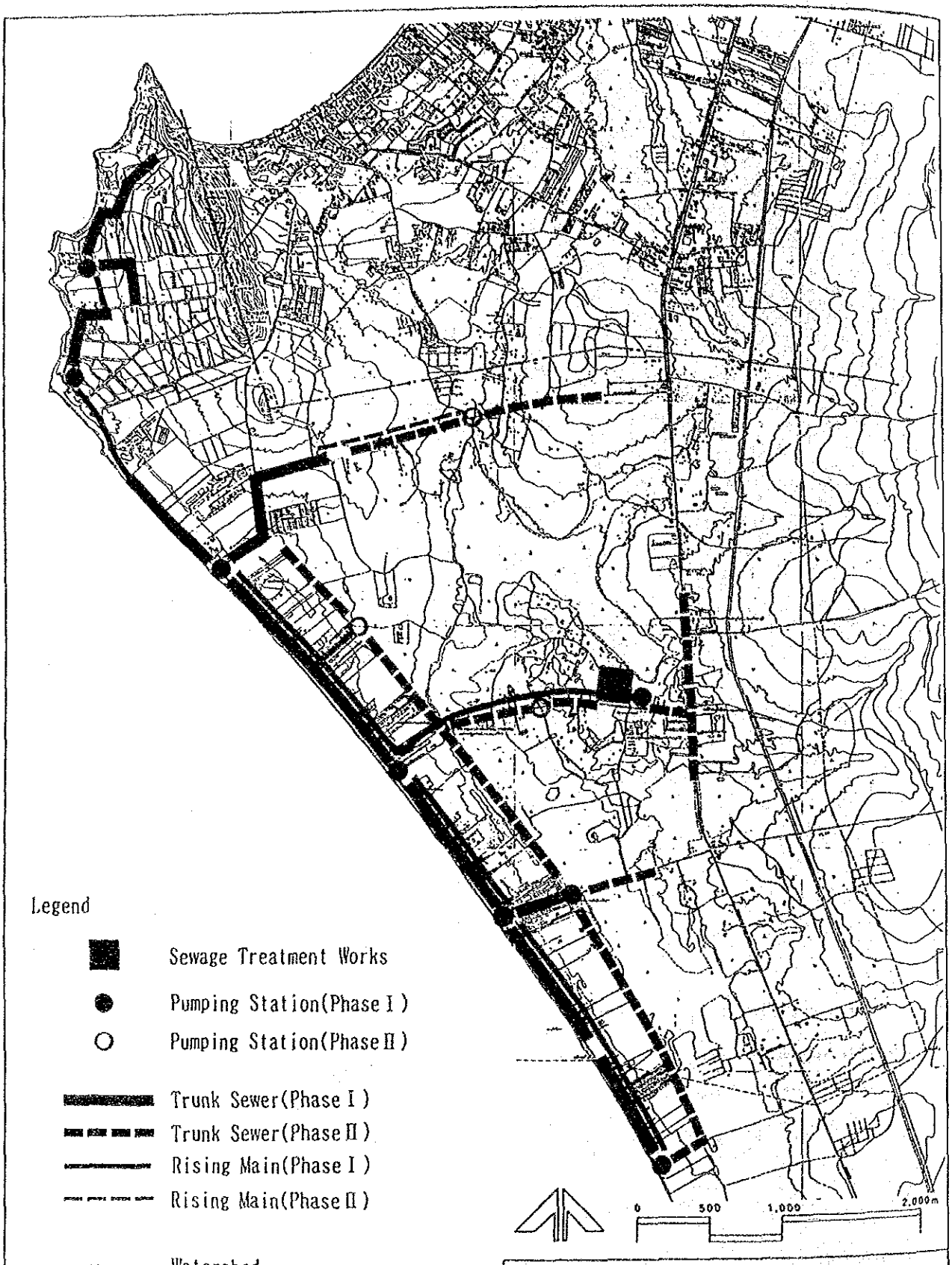
Fig. 6.2.4 Na Klua Catchment Area Details for Scheme B



THE MASTER PLAN STUDY FOR
THE DEVELOPMENT OF PHATTHAYA AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 6.2.6
Jomtien Catchment Area
General Details



THE MASTER PLAN STUDY FOR
THE DEVELOPMENT OF PHATTHAYA AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.6.2.7 Jomtien Catchment Area Project Details

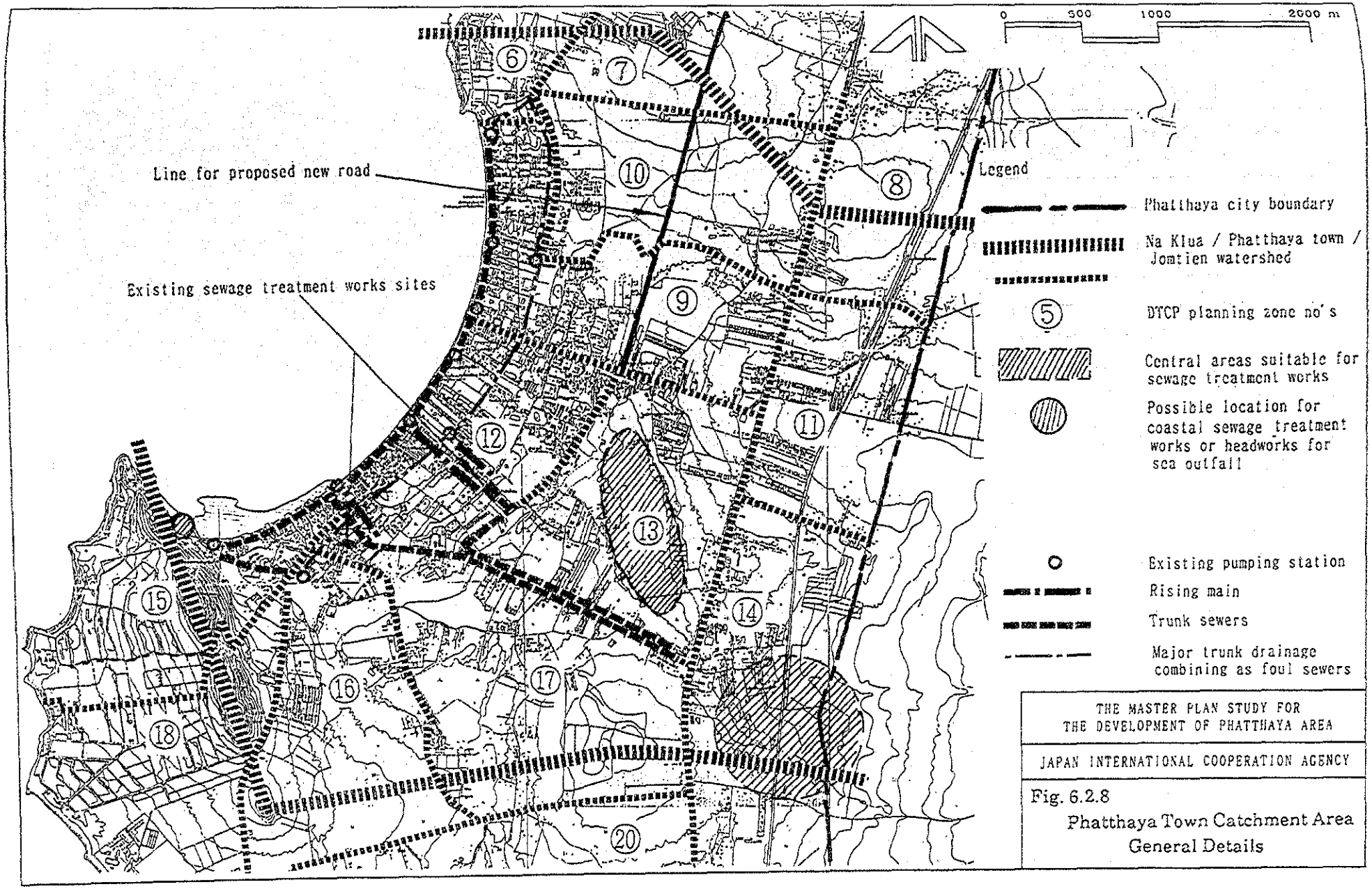


Fig. 6.2.8
Phatthaya Town Catchment Area General Details

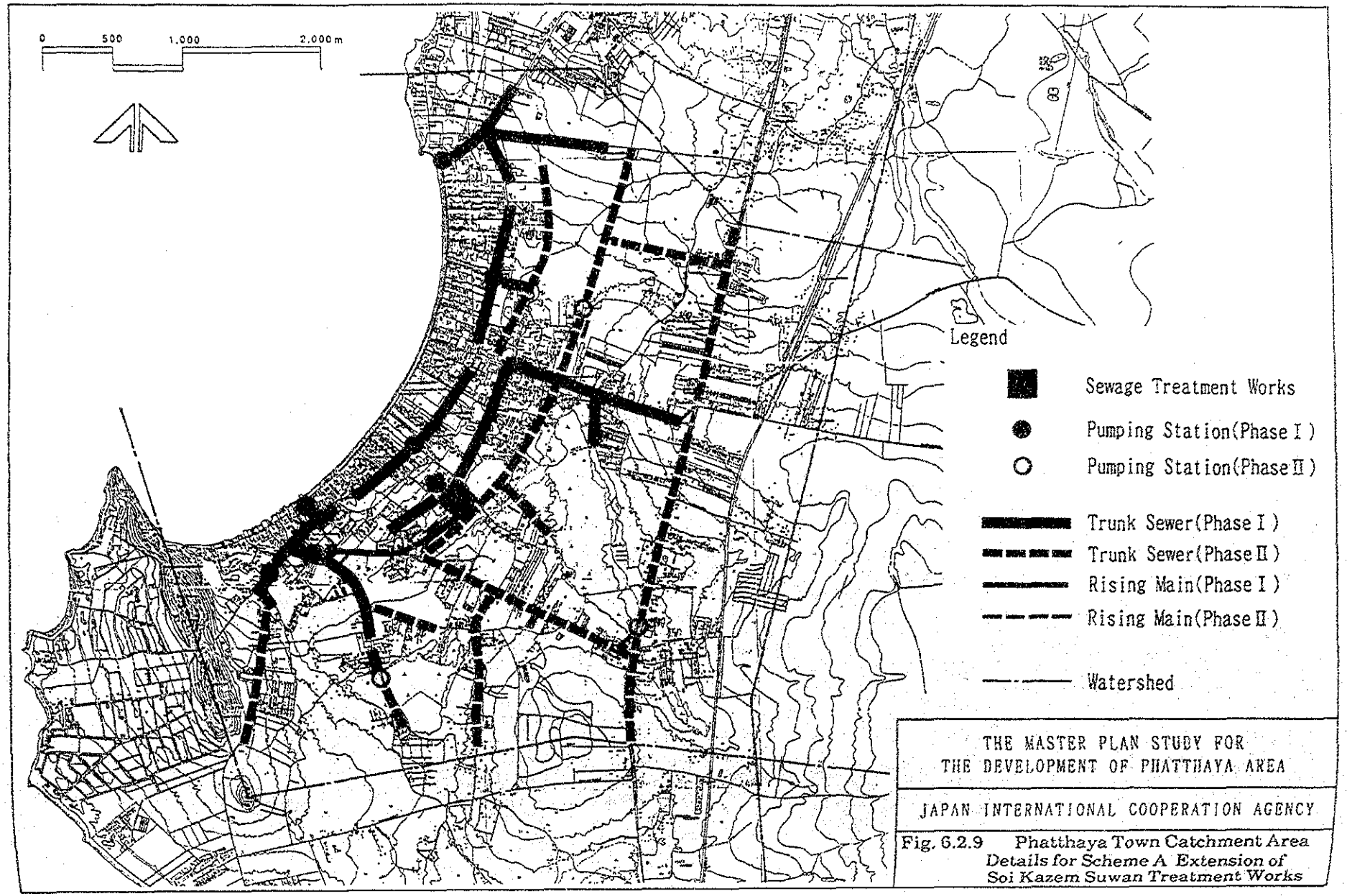


Fig. 6.2.9 Phatthaya Town Catchment Area
Details for Scheme A Extension of
Soi Kazem Suwan Treatment Works

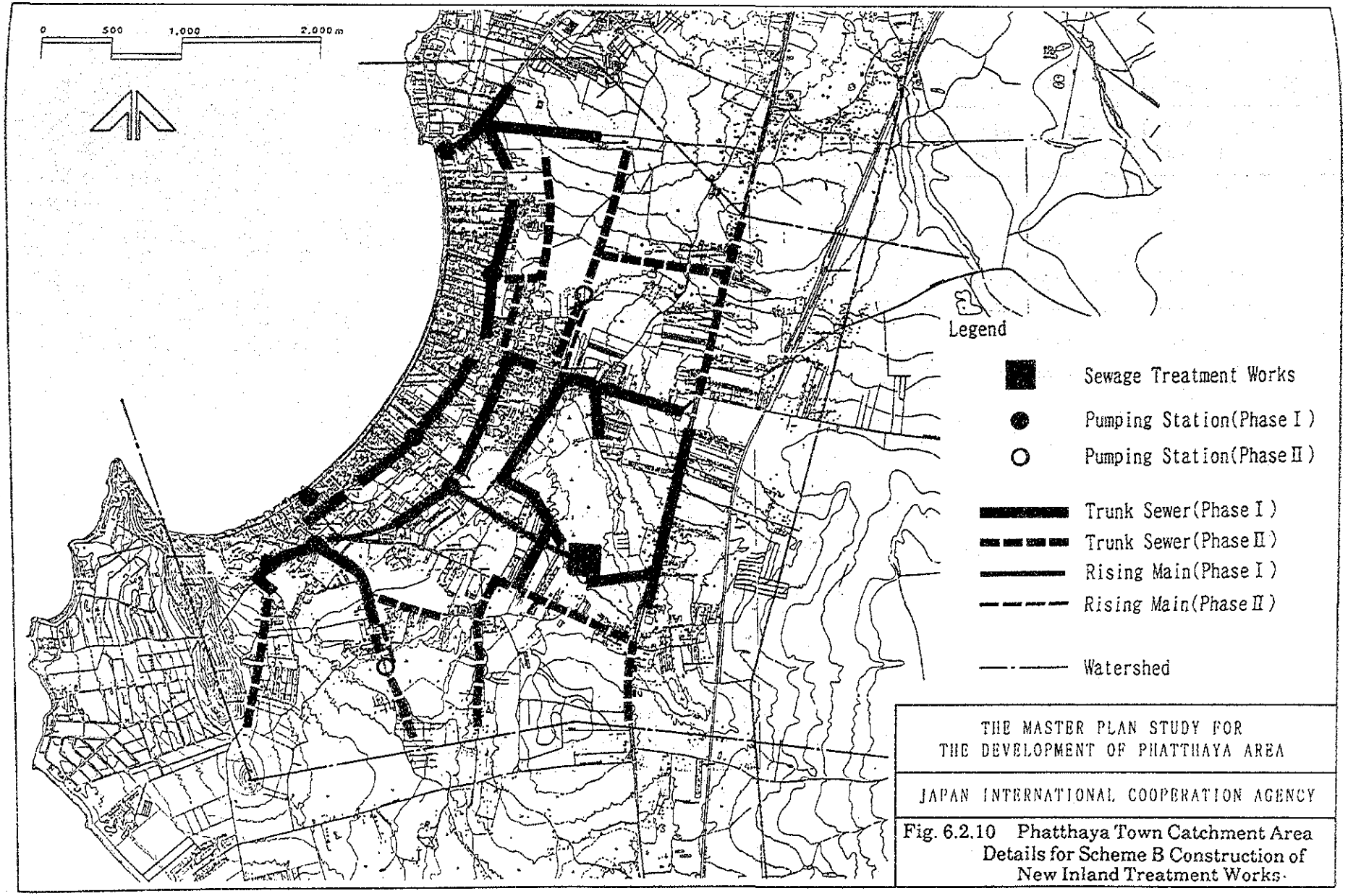


Fig. 6.2.10 Phatthaya Town Catchment Area Details for Scheme B Construction of New Inland Treatment Works.

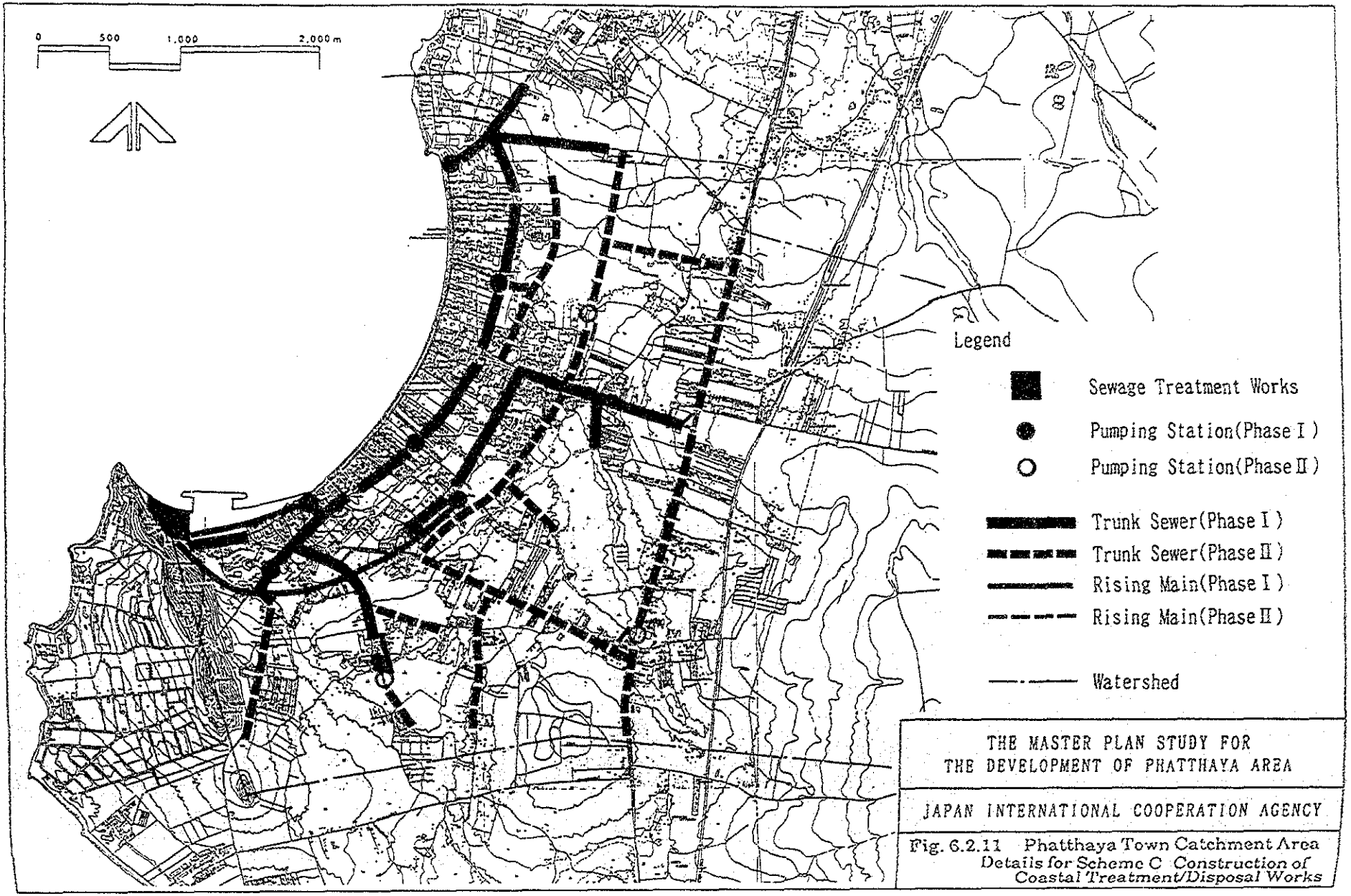
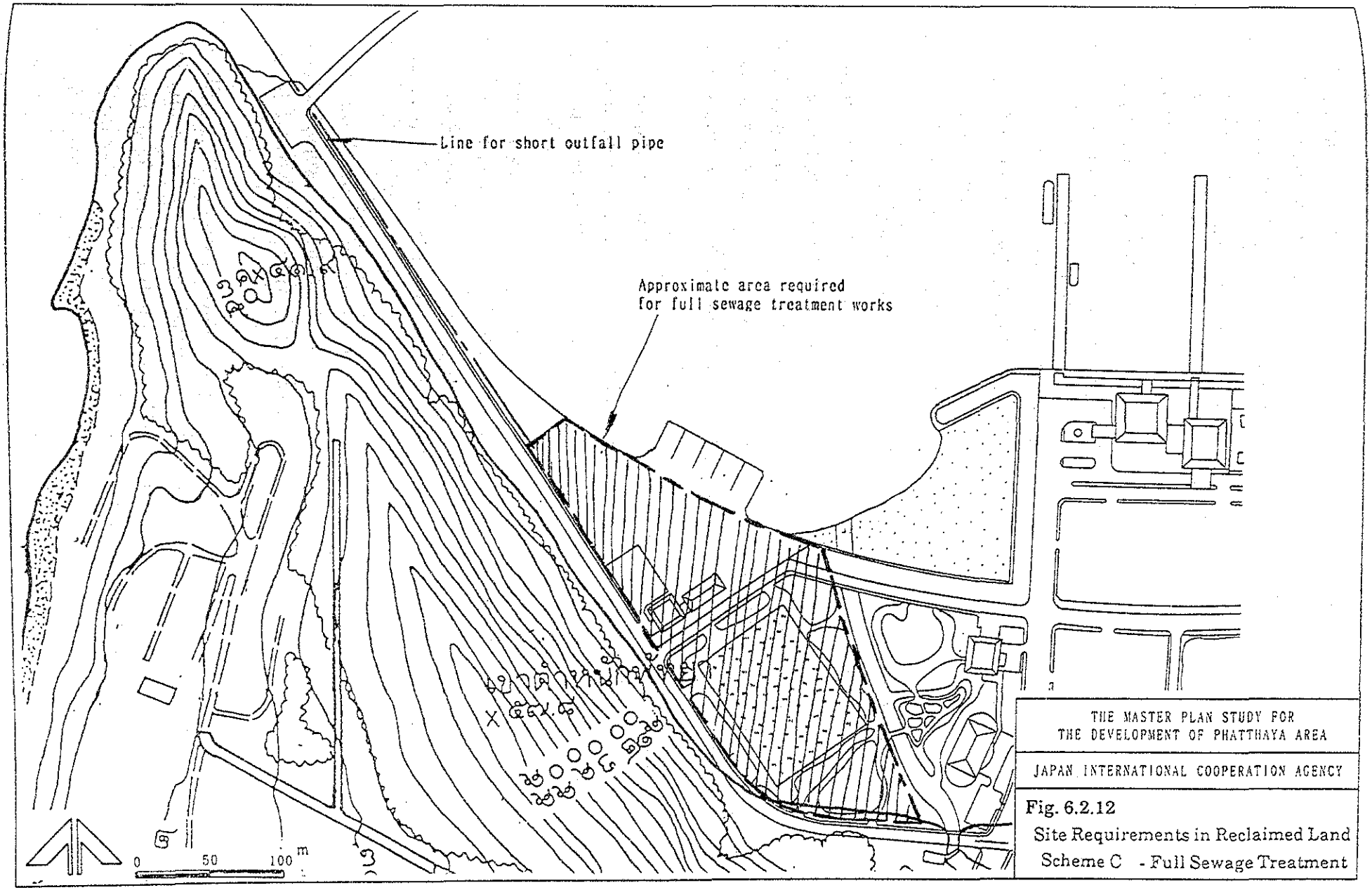


Fig. 6.2.11 Phatthaya Town Catchment Area Details for Scheme C Construction of Coastal Treatment/Disposal Works



THE MASTER PLAN STUDY FOR
THE DEVELOPMENT OF PHATTHAYA AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 6.2.12
Site Requirements in Reclaimed Land
Scheme C - Full Sewage Treatment

6.2.2 Rainwater Drainage

1) Selection of Priority Projects

Priority projects are selected from the following reasons.

[Priority Projects]

- Puk Plub Canal Improvement Project
- Phatthaya Town Box Culvert Construction Project
- Phatthaya Canal Improvement Project
- Jomtien Area Box Culvert Construction Project

① Puk Plub Canal is located lower place in South Na Klua area.
Downstream of this river which goes across Phatthaya - Na Klua road, high density residential area is distributing. Discharge capacity of the box culvert which was constructed under Phatthaya - Na Klua road is small and often causes inundation in lower area, upstream of this box culvert. This lower area has been developed recently and it seems that flood area will extend the existing developed area around.
Therefore, urgent improvement of Puk Plub Canal will be required in order to get safer against flood in the existing developed area and to create safety zone so that development in lower area can be possible in the near future.

② Behind the developed area in Phatthaya town, the lower area is distributing and had a function of retarding in the rainy season. However, rapid development and reclamation in the lower area disturbs this retarding function.
Development in this lower area will cause large flood damage in accordance with extinction of inundation and increment of properties. On the other hand, construction of rainwater drainage facilities is not sufficient.
Countermeasures for rainwater drainage under rational plan will be urgently required to construct sufficient infrastructure so that protecting many function of Phatthaya city and resort facilities from flood damage concentrates in this project area.

③ Phatthaya canal is the only river which flows in the main part of Phatthaya town downstream of this river, South Phatthaya Area where is the most density developed are in Phatthaya town. Development and reclamation in the lower area which extends upstream of Phatthaya canal, will bring serious flood problem to the existing developed area located downstream.
On account of insufficient discharge capacity in Phatthaya canal, urgent improvement will be required.

④ Jomtien area is located in the southern part of Phatthaya City. Rainwater in this area is once ponding in the lower area extending behind Jomtien beach, and flows to Huay Yai river gradually. Development area in Jomtien is mainly along beach at present, and started to expand into the lower area by reclaiming the land.

Considering the insufficiency of rainwater facilities, urgent construction of rainwater drainage facilities will be required urgently for protecting Jomtien area from flood damage.

Location of the selected priority projects area are shown in Fig. 6.2.13.

2) Description of Priority Projects

(1) Puk Plub Canal Improvement Project

① Objectives of the project
Objective of this project is to raise safety degree against flood in Puk Plup catchment area by carrying out improvement of this river to get sufficient discharge capacity.

② Project description
River improvement more than 400m will be carried out in this project from river mouse to lower area which extends behind Phatthaya - Na Klua road. Open channel system will be applied basically, however box culvert will be constructed under Phatthaya - Na Klua road.

Dimensions and calculation conditions are summarized in Table 6.2.1 and general plan is shown in Fig. 6.2.14.

Rainwater drainage facilities in this project are planned on the basis of the following matters.

- Channel alignment is planned along existing river basically.
- Channel profile is designed taking account of present channel bed level. Proposed high water level is designed not to exceed present ground height taking into consideration of ground level and sea water level.
- Open channel system is applied main parts in this project, However box culvert will be constructed under the Phatthaya - Na Klua road and adjoining residential area.
- Improvement will be done from river mouse to lower area extending behind residential area.
- The structures which are illegally made downstream of Puk Plub river in the present will be removed.

③ Expected effects

Effects of this project will be expected as follows ;

- To raise safety degree against flood in the developed area by preventing flood damage.
- Development of lower area which extends behind residential area will be possible by solution of flood problem.
- Living condition will keep stability in accordance with protecting Phatthaya - Na Klua road from flood, which is indispensable in this area and around area.

(2) Phatthaya Town Box Culvert Construction Project

① Objectives of the project

Objectives of this project is to protect the developed town area and developing area by constructing a main box culvert under the present road in the lower area upstream to the sea.

② Project description

In this project, the main box culvert will be constructed under the present road located in the lower area behind the developed area to drain rainwater from upstream area. The reasons why box culvert under the existing road is planned in this project are as follows ;

- At present, a main open channel does not exist in this project area.
- Difficulty of land acquisition to construct new open channel on account of high density in land use.

Project area covers Phatthaya town area widely as shown in Fig - However the area along Phatthaya beach and the northern part of the town are excluded in this project area on account of the following reasons ;

- Drainage facilities were already constructed in the area along Phatthaya beach already.
- Ground level and gradient in the northern part of town is comparatively higher than the vicinity area and drainage facilities were already constructed along downstream of North Phatthaya road in order to drain rainwater in this area to the sea. Rainwater in this northern area should be drained along North Phatthaya road.

Proposed box - culvert construction plan is shown in Table 6.2.2 - and Fig. 6.2.15.

Dimensions of box culvert was planned on the basis of the following matters ;

- Box culvert is planned as a main drainage facility in this area on account of difficulty of land acquisition to construct open channel.
- Location of box culvert is decided in the lower area which extends over developed area in order to catch rainwater from upstream area.
  To drain rainwater directly to the sea, box culvert is also planned under the South Phatthaya road.

- Proposed high water level is designed taking into account of present road level, sea water level and overborder of box culvert.
- Runoff coefficient of 0.3 is applied to calculate design peak discharge taking into consideration of present land use and construction possibility of box culvert under the existing road.
  In case of more developed condition in the future, another box culvert which will be designed applying 0.5 of runoff coefficient for design peak discharge, should be constructed under the Central Phatthaya road in order to drain half part of this project area approximately.
  If this new box culvert is constructed, the box culvert planned in this project will have same capacity as applied 0.5 of runoff coefficient by reduction of half project area.
- Upstream area of Sukhumvit road will consider as an indirect area on account of disturbance of rainwater flowing by reclamation of Sukhumvit road and railway. Present land use condition in this area is covered with grass mainly and same land use condition will be presumed to continue in the future.
  To apply same runoff coefficient which applied in the direct area will cause excessive calculation result of design peak discharge in the indirect area. Therefore, runoff coefficient of 0.1 is applied in this indirect area.

③ Expected effects

Expected effects which will be brought by this project are considered as follows ;

- To raise safety degree against flood in the developed area which extends along Phatthaya beach.
- To protect the exiting flood prone area from flood damage.
- Development in the present flood prone area will become possible by solution of flood problem in the lower area which extends behind the existing residential area.

(3) Phatthaya Canal Improvement Project

① Object of the project

Objective of this project is to raise safety degree against flood and to reduce flood damage in Phatthaya canal catchment area by carrying out improvement of the existing river to keep sufficient discharge capacity.

② Project description

In this project, improvement of Phatthaya canal which is the only main open channel in Phatthaya area to drain rainwater in the southern part of Phatthaya area will be carried out more than 1,000m from river mouth to the lower which extends upstream of Phatthaya canal.

Proposed river improvement plan is shown in Table 6.2.3 and Fig. 6.2.16.

Improvement of Phatthaya canal is planned on the basis of the following matters :

- Channel alignment is planned along the existing river as much as possible in order to minimize the land acquisition in the project.
- In order to increase discharge capacity, excavation of the river bed should be carried out.
- Proposed high water level is designed not to exceed the present ground level taking into consideration of the ground level and sea water level.
- Open channel system is adopted.
- Improvement will be done from the river mouse to the lower area extending upstream of Phatthaya canal.

③ Expected effects

Effects of this project will be expected as follows ;

- To raise safety degree against flood in the developed area by preventing flood damage.
- Development in the present flood prone area will be possible by solution of flood problem in the lower area which extends behind residential area
- To create open space in the south Phatthaya area by aesthetic aspect on river.

(4) Jomtien Area Box Culvert Construction Project

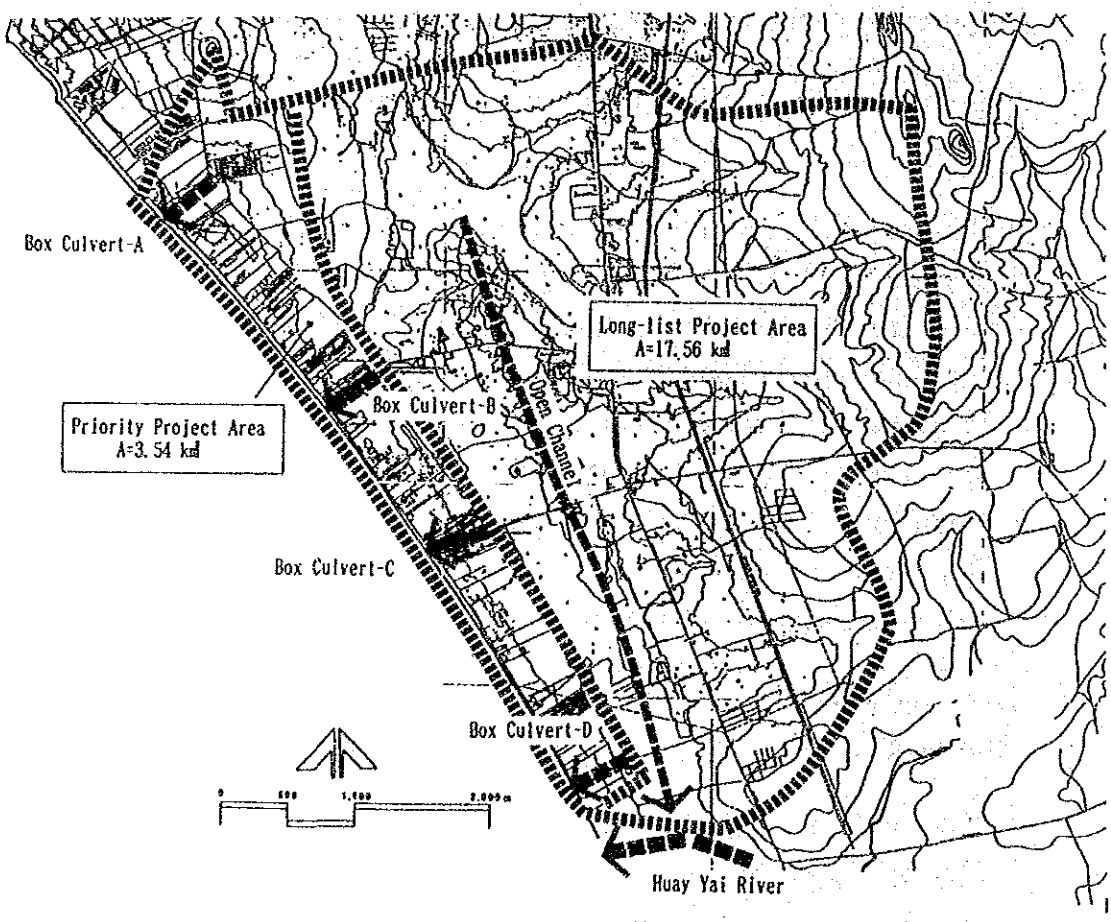
① Objectives of the project

Objectives of the project is to protect the developed beach area and developing area by constructing box culverts under the existing road.

② Project area

Rainwater drainage project will be planned in the development area of Jomtien area but the undeveloped area will be excluded from the objective area of the priority project.

Drainage project area and basic drainage systems of priority project and long-list project are shown in bellow.



Box culvert system are planned as a priority project and open channel system along planned Jomtien 3 road will be proposed as a long-list project.

Aesthetic aspect of box culverts' outlets and protection of beach sand from erosion should be duly considered.

③ Project description

In this project, the main box culverts will be constructed under the existing roads to drain rainwater from upstream area to the sea. The reasons why box culverts under the existing roads are planned in this project area are shown as follows:

° At present, a main rainwater drainage facilities do not exist in this area

° Difficulty of land acquisition to construct new open channel due to private land use.

Proposed box culverts construction plan is shown in Table 6.2.4 and Fig. 6.2.17. Dimensions of box culverts was planned on the basis of the following matters;

° Box culverts are planned as a main drainage facility in this area on account of difficulty of land acquisition to construct open channel.

° Box culverts will be constructed originating from the lower area extending behind Jomtien in order to catch rainwater from upstream area.

° Proposed high water level is designed taking into account present road level, sea water level and overburden of box culvert.

④ Expected effects

Expected effects which will be brought by this project are as follows:

° To raise safety degree against rainwater in the developed area which extends along Jomtien beach.

° Development in the Jomtien beach area and its vicinity will become possible by solving flood problem in the lower area which extends behind the existing residential area.

Table 6.2.1 PUK PLUB CANAL IMPROVEMENT PROJECT

	Item	Content
Dimension	a. Project Name	Puk Plub Canal Improvement
	b. Upstream	Lower area behind Phatthaya - Na Klua road
	c. Downstream	River mouse (sea)
	d. Length	450m
	e. Drainage Facilities	Open channel (400m), Box culvert (50m)
	f. Channel bed gradient	1/500
Conditions	g. Calculation Method	Rational method
	h. Catchment Area	2.6km^2
	i. Return Period	5 years
	j. Rainfall Intensity Curve	6000/ (t+35) mm/hr
	k. Runoff Coefficient	0.5
	l. Time of Concentration	60 min
	m. Roughness coefficient	0.015
	n. Design Discharge	25 m^3/s

Table 6.2.2 PHATTHAYA TOWN BOX CULVERT PROJECT

	Item	Content
Dimensions	a. Project Name	Phatthaya Town Box Culvert Construction Project
	b. Upstream	Lower area behind Phatthaya 2 road
	c. Downstream	River mouse (sea)
	d. Length	3150m
	e. Drainage Facilities	Box culvert under South Phatthaya road (1000m) Box culvert under exiting road located behind Phatthaya 2 road (2150m)
	f. Channel bed gradient	1/1000
Conditions	g. Calculation Method	Rational method
	h. Catchment Area	14.17km^2 (Direct area 7.60km^2 Indirect area 6.57 km^2)
	i. Return Period	5 years
	j. Rainfall Intensity Curve	6000/ (t+35) mm/hr
	k. Runoff Coefficient	0.3 (Direct area) 0.1 (Indirect area)
	l. Time of Concentration	200 min
	m. Roughness coefficient	0.015
	n. Design Discharge	22 m^3/s

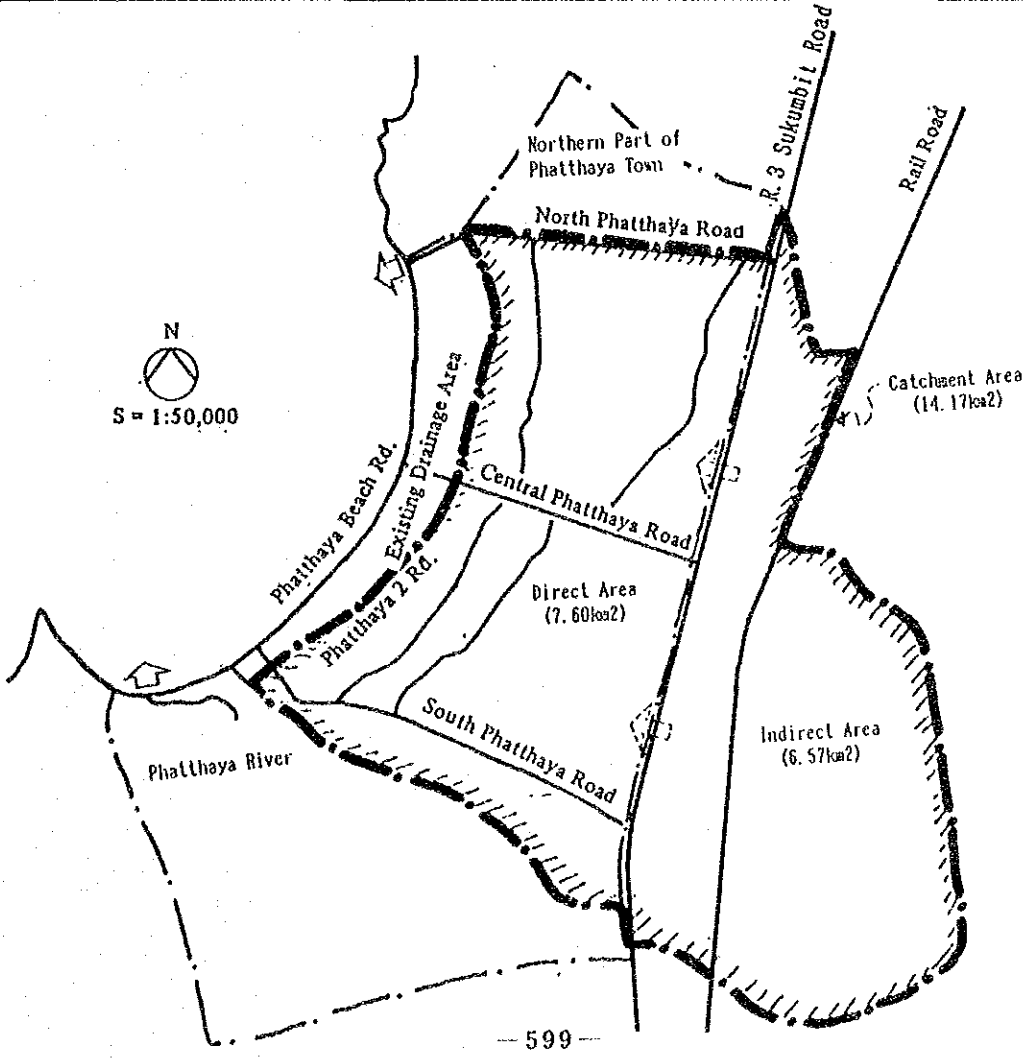
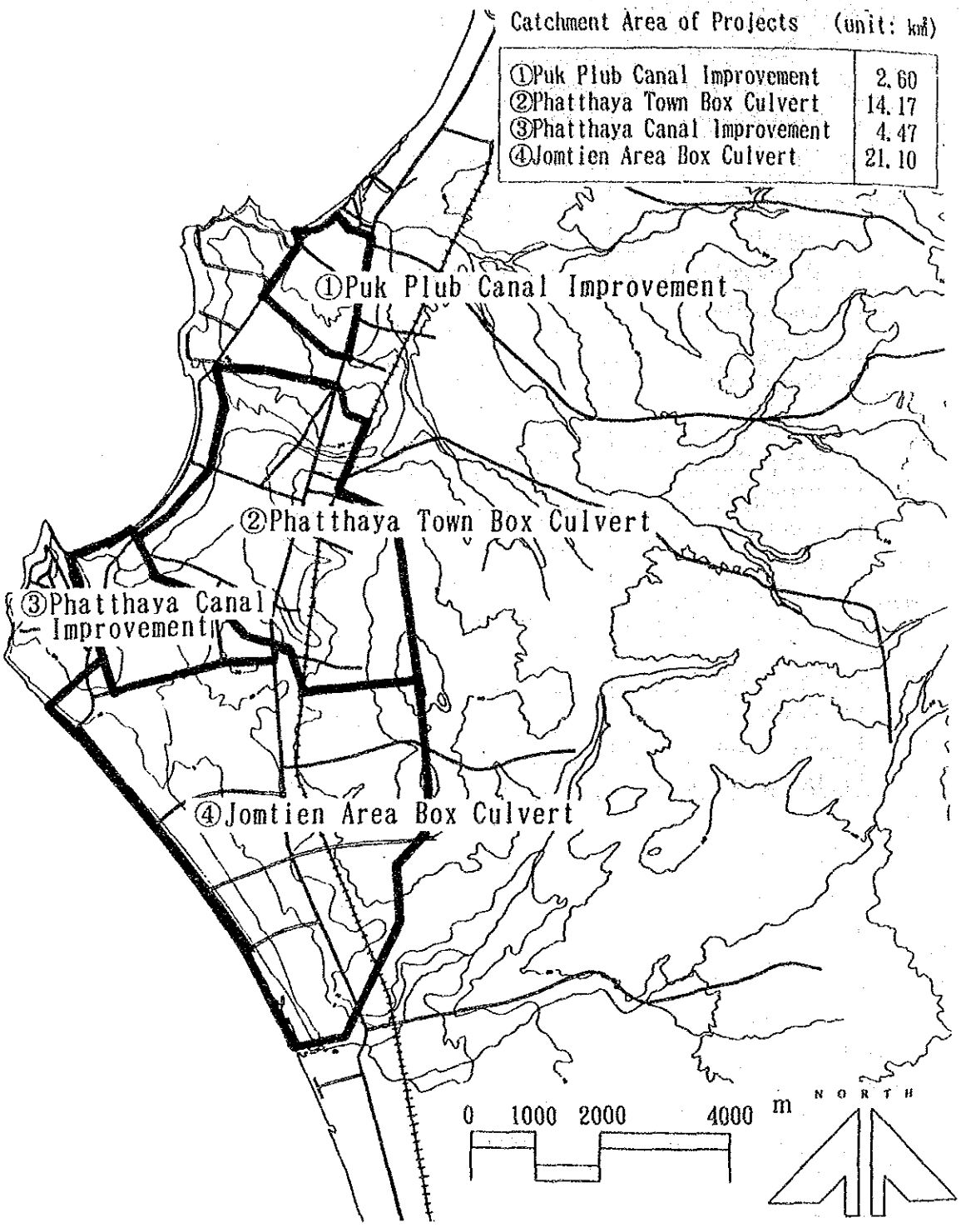


Table 6.2.3 PHATTHAYA CANAL IMPROVEMENT PROJECT

	Item	Content
Dimensions	a. Project Name	Phatthaya Canal Improvement Project
	b. Upstream	Lower area Phatthaya 2 road
	c. Downstream	River mouse (sea)
	d. Length	1150m
	e. Drainage Facilities	Open channel (1150m)
	f. Channel bed gradient	1/700
Conditions	g. Calculation Method	Rational method
	h. Catchment Area	4.47km^2
	i. Return Period	5 years
	j. Rainfall Intensit Curve	6000/ (t+35) mm/hr
	k. Runoff Coefficient	0.5
	l. Time of Concentration	125 min
	m. Roughness coefficient	0.015
	n. Design Discharge	24 m^3/s

Table 6.2.4 JOMTIEN AREA BOX CULVERT CONSTRUCTION PROJECT

Item		Content			
		Box Culvert-A	Box Culvert-B	Box Culvert-C	Box Culvert-D
Dimensions	a. Project Name	Jomtien Area Box Culvert Construction Project			
	b. Upstream	Behind Jomtien Beach			
	c. Downstream	Jomtien Beach			
	d. Length	400 m	500 m	500 m	350 m
	e. Drainage Facilities	Box Culverts under Existing Roads			
	f. Channel bed gradient	1/150	1/200	1/200	1/150
Conditions	g. Calculation Method	Rational method			
	h. Catchment Area	1.14 km^2	1.21 km^2	0.79 km^2	0.40 km^2
	i. Return Period	5 years			
	j. Rainfall Intensity Curve	6000/ (t + 35) mm/hr			
	k. Runoff Coefficient	0.5			
	l. Time of Concentration	50 min	65 min	60 min	50 min
	m.Roughness Coefficient	0.015	0.015	0.015	0.015
	n. Design Discharge	11 m^3/s	10 m^3/s	7 m^3/s	4 m^3/s

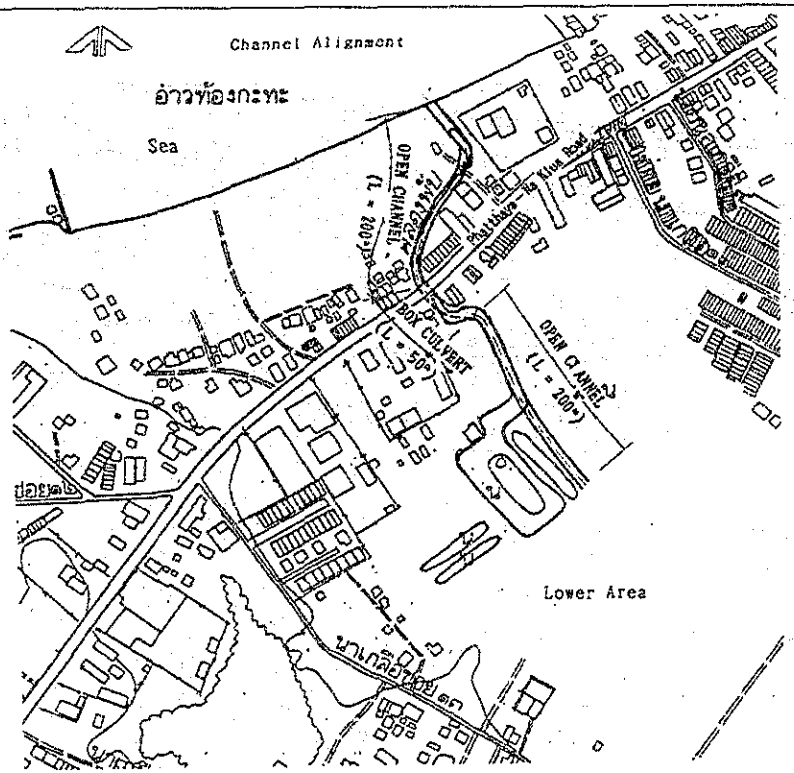


LEGEND

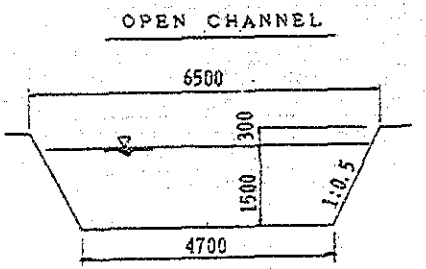
THE MASTER PLAN STUDY FOR
THE DEVELOPMENT OF PHATTHAYA AREA

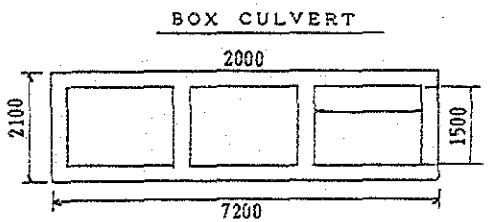
JAPAN INTERNATIONAL COOPERATION AGENCY

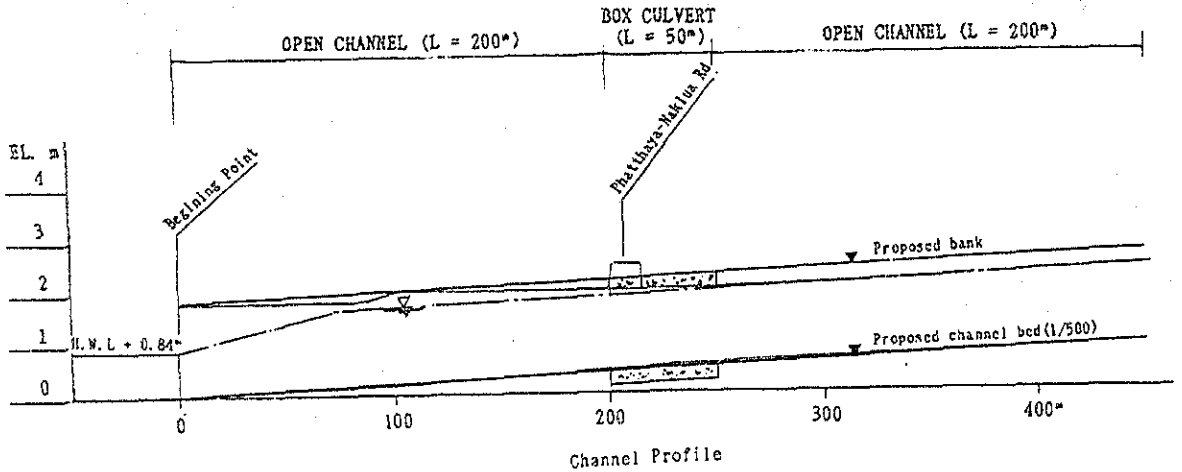
Fig. 6.2.13 Priority Project Area (Rainwater Drainage)



Cross Section







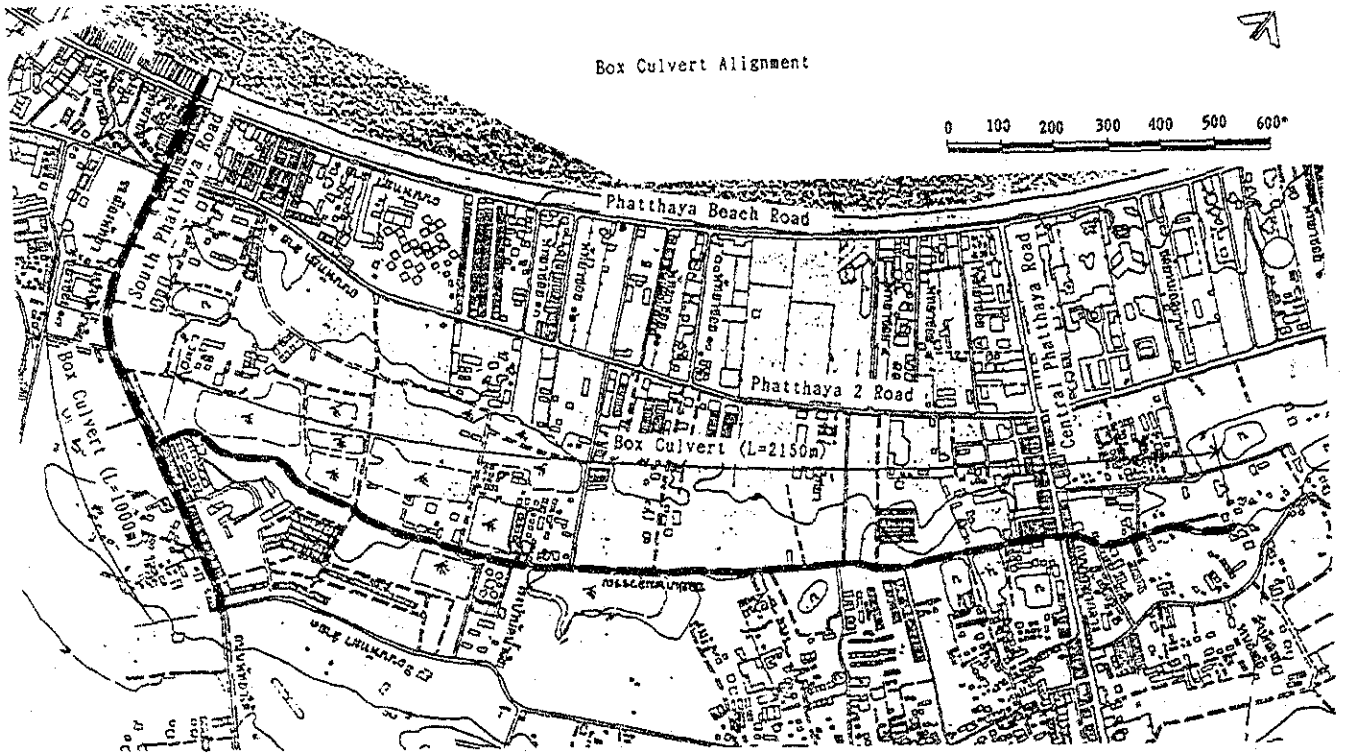
Channel Profile

LEGEND

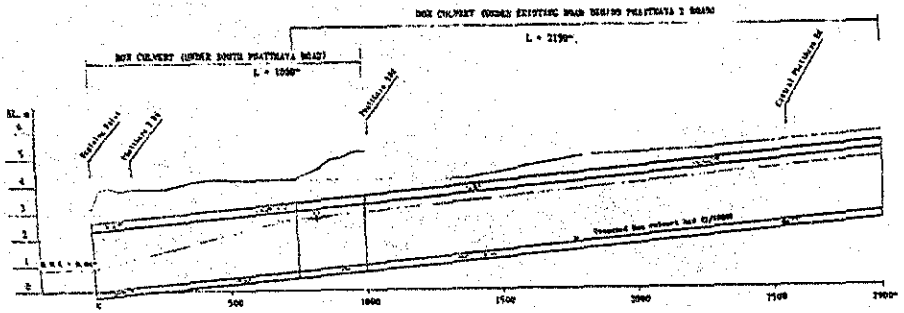
THE MASTER PLAN STYDY FOR
THE DEVELOPMENT OF PHATTHAYA AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

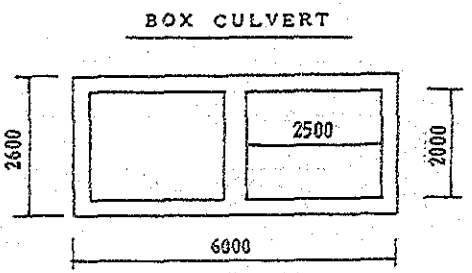
Fig. 6.2.14 Puk Plub Canal Improvement Project Plan



Box Culvert Profile



Cross Section

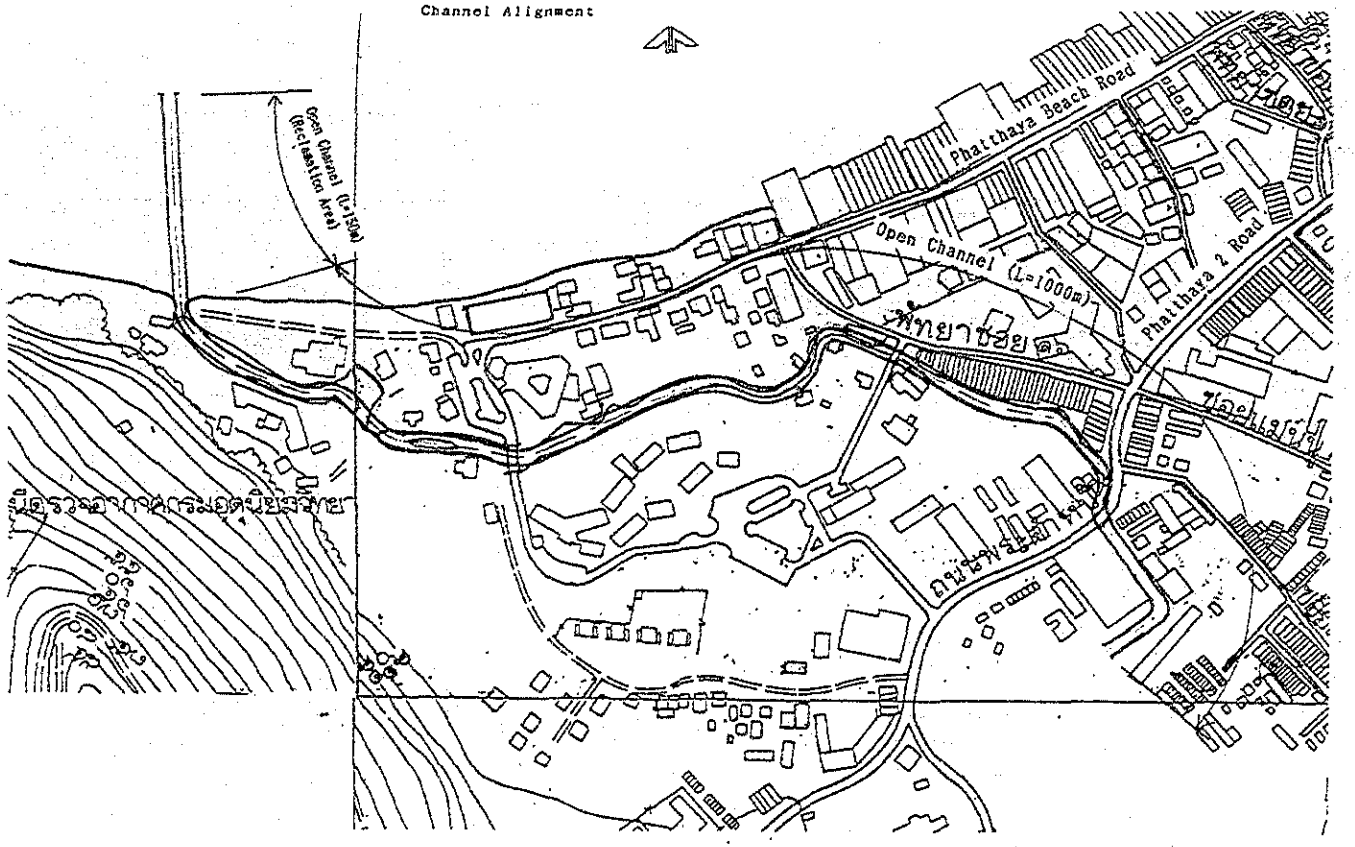


LEGEND

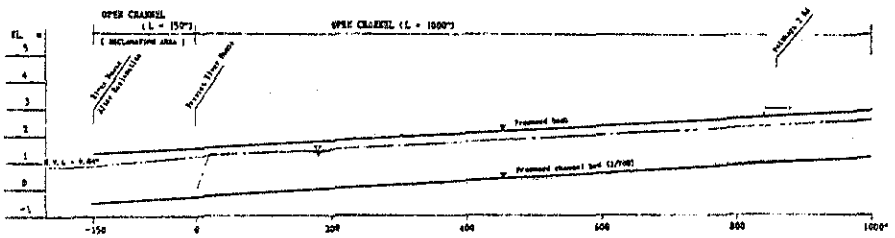
THE MASTER PLAN STYDY FOR
THE DEVELOPMENT OF PHATTHAYA AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 6.2.15 Phatthaya Town Box Culvert Construction Project

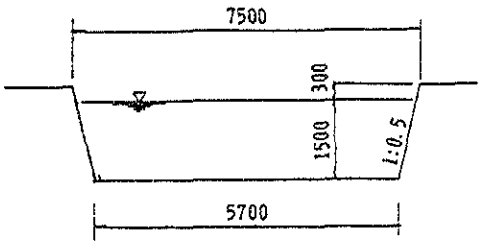


Channel Profile



Cross Section

OPEN CHANNEL



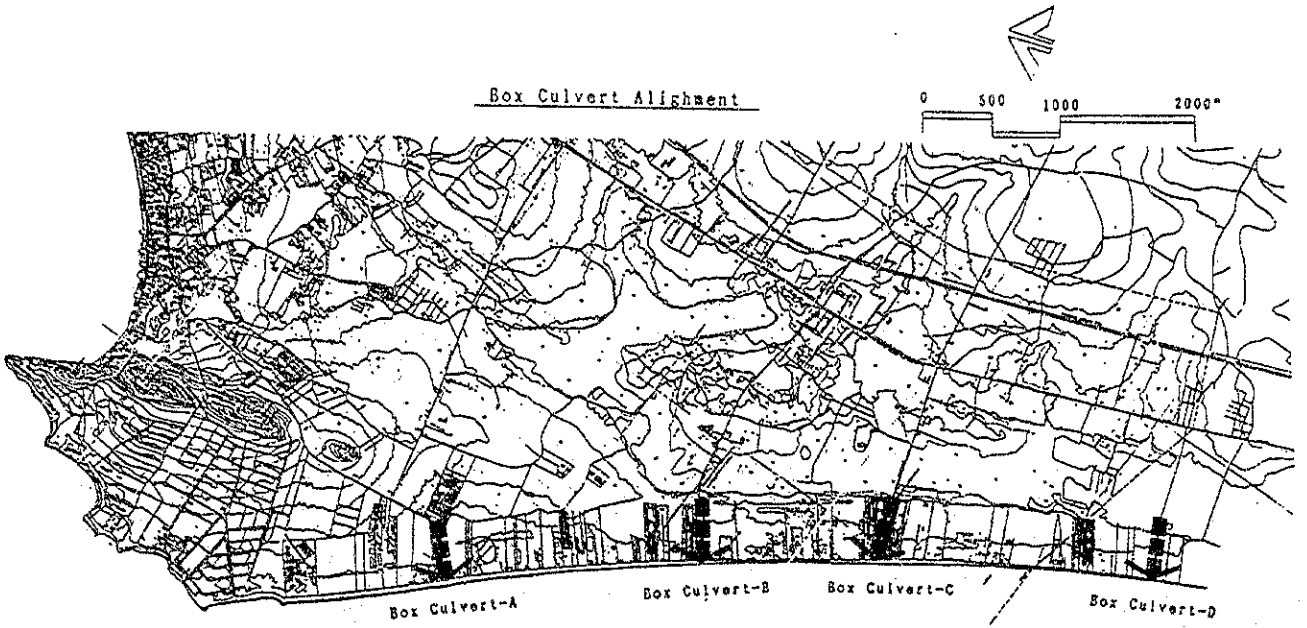
LEGEND

THE MASTER PLAN STYDY FOR
THE DEVELOPMENT OF PHATTHAYA AREA

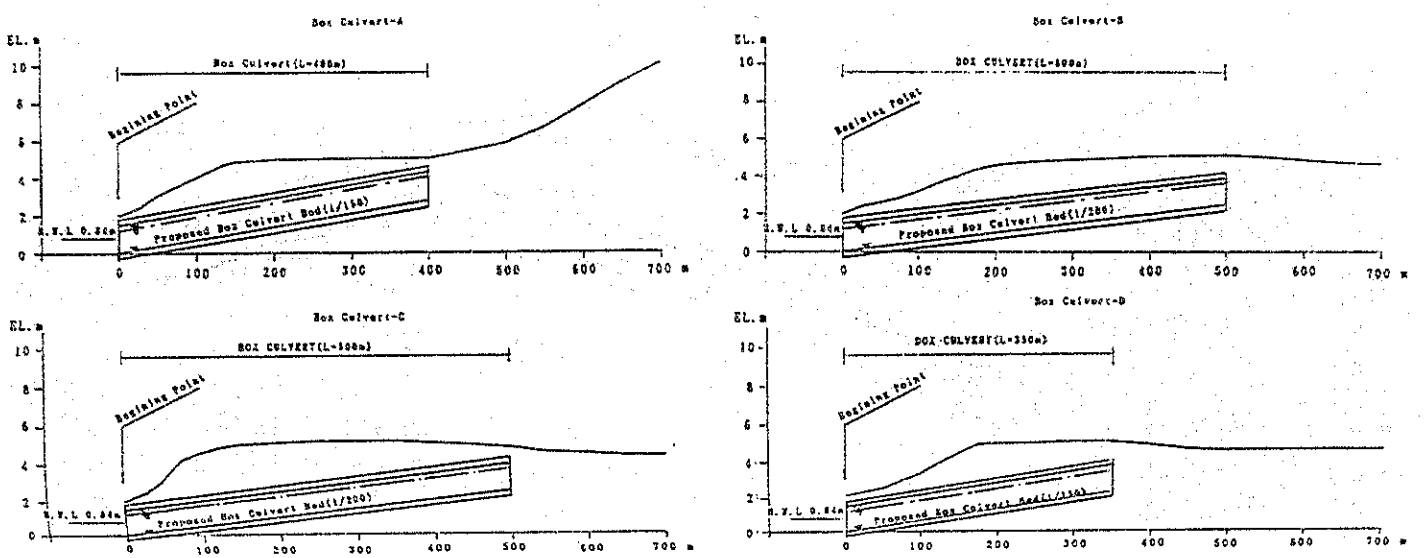
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 6.2.16 Phatthaya Canal Improvement Project

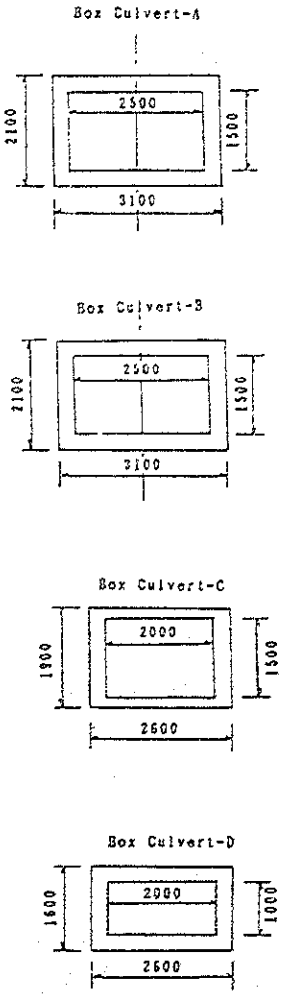
Box Culvert Alignment



Box Culvert Profile



Cross Section



THE MASTER PLAN STYDY FOR
THE DEVELOPMENT OF PHATTHAYA AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 6.2.17 Jomtien Box Culvert Project

6.2.3 Water Supply

1) General

The project takes aim at as summarized below :

	First phase	Second phase
Target year	1996	2006
Demand Average day (MCM/y)	30.2	47.5 (Additional 17.3)
(cu m/d)	82700	130100 (Additional 47400)
Maximum day (cu m/d)	107500	169200 (Additional 61700)
Major Component	Distribution facilities Raw water transmi-ssion facilities Treatment plant Pump station	Treatment plant Distribution facilities Pump station
Water source (Reservoir)	Map Prachan, Nong Klong Dong, Huay Sapan, Huay Khun Jit, Huay Chuk Nok	
	Nong Kho	Nong Kho
		Nong Pla Lai

Each facilities are planned based on the following design flow with proper peak factors ;

— Distribution facilities in first phase (1996) : 128,900 cu m/d
(Peak hour demand in 1996)

— Intake and raw water transmission facilities : 66,700 cu m/d
for second phase (2006)
(Maximum day demand + treatment loss)

— Treatment plant for first phase (2006) : 16,700 cu m/d
(Maximum day demand + treatment loss)

The facilities which are necessary in the beginning of the term of second phase (1997 - 2006) are classified into first phase works and are planned to complete by 1996.

2) Raw water transmission pipeline (First Phase)

Proposed pipeline from Nong Kho reservoir to treatment plant has total length of about 27.9 km which is laid beside existing - Nong Kho - Laem

Chabang pipeline and the projected highway. The pipeline comprises the following components (See Fig. 6.2.18):

Diameter (mm)	Length (km)
900	22.1
600	2 × 3.2
500	2 × 2.6

As the pipeline is required in operation in the beginning of second phase, the pipeline is to be constructed as the first phase project.

3) Pump station (First phase & Second phase)
A pump station is planned on the route of raw water transmission pipeline, with following features and facilities.

- Location : 6.9 km from the junction of Nong Kho - Laem Chabang pipeline and projected highway.
- Design flow : 46.3 cu m/min
- Pumps and pump house : Large pump, 14 cu m/min x 62 m(H) x 3 units (one standby)
  : Small pump, 9.6 cu m/min x 62 m(H) x 3 units (one standby)
- Power substation
- Staff house

Following works are scheduled to be completed as the first phase projects:

- Civil and building works
- Installation of each one units of large and small pumps.

Remaining pump units would be installed in accordance with increase of demand.

4) Treatment plant (First phase & Second phase)
Each component of the plant will be placed at an open space of the existing treatment plant site. The plant comprises four independent treating units and phased construction would be carried out, meeting the increase of demand, to final capacity of 66,700 cu m/d. The major features of facilities proposed are described below :

- Water source : Nong Kho and Nong Pla Lai reservoirs
- Design capacity : 66,700 cu m/d

— Receiving well : 1 well
5.5 m diameter x 3.5 m H
Detention time 1.5 min

— Mixing well : 1 well x 4 units
2.4 m(W) x 2.4 m(L) x 2.5 m(H) x 2 basins/1 well
Detention time 1.04 min

— Flocculation basin : 2 basins x 4 units
11 m(W) x 7 m(L) x 3 m(H) x 2 basins/unit
Detention time 33 min

— Sedimentation basin : 2 basins x 4 units
11 m(W) x 42 m(L) 3.6 m(H) x 2 basins/unit
Detention time 4.0 hr

— Rapid sand filter : 8 filter beds x 4 units
4.0 m(W) x 5.3 m(L) 8 basins/unit

— Clear water reservoir :
- 35 m(W) x 45 m(L) 3.5 m(H) (5,500 cu m) x 1 reservoir
- 25 m(W) x 45 m(L) 3.5 m(H) (4,000 cu m) x 2 reservoir
- 55 m(W) x 80 m(L) 3.5 m(H) (15,400 cu m) x 1 reservoir
- Detention time 7.5 hr

— Elevated tank for backwashing of filter bed : 2 tanks
8.2 m(dia.) x 3.5 m(H)

— Chemical feeding equipment with house

— Installation

— Power substation

One treating unit (1/4 of final design capacity) and two reservoirs of each 4000 cu m capacity are scheduled to be constructed as the first phase projects before 1996 (see Fig. 6.2.19).

5) Distribution facilities

(1) Distribution pipeline

Preliminary design of distribution pipeline are planned based on several engineering aspects ;

— Designs are basically carried out incorporating proposed facilities and existing ones on each phase

— The pipes shall be laid as much as possible in the roadway and other public zones.
— After due consideration of planning framework (land use, tourism and population, road planing), areawise water demand by the type of consumers are computed and the routes of pipeline are determined.
— Distribution pipelines are sized to serve peak hour demand with minimum service pressure of 1.0 kg/cm^2 by means of network analysis.
— Pipe materials are to be asbestos cement preferably for economic reason and in case strength is required, ductile iron pipes are to be employed.

As a result of the study, installation of distribution main for each phase are summarized below and shown in Fig. 6.2.20 and 6.2.21.

Diameter	Length (m)			
(mm)	First phase (1996)		Second phase (2006)	
	Design*	Construction**	Design*	Construction**
100	107600	137230	118500	88870
150	28600	28600	21900	21900
200	12000	12000	22400	22400
250	1800	1800	6400	6400
300	25100	25100	18300	18300
350		-	12600	12600
400	22100	22100	2700	2700
500	2100	6200	4100	-
600	-	6800	6800	-
700	-	5900	5900	-
800	-	-	8700	8700
Total	199300	245730	228300	181870

* Necessary length based on the demand.

** Length proposed to be constructed.

(2) Na Klua booster pump station

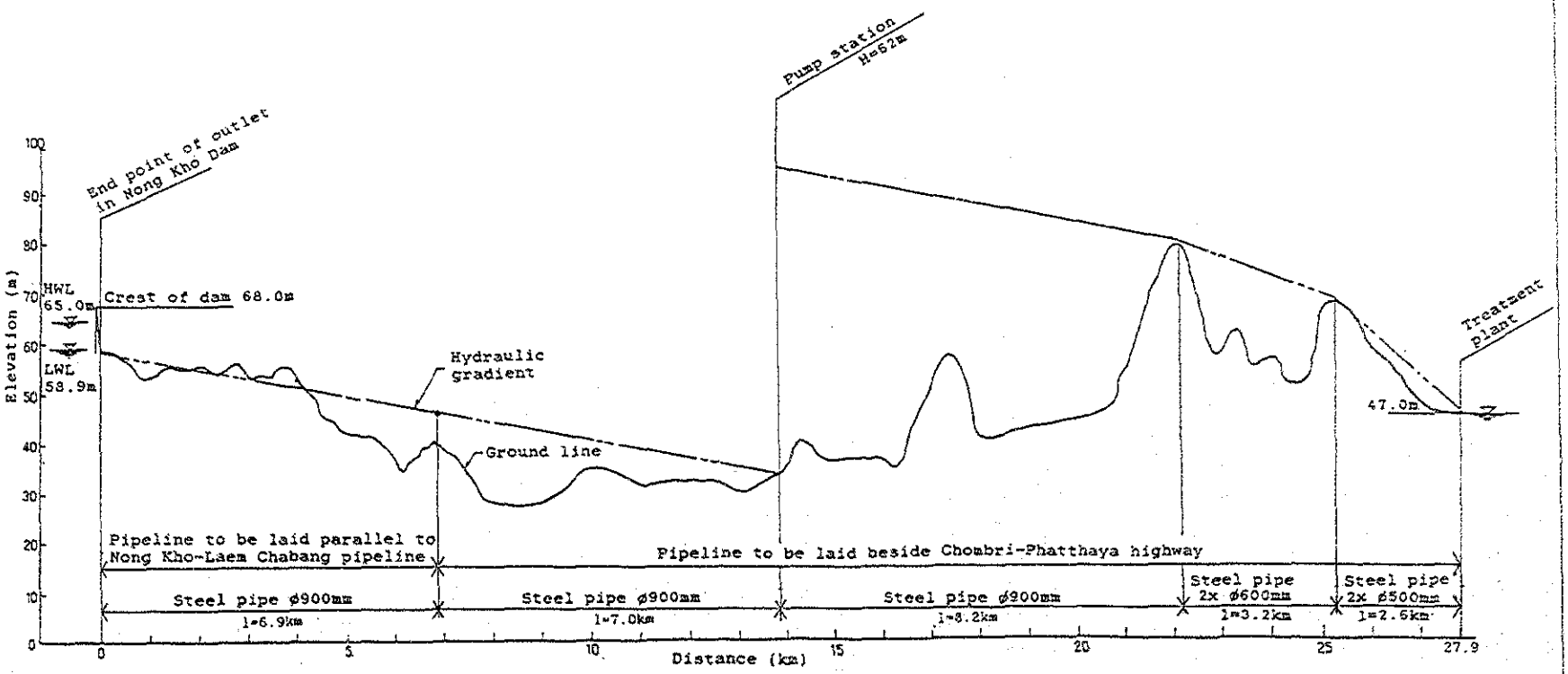
Existing booster pump station for the supply to high land is reinforced as below.

	First phase	Second phase
Location	Existing booster pumpstation at Phattahaya - Na Klua waterworks office	
Pump	9.7 cum/min x 65 m(H) x 1 unit	6.6 cum/min x 67 m x 1 unit

(3) Distrubution reservoir at Khao Phatthaya

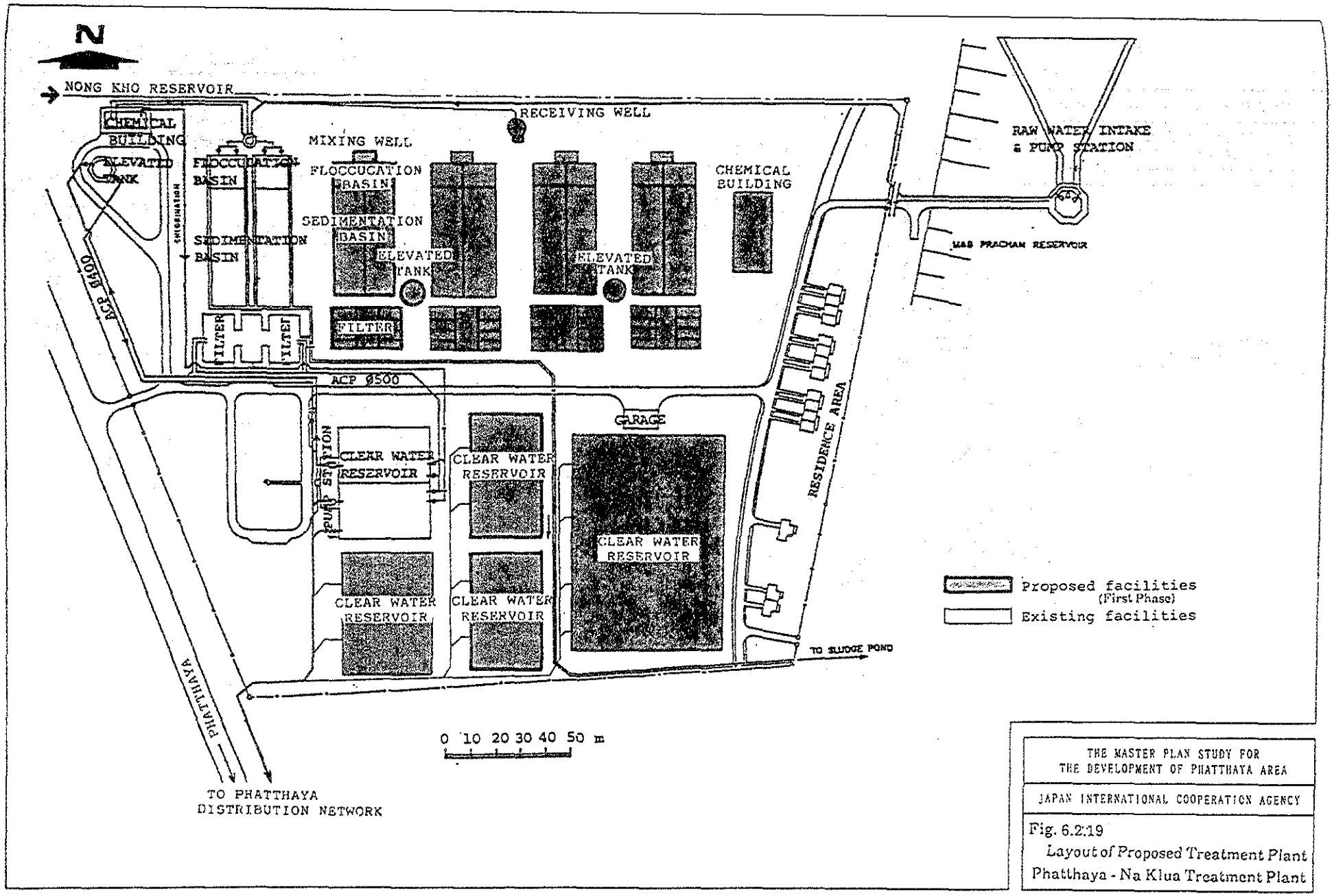
The capacity of distribution reservoir is planned for additional amount in each case.

	First phase	Second phase
Volume (cu m)	3300	2700
Detention time	8 hour storage of maximum day demand	



Source -Feasibility study report on Nong Kho-Laem Chabang water pipeline project
-Preliminary design report on Chombri-Phatthaya highway project

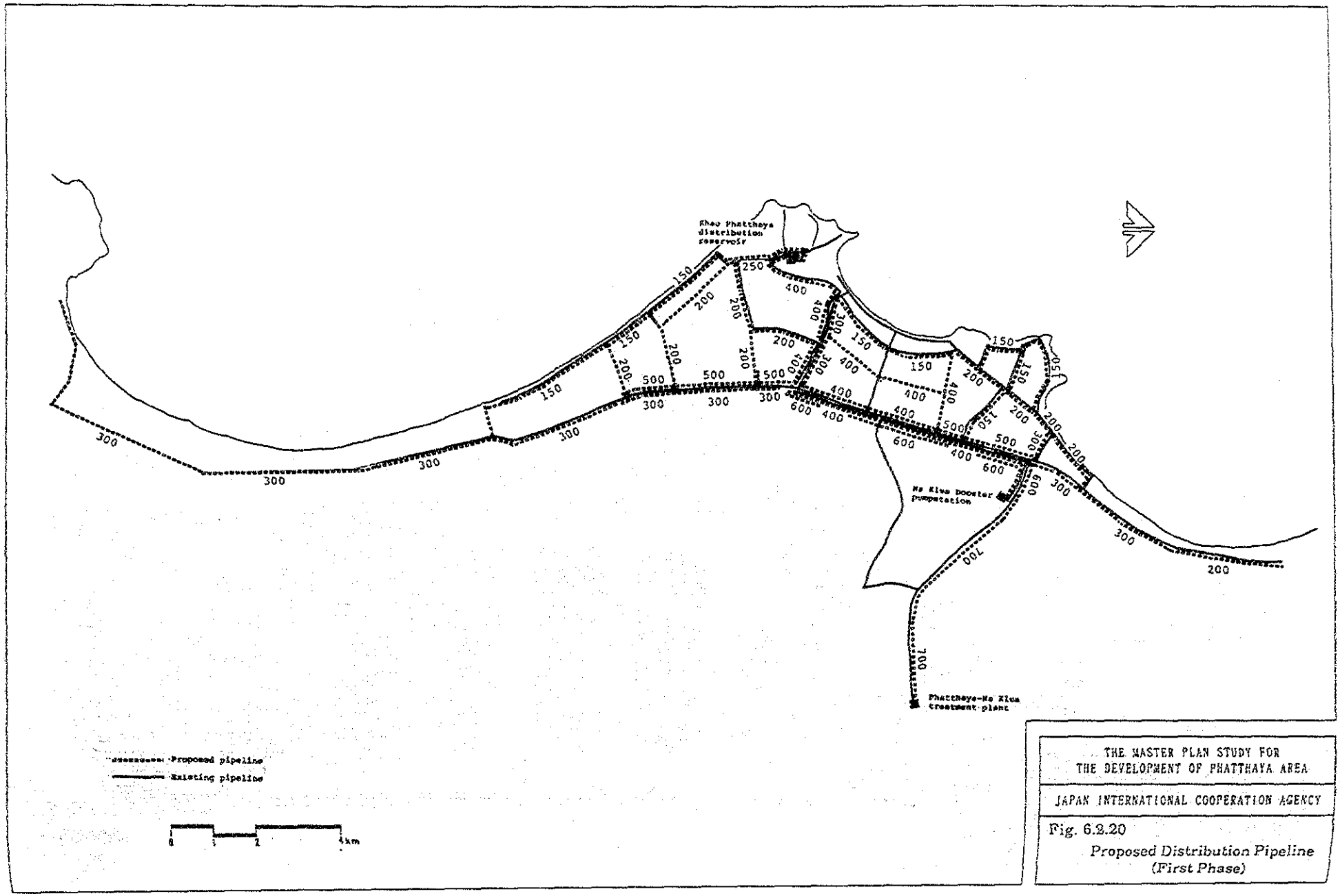
THE MASTER PLAN STUDY FOR THE DEVELOPMENT OF PHATTHAYA AREA
JAPAN INTERNATIONAL COOPERATION AGENCY
Fig. 6.2.18 Longitudinal Profile Of Pipeline



THE MASTER PLAN STUDY FOR THE DEVELOPMENT OF PHATTHAYA AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 6.2.19
Layout of Proposed Treatment Plant
Phatthaya - Na Klua Treatment Plant

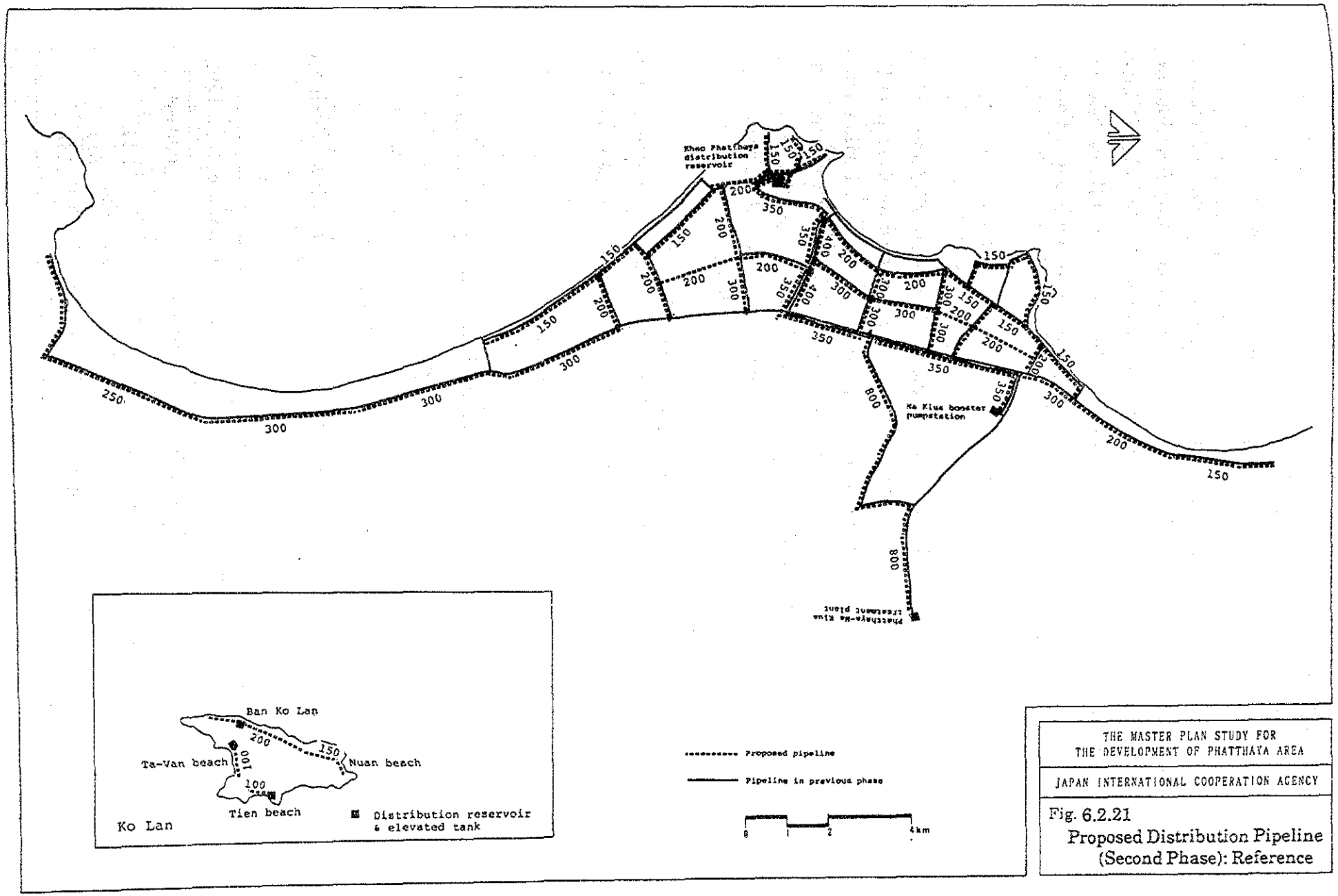


THE MASTER PLAN STUDY FOR
THE DEVELOPMENT OF PHATTHAYA AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 6.2.20

Proposed Distribution Pipeline (First Phase)



THE MASTER PLAN STUDY FOR
THE DEVELOPMENT OF PHATTHAYA AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 6.2.21
Proposed Distribution Pipeline
(Second Phase): Reference

6.2.4 Solid Waste Disposal

1) Service area

The service area for the priority project was set as the whole Phatthaya City because solid waste disposal problem of Phatthaya City is serious and urgent and because each local government is responsible for its solid waste management. The other study area in south Jomtien and Bang Sare will be managed by themselves with their disposal site owing to short distance, economy and efficiency.

2) Location

As studied in "Sectoral Plan", three candidate sites were compared. Site A, which has been evaluated as most preferable, is selected for the site of the project. There is a possibility to change the location as a further study would prove and recommend. Site A is located approx. 12 km from the center or 3 km from Sukhumvit Road and just outside Phatthaya city boundary. It is generally plain field. A new access road will be required.

3) Area

The area of the site was designed as total 135 rai (21.6 ha) or 600 m×180 m, which will be devided into two phases by half, 67.5 rai (10.8 ha) ×2 or 300 m×180 m×2.

4) Disposal method

As mentioned in "Sectoral Plan", sanitary landfill is adopted as final disposal method for all solid waste generated.

5) Design landfill volume

The estimated volume of waste is summarized as follows, all of which are to be landfilled.

Year	Waste amount		Accumulative amount from 1992	
	ton/day	1000 ton/year	1000 ton	1000 m^3
1996	172	62.7	277	347
1999	204	74.5	489	611
2006	289	105.3	1,131	1,414

6) Capacity

The amount of solid waste disposed of in the site will be as follows, assuming bulk density 0.8:

Phase-1	668,000 ton	(829,000m^3)
Phase-2	668,000 ton	(829,000m^3)
Total	1,326,000 ton	(1,658,000 m^3)

7) Preliminary plan of sanitary landfill

As the design of sanitary landfill is not possible without topographic and geotechnical data, the following is considered as a preliminary plan. to make the plan, the following has been taken into consideration.

- The depth is excavation is limited to 4 m anticipating a high underground water level.
- All cover soil will be obtained from excavation of the site.
- Thickness of soil cover is set as follows:
  - thickness of daily soil cover : 15 cm
  - thickness of each layer : 30 cm
  - thickness of final cover : 60 cm
- Maximum thickness of layer of waste : 2 m
- The final cover will have inclination of 3% for drainage.

In those conditions, the height of filling will be approx. 7.2 m~11.6 m from original ground level, with 3 layers of 2.3 m thick each. This height seems practicable for local civil engineering work.
Lining with clay compaction is considered at this stage. After subsoil investigation, plastic sheet lining may be required to prevent pollution. Leachate will be collected on the slope of the bottom and piping, and be sent by pump to anaerobic ponds for treatment before discharge to natural stream.

All the collection vehicles should pass weigh bridge, which weigh the amount of waste and make records. A office will be constructed for the site staff and a maintenance house will be prepared for on-site maintenance

and housing of equipment.
Drainage ditch will be provided to drain surface water. Fence and planting will be provided to surround the site and to shield sight from outside.
Space for recycling will be prepared for admitted people. Gas vent will be provided. Monitoring wells will be dug to check effects to environments.
Utilities such as electricity, telephone, water supply should be provided.

The site will be divided into two phases. In the respective phase, the following works will be carried out;

Phase-1	Site Clearance
	Excavation
	Clay Liner
	Leachate Piping & Gravel
	Leachate Pond
	Leachate Manhole
	Pump
	Gas Vent
	Site Drainage
	Access Road
	In-site Road, Parking
	Fence & Gate
	Site Office
	Weigh Bridge (with House)
	Maintenance House
	Monitoring Well
	Utilities
	Planting
	Personal Computer
	Software
Phase-2	Excavation
	Clay Liner
	Leachate Piping & Gravel
	Leachate Pond
	Leachate Manhole
	Pump
	Gas Vent
	Site Drainage

In-site Road, Parking
Monitoring Well

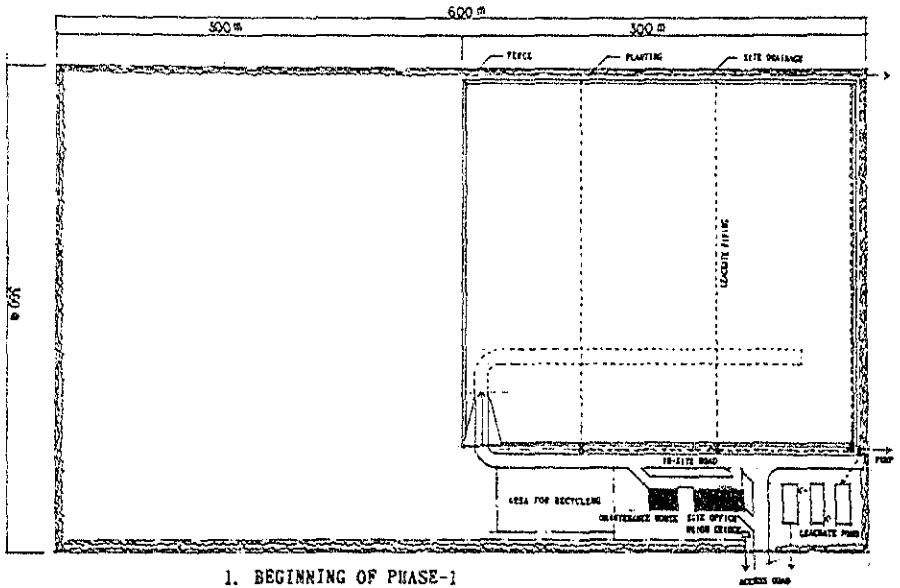
8) Equipment

As mentioned in "Sectoral Plan", the following equipment will be required:

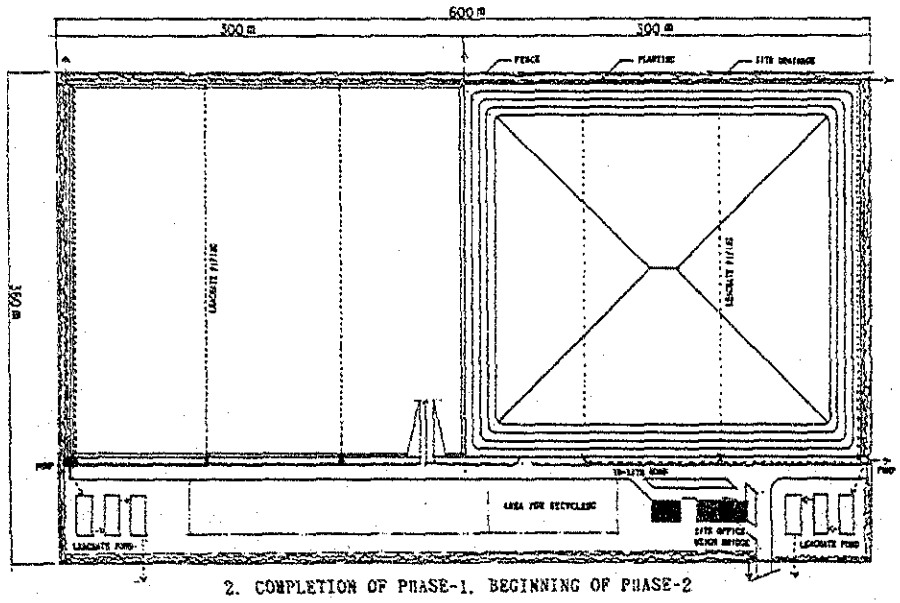
	NO.
Bulldozer (140 Hp)	2
Compactor (140 Hp)	1
Wheel Loader (140 Hp)	1
Dump Truck (20 Ton)	2

9) Organization

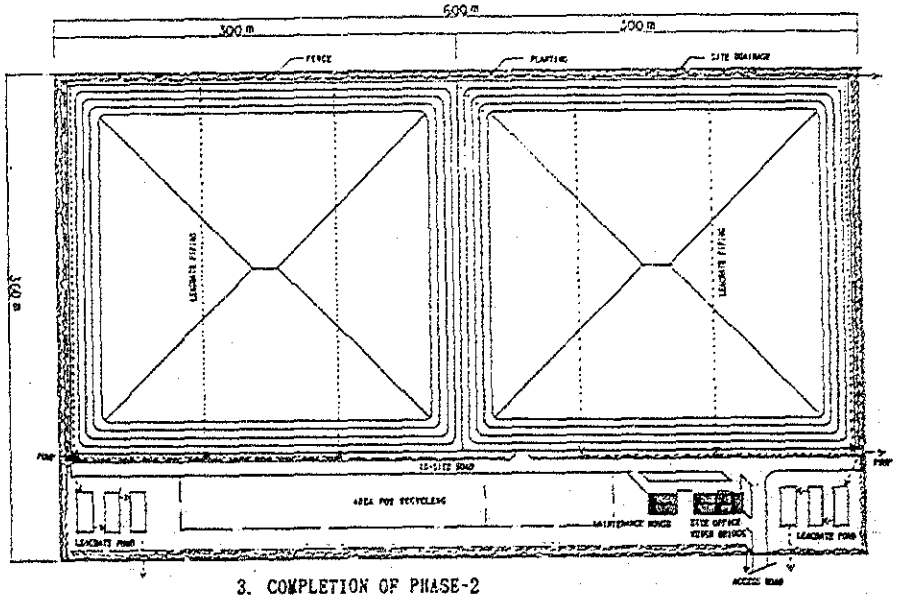
Before formation of solid waste management division, a work force should be made for implementation of sanitary landfill project, data collection and construction of data base system.



1. BEGINNING OF PHASE-1



2. COMPLETION OF PHASE-1, BEGINNING OF PHASE-2



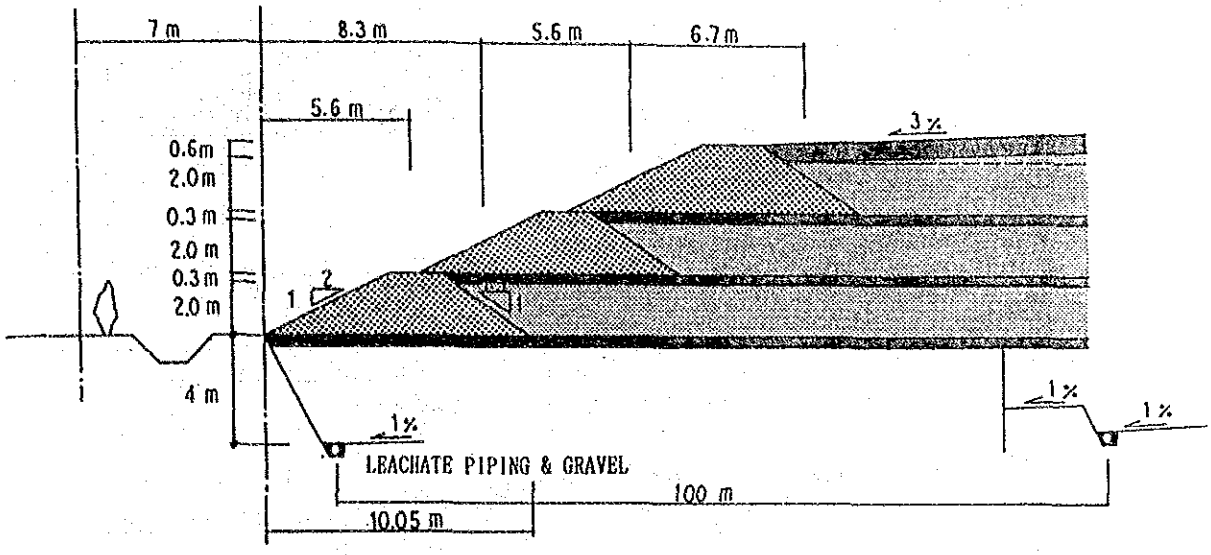
3. COMPLETION OF PHASE-2

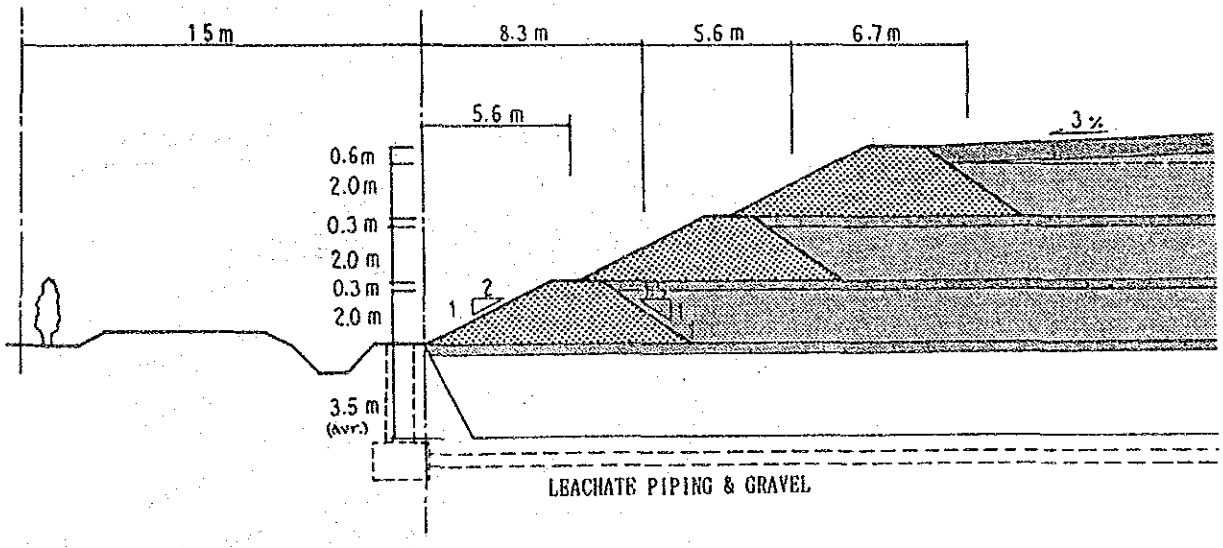
THE MASTER PLAN STUDY FOR
THE DEVELOPMENT OF PHATTHAYA AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 6.2.22

Plan of Sanitary Landfill





LEGEND

THE MASTER PLAN STUDY FOR
THE DEVELOPMENT OF PHATTHAYA AREA

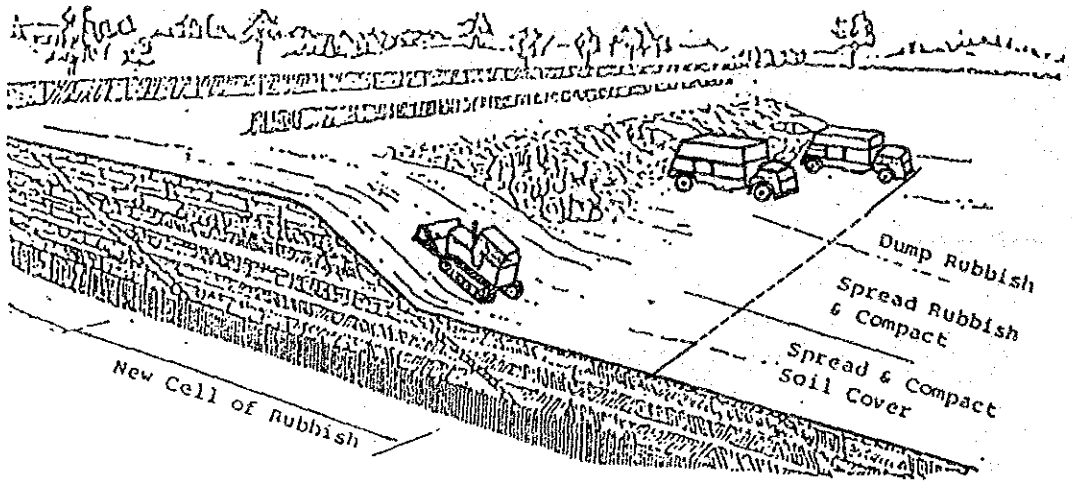
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 6.2.23
Typical Section of Landfill

1. DUMP SOLID WASTE

2. SPREAD AND COMPACT SOLID WASTE

3. SPREAD AND COMPACT COVER SOIL



(SOURCE: "SOLID WASTE DESIGN NOTES, 1985")

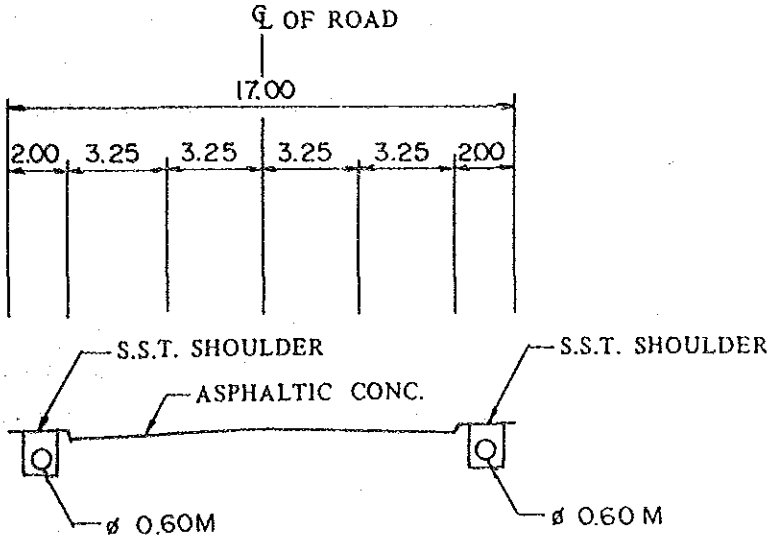
LEGEND	THE MASTER PLAN STUDY FOR THE DEVELOPMENT OF PHATTHAYA AREA
	JAPAN INTERNATIONAL COOPERATION AGENCY
	Fig. 6.2.24 Procedure of Sanitary Landfill

6.2.5 Road Improvement Plans

In addition to Phatthaya 2 road, Jomtien beach road and Sukhumvit road of which the improvement and construction are already committed by DOH and PCG, the construction of phatthaya 3 road is strongly recommended in order to expand road network capacity to meet the traffic requirement in the target year as well as to guide urban development. Intersection improvements are also needed to ensure traffic operation and safety as well as intersection capacity.

1) Improvement Plan of Phatthaya 3 Road

As the rapid development in Jomtien proceeds, the improvement of Thapphaya Road alone will not be enough to serve the future traffic demand. Therefore, Phatthaya 3 should be extended to completely connect Phatthaya and Jomtien. The proposed road will be a 4 lane road for all sections (See Table 6.2.5). The project includes widening of existing Phatthaya 3 and Soi 17, a new alignment from North to Central Phatthaya Road, South Phatthaya Road to Mountain Road. It also includes widening of connecting road to the reclamation area to be 4 lanes in order to make Phatthaya 3 as the main arterial access to the new reclamation area. The typical cross section is designed as follows.



2) Preliminary Design

Design Standard

Design standards used in this Master Plan Study are limited to basic design criteria such as typical cross-section , pavement design, etc., which are based on the Design Manual of the Department of Highways, 1989. However, judgment was taken into account where appropriate in order to make the design suitable for Phatthaya City where the land price is very high while the City's budget is quite limited.

Pavement

In order to minimize the cost, asphalted concrete was selected for all proposed road surface except that Phatthaya New Highway is of concrete pavement in conformity with DOH's design for the prior section.

For pavement structure, the design was done under consideration of the latest structural design for North Phatthaya and Wat Boon road improvement projects since the available data was not sufficient to carry out an independent design.

Alignment

The horizontal alignment of proposed road was examined based on the map of 1 : 4,000 scale, which was established by the Department of Town and Country Planning in 1987. The route alignment was decided by taking into account the minimum land acquisition and demolishing, and ordinary design guidelines.

Intersection Improvements

Intersection improvements dealt in this study were mostly signal installation due to the high land price and the difficulty in acquisition. However, other improvement types such as interchange or flyover were considered for DOH roads.

The identification of improvements was made based on turning movements forecasted by the study team's analytical mode. All major intersections in the study area were taken into account.

The resulting for intersection improvements are shown in Table 6.2.6.

Table 6.2.5 IMPROVEMENT PLAN OF PHATTAYA 3 ROAD (SHORT LIST PROJECTS)

Road	Section	Length (m.)	Project Description
1. North - Central Phatthaya		1,900	New 4 lane
2. Central - South Phatthaya		1,750	Windenning to 4 lane
3. South - Mountain Rd.		1,500	New 4 lane
4. Mountain Rd. - Reclamation Area		800	Windenning to 4 lane
5. Soi 17		1,400	Windenning to 4 lane

Table 6.2.6 SUMMARY OF INTERSECTION IMPROVEMENT (SHORT LIST PROJECTS)

Intersection	Traffic volume on main stream (both direction /hr.)	Crossing or Turning Volume (one direction/hr.)	Type of Improvement
1. Phatthaya 3 - Central Phatthaya	3,298	1,738	Signal Installation
2. Phatthaya 3 - South Phatthaya	3,163	950	Signal Installation
3. Phatthaya 3 - Thapphaya	2,591	1,249	Signal Installation