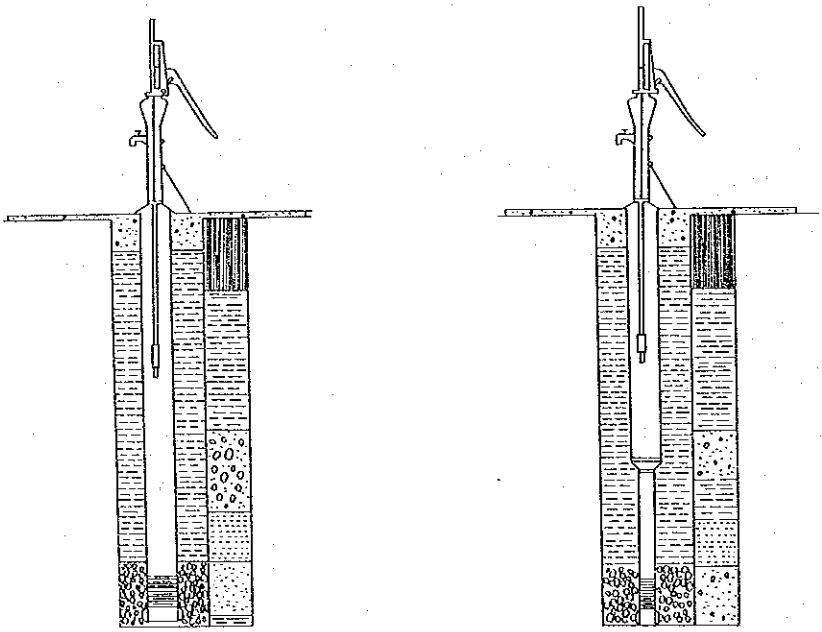
The water wells drilled by official agencies under NPWP were usually approximate 30 m (100 feet) in depth, installed 10 - 15 cm (4 - 5 inch) diameter of casing with strainer and set a handpump. A typical profile of water well in Thailand is shown as follows (This is an example of well drilled by PWD).

Typical Profile of Water Well



(2) Deep Well Data around the SDs

Deep well data in and around the SDs are mainly collected from government agencies such as PWD, DMR, DH, ARD and RID (the last one had no deep well in the concerned areas as the result).

Data collected during the study term were as follows;

SD	No. of Wells	W.Q.Test*	Logs
Kham Sakae Sang	19	14	5
Huai Thaleang	31	16	7
Kusuman	19	9	2
Phon Charoen	20	5	6
Nong Song Hong	17	5	5
Total	106	49	25

* including data tested in this study

The situations of existing deep wells in each SD are explained briefly and detail location of deep wells inside of SD are shown in the location map of geoelectric prospecting.

Kham Sakae Sang: Total four deep wells were located in the boundary of SD and all of them were drilled by DMR. Among these four wells, two wells were already abandoned because of salty water, and only two remaining wells are still at work.

Besides the wells inside of the SD, other two wells drilled by DMR were also abandoned already due to salty groundwater. The matter suggested that the area near around the SD Kham Sakae Sang may be suffered from salty water widely, and the test well position should be selected carefully not to yield salty groundwater.

According to the geological logs, the area is underlain by brown to reddish brown shale (supposed to belong the Maha Sarakam Formation). The overburden mainly consisted of clay extends widely, ranging from 3 to 8 meters in depth.

Huai Thaleang: 31 deep well data around the SD were collected from DMR, ARD and DH. Among them, 9 wells were located inside of the SD.

In this area, there is no well abandoned due to salty water, although the water qualities of some wells are not excellent in Fe, Cl and/or total hardness. By the data, the yields of groundwater are generally poor ranging from 1.0 to 7.7 m^3/hour with the draw down from 11 to 30 m.

The depth of wells are mostly from 30 to 36 m (100 - 120 feet) but the deepest well in the SD is about 152 m (500 feet) in depth. The bedrock of the area is almost all shale but interbedding some gypsum layers. Partly a laterite overlies the bedrock, and overburden mainly consisted of clay covers the area wholely but rather thin (in 1.5 - 3.0 m of thickness except laterite).

Kusuman: Nevertheless the town area of SD Kusuman is not so wide, rather many deep wells could be confirmed by the team. There were 10 deep wells drilled by government agencies. Besides, many shallow wells were observed in the site. These matter suggests that the area should be abundant in groundwater both shallow and deep aquifers.

Although there is no salty water well, the water qualities of some wells are not favorable for drinking water because of high contents of Fe and total hardness.

The deepest well in front of the railway station G7 SN6 by DMR) was drilled to the depth of 319 m (already abandoned though). According to the geological log of the well, the bedrock consists of mainly shale but includes some anhydorite or gypsum in lower portion.

Phon Charoen: In this area total 20 wells were listed in the well data, and 14 wells were checked by the team in the boundary of SD. Among them, 12 wells out of 14 wells were drilled by government agencies concerned and the other two well were private wells. Remarkably, these two private wells are spring with yielding groundwater of considerably good quality.

The water qualities of most deep wells around the SD are rather good except some wells. The yields vary from 1.4 to more than 10 m^3/hour with draw down of 15 - 20 m.

The bedrock of the area consists of shale and mudstone overlain by laterite or lateritic soil. Generally the overburden lies from 1.5 to 6.0 m in thickness but partially it exceeds 10 m in depth.

Nong Song Hong: In the area, deep well data of altogether 17 wells were collected from in and around the SD. In the service area of SD Nong Song Hong, eight deep wells were checked in the list and map. However, four wells out of total were already abandoned due to salty water. Outside of the SD, also some wells were abandoned because of salty water or dried up.

The water qualities of wells show a quite contrast that some wells are so salty that they must be abandoned but the other wells yield groundwater of rather good quality comparing with other SDs investigated.

The deepest well in the SD is drilled with the depth of about 460 m (1,510 feet) by DMR. The depth of overburden varies from 0 to more than 20 m, and the layers consist of clay, sand and laterite or lateritic soil. The bedrock is composed of mainly shale but intercalating rock salt partially.

A.4.4. Geoelectric Prospecting

(1) General

In each subject SD, a geomorphological and hydrogeological reconnaissance survey had been done to grasp a general physical condition and to make an actual geoelectric prospecting plan. Existing deep wells in the SD were checked by the team simultaneously.

Geoelectric prospecting applied in hydrogeological or civil engineering aspect is generally a resistivity method prospecting. The resistivity method of geoelectric prospecting is classified into two major methods from a removing process of electrode system; a horizontal resistivity prospecting (resistivity mapping) and a vertical resistivity prospecting (resistivity sounding).

For this project, the vertical prospecting method with Wenner's electrode arrangement, the most prevailing and simple way, was adopted based on the consideration that the field work should be carried out with laborers without knowledge of this kind of work, during limited working time.

The geoelectric prospecting stations were selected in the sites based on the geomorphological reconnaissance survey. The numbers of station in each SD ranges from 28 (at Phon Charoen) to 31 points (at Huai Thaleang, Kusuman and Nong Song Hong), as just enough/minimum to investigate a hydrogeological condition of the sites.

Usually the stations were allocated along 200 or 400 m grid according to the wideness of each SD area. Although the most of stations were set on the side of roads, some were settled on a paddy field or rough when the road net was not suitable for the prospecting grid.

(2) Hydrogeological Assessment

The consideration and assessment for the hydrogeological condition of each project site, were made based on the analysis of geoelectric prospecting and geomorphological reconnaissance mentioned in the previous paragraph.

As a general, the assessment has been done based on the fundamental ideas or concepts, those are (1) the shallow aquifer shall not be used for water resource because it does not bear groundwater firmly throughout a year and it is easily polluted generally, (2) the deep aquifer should be a target for water source, (3) since the deep aquifer is a fissure water type, a weathered rock zone and some kinds of structure line like a fault zone shall have dominant groundwater, and (4) the groundwater-flow of a certain region shall be conformable to the physiographic trend as a whole.

Based on the basic ideas mentioned above, a contour map or iso-bath of bedrock surface and an equi-thickness contour map of weathered rock zone were drawn up and the most adequate test well position was selected out in each site. The followings are the description of hydrogeological assessment of each site investigated.

Kham Sakae Sang

The town area of King Amphoe Kham Sakae Sang situates on the remnant of low terrace surrounded by wide and a little low lying paddy field (alluvial plain). The ground surface trends to south or southeast as a whole but very gently. The small streams, Huai Raam and Huai Yana, flow down trending from NW to SE passing through the southwest end of the SD.

Based on the analysis of p-a curves, a contour map of bedrock surtace was drawn (Figure A-4-1). As shown in the map, the bedrock surface also inclines gently toward south and one main valley on the rock surface separates the area into two zones. The valley is significantly clear and is supposed as a kind of structure line in the base geology. An equi-thickness contour of weathered rock zone was not made because the weathered zone was not so clear in the site.

The most severe hydrogeological problem in the SD is an existing of salty groundwater both in shallow and deep aquifers. The distribution of salty groundwater is shown on Figure A-4-2. Salty groundwater in shallow aquifer distributes only at restricted area. While the distribution of salty water in deep aquifer is rather wide and in complecated feature. However, as shown on the distribution map, the salty water aquifers develope at north and northwest part of the area. In other words, they distribute only northwestern side of the structure line mentioned above. By the figure, the structure line seems to work as a kind of partition or barrier to the aquifer.

Based on the matter mentioned above, the most part of the town area has hardly a chance to yield non-salty water. While the southern side of the said structure line do not show the existing of salty water (in deep aquifer) so far forth. So the test well should be drilled at outside of the town, and the position between geoelectric prospecting station No.2 and No.3 was recommended as the test well position to be drilled by PWD (Figure A-4-1).

Huai Thaleang

Amphoe Huai Thaleang is located on the one of very gentle slopes of rolling peneplain, toward northeast as a whole. A small stream passes through the SD from the west to the east and flows down to northeast after this.

Figure A-4-3 shows an isobath of the bedrock surface. As shown in the figure, the depth of bedrock ranges from 4 m to more than 10 m in the figure, the depth of bedrock ranges from four meters to more than 10 m below the ground surface, and a linear valley on the rock surface is distinguished clearly. The valley was certainly formed along a weak zone like a fault. Then, an equi-thickness contour was also illustrated in Figure A-4-4. The figure indicates a notably thick weathered zone center (more than 35 m in thickness) at nearly center of the town, just west of the structure line described above. Further it suggests a discrepancy of the weathered zone thickness between western and eastern sides of the said structure line.

In these structure, the groundwater is supposed to be recharged mainly through the structure line and stored at thick weathered rock zone, and totally flows down toward northeast. The bedrock itself is rather hard shale and this kind of rock has few effective pores when it is sound excepting the case it has heavy bedding plains or concentrated joint system. Based on the consideration mentioned above, the test well should be drilled at the point where the thickness of weathered rock zone is large. Thus, the position between station No.19 and No.20 was recommended (Figure A-4-3).

However, although there is no problem concerning to salty water, the potential of groundwater for a water resource shall be estimated as rather low, because the bedrock consists of hard shale and most of the existing deep wells indicate low yield. If the test well yielded less than 10 m^3/hour of groundwater in safety draw down, the water resource of the project shall be sought except for groundwater.

<u>Kusuman</u>

The area including the SD is a gently undulating land and the site is situated in one of the very gentle valley. This undulating land is a dissected terrace and the low portions dissected are already covered by some alluvial deposits. The main stream near the SD is Huai Saphoe flowing down toward north at the western margin of the SD. A small tributary of Huai Saphoe flows down to southwest passing across the town and separates it into two zones; the major town zone and Amphoe Office area. The ground surface near around the SD inclines toward southwest or westward because Huai Saphoe is forming a basin at southwest of the SD, nevertheless the total landscape slopes down toward north.

Based on the p-a curve analysis, a contour map of the bedrock surface was drawn as shown in Figure A-4-5. As easily read out from the figure, a flat top bedrock ridge lies at the main part of the town and a clear valley is dissecting as separating the SD into two zones. The flat top ridge coincides roughly to the distribution of laterite layer, and the valley situates nearly same position of the current stream mentioned above. Then, Figure A-4-6 shows an equi-thickness contour map of weathered rock zone. The figure is not so conformable to the shape of bedrock surface but rather complecated. However, the high portion of bedrock has shallow, the lower portion of bedrock has deep weathered rock zone as a general tendency.

For the test well location, the most deep weathered rock zone portion should be preferred as the drilling point as a general tendency. However, the most deep weathered rock zone in this site extends along to the existing stream, where the loose overburden is being deposited thickly. The condition is not preferable to actual drilling works. While, one narrow sub-valley on the contour map extends from the main valley to the ridge. The zone along this narrow valley should have rather deep weathered rock zone and the depth of overburden is expected as shallow. These consideration results out the position along the narrow valley on the equi-thickness contour map as a recommended test well position, as shown in Figure A-4-5.

The site seems to be abundant relatively for groundwater from the existing well condition; some of them yield more than 20 m^3/hour of groundwater. However, if the test well yield is not sufficient compared with the demand, the formulation of succeeding well plan seems to be difficult because the prospected test area of drilling is rather narrow. So the availability of water resource from groundwater in this SD will be depending on the result of test well.

Phon Charoen

The SD Phon Charoen is located at southwestern slope of a terrace trending NW-SE, and the town area consists of remnants of terrace and dissected low and flat plain (alluvial plain). Although the total landscape inclines toward southwest, it slopes down to west at near around the SD.

A contour map of bedrock surface was illustrated based on the analysis (see Figure A-4-7). As shown on the figure the contours indicate an irregular or obscure pattern, but it shows as a total that the rock surface inclines toward west gently. An equi-thickness contour map of weathered rock zone also was drawn as Figure A-4-8. The figure indicates that the thickness of weathered rock zone becomes large and large toward southern part of the SD. A small isolated thick weathered zone basin is located at right front of the Amphoe Office.

Concerning to the test well position, the southern end of the site is preferred than inside of the town from the viewpoint of the thick weathered rock zone where have much groundwater. However, from the viewpoint of succeeding practical waterworks, well location is preferable near or in the town area. By these discussion, two test well positions were recommended; one is located at front of the Amphoe Office and another is at southern part of the SD.

The quality of groundwater is rather good comparing with other SDs, but the yields in existing well data are not preferable for the project purpose so far because of most of the wells yield are less than 10 m^3/h. Otherwise, the SD area is so wide and extended that several wells can be settled with enough distance not to influence each other. Further, there is considerably shallow but artesian aquifer at southwest of the site. It must be reconsidered depending upon the result of test well when it were a pessimistic result. As a conclusion, the site still has relatively high possibility to get groundwater as a water resource for the project.

Nong Song Hong

The service area of the SD is a gently undulated land, and the SD situates at one of high portions. Mostly the high portions of the vast undulation are terrace and the low portions are dissecting alluvial plains. Inside the SD, the western half of the town stands on terrace and eastern half stands on dissecting slope and low alluvial plain. It means the total landscape slopes down toward east.

Figure A-4-9 is a contour map of the bedrock surface drawn based on the analysis. The figure shows rather complecated configuration of the bedrock surface, and it suggests one structure line passing across the site at southern half of the town. The most high portion ot bedrock surface is found out at the cross point of subordinate national road (route No.211) and the railway. The ridge of bedrock surtace continued from far west of the site extends toward center of the town and then turns to north diminishing gradually.

The SD is involved in salty water problem. More than 10 geoelectric prospecting stations indicate an existing of salty groundwater. Figure A-4-10 shows a distribution of salty water separating three depths of aquifers; upper than EL 80 m (tentative elevation), upper than EL 60 m and lower than EL 60 m. As shown in this figure, salty water aquifers cover a considerable part of the town area, but they distribute only southern side of the bedrock ridge, and it seems that they extend along or centralized to the structure line mentioned above. These condition is more easily recognized from the Figure A-4-11. The figure A-4-11, shows an equi-thickness contour map of weathered rock zone as well as the distribution of salty groundwater. As easily read from the figure, the center of the most thick weathered rock zone coincides to the structure line, and the zone is also a center of salty water distribution.

As mentioned above, the prime issue for selecting the test well position should be to avoid salty water, in the SD. For the matter, Figure A-4-11 is available to consider them. As shown on the figure, salty water distributes at southern side of the bedrock ridge and is limitable near along the railway. It means, to the contrary, aquifer at northern side of the ridge has not salty water. Actually a deep well drilled by DMR (No.1 well in the well data) yields rather good quality groundwater about 27 m^3/hour. Then, although groundwater should be recharged from western side of the SD from the total geomorphological viewpoint, the the west side of the town area has rather thin weathered rock zone. Based on these considerations, the test well drilling portion was selected at northern part of the town along the road route No.2, as shown on Figure A-4-11.

The half of this SD has a potential to yield considerably good quality and quantity of groundwater, but the other half shall yield salty water. Although the distribution of salty water was defined by this investigation, there still be anxiety about an introducing salty water by abstracting groundwater of considerable amount and for long time even in the northern side of the town. To estimate the risk exactly, more detail and extensive hydrogeological investigation shall be required to know the direction of groundwater flow, amount of recharge monthly and yearly, influence circle of resource well, etc. So the water resource from the surface water for the project shall be sought from the viewpoint of long term stability of water resources, excepting the case the test well yields enough amount of water.

Figure A-4-1 Contour Map of Bedrock Surface

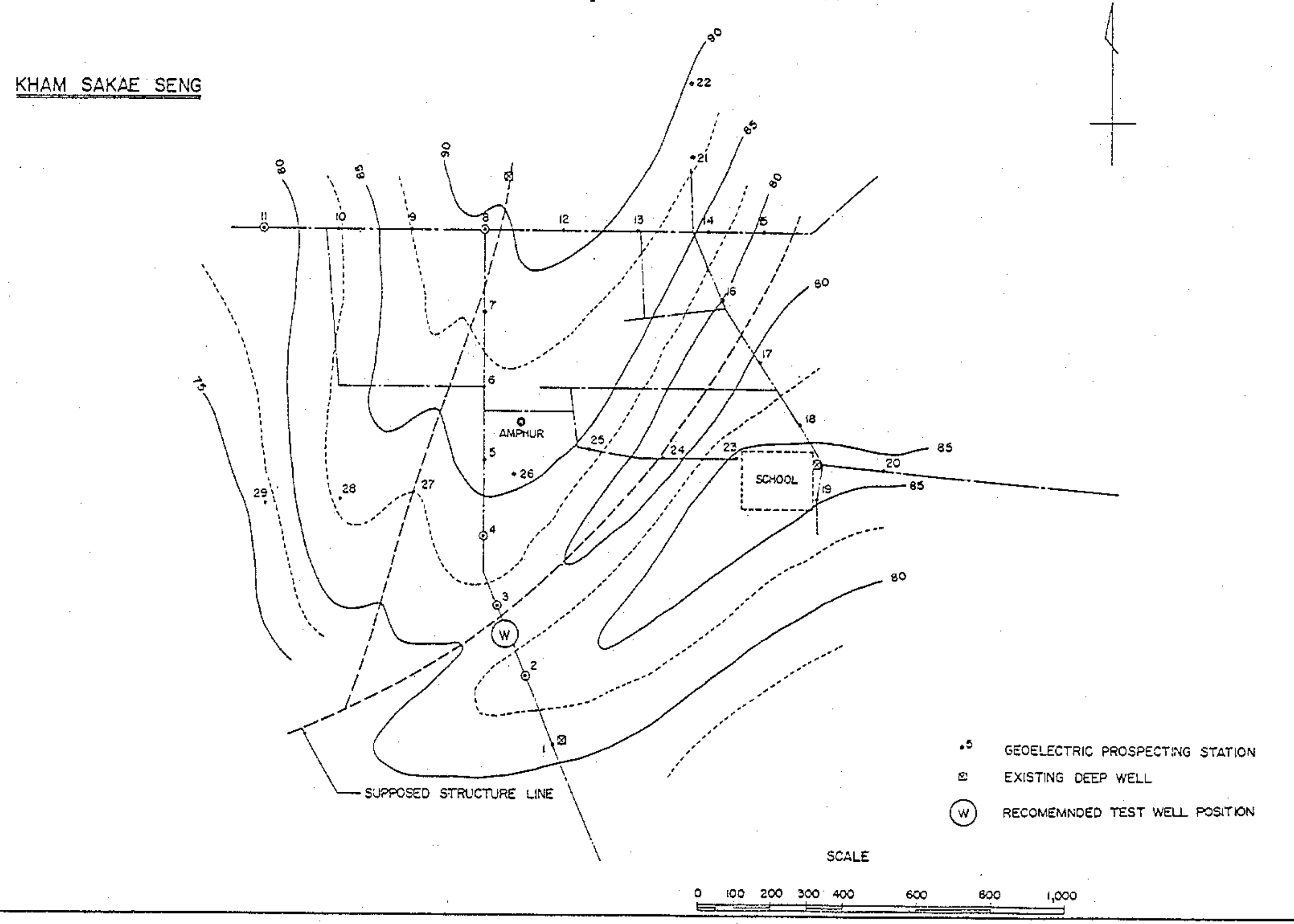
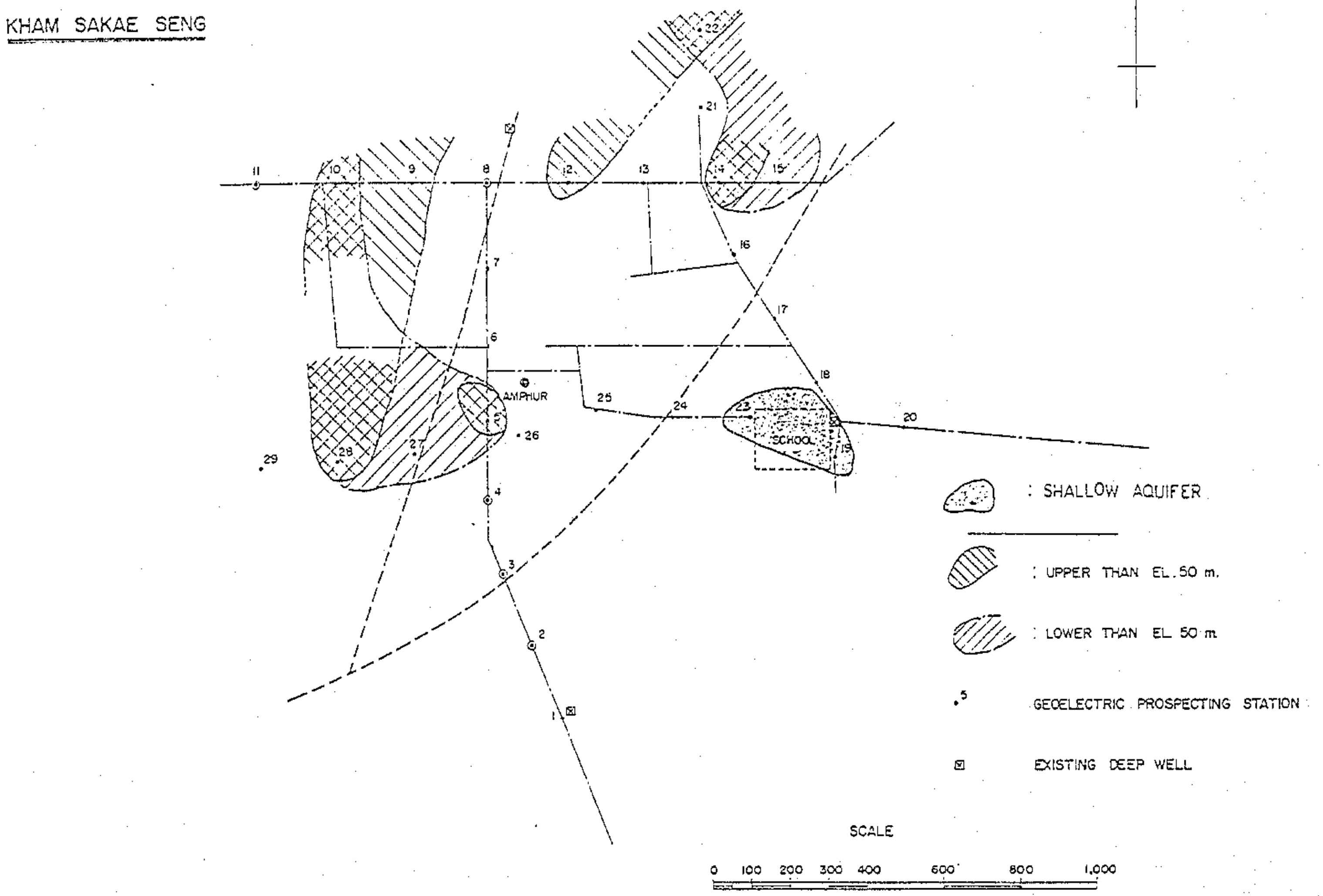
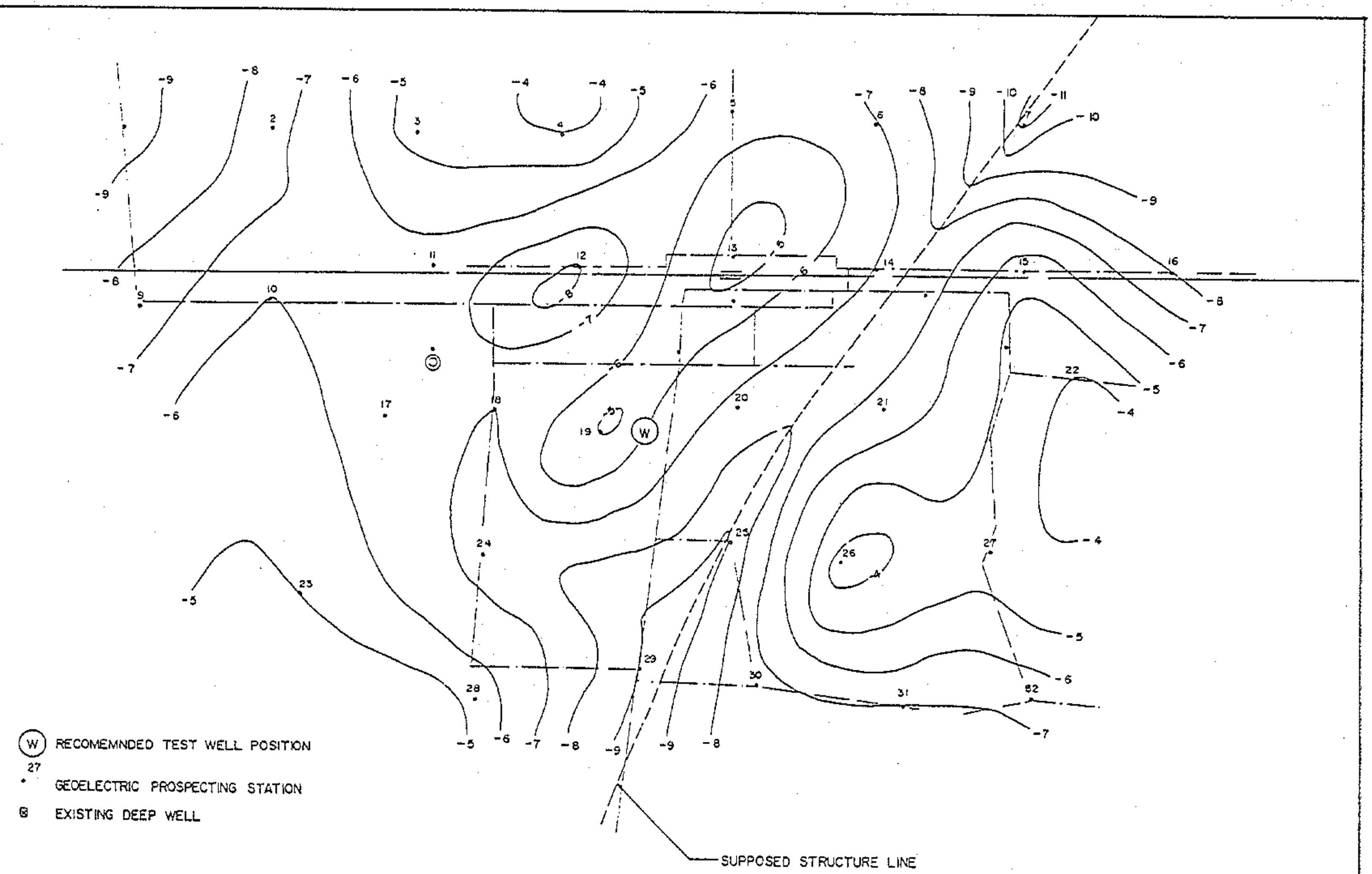


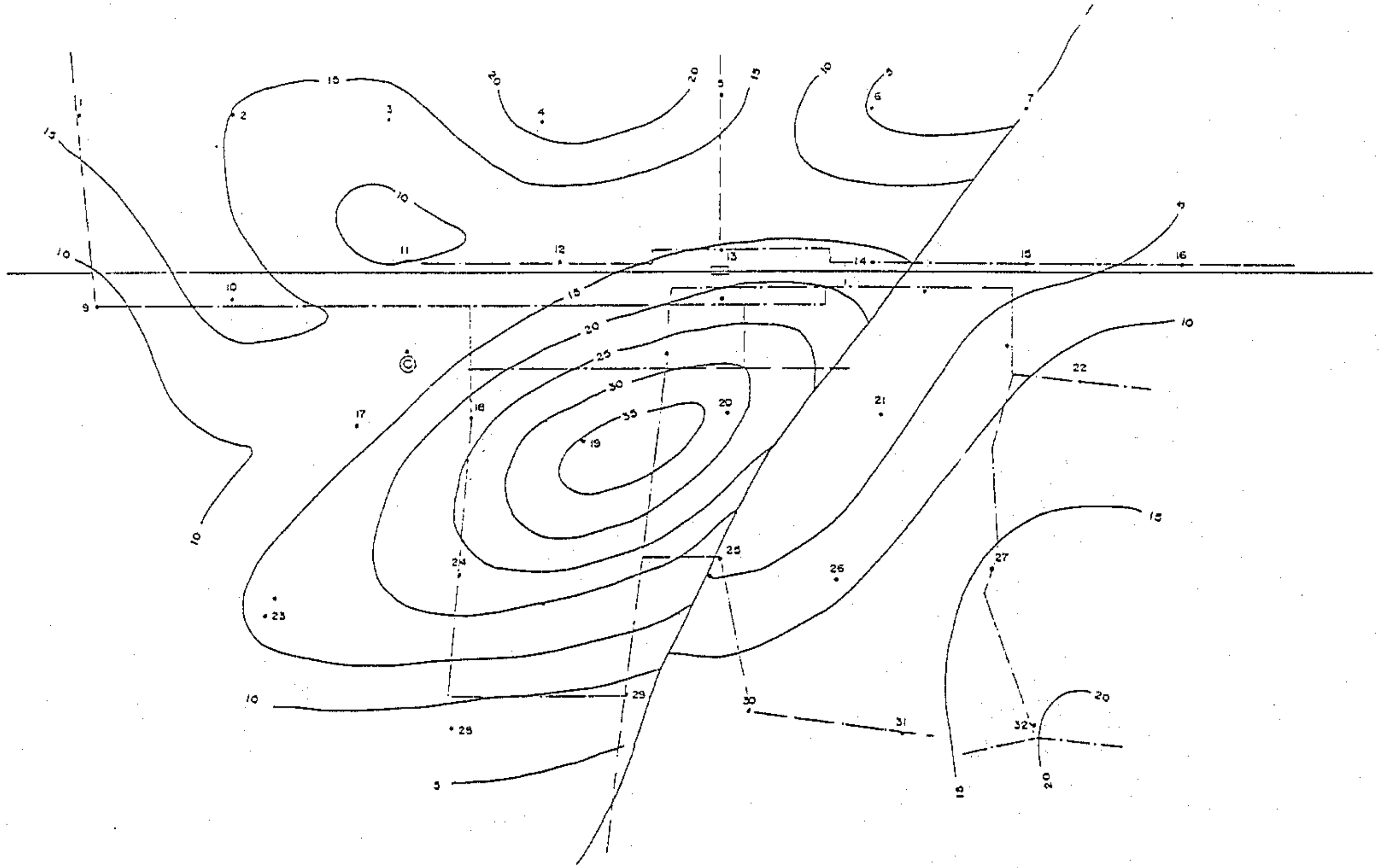
Figure A-4-2 Distribution of Salty Groundwater





HUAI TALEANG

Figure A-4-3 Isobath of Bedrock Surface

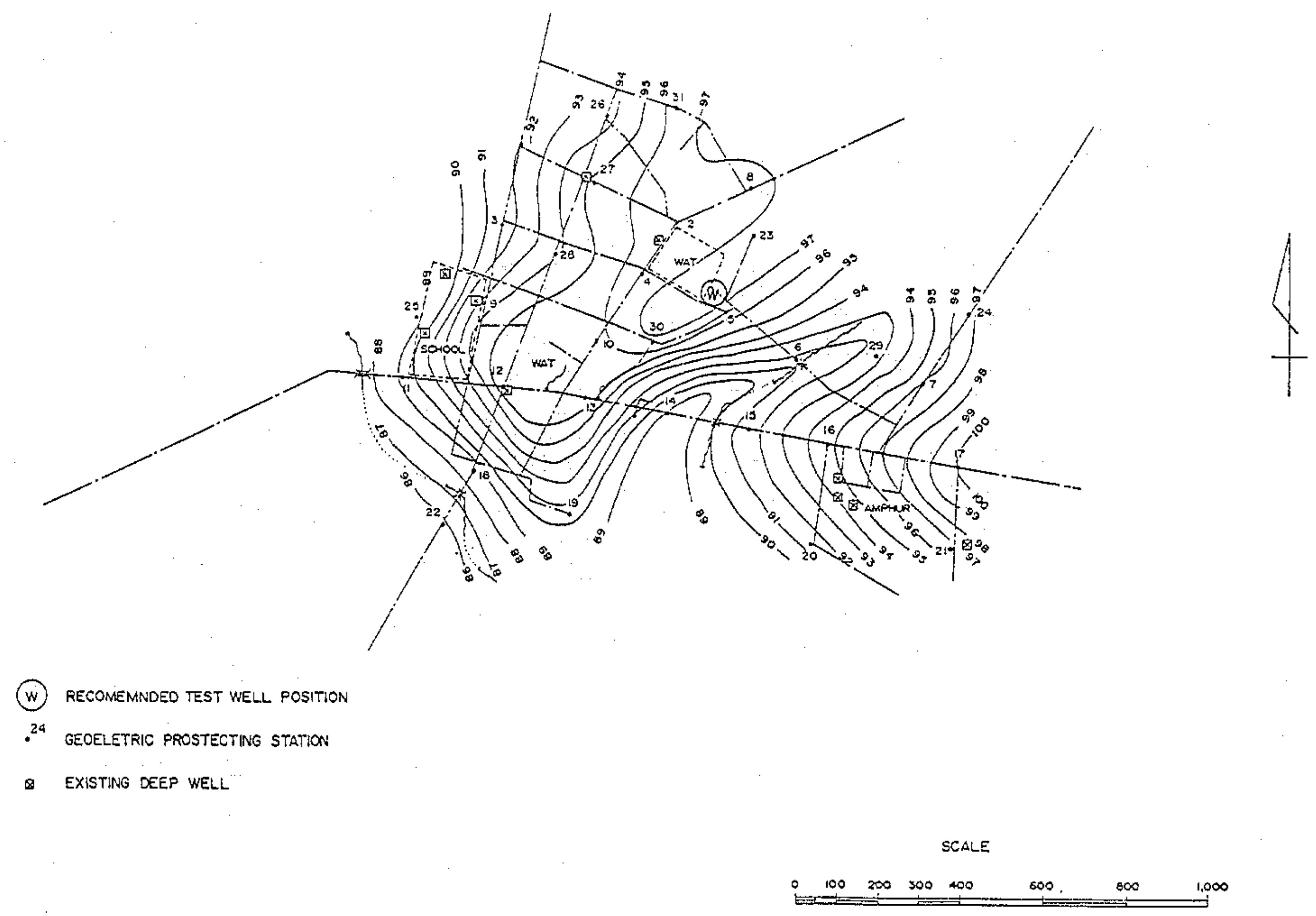


HUAI TALEANG

Figure A-4-4 Equi-Thickness Contour Map of Weathered Rock Zone

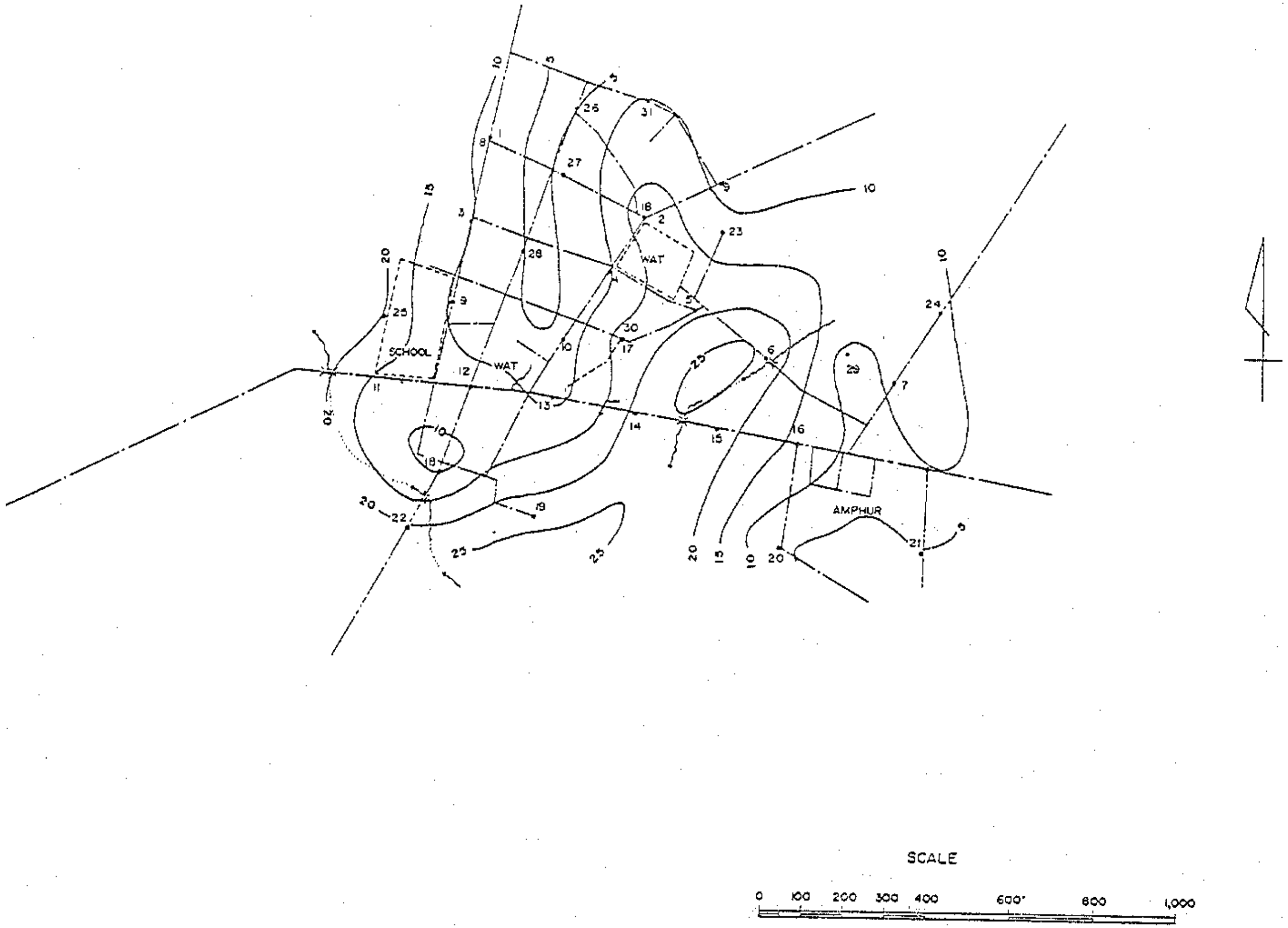
Figure A-4-5 Contour Map of Bedrock Surface (Tentative Elevation based on SD Map)

KUSUMAN



KUSUMAN

Figure A-4-6   Equi-Thickness Map of Weathered Rock Zone



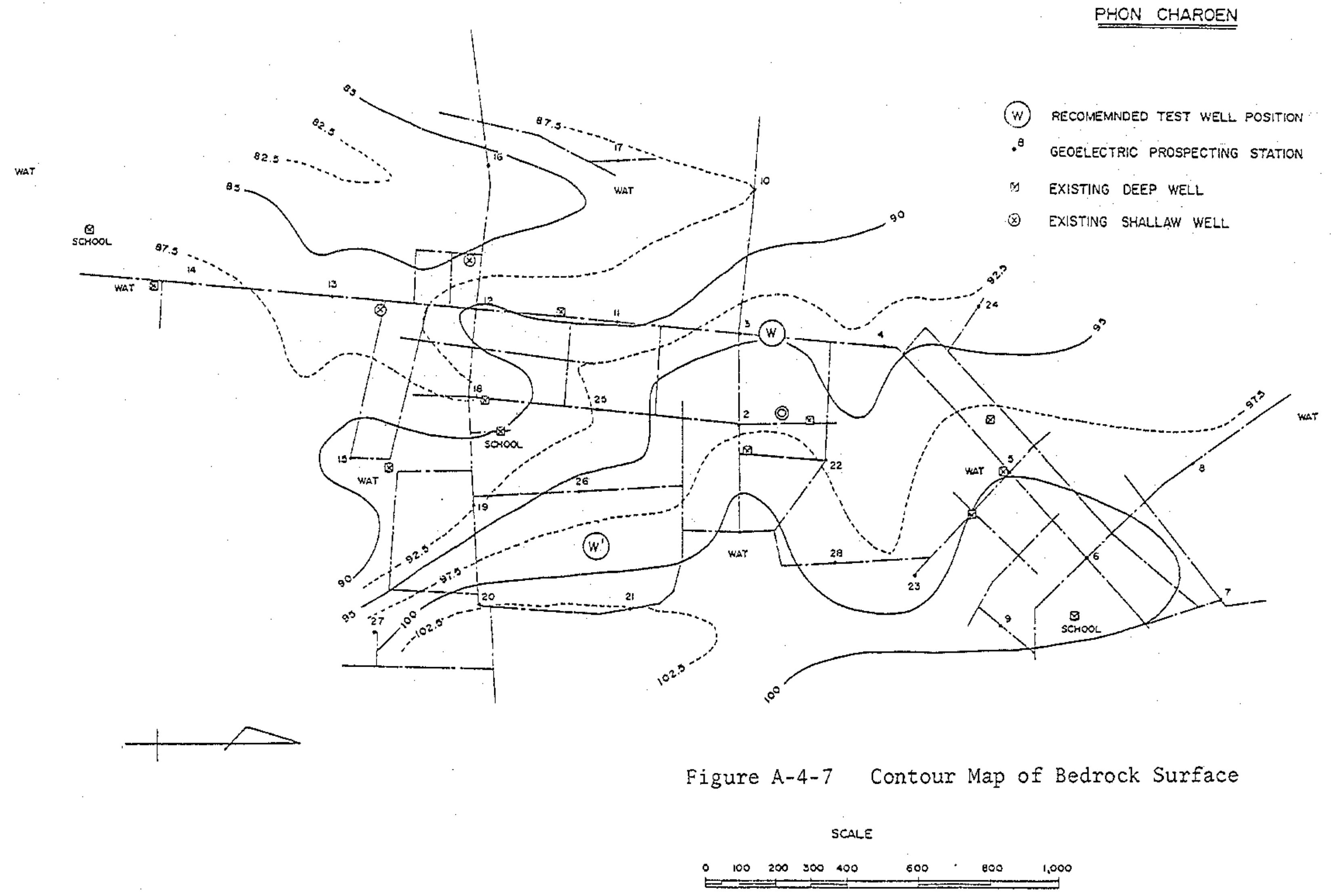


Figure A-4-7 Contour Map of Bedrock Surface

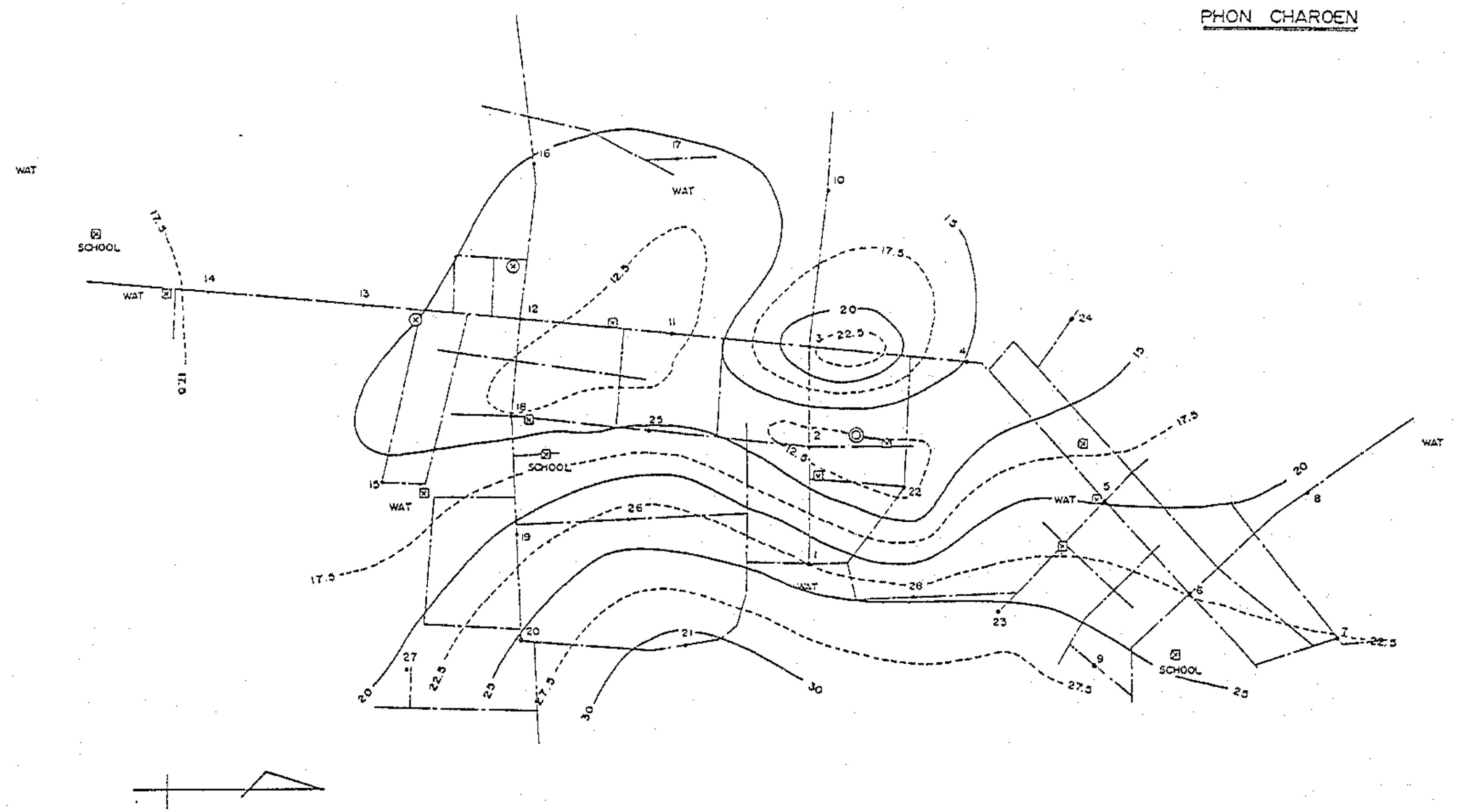
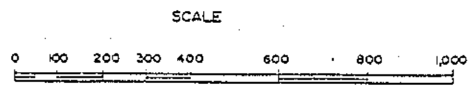


Figure A-4-8 Equi-Thickness Contour of Weathered Rock Zone



NONG SONG HONG

Figure A-4-9 Contour Map of Bedrock Surface

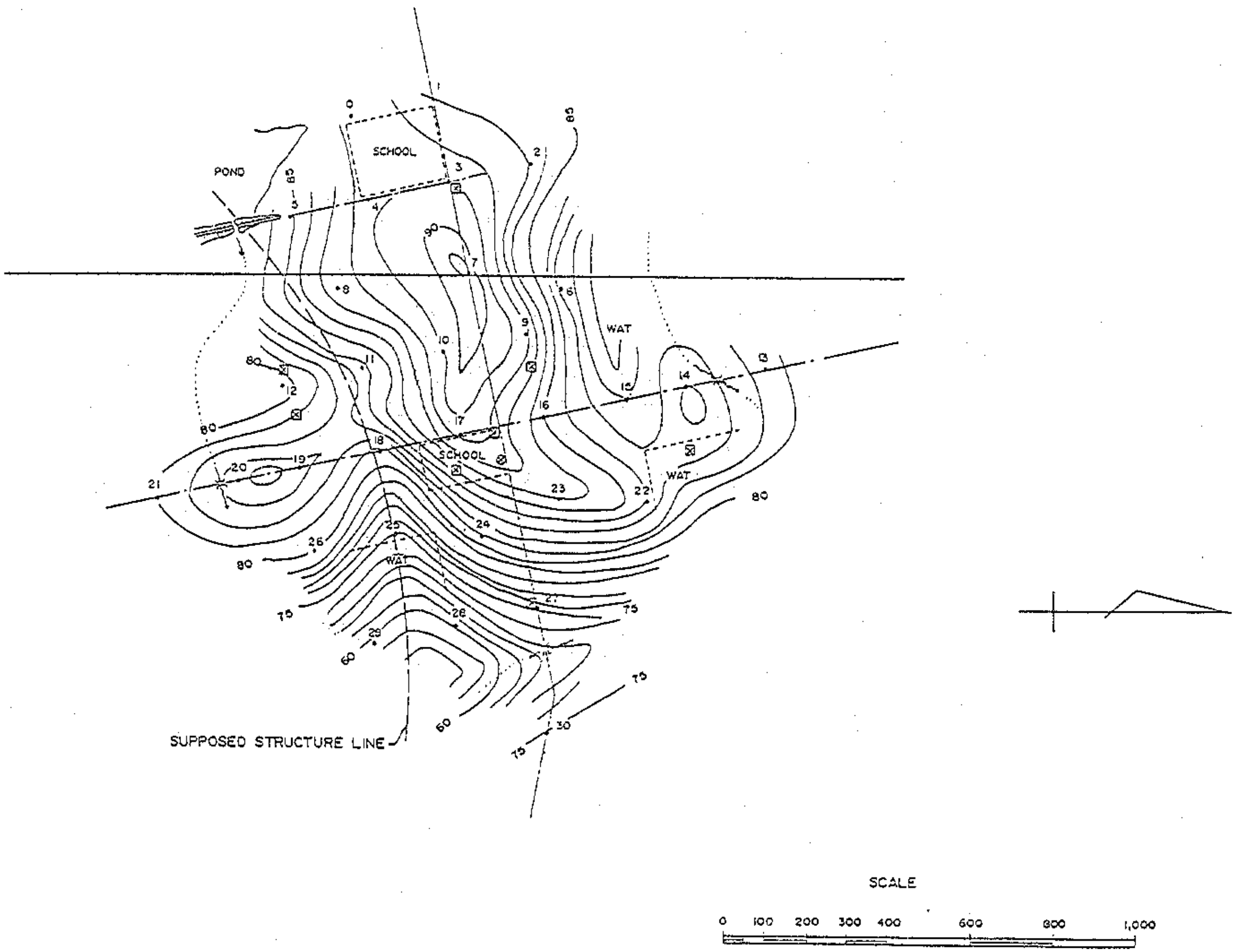
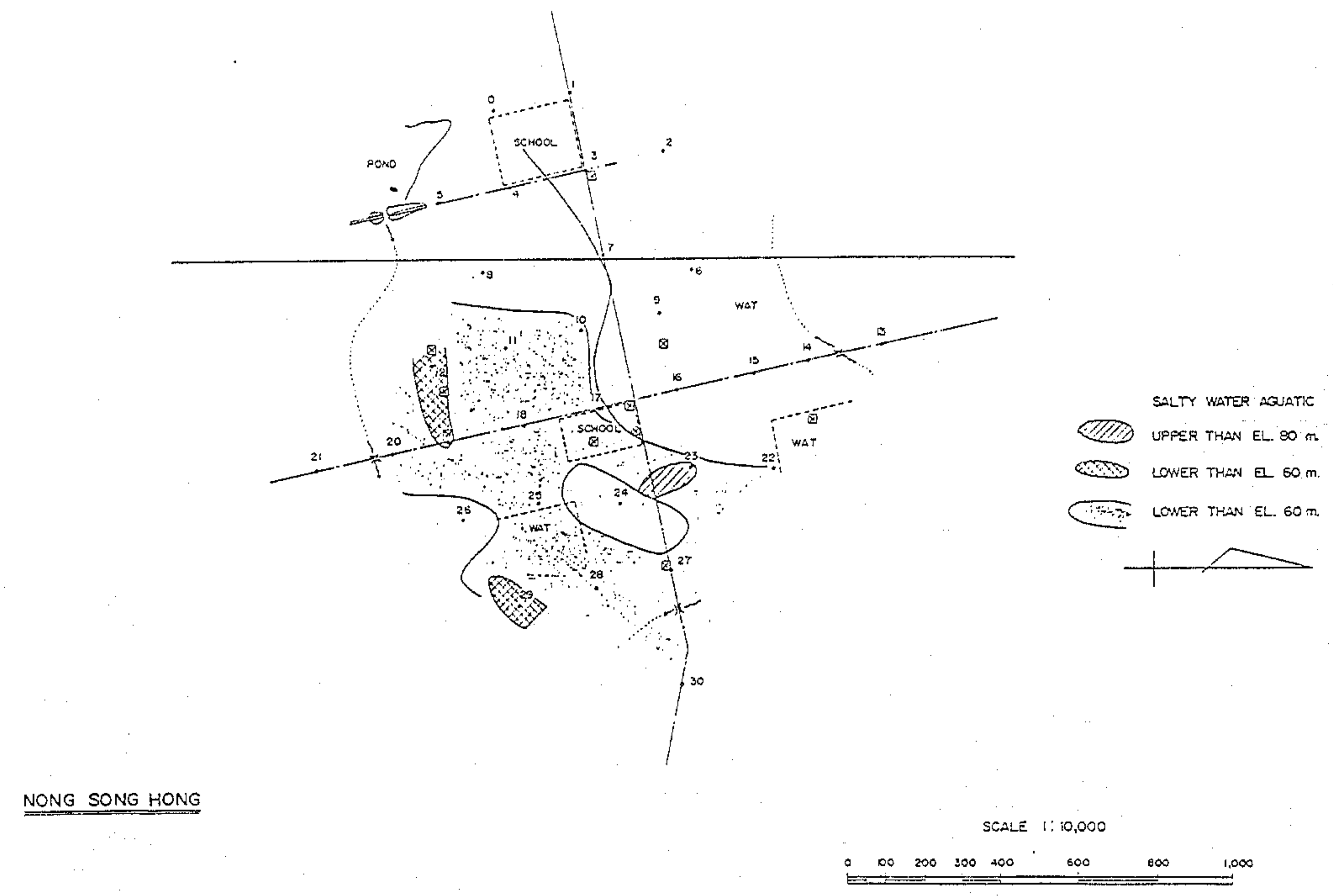
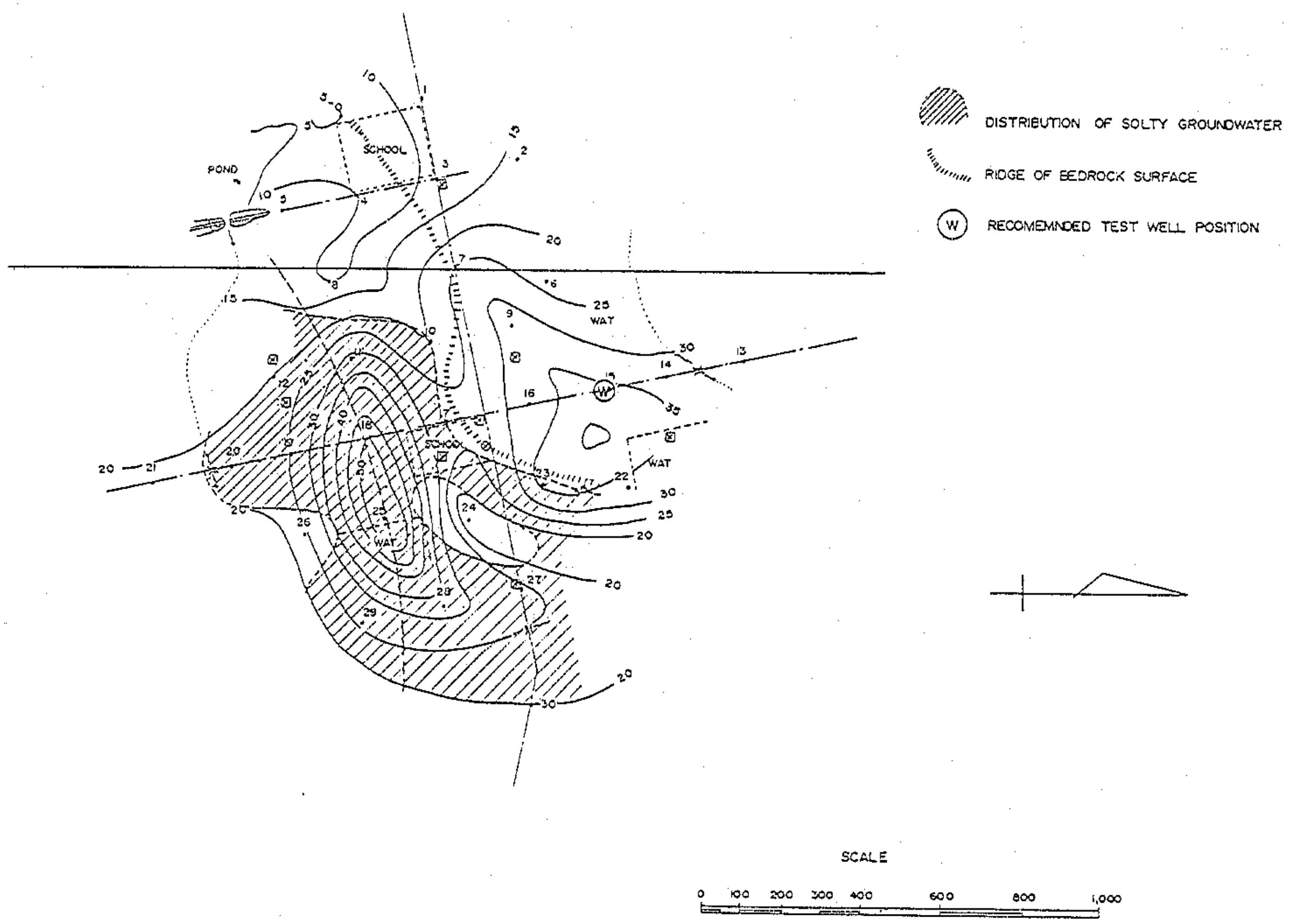


Figure A-4-10 Distribution of Salty Groundwater



NONG SONG HONG

Figure A-4-11 Equi-Thickness Contour Map of Weathered Rock Zone



A.4.5. Well Log and Result of Pumping Test

Figure A-4-12. Well Log at Kham Sake Sang

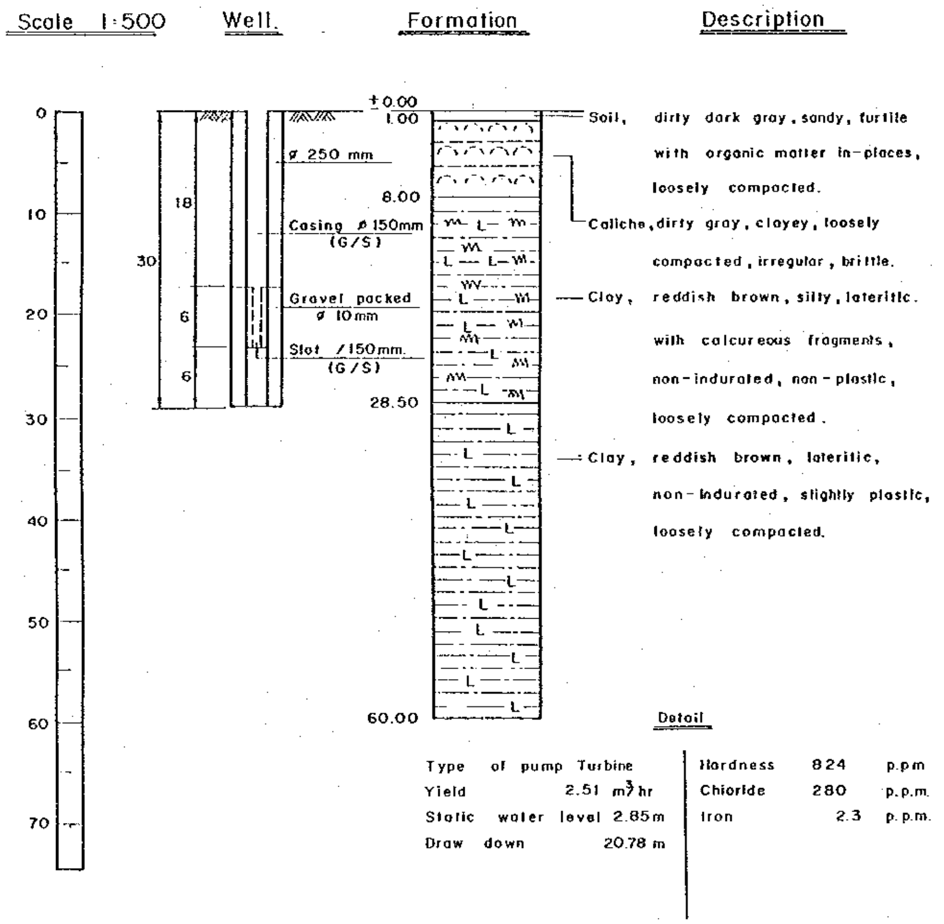


Figure A-4-13 Time-Residual Draw Curve at Kham Sakae Sang

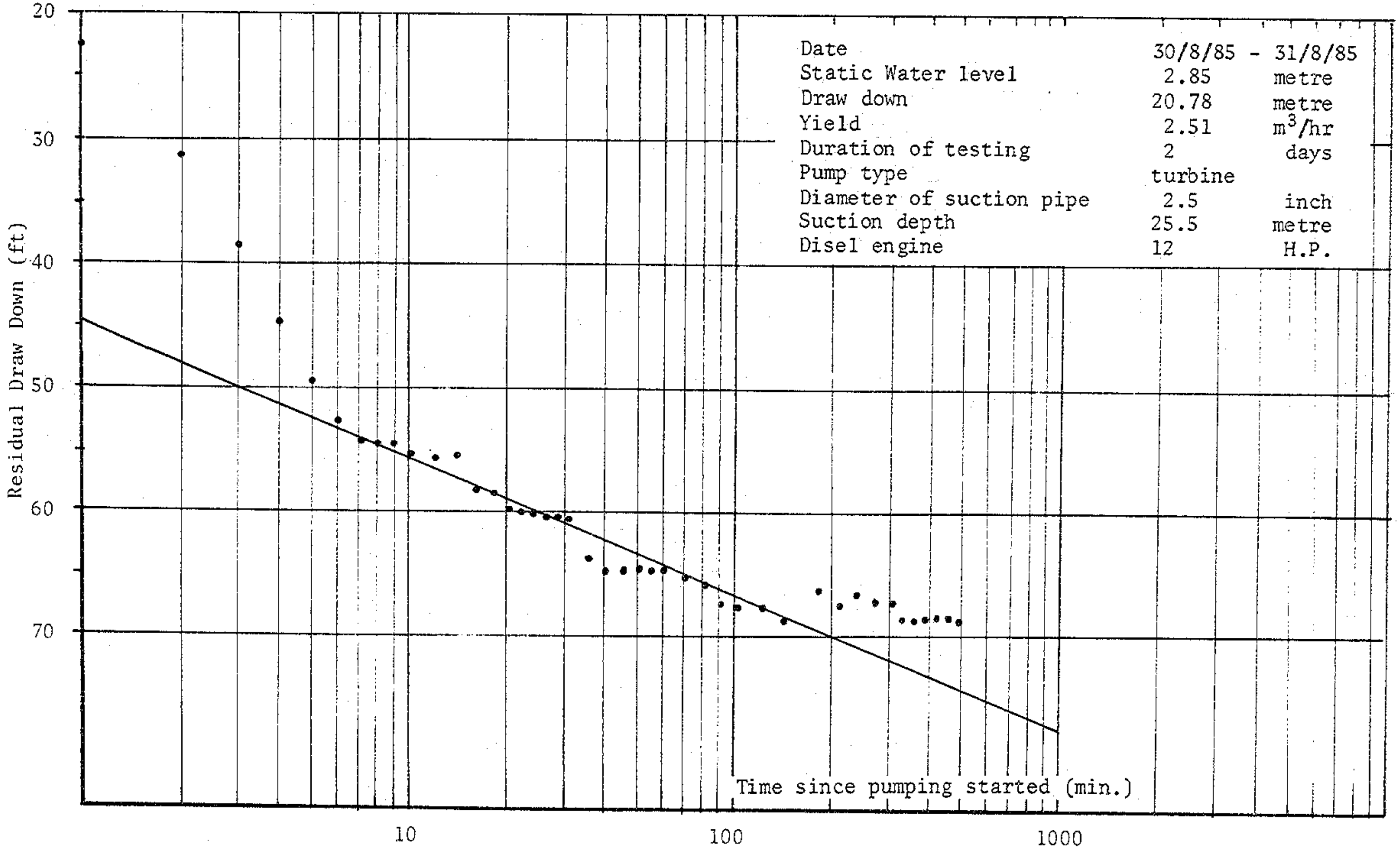
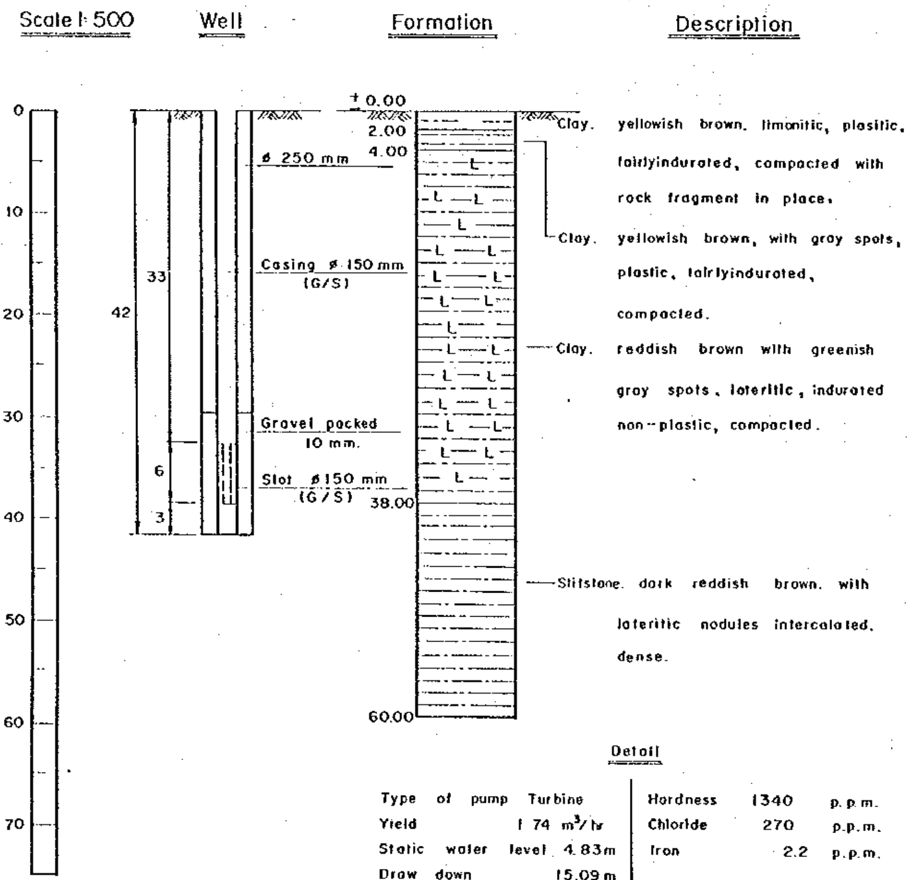


Figure A-4-14 Well Log at Huai Thalaeng



Detail

Type of pump	Turbine	Hardness	1340 p.p.m.
Yield	1.74 m^3/hr	Chloride	270 p.p.m.
Static water level	4.83 m	Iron	2.2 p.p.m.
Draw down	15.09 m		

Figure A-4-15 Time-Residual Draw Curve at Huai Thalaeng

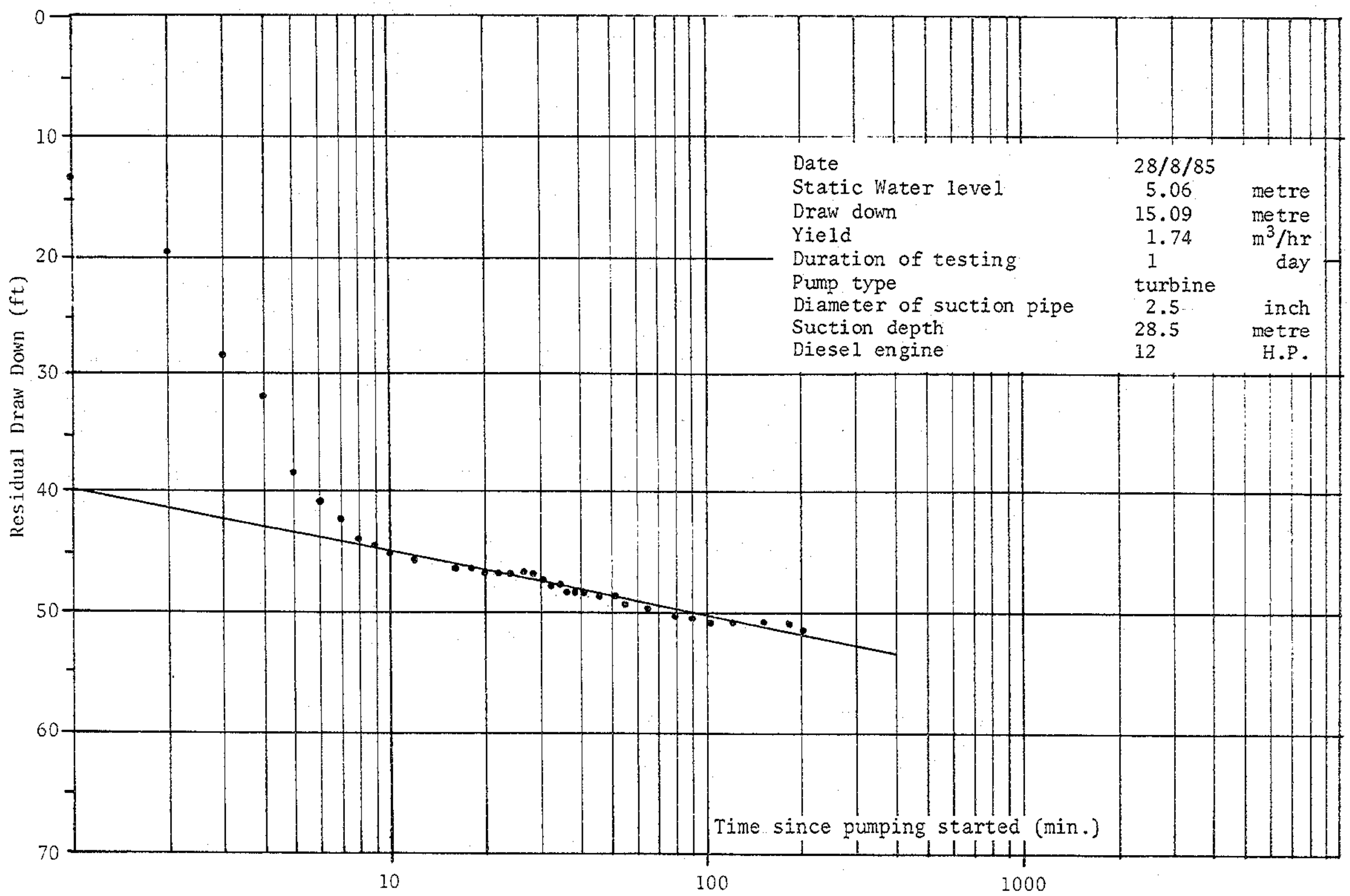
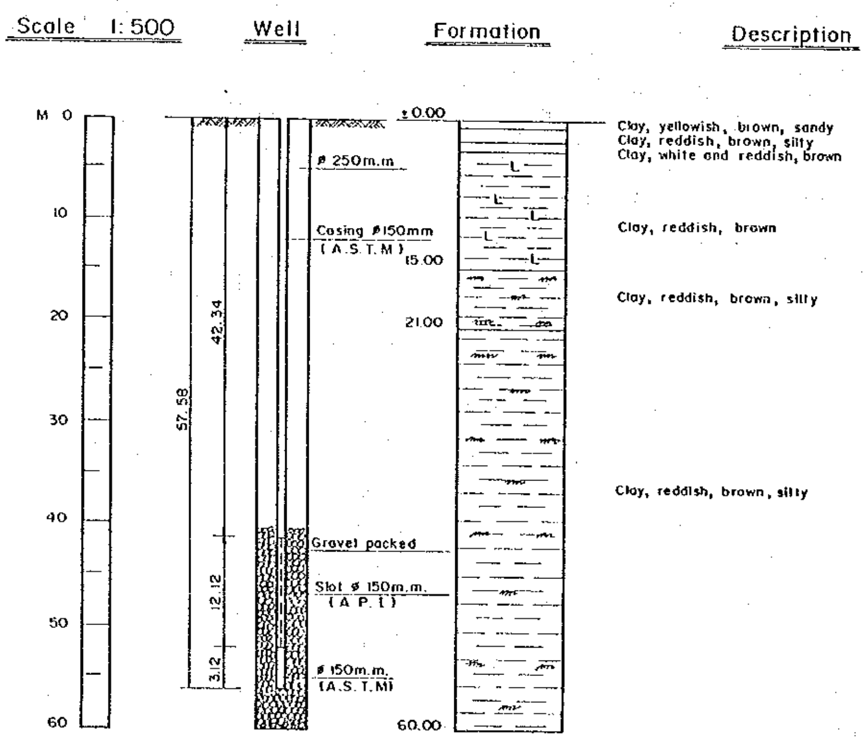


Figure A-4-16 Well Log at Kusuman



Detail

Type of pump	Turbine		Hardness	35.4	p.p.m.
Yield	18.40	m^3/hr.	Chloride	70	p.p.m.
Static water level	3.50	m.	Iron	0.71	p.p.m.
Draw Down	6.6	m.			

Figure A-4-17 Time-Residual Draw Curve at Kusuman

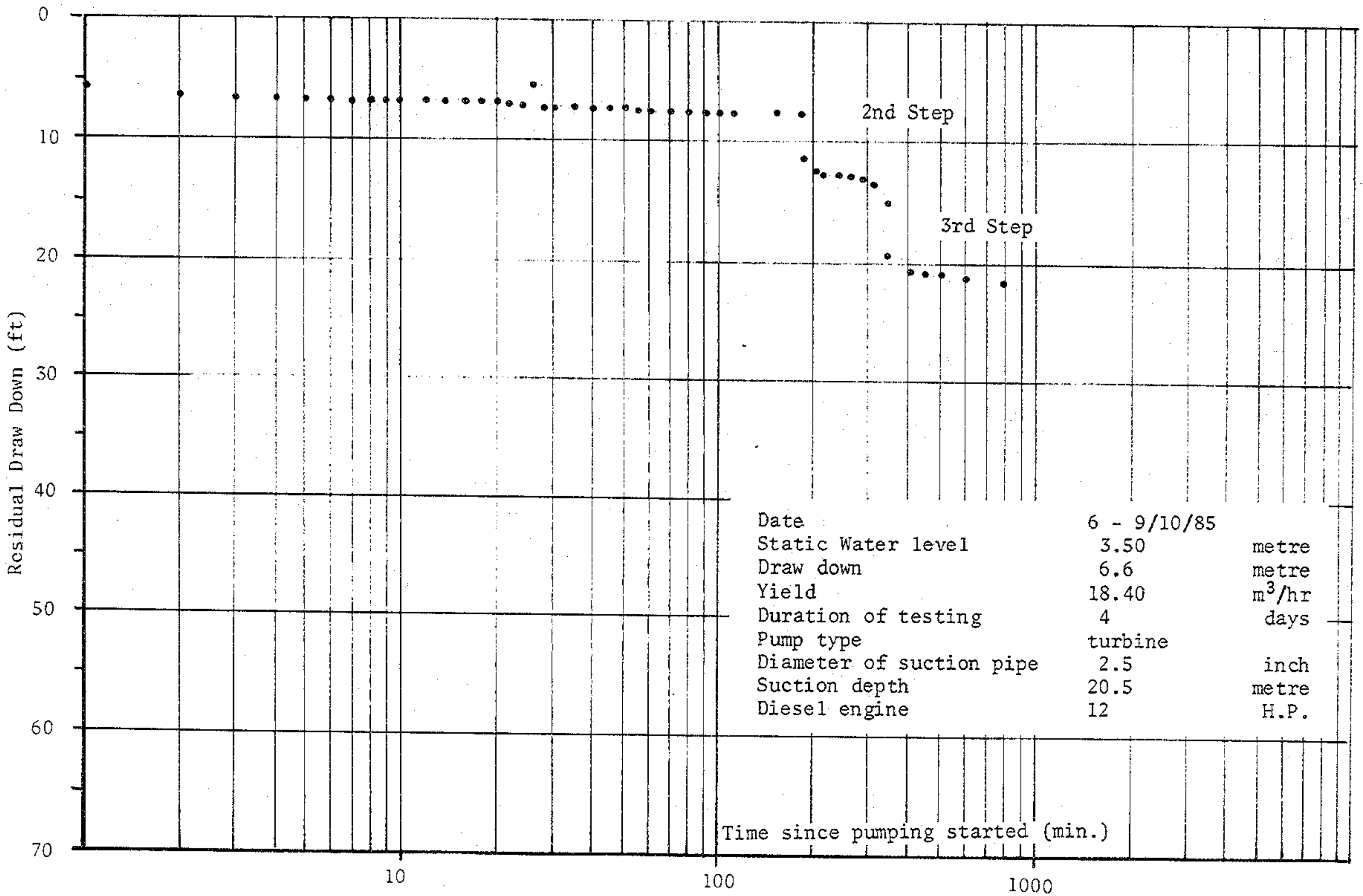
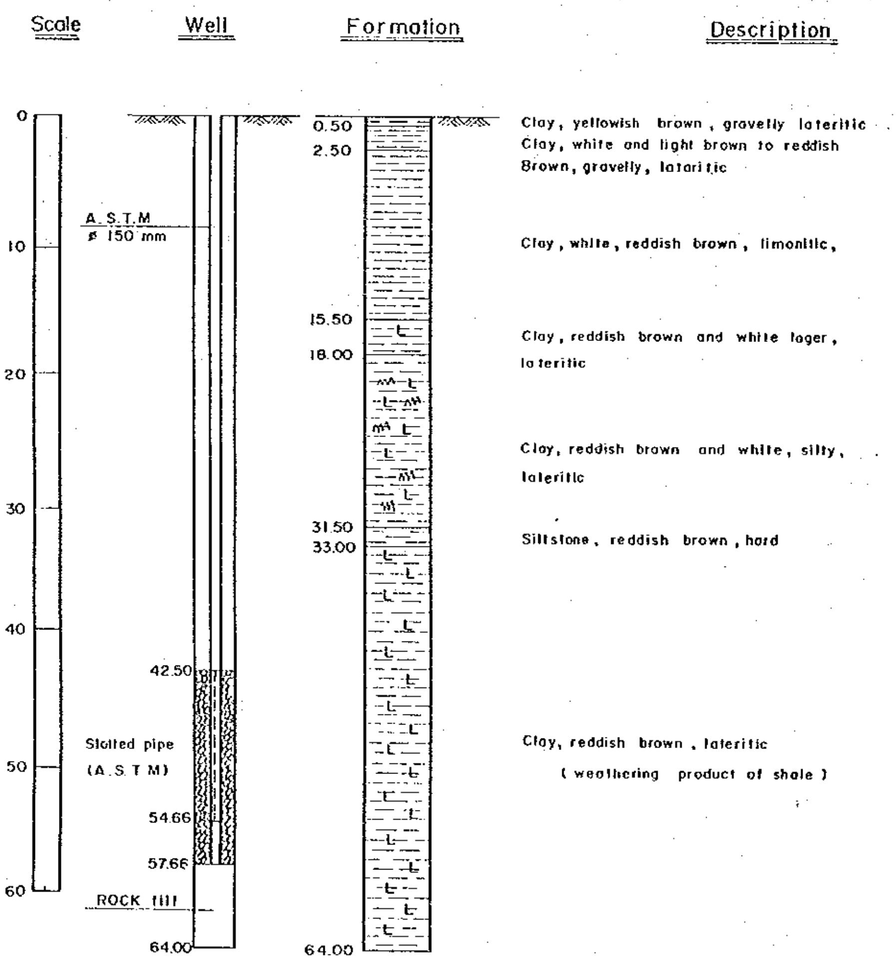


Figure A-4-18 Well Log at Phon Charoen



Detail

Type of pump	Turbine	Hardness	190 p.p.m.
Yield	9.97 m^3/hr	Chloride	8.0 p.p.m.
Static water level	2.5 m	Iron	0.55 p.p.m.
Draw down	18.18 m		

Figure A-4-19 Time-Residual Draw Curve at Phon Charoen

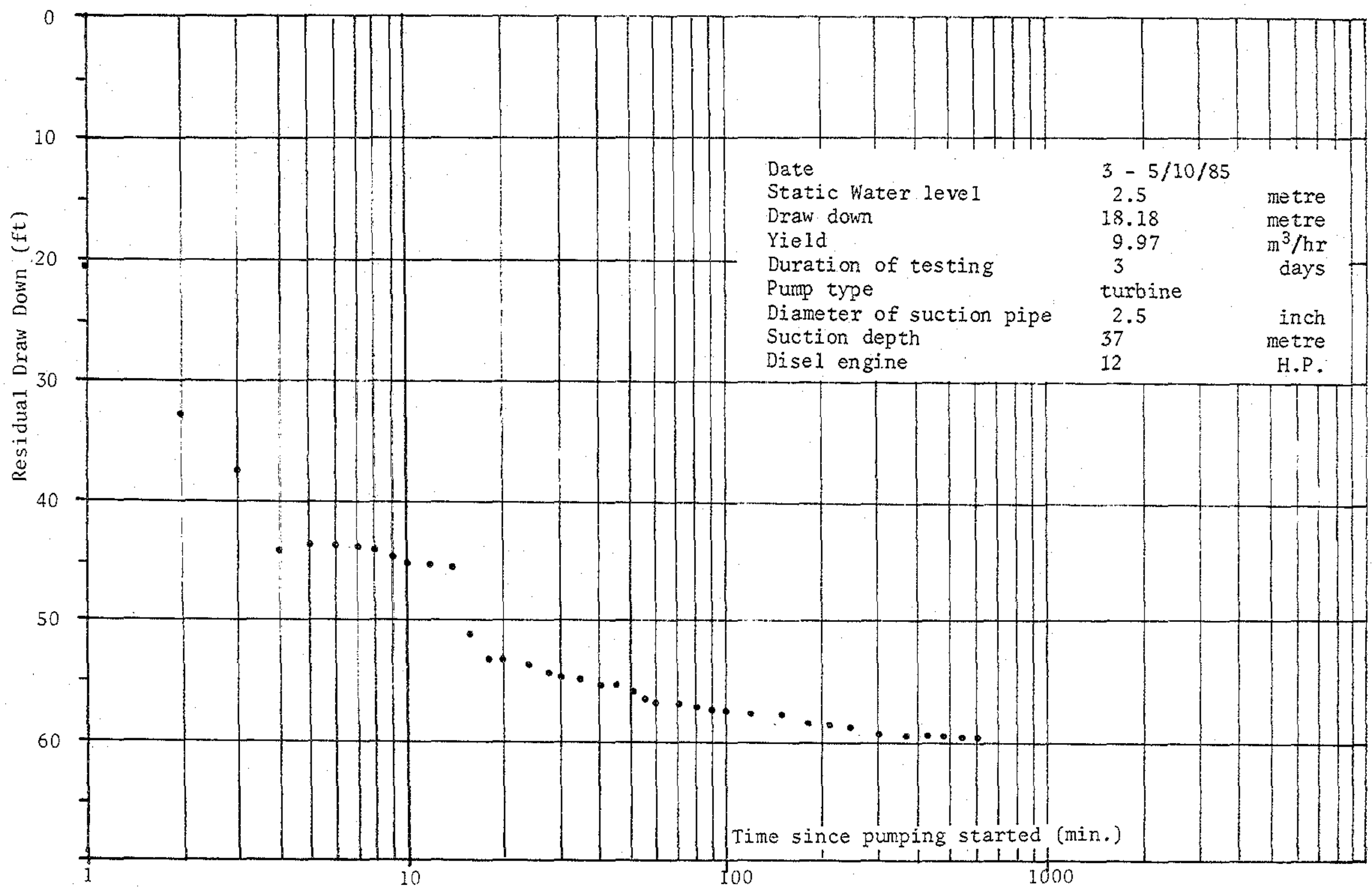
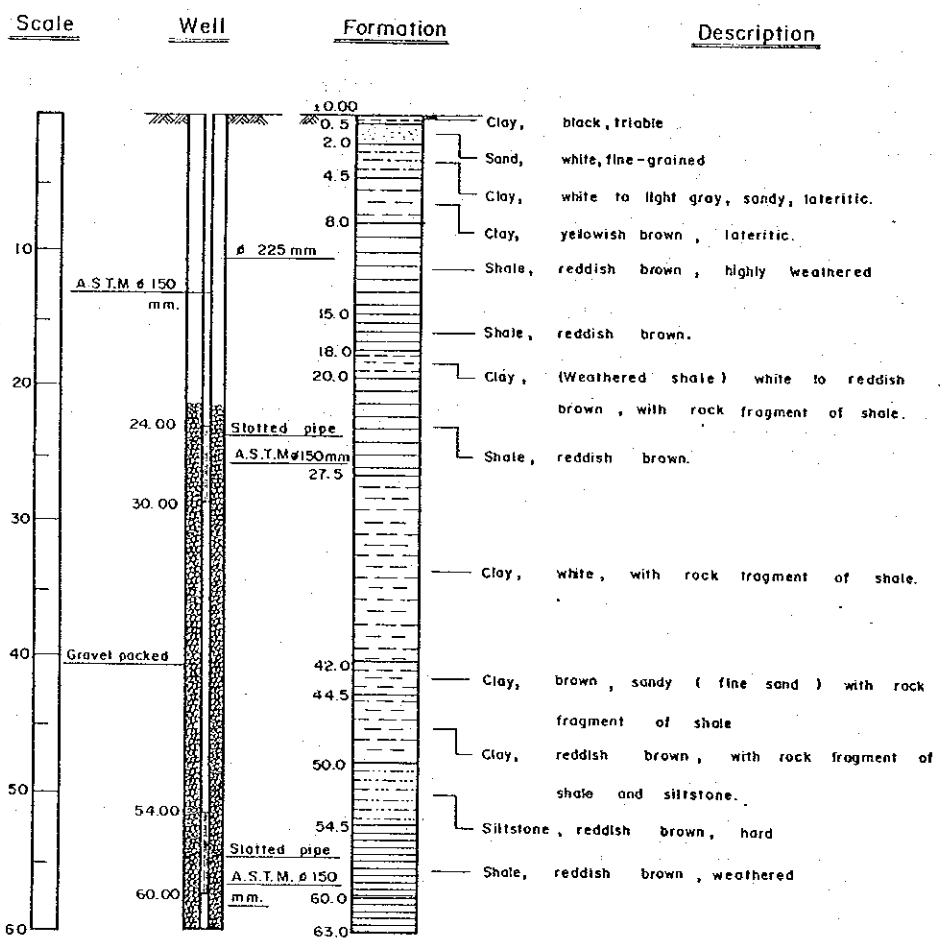


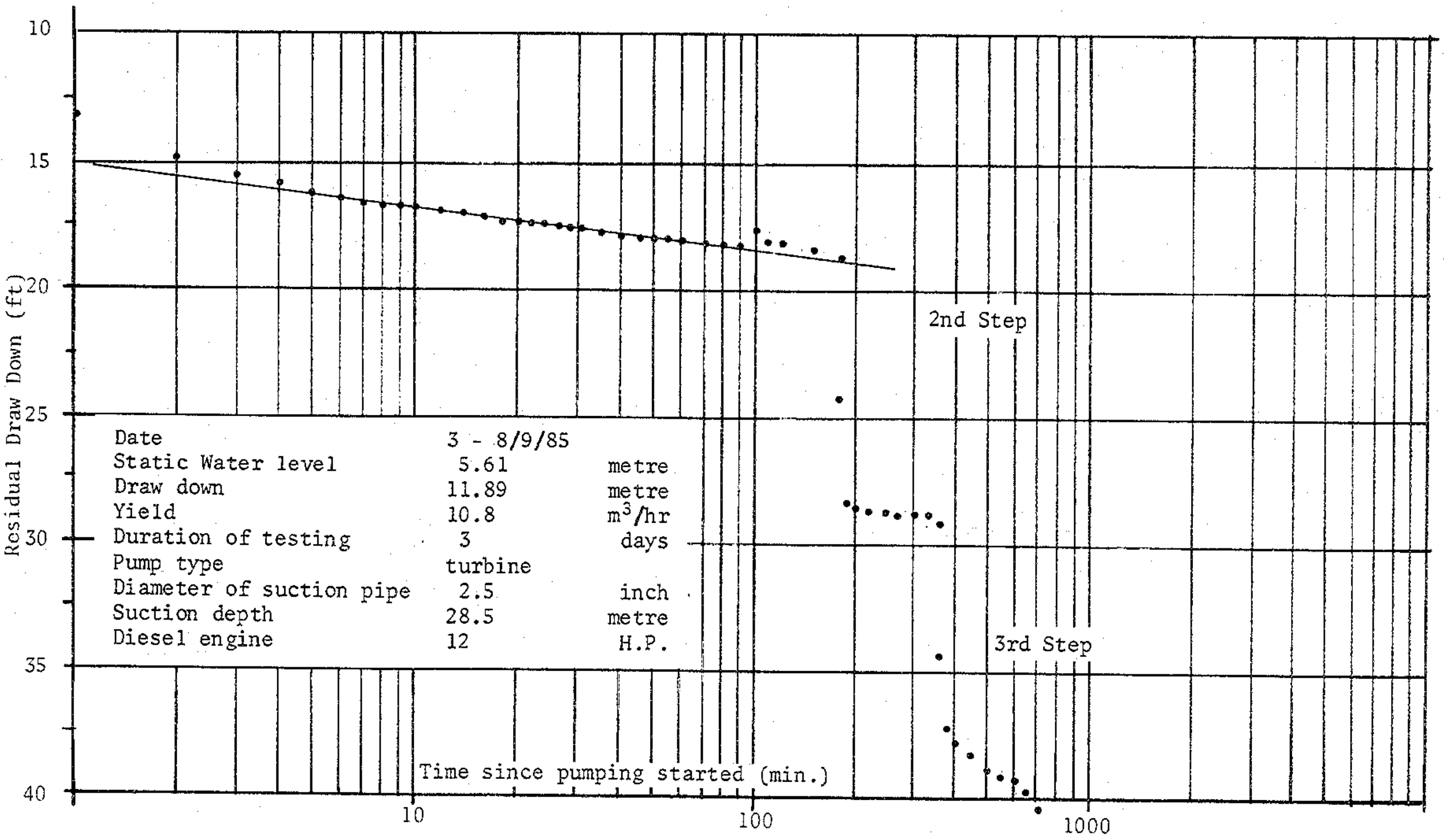
Figure A-4-20 Well Log at Nong Song Hong



Detail

Type of pump	Turbine		Hardness	240	p.p.m.
Yield	10.8	m^3/hr.	Chloride	6.0	p.p.m.
Static water level	5.61	m.	Iron	0.88	p.p.m.
Draw Down	11.89	m.			

Figure A-4-21 Time-Residual Draw Curve at Nong Song Hong



Date	3 - 8/9/85	
Static Water level	5.61	metre
Draw down	11.89	metre
Yield	10.8	m^3/hr
Duration of testing	3	days
Pump type	turbine	
Diameter of suction pipe	2.5	inch
Suction depth	28.5	metre
Diesel engine	12	H.P.

A.5. WATER QUALITY

LIST OF TABLES

Table A-5-1 Water Source of ESD

NO.	SD Name	Construction Year	Source	Capacity	Status	Remark
1	Cho Ho	1977	Lam Takhong reservoir	-	Sufficient	
2	Nong Thai	1972	Pond	800,000cu.m	Shortage	Planning of intake canal
3	Prang Ku	1970	Deep Well	11,000cu.m/ year	Shortage	Water source will be changed into river
4	Tha Rae	1968	Nong Han Lake	-	Sufficient	
5	Akat Amnuai	1969	Deep Well	53,000cu.m/ year	Sufficient	Water source will be changed into reservoir
6	Sangkha	1975	Reservoir	300,000cu.m	Sufficient	
7	Ban Phu	1966	Deep well	57,000cu.m/ year	Sufficient	
8	Khuang Nai	1970	Deep well	25,000cu.m/ year	Shortage	Water source will be changed into reservoir
9	Chanuman	1972	Mekhon rivel	-	Sufficient	
10	Khamcha-i	1984	Huai Muk reservoir	6.3MCM	Sufficient	

Note : Yield of well has been estimated by water charge.

Table A-5-2 Drinking Water Standards[*1/], 1978

Item	Highest Desirable Level	Maximum Permissible Level
1. Physical Condition		
Colour	5	15
Taste	Unobjectionable	Unobjectionable
Odour	Unobjectionable	Unobjectionable
Turbidity	5	20
PH range	6.5 to 8.5	Under 9.2
2. Chemical Condition (unit: ppm)		
Total solids	500	1,500
Fe	0.5	1.0
Mn	0.1	0.3
Fe + Mn	0.5	1.0
Cu	1.0	1.5
Zn	5.0	15
Ca	75	200
Mg	50	150
So_4	200	250
Cl	250	600
F	0.7	1.0
NO_3	45	45
Alkylbenzyl sulfonates, ABS	0.5	1.0
Phenolic-substances, as phenol	0.001	0.002
3. Toxin (unit: ppm)		
Hg	0.001	
Pb	0.05	
As	0.05	
Se	0.01	
Cr Hexavalent	0.05	
CN	0.2	
Cd	0.01	
Ba	1.0	
4. Bacteriological Condition		
Total Standard	500	
Place count/ml	< 2.2	
MPN/100 mℓ E. Coil	0	

Note: *1 ..... Data Source PWD. Laboratory Office

Table A-5-3 Raw Water Quality of Surface Water in ESD

Sampling Date Nov., Dec./1984

No.	ESD	Water Source	Treatment System	PH	Turb. unit	Temp. °C	DO ppm	COND ms/cm^2	Alkali ppm	Chlorid ppm	Jar Test Floc forming	Jar Test Alum feeding ppm	Capacity m^3/Hr
1	Cho Ho	Reservoir	RA	7.8	45	28.2	2.5	0.5	157	92	4/5	20	50
2	Non Thai	Pond	RB	7.1	80	26.7	2.7	0.6	78	102	4/5	20	30
4	Tha Rae	Reservoir	RA	7.4	6	24.0	2.5	0.3	40	18	2/5	10	50
6	Sankha	Reservoir	RB	7.1	18	27.0	4.7	0.1	20	11	2/5	10	30
9	Chanuman	River	RA	8.0	144	24.6	4.2	0.7	75	14	4/5	20-30	20
10	Kham Chai	Reservoir	RA	7.5	9	22.8	3.3	0.2	45	4	2/5	10	30

Remarks:
- RA ; Rapid sand filtration process standard
- RB ; Rapid sand filtration process simple type standard
- Turb. ; Turbidity (NTU)
- Temp. ; Temperature
- DO ; Dissolved oxygen
- COND ; Electric conductivity (min. semens/cm^2)
- Jar Test ; Floe forming index 5 is best condition and Alum feeding is nearly amount it.

Table A-5-4 Raw Water Quality of Ground Water in ESD

Item	Unit	[3] Prang Ku	[5] Akat Amnuai			[7] Ban Phu	[8] Khuang Nai
1. Water Source	-	Ground Water	Ground Water			Ground Water	Ground Water
2. Treatment System	-	C	C			A + RA	A + RA
3. PH	-	7.5	7.5	9.0	7.6	8.4	6.0
4. Turb. unit	-	5	5	8	5	7	10
5. Temperature	°C	31.6	25.5	21.7	27.7	25.0	27.0
6. DO	ppm	3.1	0.4	2.2	1.6	2.1	3.3
7. COND	ms/cm^2	1.9	0.5	0.2	0.5	1.7	0.7
8. Alkali	ppm	-	-	-	-	205	15
9. Chlorid	ppm	-	-	-	-	540	56
10. Setting Water							
- PH	-	-	-	-	-	-	6.0
- Turb.	ppm	-	-	-	-	-	8
11. Filtrated Water							
- PH	-	-	-	-	-	8.5	6.0
- Turb.	ppm	-	-	-	-	7	7
12. Capacity	m^3/Hr	10	30	-	-	20	30

Remark: Treatment System C ; Chlorination process

Treatment System A + RA; Aeration and Rapid Sand Filtration Process

Water Quality Unit is same as Table 3-3-1.

Table A-5-5 Raw Water Quality of Water Source in New Proposed Area (1)

17 June to 11 July, 1985
(11 November to 16 December, 1984)

No.	NSD	Samples	PH	Turb. (unit)	Color (unit)	$KMnO_4$ consum-tion (mg/ℓ)	Hardness (mg/ℓ) as $CaCO_3$	Ca (mg/ℓ)	Mg (mg/ℓ)	Fe (mg/ℓ)	CI (mg/ℓ)	Alka-lity (mg/ℓ)	Sample No.	Jar Test Floc Form	Jar Test Alum Feeding
5	Kham Sakae Song	Surface Water Bunchiwuk Reservoir	(7.8) 6.7	(50.0) 22.0	(-) 25	(-) 30.5	(-) -	(-) -	(-) -	(-) 0.1	(-) 900	(-) 86	S_3	4/5	20-30
"	"	Surface Water Temple Pond	7.1	14.5	10	29.0	-	-	-	0.9	65.0	126	S_4		
"	"	Deep Well Temple	8.0	8.0	none	-	146	32	16	0.35	417.5	928	G_1		
6	Nong Bua Lai	Surface Water Nong Sanp Reservoir	(7.3) 7.5	(36.0) 54.5	(-) 15	(-) 28.5	(-) -	(-) -	(-) -	(-) 9.0	(11) 19.0	(50) 73	S_7	4/5	20-30
"	"	Deep Well No. 11 Muban	6.9	16.5	10	-	412	115	30	6.8	211.5	316	G_6		
7	Huai Thalaeng	Surface Water Nong Takai Reservoir	(7.15) 7.4	(7.0) 12.0	(-) 15	(-) 20.8	(-) -	(-) -	(-) -	(-) 1.2	(19) 15.0	(83) 146	S_5		
"	"	Deep Well Amphoe office	7.9	20.0	10	-	330	107	15	3.8	11.5	421	G_2		
"	"	Deep Well Hospital	7.6	9.0	none	-	592	160	49	1.8	108.5	476	G_3		
"	"	Deep Well School	7.3	86.0	15	-	364	111	21	10	6.5	474	G_4		
"	"	Deep Well Market	7.0	88.0	15	-	442	147	18	25	760	430	G_5		
"	"	Surface Water Lam Chamuak Reservoir	7.6	8.0	5	7.6	-	-	-	0.9	8.0	49	S_6		
8	Nong Ki	Surface Water Toong Katen Reservoir	(7.0) 7.5	(207) 34.0	(-) 30	(-) 30.8	(-) -	(-) -	(-) -	(-) 2.25	(41) 20.0	(82) 148	S_9	4/5	40
"	"	Deep Well 2nd School	7.0	12.5	none	-	424	98	44	2.8	8.5	492	G_7		
"	Nong Ki	Deep Well Temple	7.6	6.0	none	-	214	50	22	0.4	183.0	476	G_8		

Note : Underlined figure is comparatively high value
Jar Test : Floc Forms/S is best condition
: Alum Feeding rate mg/ℓ
: Ca Feeding rate mg/ℓ

Table A-5-5 Raw Water Quality of Water Source in New Proposed Area (2)

No.	NSD	Samples	PH	Turb. (unit)	Color (unit)	$KMnO_4$ consum-tion (mg/ℓ)	Hardness (mg/ℓ)as $CaCO_3$	Ca (mg/ℓ)	Mg (mg/ℓ)	Fe (mg/ℓ)	CI (mg/ℓ)	Alka-lity (mg/ℓ)	Sample No.	Jar Test Floc Form	Jar Test Alum Feeding
8	Nong Ki	Deep Well School	8.2	5.5	none	-	136	31	14	0.1	54.5	434	G_9		
"	"	Deep Well Hospital	7.1	6.0	none	-	492	108	54	0.1	847.5	128	G_{10}		
10	Huai Rat	Surface Water Ram Huai Rat River	(7.4) 7.3	(17.8) 220.0	(-) 20	(-) 28.5	(-) -	(-) -	(-) -	(-) 10	(9) 13.0	(69) 63	S_9	4/5	40
12	Khun Han	Surface Water Nong Si Reservoir	(6.8) 6.4	(7.5) 5.9	(-) -	(-) -	(-) 16	(-) 3	(-) 1.9	(-) 0.44	(7) 4.0	(20) -	- S_5	2/5	Alum 10 Ca 10
13	Kusuman	Surface Water Huai Daeng Reservoir	(6.9) 7.5	(7.5) 30.0	(-) 20	(-) 7.4	(-) -	(-) -	(-) -	(-) 1.15	(7) 4.5	(19) 17	S_{11}	2/5	Alum 20 Ca 10
"	"	Deep Well Temple	8.1	4.0	none	-	50	16	2	0.2	57.0	242	G_{11}		
"	"	Deep Well Market	7.7	5.5	none	-	1,712	614	92	0.9	8,500	90	G_{12}		
"	"	Deep Well Amphoe office	7.9	24.0	30	-	354	109	21	4.0	7.0	328	G_{13}		
17	Phon Charoen	Surface Water Nong Loeng Reservoir	(8.3) 6.8	(25.0) 16.0	(-) 30	(-) 22.8	(-) -	(-) -	(-) -	(-) 0.45	(-) 7.5	(-) 10	S_{13}	2/5	Alum 20 Ca 20
"	"	Deep Well Spring No.1	8.0	5.0	none	-	194	64	8	0.7	54.0	240	G_{16}		
"	"	Deep Well Temple Road No.2	6.7	10.5	15	-	92	22	9	3.0	8.0	100	G_{17}		
18	Nong Song Hong	Surface Water Nong Song Hong Reservoir	(7.25) 7.2	(9.1) 9.5	(-) 15	(-) 13.7	(-) -	(-) -	(-) -	(-) 0.85	(8.0) 3.0	(20) 20	S_{12}	2/5	Alum 10 Ca 10
"	"	Deep Well Elevated Tank	8.2	3.0	none	-	240	81	9	0.2	15.0	294	G_{14}		
"	"	Deep Well No.11 Muban	6.8	176.0	20	-	54	10	7	25	39.0	48	G_{15}		
20	Huai Kha Yung	Surface Water Huai Kha Yung River	(7.05) 7.4	(20.5) 40.0	(-) 15	(-) 21.5	(-) -	(-) -	(-) -	(-) 2.85	(10.0) 7.5	(24) 34	S_{10}	2/5	Alum 30 Ca 15

APPENDIX B. ALTERNATIVE PLANS

APPENDIX B: ALTERNATIVE PLANS

B.1. DESIGN CRITERIA

B.2. SELECTIVE COMPARISON OF ALTERNATIVE PLANS

B.1. DESIGN CRITERIA

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

B.1. Design Criteria

B.1.1. Hydraulic Design

(1) Water Demand of Facilities

MDWS = Maximum Daily Water Supply
= 150 l/c/d x population x 1/1,000 (cu.m/d)

MHWS = Maximum Hourly Water Supply
= 150 l/c/d x 1.5 x population x 1/1,000 (cu.m/d)

FFWS = Fire Fighting Water Demand
Population $\geqq$ 10,000 FFWS = 0.50 cu.m/min
Population < 10,000 FFWS = 0.26 cu.m/min

Design capacities of each facilities are follows.

Description	Water Demand cu.m/d
Intake, Water Transmission	MDWS x $(1 + \alpha)$
Treatment Plant	MDWS
Distribution Pipeline	MDWS or MHWS + FFWS

Note: α; Miscellaneous losses 10%

(2) Hydraulic Formula

(a) Pipeline

Hazen William's formula

$$I = 10.666\ C^{-1.85} \times D^{-4.87} \times Q^{1.85}$$

I: Hydraulic gradient
C: Velocity coefficient
D: Pipe diameter(m)

C-Value

Pipe	Transmission	Distribution
Mortal Lining Pipe	130	110
Asbestos Cement Pipe	140	110
Polyvinyl Pipe	140	110

For actual calculation ot distribution pipeline, C-value is adopted 110 taking into account miscellaneous losses such as bend loss, valve loss and so forth.

(b) Open Canal

Manning's formula

$$Q = A \times V \qquad V = \frac{1}{n} \times I^{1/2} \times R^{2/3}$$

A: Flow area (m^2)
V: Flow Velocity (m/s)
R: Hydraulic mean depth (m)
n: Coefficient of roughness
Earth canal n = 0.03
Reinforced concrete N = 0.015

(c) Weir

Fransi's formula (Rectangular weir)

$$Q = 1.833\ B \times H^{3/2}$$

B: Weir width
H: Flow depth over the weir

(d) Head losses

$$he = \alpha \times \frac{V^2}{2g}$$

α: Coefficient of loss

(3) Standard Velocity of Pipeline

Pipe Diameter	Design Velocity
ø50 - 150	0.5 - 1.0 m/s
ø200 - 400	0.7 - 1.6 m/s

B.1.2. Study on Optimum Velocity of Pump Pressurized Pipeline

The Study on the relationship between optimum velocity and pipe diameter for in the pressuring pipeline was carried out to optimize diameter of pipe from the viewpoint of pipe construction cost to be installed and pressuring power cost ot the pump systems.

Annual total Cost; T.C. = α x A + β x B

A: Pipeline cost
B: Electricity tariffs
: Accumulated present worth factor for construction cost $\alpha = 0.9465$
: Accumulated present worth factor for power cost $\beta = 8.3045$

(1) Discharge

Q = 50 and 100 cu.m/hr

(2) Pipe Unit Price and Annual Cost

Diameter (mm)	Price (฿/m)	Annual Cost (฿/y)
100	150	161
150	250	237
200	400	379
250	550	521
300	760	719

(3) Electricity Tariff

Demand charge: 95 Baht/kwh

Energy charge: 1.5 Baht/kwh

B = (95 + 1.5 x 24 x 30) x 12 x (kw) = 14,000 ฿/year

$$(kw) = 0.163 \times \frac{Q}{60 \times np} \times (1 + \alpha) \times he = 0.005930he$$

$np = 0.55$
$\alpha = 0.20$
$he = 10.666 \times C^{-1.85} \times D^{-4.87} \times Q^{1.85}$
$C = 100$

Q = 50 cu.m/hr

D mm	V m/s	I	(kW)	B	Annual Cost(฿)
100	1.783	0.04912	0.0146	206.0	1,710
150	0.792	0.00682	0.0020	28.0	232
200	0.446	0.00170	0.00051	7.2	60
250	0.285	0.00057	0.00017	2.4	20

Q = 100 cu.m/hr

D mm	V m/s	I	(kW)	B	Annual Cost(฿)
150	1.582	0.0246	0.0146	206.0	1,710
200	0.892	0.0061	0.0036	51.0	423
250	0.572	0.0020	0.0019	27.0	224
300	0.392	0.00084	0.0005	7.1	59

(4) Total annual cost

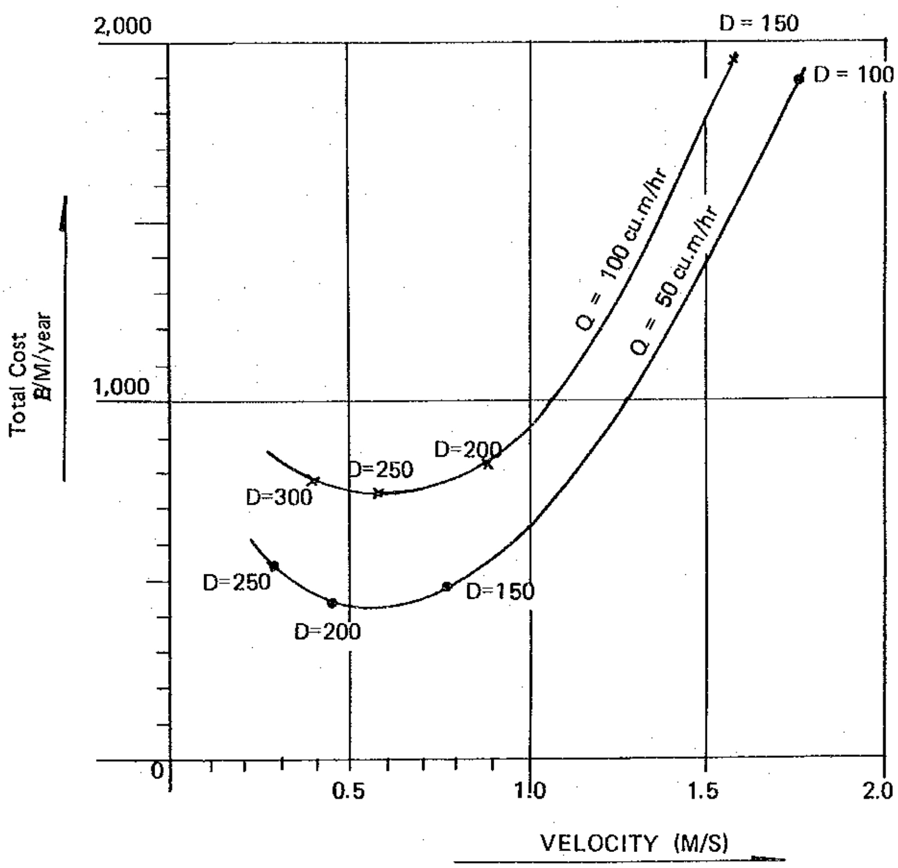
(Unit: ฿)

	Pipe Cost	Q = 50 cu.m/hr		Q = 100 cu.m/hr	
		Power Cost	Total	Power Cost	Total
100	161	1,710	1,871	-	-
150	237	232	469	1,710	1,947
200	379	60	439	423	802
250	521	20	541	224	745
300	719	-	-	59	778

(5) Conclusion

Economical velocity is 0.4 - 0.9 m/s as shown in Figure B-1-1.

Figure B-1-1 Economical Velocity



B.1.3. Capacity of Distribution Reservoir and Elevated Tank

The distribution reservoir is provided to balance the constant supply rate from the water source and treatment plant with the fluctuating water demand in the service area. The capacity should be large enough to accommodate the accumulative differences between water supply and demand.

The elevated tank is provided to supply the pressured water to the service area and its capacity should be the amount of water consumed during night, while pumps stop operating.

Their capacities are determined on the basis of the findings obtained from the field survey in Chonnabot sanitary district.

Variation of hourly water consumption in the district is shown in Figure B-1-2.

The following matters are observed in the figure.

- Maximum hourly water demand .... 78 m^3/h
- Maximum daily water demand .... 52 m^3/h
- Total water demand .... 945 m^3
- Total amount consumed during night from 10 PM to 5 AM .... 105 m^3

(1) The Capacity of Elevated Tank

$105 \div 52 \fallingdotseq 2$ hours

Therefore, the capacity is to be two hours' volume of the maximum daily water demand.

(2) The Capacity of Distribution Reservoir

The capacity is determined by considering the inflow amount, operation time of pump, capacity of elevated tank and water consumption.

The required capacity is 276 cu.m as described in Table B-1-1 and Figure B-1-3.

By adding the amount of water for fire-fighting to the said required capacity,

$$(276 + 30)/52 = 5.9 \rightarrow 6.0 \text{ hours}$$

Therefore, the capacity is to be six hours' volume of the maximum daily water demand.

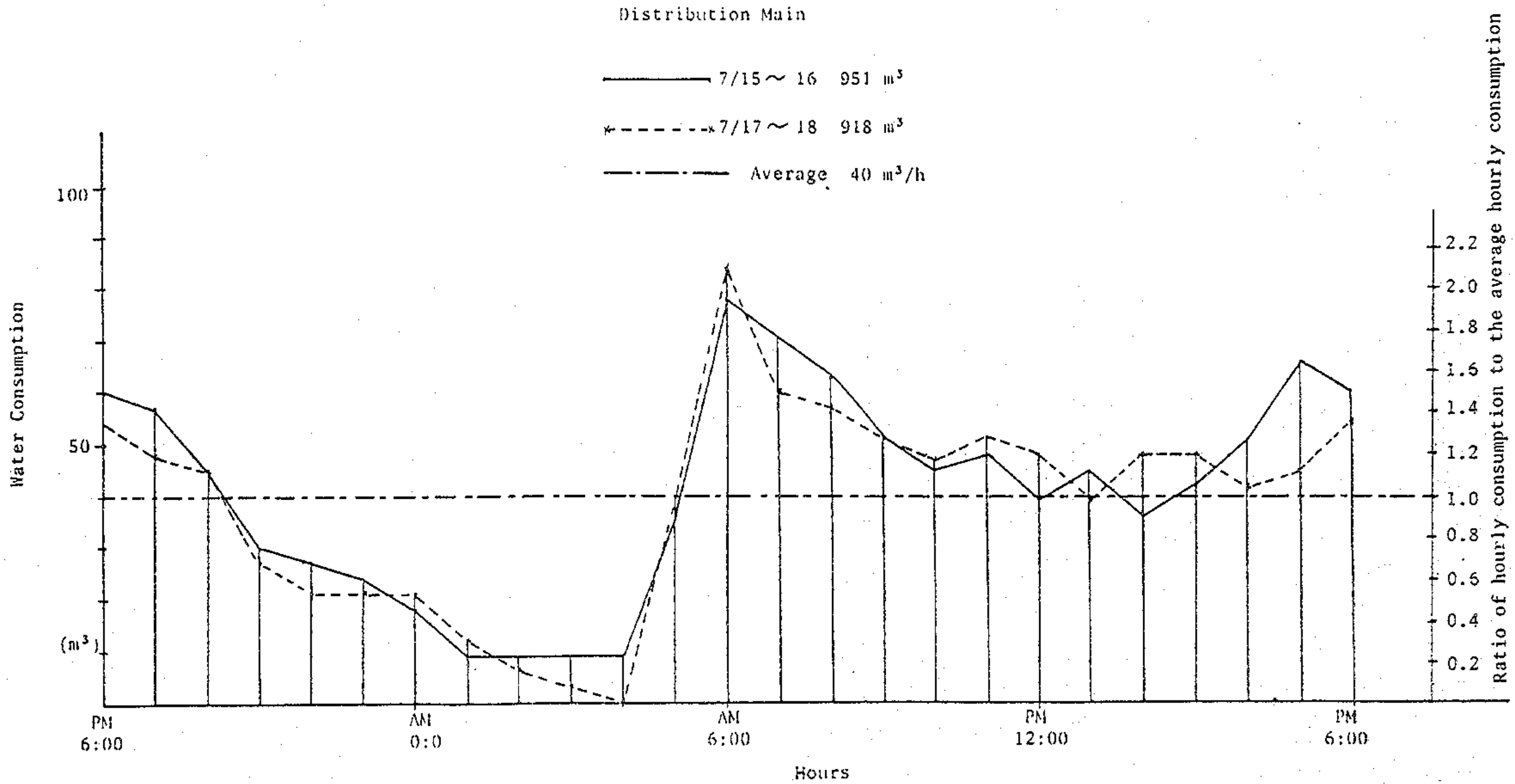


Figure B-1-2. Variation of hourly Water Consumption

Table B-1-1 Water Balance Computation

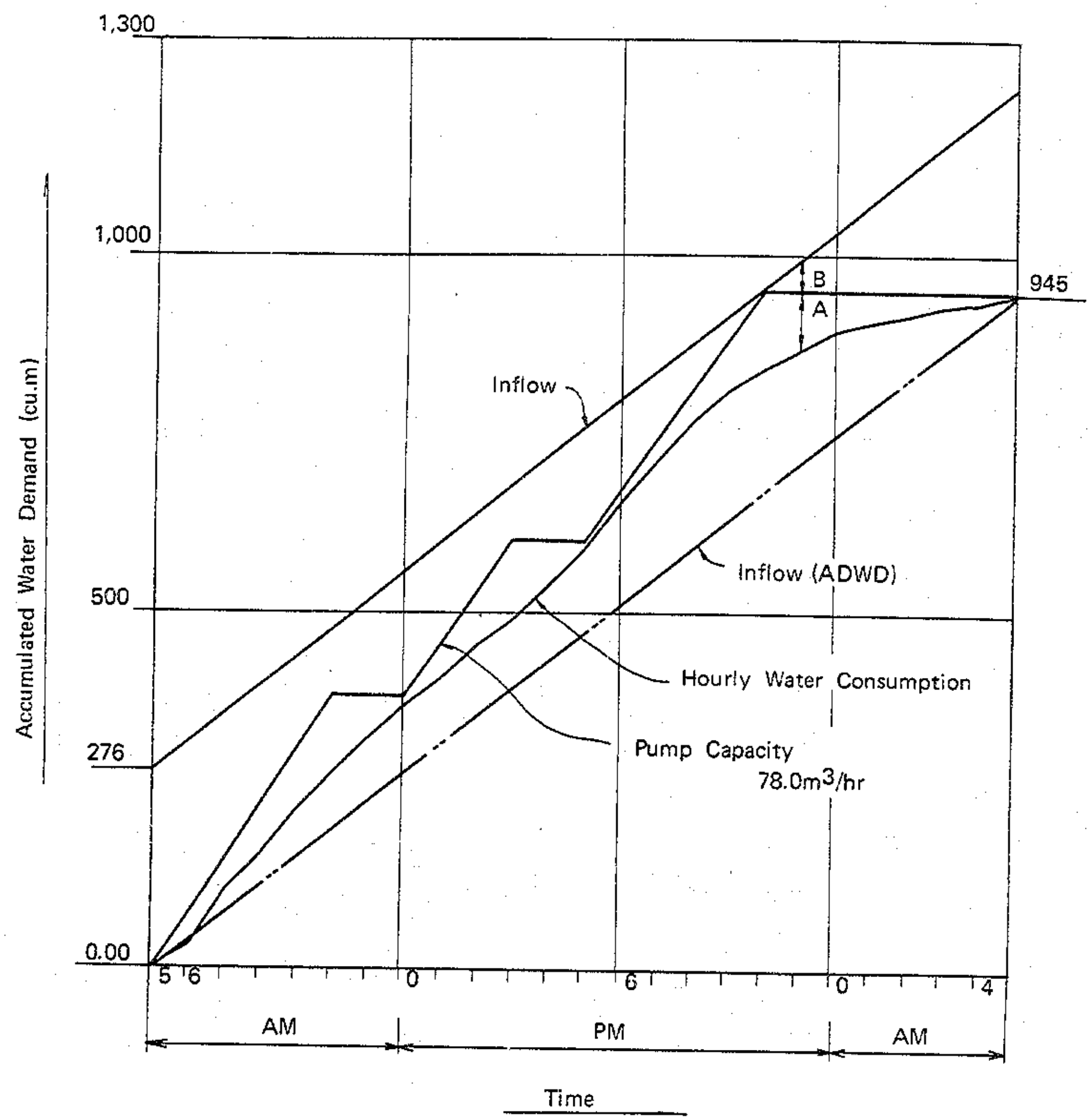
Time	Inflow	Pump Up	Consumption	Storage Volume (m^3) Total (276)	Elevated Tank	Reservoir (276)	Remarks
5~6 PM	39.4	78	36	279	42	237	
7	39.4	78	78	241	42	199	
8	39.4	78	48	238	72	160	
9	39.4	78	63	209	87	122	
10	39.4	(78)	51	197	104	93	
11	39.4	-	45	191	59	132	
12	39.4	-	48	183	11	172	
1	39.4	78	39	183	50	133	
2	39.4	78	45	178	83	95	
3	39.4	(78)	36	181	104	77	
4	39.4	-	42	178	62	116	
5	39.4	-	51	167	1	166	
6	39.4	78	66	140	23	117	
7	39.4	78	60	119	41	78	
8	39.4	78	57	102	62	40	
9	39.4	78	45	96	95	1	
10	39.4	(78)	30	105	105	0	
11	39.4	-	27	118	78	40	
12	39.4	-	24	133	54	79	
1 AM	39.4	-	18	155	36	79	
2	39.4	-	9	185	27	119	
3	39.4	-	9	215	18	158	
4	39.4	-	9	246	9	197	
5	39.4	-	9	276	0	276	

(276) ----- Initial storage volume

(78) ----- Not full operating in one hour

Total operating hours is 6 hrs.

Figure B-1-3 Capacity of Distribution Reservoir and Elevated Tank



A; Strage Volume of the Elevated Tank
Amax = 105m3 (2.0 hrs)

B; Strage Volume of the Distribution Reservoir
Bmax = 276m3 (5.3 hrs)
(Initial straged Volume)

MHWD ----- 78m3/hr
MDWD ----- 52m3/hr
ADWD ----- 39.4m3/hr

Hourly Water Consumption
Data Source ----- Chonnabot SD

B.1.4. Distribution Pipeline Materials

(1) Water Head

The static head in distribution pipeline is about 20 m. However, the design water pressure should be considered as the dynamic water pressure because of long length and closed pipeline system in spite of having the free surface in the elevated tank. The dynamic water pressure is desirably 4.0 kg/cm^2 in case of non-dynamic water pressure calculation.

(2) Pipe Materials

Following pipe diameters and materials will be generally applied for pipeline.

(Dia (mm)	50	75	100	125	150	200	250
Steel Pipe (SP)	O	O	O	O	O	O	O
Asbestos Cement Pipe (AC)	–	–	O	–	O	O	O
Polyvinyl Pipe (PVC)	O	O	O	O	–	–	–

(3) Pipe Cost

The pipe costs (Bahts per meter) are as following. The data is given by PWD.

(4) Actual Results of Pipes Used in the PWD's Water Works

The minimum diameter of distribution pipeline designed for the PWD's water works is 100 mm. Though asbestos cement pipes are used in many cases, ϕ4" PVC pipe was recently used for the SD water works project at THA-PRA in Khon-Khen changwat.

The Unit Cost of the Pipes (Materials + Installation)

(Unit: ฿/m)

D (mm)	D (")	GSP Light	GSP Medium	SP Under the Ground	AC Class 15	AC Class 20	AC Class 25	PVC "D-PLAST" Class 5	PVC "D-PLAST" Class 8.5	PVC "D-PLAST" Class 13.5
10	(1/2)	-	-	-	-	-	-	6	-	-
15	(3/8)	-	-	-	-	-	-	7	9	10
18	(1/2)	26	30	-	-	-	-	8	11	12
20	(3/4)	31	35	-	-	-	-	10	12	14
25	(1.0)	27(?)	47	-	-	-	-	13	16	22
35	(1 1/4)	-	-	-	-	-	-	16	20	27
40	(1 1/2)	58	70	-	-	-	-	19	25	34
55	(2.0)	71	92	-	-	-	-	28	37	51
65	(2 1/2)	101	118	-	-	-	-	41	55	78
80	(3.0)	122	151	-	-	-	-	57	76	108
100	(4.0)	181	218	-	118	129	140	92	124	177
125	(5.0)	-	-	-	-	-	-	148	197	261
150	(6.0)	375	393	334	170	206	263	-	-	-
200	(8.0)	-	930	544	270	338	446	-	-	-
250	(10.0)	-	1,604	718	379	461	605	-	-	-

B.2. SELECTIVE COMPARISON OF ALTERNATIVE PLAN

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

B.2.1. Outline and Cost of Alternative Plans

(1) NSD-5 Kham Sakae Sang

(a) Water Demand: 0.50 MCM/year

(b) Water Source

Bun Chiwuk reservoir with a capacity of 0.34 MCM is located at 5.0 km west of the district. An unidentified reservoir is also located near the Ban Non Chang reservoir and 5.2 km north of the district. Ponds with the total capacity of 0.05 MCM are located near the temple lot. Two rivers are also located at the west side of the district, and may run dry in the dry season.

(c) Alternative Plan

The following water sources are available,

- Bun Chiwuk reservoir
- Ban Non Chang reservoir
- Existing pond in the temple lot
- Construction of new reservoir
- Existing pond in the temple lot
- Construction of new reservoir

In comparison of Bun Chiwuk reservoir with Ban Non Chang reservoir, the Bun Chiwuk is more suitable source because of the shorter transmission pipeline.

The capacity of the pond in the temple lot (only 50,000 m^3) is so small that a feeder canal from Huai Fuam reservoir is required and costs much more than the construction of new reservoir.

Therefore, the following two cases are further studies.

Case-1: Rehabilitation of Bun Chiwuk reservoir

Case-2: Construction of new reservoir

(d) Selective Comparison

(i) Outline of Facilities

Outline of Facilities

Case	Intake Weir	Feeder Canal	Transmission Length	Motor Output	Remarks
1	1 LS	2,000 m	∅ 150 mm 5,800 m	11 KW	
2	1 LS	-	∅ 150 mm 500 m	3.7 KW	

(ii) Cost Estimate

Initial Cost and Running Cost

(Unit: ฿ 1,000)

Case	Intake & Feeder Canal	Trans-mission	New Reservoir	Sub-total	Electric Charge	Total
1	600	1,450	-	2,050 (1,940)	157 (1,303)	 (3,243)
2	100	130	7,300	7,530 (7,130)	53 (440)	 (7,570)

(e) Proposed Plan

Case-1 is proposed as the optimum plan because Case-1 is more economical.

(2) NSD-6 Nong Bua Lai

(a) Water Demand: 0.20 MCM/year

(b) Water Source

A big pond named Nong Samp Pond is located in the district, its capacity is 0.30 MCM.

This pond is connected by earth canal with Phai Lung reservoir which is located at 2.0 km south-east of the district and its capacity is 0.37 MCM.

Huai Yang river located at south and west of the district may be dried up in dry season.

(c) Alternative Plans

The following water sources are available.

- Nong Samp Pond
- Construction of new reservoir

Nong Samp Pond is being used for demotic use at present because the pond can reserve enough capacity for new water works by releasing water from Phai Lung reservoir during the dry period.

It is clear that the utilization of Nong Samp Pond is more economical than construction of new reservoir. Accordingly the Nong Sam is used as the water source.

The location of treatment plant can be considered for alternative.

Case-1: Outside the pond
Case-2: Public plaza in the pond

(d) Selective Comparison

(i) Outline of facilities

Case-2 has the following construction problems

- The area is not large enough to construct the whole treatment facilities.
- Firm foundation is required.
- Work and maintenance road is required.
- The area around the pond is used as recreation area for the inhabitants.
- The construction work deteriorates the water quality.

(ii) Cost Estimate

Initial Cost and Running Cost

	Case-1	Case-2
Treatment plant	600	760 (16)
Distribution reservoir	210	430 (22)
Elevated tank	420	460 (4)
Distribution pump station	160	160
Land acquisition	20	-
O & M Road	-	40
Total	1,410	1,850

Note: ( ); Number of piles
Case-1 cost is referred from the interim report.

(iii) Proposed Plan

Case-1 is proposed as the optimum plan because Case-1 is more economical in the cost and more simple in the construction work.

(3) NSD-7 Huai Thalaeng

(a) Water Demand: 0.64 MCM

(b) Water Source

Nong Takai reservoir with a capacity of 0.16 MCM is located at 6 km north-west of the district and Lam Chamuk reservoir with a capacity of 22.2 MCM is located at 20 km north-west of the district.

There is also a small river named Huai Tako with the catchment area of 5 km^2 at south of the boundary.

(c) Alternative Plans

The following water sources are available.

- Nong Takai reservoir
- Lam Chamuk reservoir
- Construction of new reservoir

The capacity of Nong Takai reservoir is not enough to supply for new water works without any improvement.

Case-1: Improvement of Nong Takai reservoir
Case-2: Utilization of Lam Chamuk reservoir

(d) Selective Comparison

(i) Outline of Facilities

For heightening the dam embankment, there are three methods; front, whole and backside.

The front and whole methods have some difficulties in construction works such as;

1) Proper drainage is required.
2) Foundation of slope tip is loosen.
3) Embankment volume is increased. (See Fig. B-2-1)

So the backside embankment method is preferable.

Outline of Facilities

Case	Transmission Length	Transmission Dia.	Pump Output	Increased Dike Height	Remarks
1	6,000m	ϕ200mm	30 KW	1.5m	
2	20,000m	ϕ200mm	55 KW	-	

(ii) Cost Estimate

Cost Estimation

(Unit: ฿ 1,000)

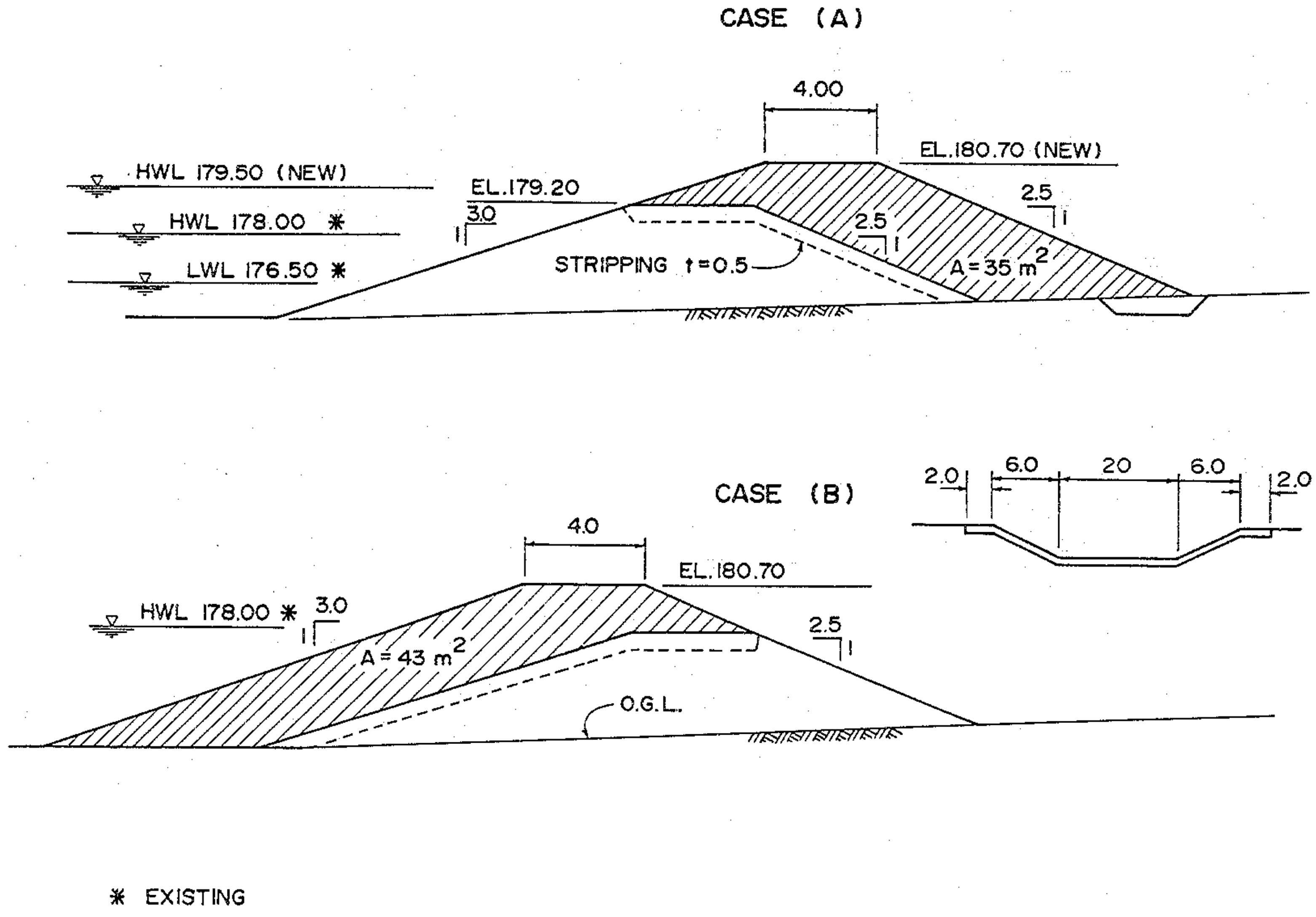
Case	Pipe	Embankment	Sub-total	Running Cost	Total
1	2,400	5,400	7,800	428	
			(7,400)	(3,600)	(11,000)
2	8,100	-	8,100	785	
			(7,700)	(6,500)	(14,200)

Note: Intake pumping station cost is excluded from the table because the both alternative costs almost same.

(e) Proposed Plan

Case-1 is proposed as the optimum plan because of the lower cost.

Figure B-2-1 Nong Takai Reservoir Heightening Method



(4) NSD-8 Nong Ki

(a) Water Demand: 0.81 MCM/year

(b) Water Source

Water sources available around the district are Tung Kraten reservoir and small ponds with no river and stream flowed into.

Tung Kraten reservoir with the capacity of 1.60 MCM is located at 2.5 km north-west from the district. The reservoir was constructed for multipurpose use under the ARD's accelerated rural development project.

Small pond with the total capacity of 30,000 cu.m are located at southern part of the district and is being used for domestic use.

(c) Alternative Plans

Since the water source available is only Tung Kraten reservoir, no alternative plan can be considered. Major facilities from the said reservoir to water treatment plant are the 3.1 km long transmission pipeline with 250 mm in diameter and 22 KW intake pump in output capacity.

(5) NSD-10 Huai Rat

(a) Water Demand: 0.24 MCM

(b) Water Source

Huai Talet reservoir with a capacity of 18.5 MCM is located at 15 km south-west and a small pond with a capacity of 0.03 MCM is located in the west part of the district.

There are two main irrigation canals, however, these canals are not being used because they are so damaged that soils are deposited at the bottom of the canal.

The rehabilitation work will be completed by 1987 under the NESSI project of RID.

It is possible to construct a water transmission canal from the RID's canal.

(c) Alternative Plans

The following two cases are considered to be alternative plans.

Case-1: Utilization of Huai Kadong river
Case-2: Utilization of Huai Talet reservoir

(d) Selective Comparison

(i) Outline of Facilities

Outline of Facilities

Case	Transmission Length	Transmission Dia.	Pump Output	Increased Dike Height	Remarks
1	600	150	3.7 KW		
2	100	-	2.2 KW		

(ii) Cost Estimate

Cost Estimation

(Unit: ฿ 1,000)

Case	Transmission	Running Cost	Total	Remarks
1	150	53		
	(140)	(440)	(580)	
2	100	31		
	(100	(260)	(360)	

Pumping station cost is excluded.

Figures in parenthesis indicate discounted amount.

(e) Proposed Plan

Case-2 is proposed as the optimum plan.
Further, Case-2 requires a storage pond to supply the water shortage in the case of periodical canal rehabilitation work. The existing pond, which has a sufficient capacity of 30,000 cu.m (45 days' water demand), is recommendable to be used as a storage reservoir.

(6) NSD-12 Khun Han

(a) Water Demand: 0.22 MCM

(b) Water source

Nong Si reservoir with a capacity of 3.8 MCM is only one water source and its outlet is Nong Si river.

(c) Alternative Plans

The following three intake methods are considered to be alternative plans.

Case-1: Direct pumping from the Nong Si reservoir (See Fig. B-2-2)

Case-2: Natural flowing from the Nong Si reservoir (See Fig. B-2-2)

Case-3: Direct pumping from the Nong Si river

(d) Selective Comparison

(i) Outline of Facilities

Outline of Facilities

Case	Transmission Length	Transmission Dia.	Gate or Valve	Bank Cut	Motor Output
1	120m	ϕ150	-	-	2.2KW
2	120m	ϕ150	ϕ150	open	2.2
3	500m	ϕ150	-	-	2.2

Cost Estimate

(Unit: ฿ 1,000)

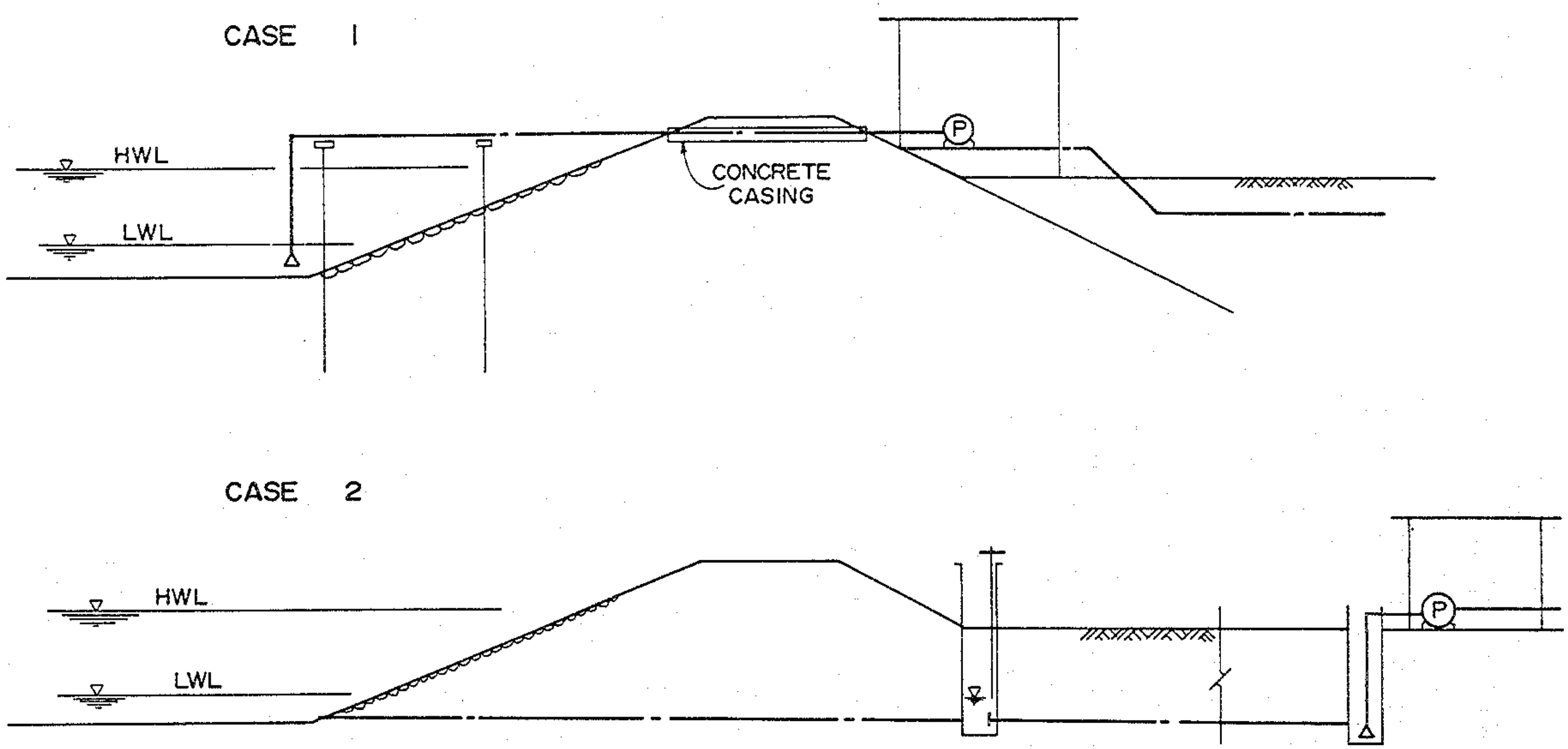
Case	Intake	Trans-mission	Sub-total	Running Cost	Total
1	130	30	160	31	
			(150)	(260)	(410)
2	1,100	40	1,140	31	
			(1,080)	(260)	(1,340)
3	100	100	200	31	
			(190)	(260)	(450)

Note: Cost of pumping station is included in the cost of intake.

(c) Proposed Plan

Case-3 is proposed as the optimum plan because Case-1 is more economical in the construction work than Case-2. In Case-1 and 2, however, constructing any structures on the embankment or excavating the embankment are prohibited under the RID regulation.

Figure B-2-2 Intake Method and Pumping Station



(7) NSD-13 Kusuman

(a) Water Demand: 0.3 MCM

(b) Water Source

Huai Daeng reservoir with a capacity of 1.2 MCM is located at 4.0 km east of the district, and there are two rivers, Huai Sophoe and Huai Rong Pho. The both rivers, however, as dried up in dry season.

The hydrogeological survey and the pumping test shows that groundwater is available in the district and the yield is sufficient for new water supply. In consideration of safety yield the required water demand is supplied by three wells (18.0 m^3/h x 3).

(c) Alternative Plans

The following water source are available.

- Huai Daeng reservoir
- Three deep wells
- Construction of new reservoir

First of all, the following two cases are considered to be alternative plans among the surface water available.

Case-1: Utilization of Huai Daeng reservoir
Case-2: Construction of new reservoir

The outline of facilities are:

Case	Transmission Length	Transmission Dia.	Motor Output	Proposed New Reservoir Size
1	4,250m	ϕ150mm	7.5 KW	-
2	-	-	2.2 KW	270mx270mx4.5m

The construction cost estimate is:

(Unit: ฿ 1,000)

Case	Pipe	Reservoir	Sub-total	Running Cost	Total
1	1,100	-	1,100 (1,040)	107 (890)	 (1,930)
2	-	7,600	7,600 (7,200)	31 (260)	 (7,460)

Accordingly Case-2 is more economical.

Secondary, the said surface water treatment is compared with the groundwater treatment in construction cost and O/M cost.

As for groundwater, the two distribution system; single point pressurizing method and multi point pressurizing method, are further studies.

Therefore, the following three cases are considered to be alternative plans.

Case-1: Utilization of Huai Daeng reservoir

Case-2: Three deep wells (single point pressurizing method)

Case-3: Three deep wells (multi point pressurizing method)

(d) Selective Comparison

The result of the hydraulic calculation of the said two methods is described in B.2.3.

The outline of facilities and the construction cost estimate is referred from Table B-2-1.

(e) Proposed Plan

Case-2 is proposed as the optimum plan.

(8) NSD-17 Phon Charoen

(a) Water Demand: 0.51 MCM/year

(b) Water Source

Nong Loeng reservoir with a capacity of 2.0 MCM is located at 9.5 km north-east of the district. Two rivers, Huai Sam Hong and Huai Mak are located at the west side and east side of the district respectively.

The catchment area of the Huai Mak is larger than that of the Huai Sam Hong, but located much far from the district. The required catchment area for new reservoir is 5 km^2 at least.

The hydrogeological survey and the pumping test shows that groundwater is available, but its yield is not sufficient for supplying the whole required volume.

The wells available in the district are four wells in which safety yield of a well is 7.0 m^3/h.

(c) Alternative Plans

First of all, the following two cases are considered to be alternative plans among the surface water available.

Case-1: Utilization of Nong Loeng reservoir

Case-2: Construction of new reservoir

The outline of facilities are:

Case	Transmission Length	Dia.	Pump Output	New Reservoir	Remark
1	12,500m	ϕ200mm	22 KW	-	
2	1,300m	ϕ200mm	11 KW	370m x 370 h = 4.5m	

The construction cost estimate is:

(Unit: ฿ 1,000)

Case	Pipe	Pond	Sub-total	Running Cost	Remark
1	5,500	-	5,500 (5,200)	314 (2,600)	(7,800)
2	520	11,000	11,520 (10,900)	157 (1,300)	(12,200)

Accordingly, Case-1 is more economical.

Secondly, the said surface water treatment is compared with the combined use of the surface water treatment (Q = 40 m^3/h) and the groundwater treatment (Q = 20 m^3/h)

As for ground water treatment, the two distribution system; single point pressurizing method and multi point pressurizing method, are further studied.

Therefore, the following three cases are considered to be alternative plans.

Case-1: Utilization of Nong Loeng reservoir

Case-2: Combined use of Nong Loeng reservoir and four deep wells (single point pressurizing method)

Case-3: Combined use of Nong Loeng reservoir and four deep wells (multi point pressurizing method)

(d) Selective Comparison

The result of the hydraulic calculation of the said three cases is shown in B.2.3.

The outline of facilities and the construction cost and O/M cost estimate are referred from Table B-2-1.

(e) Proposed Plan

Case-1 is proposed as the optimum plan.
Case-1 and 2 is nearly the same in construction cost, however, Case-1 will cost less if operation and maintenance cost for a long period is considered.

(9) NSD-18 Nong Song Hong

(a) Water Demand: 0.42 MCM

(b) Water Source

Nong Song Hong reservoir with a capacity of 0.38 MCM is located at 0.1 km west of the district.

Nong Kom Ko lake with a capacity of 10.0 MCM is located at 6 km north-west of the district. There are no available rivers in the district and its surrounding area.

The hydrogeological survey and the pumping test shows that groundwater is available, but its yield is not sufficient for supplying the whole required volume.

The wells available in the district are three wells in which safety yield of a well is 7.5 m^3/h.

(c) Alternative Plans

First of all, the following two cases are considered to be alternative plan among the surface water available.

Case-1: Utilization of Nong Song Hong reservoir
Case-2: Utilization of Nong Kom Ko Lake

Since Nong Song Hong reservoir has an insufficient capacity for new water supply, the reservoir requires a 1.5 m heightening of the embankment.

As for the embankment, the backside embankment method as shown in Figure B-2-3 is recommendable from the viewpoint of construction works.

The outline of facilities are:

Case	Transmission Length	Transmission Dia.	Increased Dike Height	Pump Output	Remark
1	200m	ϕ150	1.30m	3.7 KW	
2	8,500m	ϕ200	-	11.0 KW	

Their construction cost is estimated as follows:

(Unit: ฿1,000)

Case	Pipe	Reservoir	Sub-total	Running Cost	Total
1	50	4,050	4,100	53	
			(3,880)	(440)	(4,320)
2	3,500	-	3,500	157	
			(3,300)	(1,300)	(4,600)

Accordingly Case-1 is more economical.

Since groundwater, which covers a part of the required volume, is available, Nong Song Hong reservoir (20 m^3/h) and three wells (30 m^3/h) are used in combination.

Figure B-2-3 Embankment Method

NSD - 18 NONG SONG HONG

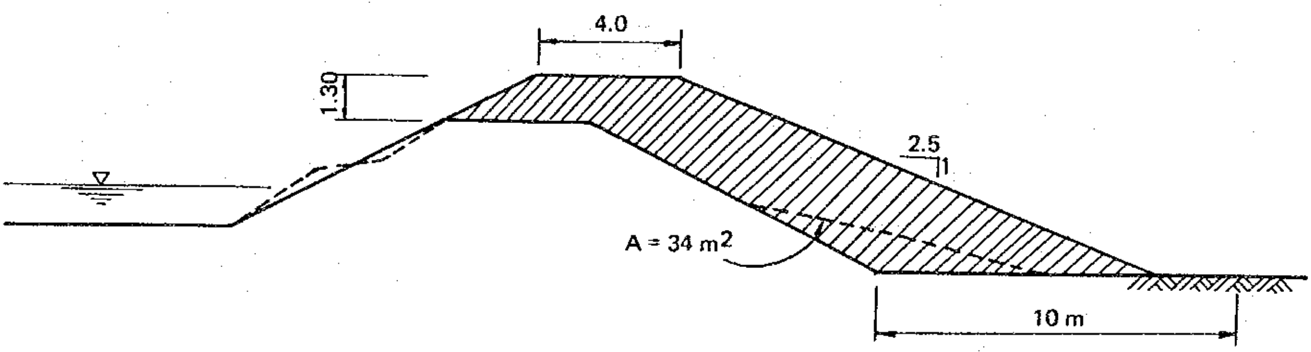


Table B-2-1 Comparative Table of Construction Cost

(Unit: x1,000฿)

No.	NSD	Design Capacity		Water Source: Capacity	Water Source: Working Cost	Intake Works: Pump station	Intake Works: Pump cost	Transmission Work: Pipe length	Transmission Work: Pipe cost	Treatment Works: Treatment Type	Treatment Works: Working cost	Treatment Works: Storage Reservoir	Treatment Works: Elevated tank	Treatment Works: Distribution pump	Treatment Works: Sub-Total	Distribution Works: Pipe line Total length	Distribution Works: Cost	Total cost	O/M Cost	Unit cost m3/h	Priority
13	Kusuman	1	40	Reservoir	-	100	300	ø150 ℓ = 4,250	1,060	RA	720	350	780	740	2,590	9,560m	780	4,830	324	128	3
		2	40	Deep Well W x 3	540	30	180	ø100 ℓ = 1,690	190	A,F,C	300	350	770	740	2,160	9,210m	710	3,780	303	102	1
		3	40	"	540	30	180	-	-	A,F,C	300	350	1,325	740	2,715	9,210m	650	4,115	303	110	2
17	Pon-charoen	1	60	Reservoir	500	120	300	ø200 ℓ = 12,500	5,000	RA	1,200	600	770	820	3,390	12,260m	1,310	10,620	794	190	2
		2	40	Reservoir W x 4	500	100	300	ø150 ℓ = 12,500	3,125	RA	750	370	770	800	3,540	12,100m	1,270	10,100	831	182	1
			20			40	800	ø100 ℓ = 3,820	420	A,F,C	600	250									
		3	40	Reservoir W x 4	500	100	300	ø150 ℓ = 12,500	3,125	RA	750	370	2,340	800	5,110	12,100m	1,030	11,000	831	197	3
			20			40	800			A,F,C	600	250									
18	Nong Song Hong	1	50	Reservoir	4,050	120	200	ø150 ℓ = 200	50	RA	800	480	740	860	2,880	8,850m	910	8,210	294	170	1
		2	30	Reservoir W x 3	3,650	100	200	ø150 ℓ = 200	50	RA	750	320	740	800	3,310	8,850m	910	9,100	309	188	3
			20		-	30	600	ø100 ℓ = 2,700	300	A,F,C	500	200									
		3	30	Reservoir W x 3	3,650	100	200	ø150 ℓ = 200	50	RA	750	320	1,870	800	4,440	9,590m	840	9,900	309	204	4
			20		-	30	600	-	-	A,F,C	500	200									
		4	30	Reservoir W x 3	3,650	100	200	ø150 ℓ = 200	50	RA	750	320	1,000	800	3,570	10,590m	730	8,930	309	184	2
			20		-	30	600	-	-	A,F,C	500	200									

Note; RA ; Rapid Sand Filtration F ; Filtration
A ; Aeration C ; Chlorination

The following four cases are considered to be alternative plans.

Case-1: Utilization of Nong Song Hong reservoir (the 1.3 m heightening of embankment)

Case-2: Combined use of Nong Song Hong reservoir (the 1.1 m heightening of embankment) and three deep wells (single-point pressurizing method)

Case-3: Combined use of Nong Song Hong reservoir (the 1.1 m heightening of embankment) and three deep wells (multi-points pressurizing method)

Case-4: Nong Song Hong reservoir (the 1.1 m heightening of embankment) covers the southern part of the district and three deep wells (single-points pressurizing method) cover the northern part of the district.

(d) Selective Comparison

The result of the hydraulic calculation of the said four cases is show in B.2.2.

The outline of facilities and the construction cost and O/M cost estimate are referred from Table B-2-1.

(e) Proposed Plan

Case-1 is proposed as the optimum plan.

(10) NSD-20 Huai Kya Yung

(a) Alternative Plans

Available water source around the district is only Huai Kya Yung river, which is located at south and west of the district, flows to the north and its discharge is 11.7 cu.m/s in dry season.

Two suitable sites for pump station are considered, one is the upstream of railway bridge, 1.5 km from treatment plant. The south of the district is proposed as the intake pump station site.

Since the seasonal fluctuation of water level in the river attains approximately 10 m and the velocity becomes 2.0 m/s in flow period, the following three types of the intake pump are considered to be alternative plan.

Case-1: Inclined shaft pump (See Fig. B-2-14)
Case-2: Vertical shaft pump (see Fig. B-2-15)
Case-3: Horizontal shaft pump on boat

(b) Selective Comparison

Case-3 is not preferable to use as permanent facility even through Case-3 has less constructional problems than the other cases. Case-2 requires much excavation and concrete volume.

(c) Proposed Plan

Case-1 is proposed as the optimum plan.

Figure B-2-4 Pumping Station for Inclined Type

NSD - 20 HUAI KYA YUNG

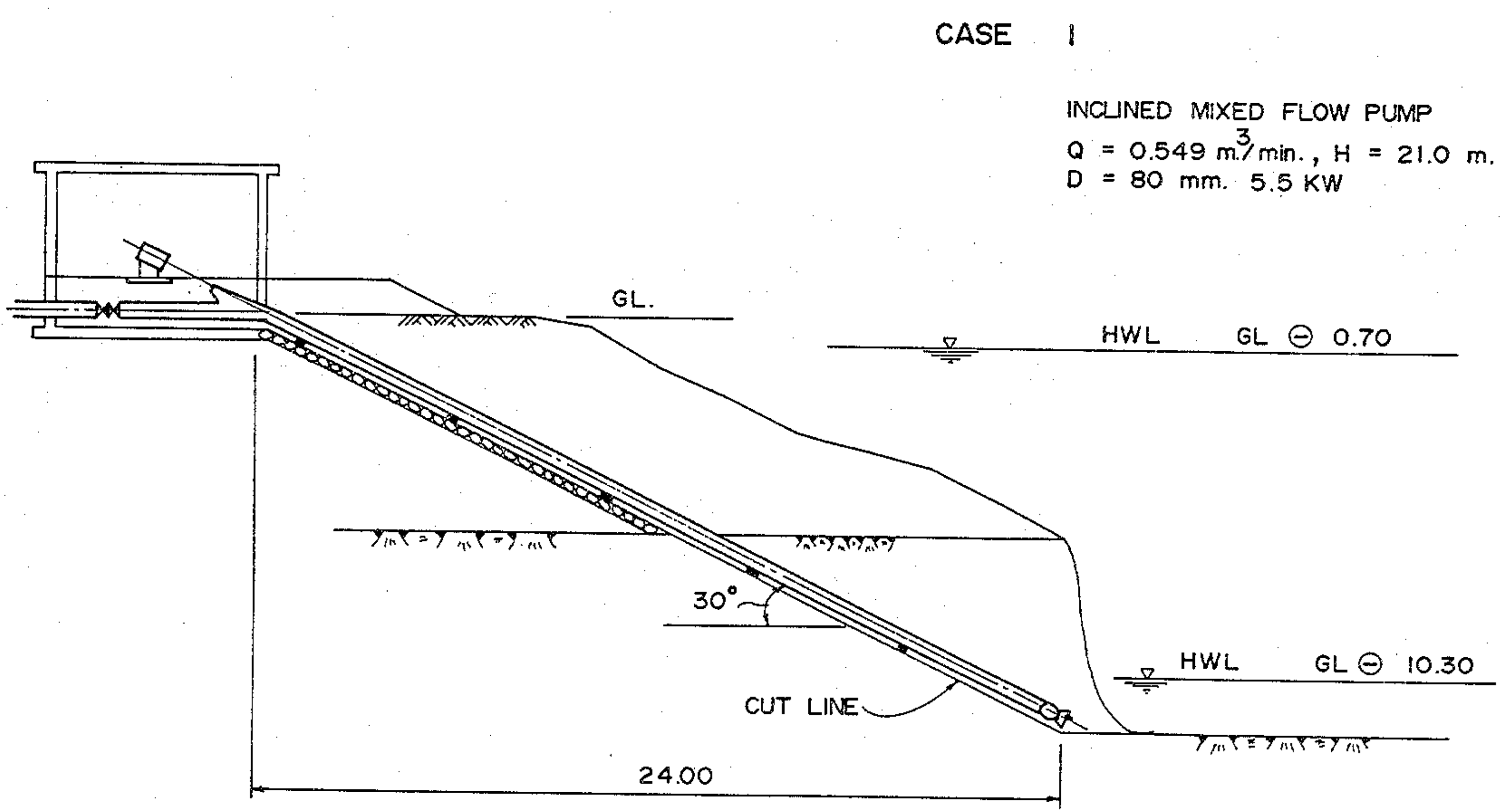
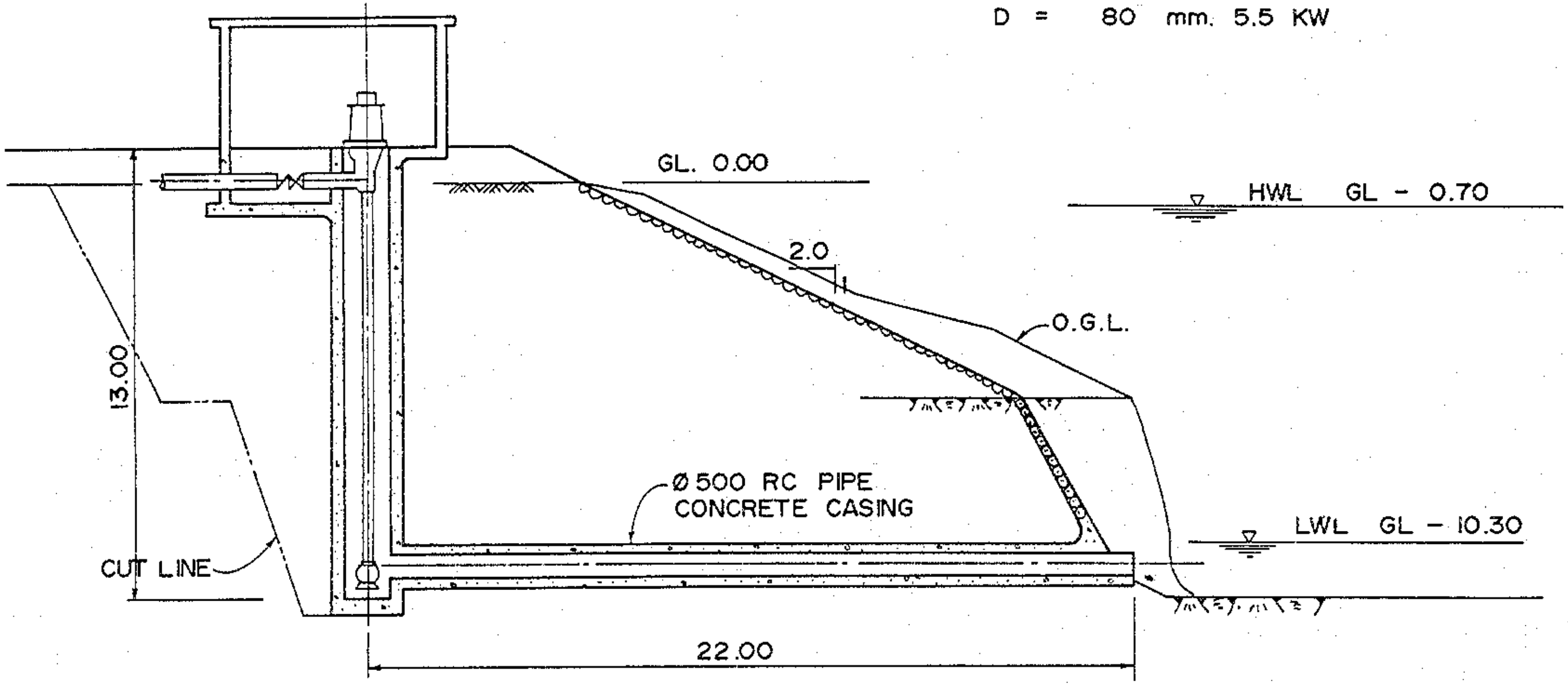


Figure B-2-5 Pumping Station for Vertical Shaft Type

NSD - 20 HUAI KYA YUNG

CASE 2

VERTICAL SHAF MIXD FLOW PUMP
Q = 0.549 m./min. , H = 21 m.
D = 80 mm. 5.5 KW



B.2.2. Drawings of Alternative Plan

Figure B-2-6 Alternative Plan of Kham Sakae Sang

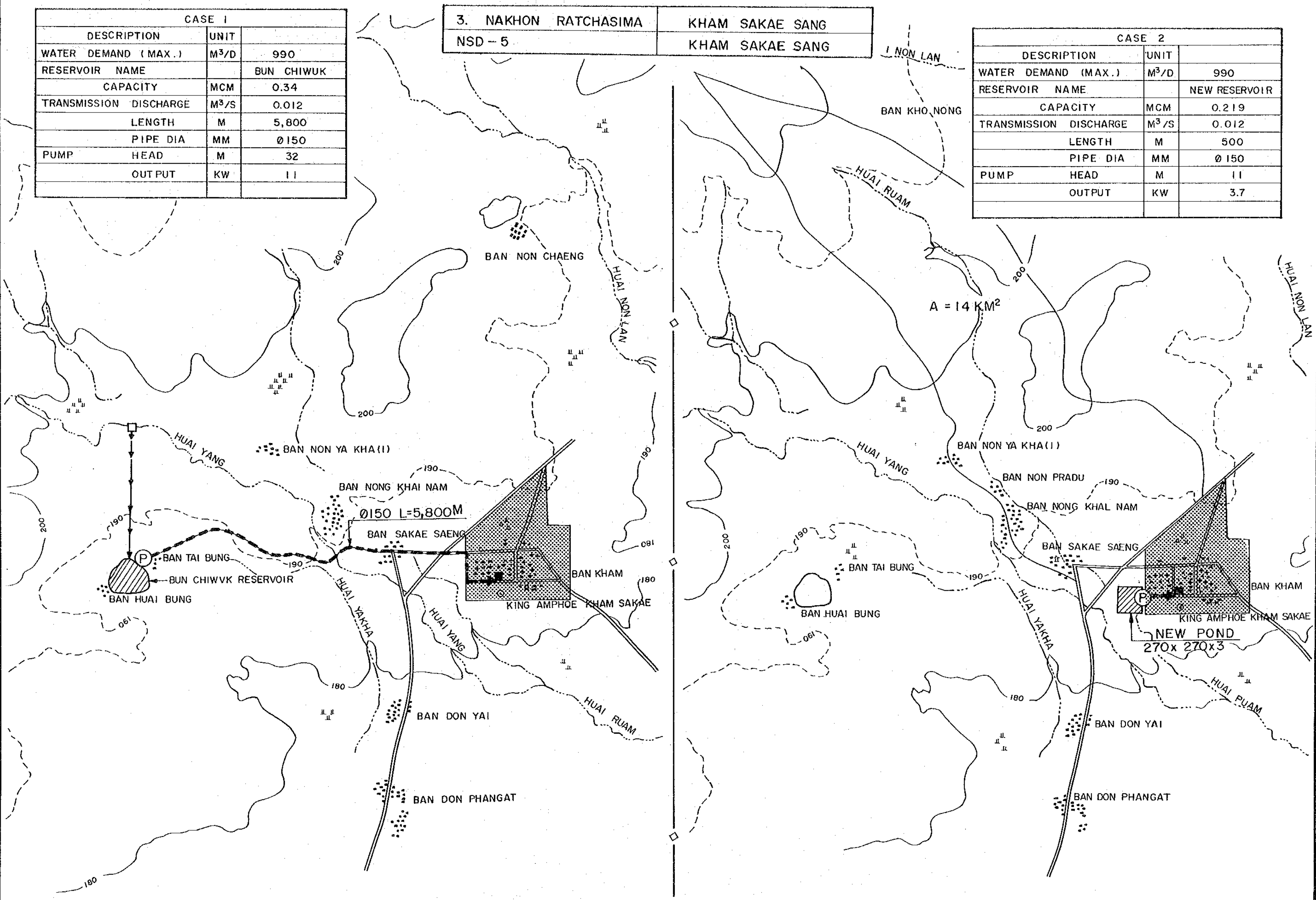
3. NAKHON RATCHASIMA	KHAM SAKAE SANG
NSD – 5	KHAM SAKAE SANG

CASE 1

DESCRIPTION		UNIT	
WATER DEMAND (MAX.)		M^3/D	990
RESERVOIR NAME			BUN CHIWUK
	CAPACITY	MCM	0.34
TRANSMISSION	DISCHARGE	M^3/S	0.012
	LENGTH	M	5,800
	PIPE DIA	MM	Ø150
PUMP	HEAD	M	32
	OUTPUT	KW	11

CASE 2

DESCRIPTION		UNIT	
WATER DEMAND (MAX.)		M^3/D	990
RESERVOIR NAME			NEW RESERVOIR
	CAPACITY	MCM	0.219
TRANSMISSION	DISCHARGE	M^3/S	0.012
	LENGTH	M	500
	PIPE DIA	MM	Ø 150
PUMP	HEAD	M	11
	OUTPUT	KW	3.7



3. NAKHON RATCHASIMA	BUA YAI
NSD – 6	NONG BUA LAI

Figure B–2–7 Alternative Plan of Nong Bua Lai

CASE 1,2			
DESCRIPTION		UNIT	
WATER DEMANO (MAX.)		M^3/D	675
RESERVOIR NAME.			NONG SAMP
CAPACITY		MCM	0.30
TRANSMISSION DISCHARGE		M^3/S	0.008
	LENGTH	M	—
	PIPE DIA	MM.	—
PUMP	HEAD	M	9.0
	OUTPUT	KW	2.2

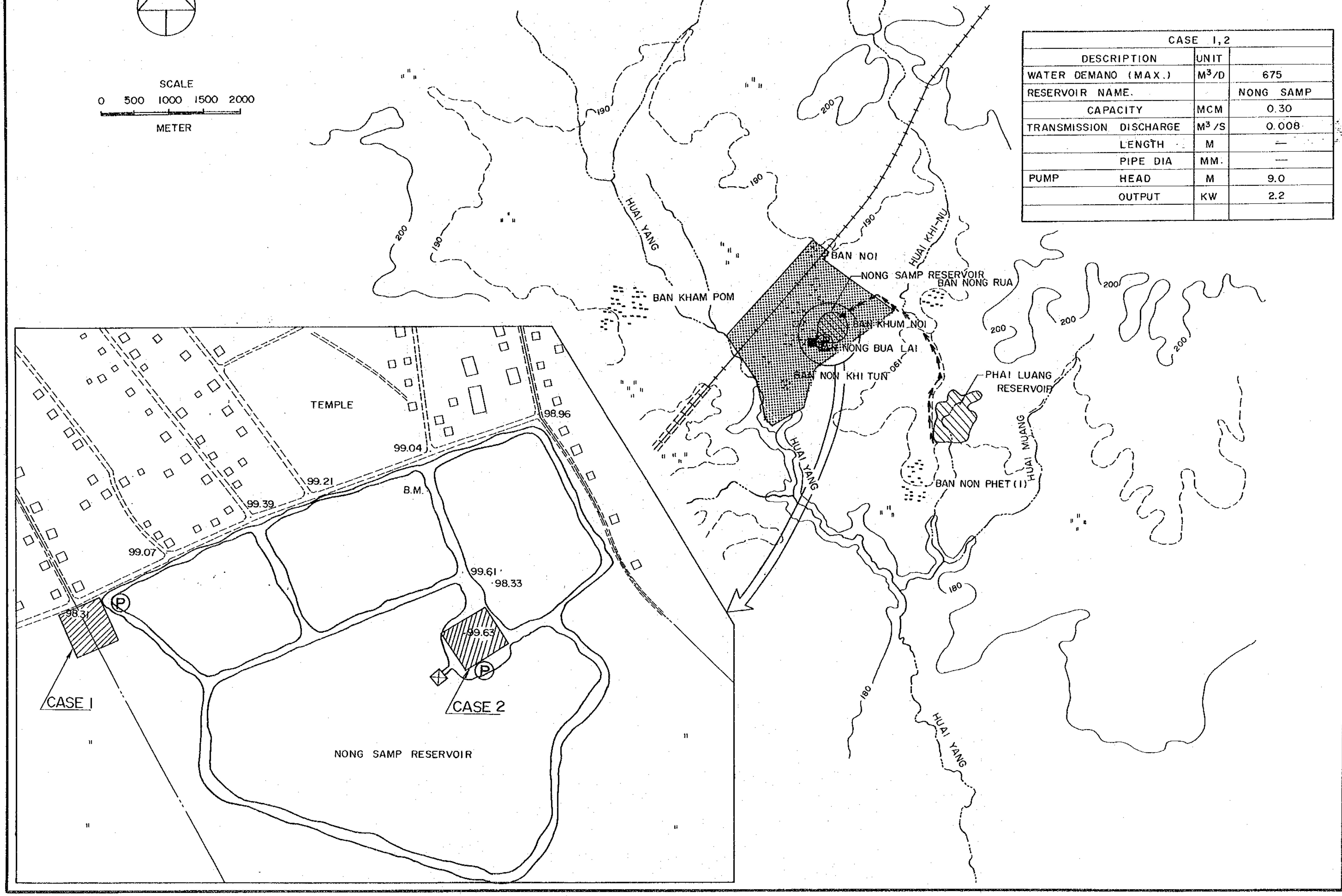
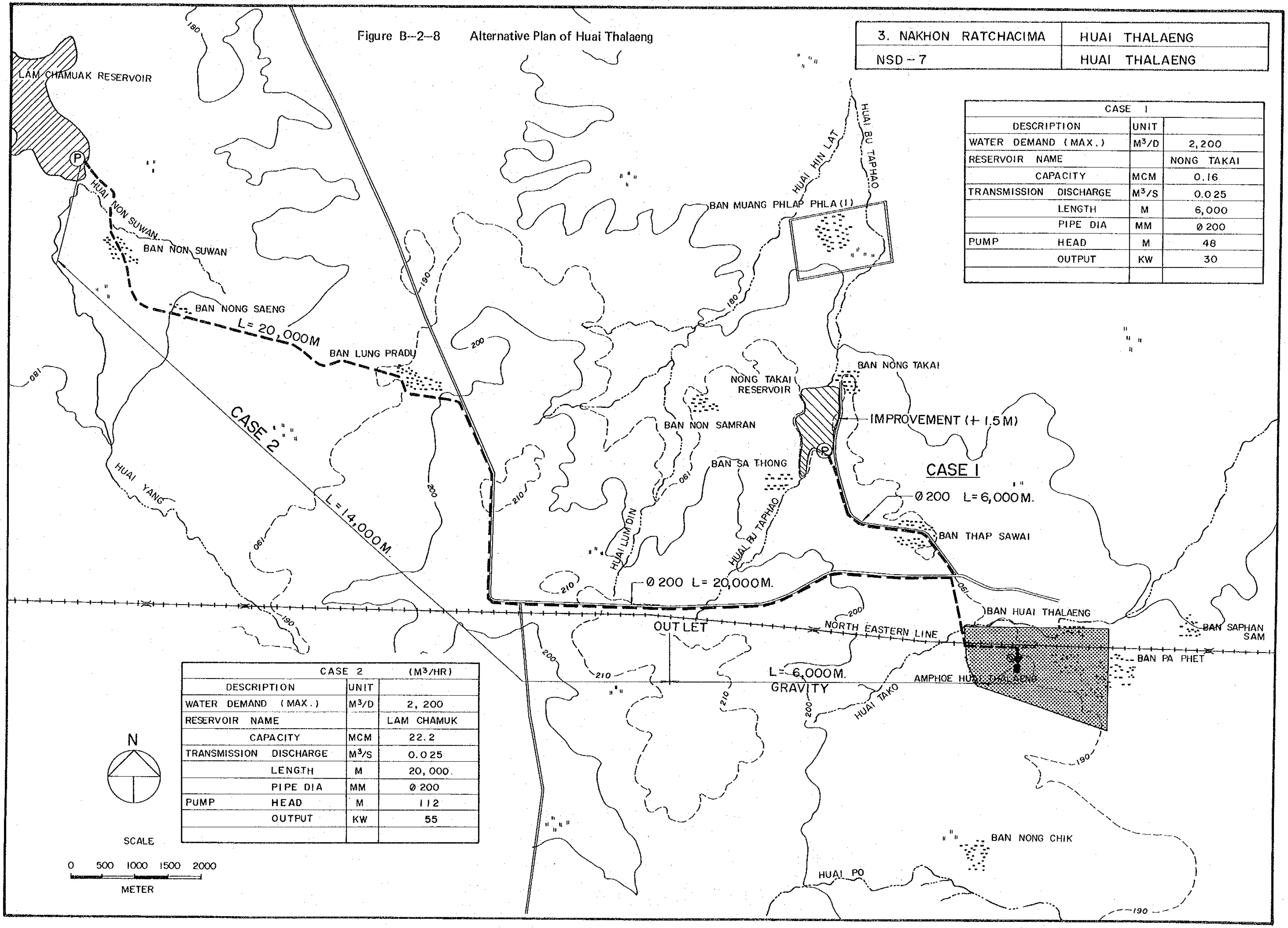


Figure B-2-8 Alternative Plan of Huai Thalaeng

3. NAKHON RATCHACIMA	HUAI THALAENG
NSD - 7	HUAI THALAENG

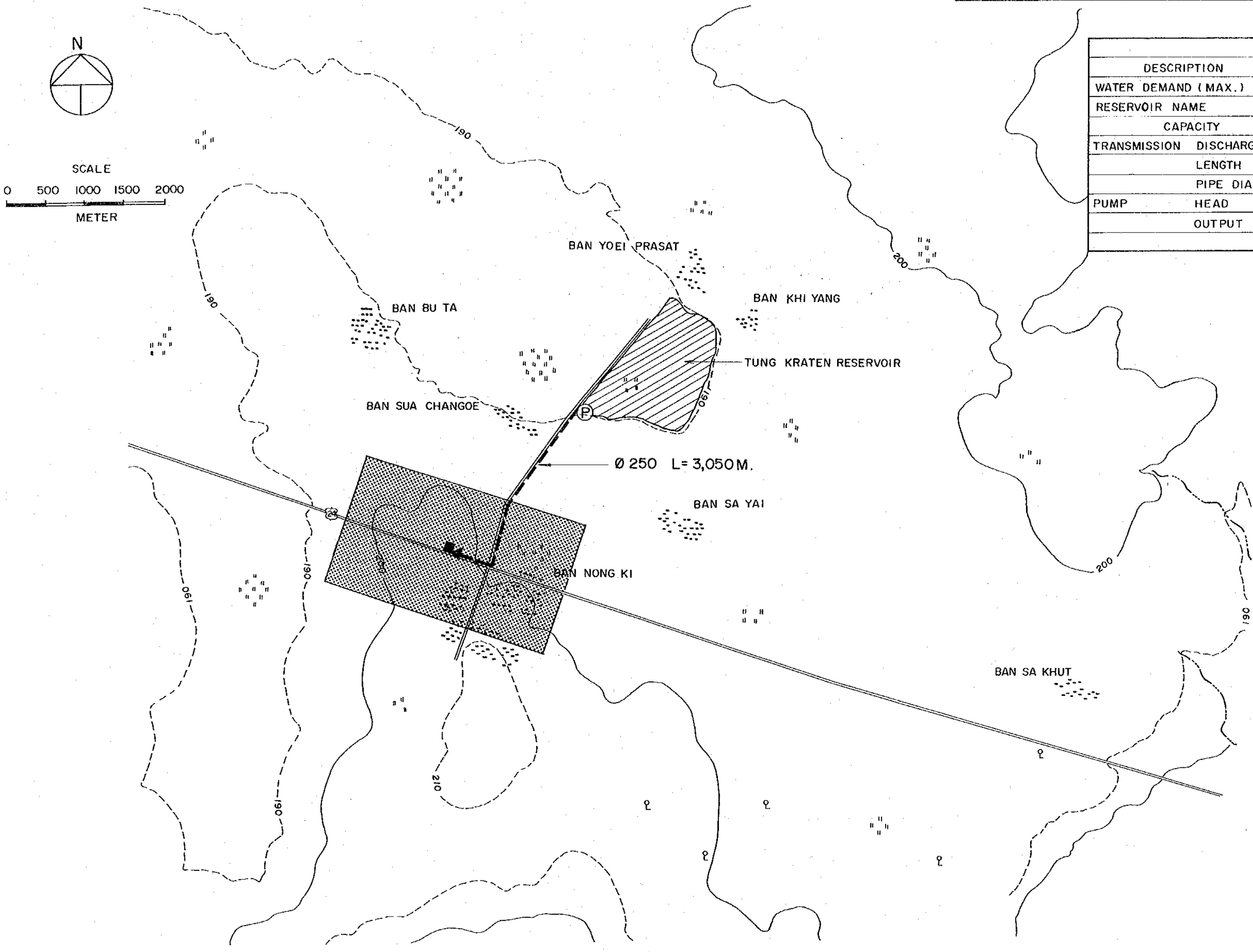


CASE I		
DESCRIPTION	UNIT	
WATER DEMAND (MAX.)	M³/D	2,200
RESERVOIR NAME		NONG TAKAI
CAPACITY	MCM	0.16
TRANSMISSION DISCHARGE	M³/S	0.025
LENGTH	M	6,000
PIPE DIA	MM	Ø 200
PUMP HEAD	M	48
OUTPUT	KW	30

CASE 2		(M³/HR)
DESCRIPTION	UNIT	
WATER DEMAND (MAX.)	M³/D	2, 200
RESERVOIR NAME		LAM CHAMUK
CAPACITY	MCM	22.2
TRANSMISSION DISCHARGE	M³/S	0.025
LENGTH	M	20, 000.
PIPE DIA	MM	Ø 200
PUMP HEAD	M	112
OUTPUT	KW	55

4. BURIRAM	NONG KI
NSD – 8	NONG KI

Figure B–2–9 Alternative Plan of Nong Ki



CASE I		
DESCRIPTION	UNIT	
WATER DEMAND (MAX.)	M³/D	2,790
RESERVOIR NAME		TUNG KRATEN
CAPACITY	MCM	1.6
TRANSMISSION DISCHARGE	M³/S	0.032
LENGTH	M	3,050
PIPE DIA	MM	Ø 250
PUMP HEAD	M	35
OUTPUT	KW	22

Figure B-2-10 Alternative Plan of Huai Rat

4. BURIRAM	MUANG
NSD - 10	HUAI RAT

DESCRIPTION		UNIT	CASE 1	CASE 2
WATER DEMAND (MAX.)		M^3/D	810	810
NAME			IRRIGATION CANAL	RIVER
CAPACITY		MCM	HUAI TALAT	18.5
TRANSMISSION DISCHARGE		M^3/S	0.009	0.009
	LENGTH	M	100	600
	PIPE DIA	MM	Ø150	Ø150
PUMP	HEAD	M	8.0	13.0
	OUTPUT	KW	2.2	3.7

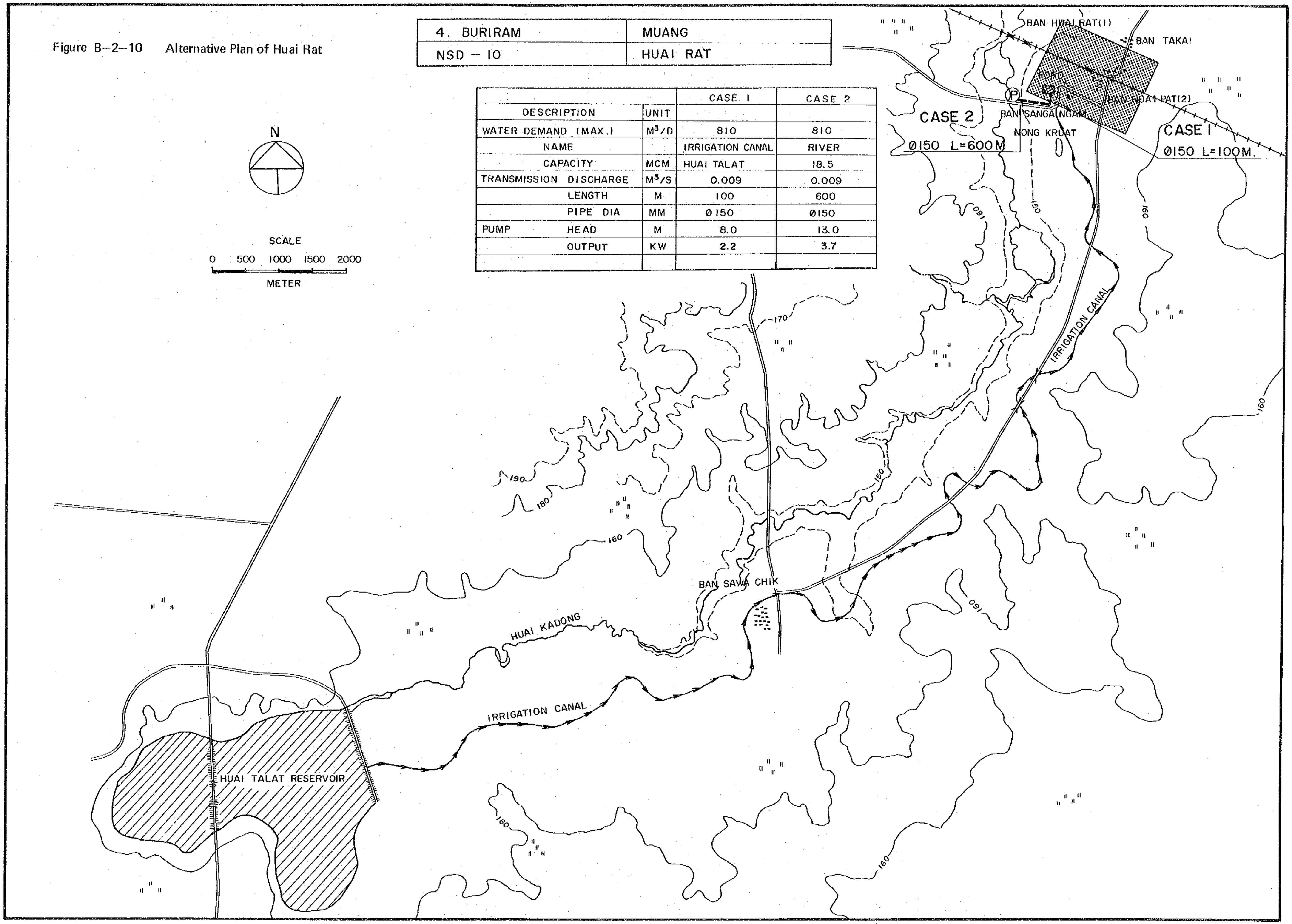
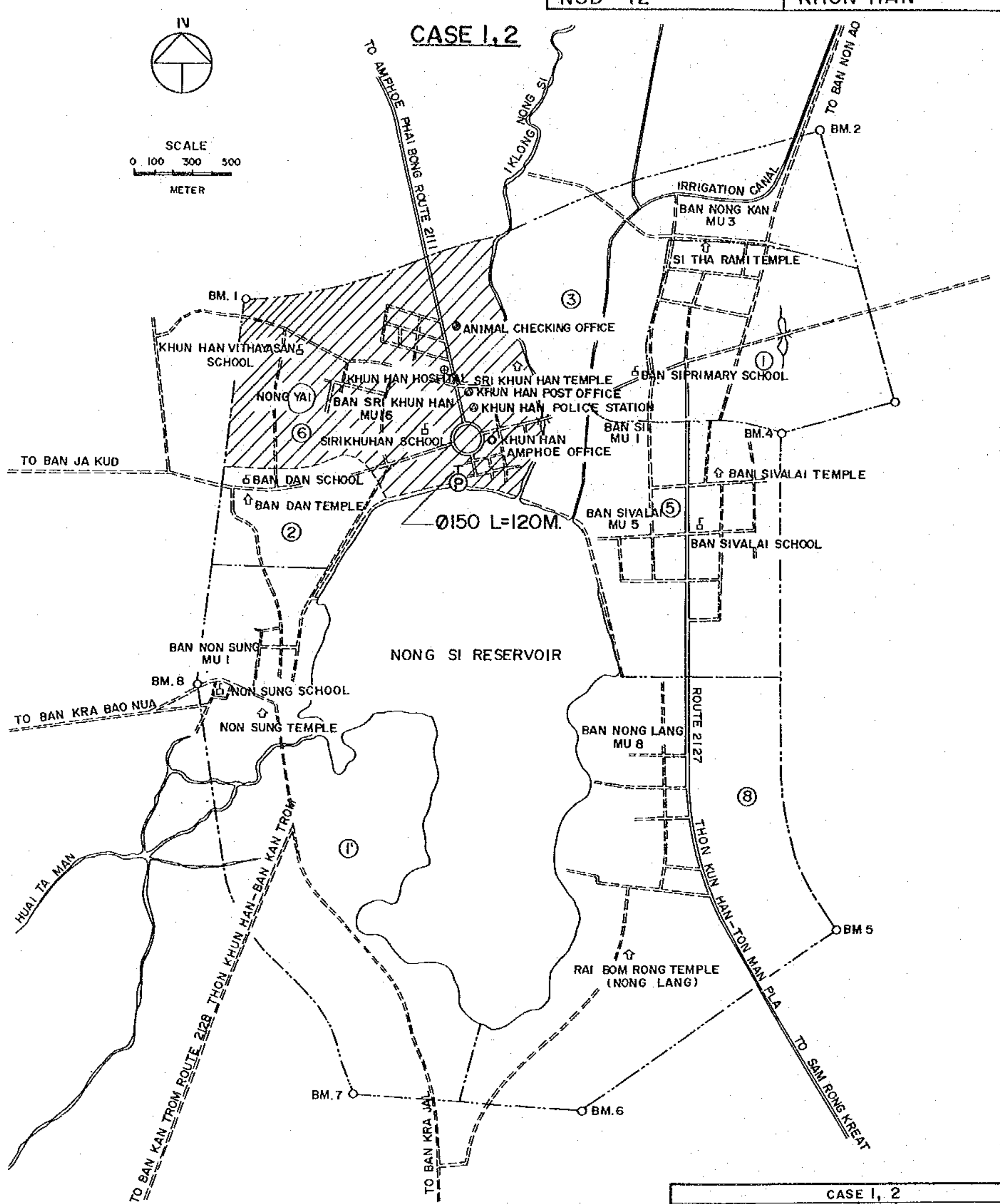
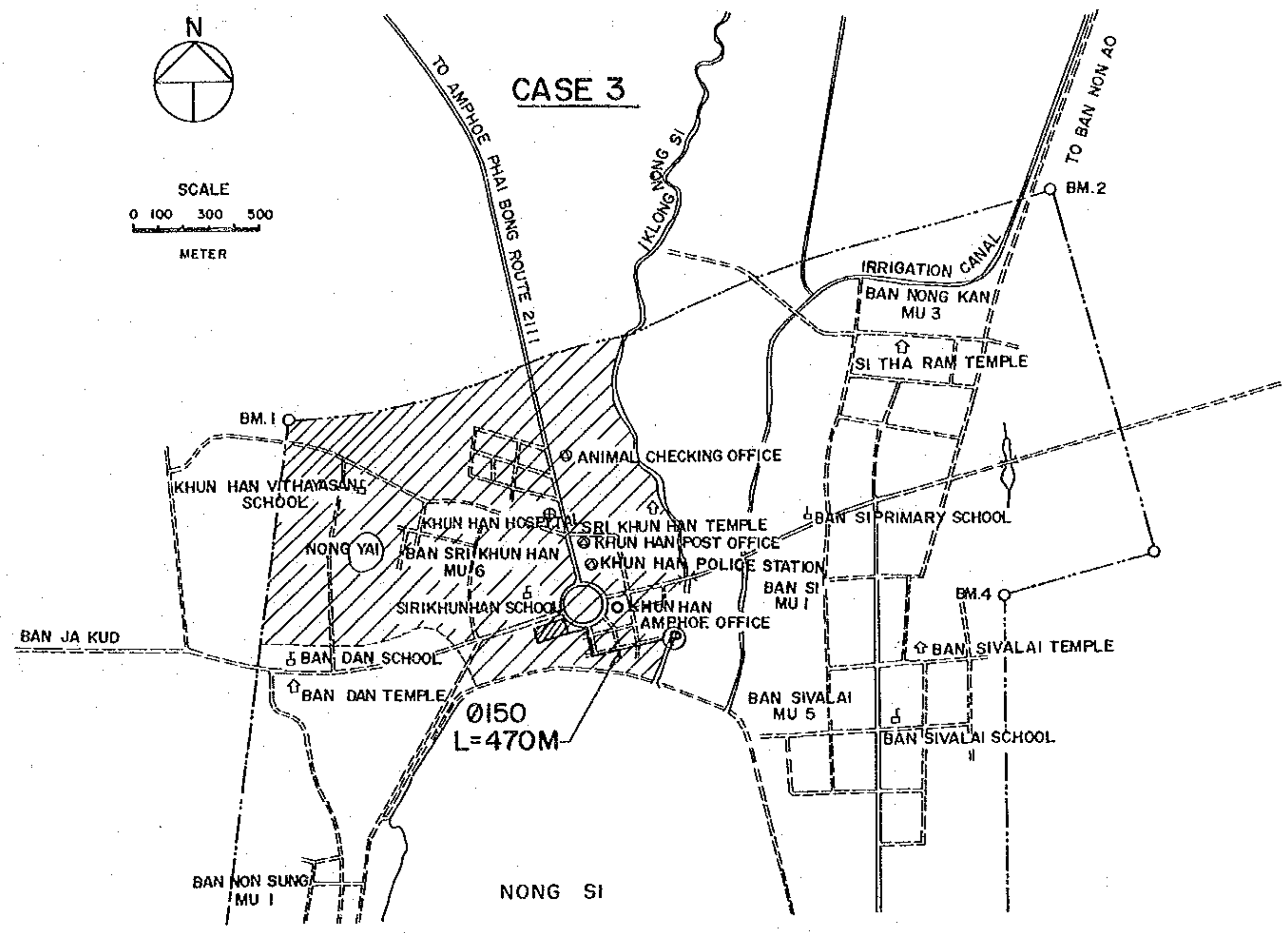


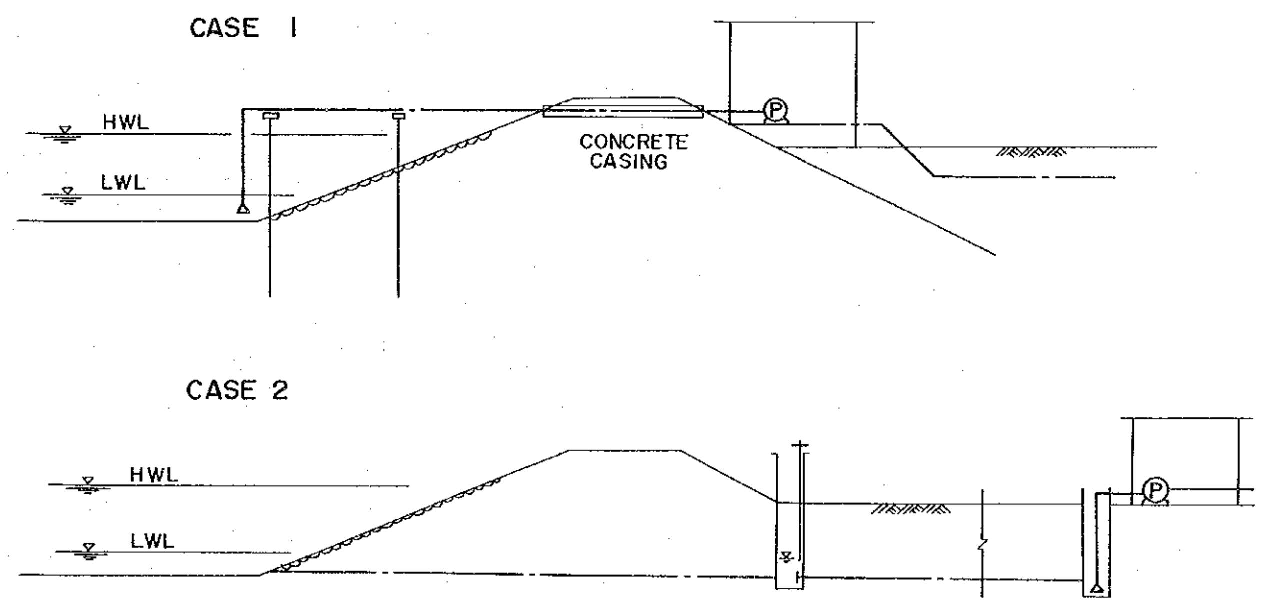
Figure B–2–11 Alternative Plan of Khun Han

6. SI SA KET	KHUN HAN
NSD – 12	KHUN HAN





INTAKE METHOD AND PUMPING STATION



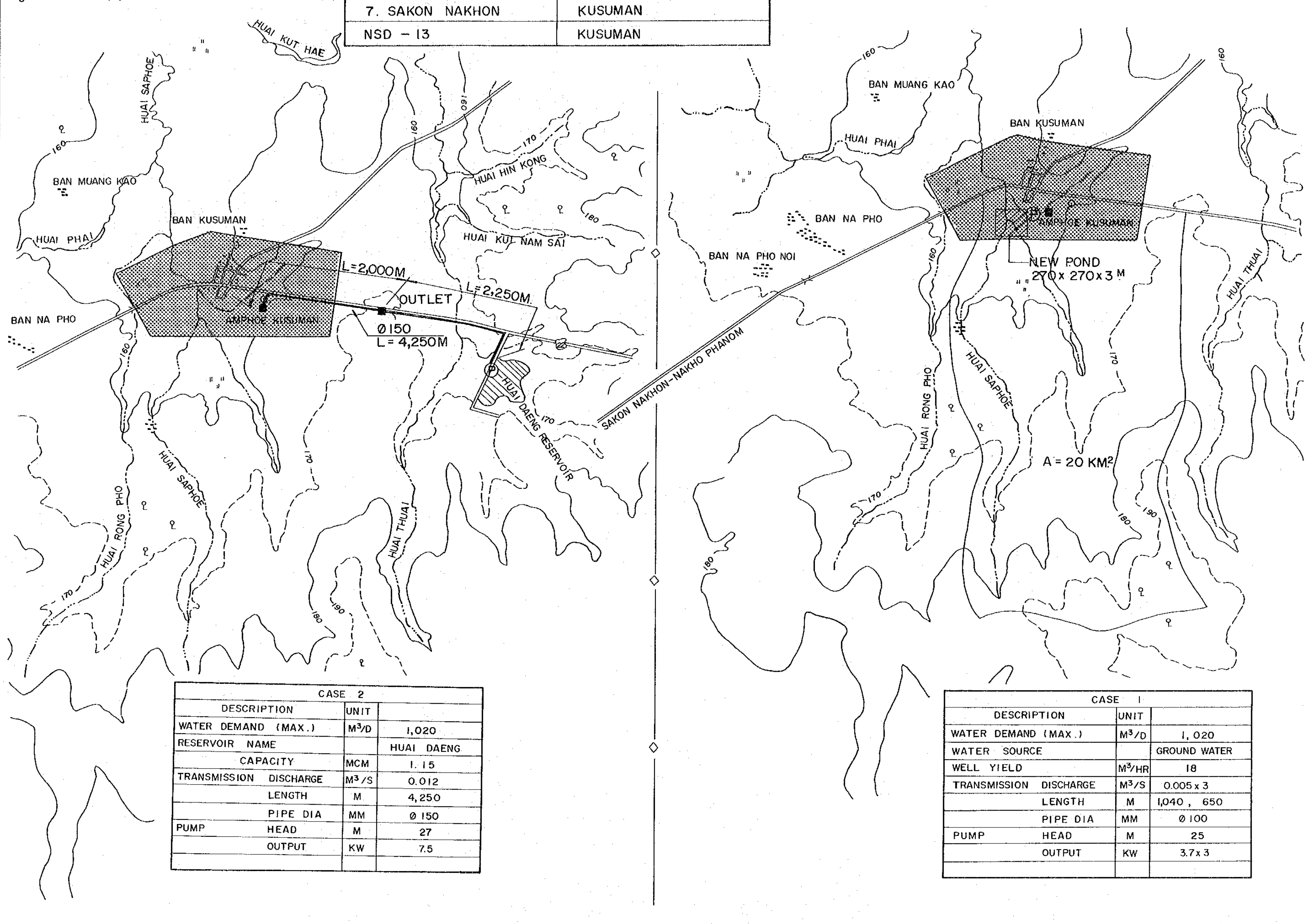
LEGEND

- SANITARY DISTRICT
- CONCRETE ROAD
- LATERITE ROAD
- BRIDGE
- RIVER, KLONG, CREEK
- RESERVOIR
- AMPHOE OFFICE
- LOCATION OF THE PUBLIC SERVICE
- TEMPLE
- SCHOOL
- HOSPITAL

CASE I, 2			
DESCRIPTION		UNIT	
WATER DEMAND (MAX.)		M³/D	750
RESERVOIR NAME			NONG SI
	CAPACITY	MCM	3.8
TRANSMISSION	DISCHARGE	M³/S	0.009
	LENGTH	M	470
	PIPE DIA	MM	Ø150
PUMP	HEAD	M	10
	OUTPUT	KW	2.2

Figure B-2-12 (1) Alternative Plan of Kusuman (1)

7. SAKON NAKHON	KUSUMAN
NSD - 13	KUSUMAN



CASE 2			
DESCRIPTION		UNIT	
WATER DEMAND (MAX.)		M^3/D	1,020
RESERVOIR NAME			HUAI DAENG
	CAPACITY	MCM	1.15
TRANSMISSION	DISCHARGE	M^3/S	0.012
	LENGTH	M	4,250
	PIPE DIA	MM	Ø 150
PUMP	HEAD	M	27
	OUTPUT	KW	7.5

CASE 1			
DESCRIPTION		UNIT	
WATER DEMAND (MAX.)		M^3/D	1,020
WATER SOURCE			GROUND WATER
WELL YIELD		M^3/HR	18
TRANSMISSION	DISCHARGE	M^3/S	0.005 x 3
	LENGTH	M	1,040 , 650
	PIPE DIA	MM	Ø 100
PUMP	HEAD	M	25
	OUTPUT	KW	3.7 x 3

Figure B-2-12 (2) Alternative Plan of Kusuman (2)

Figure B–2–12 (3)   Alternative Plan of Kusuman (3)

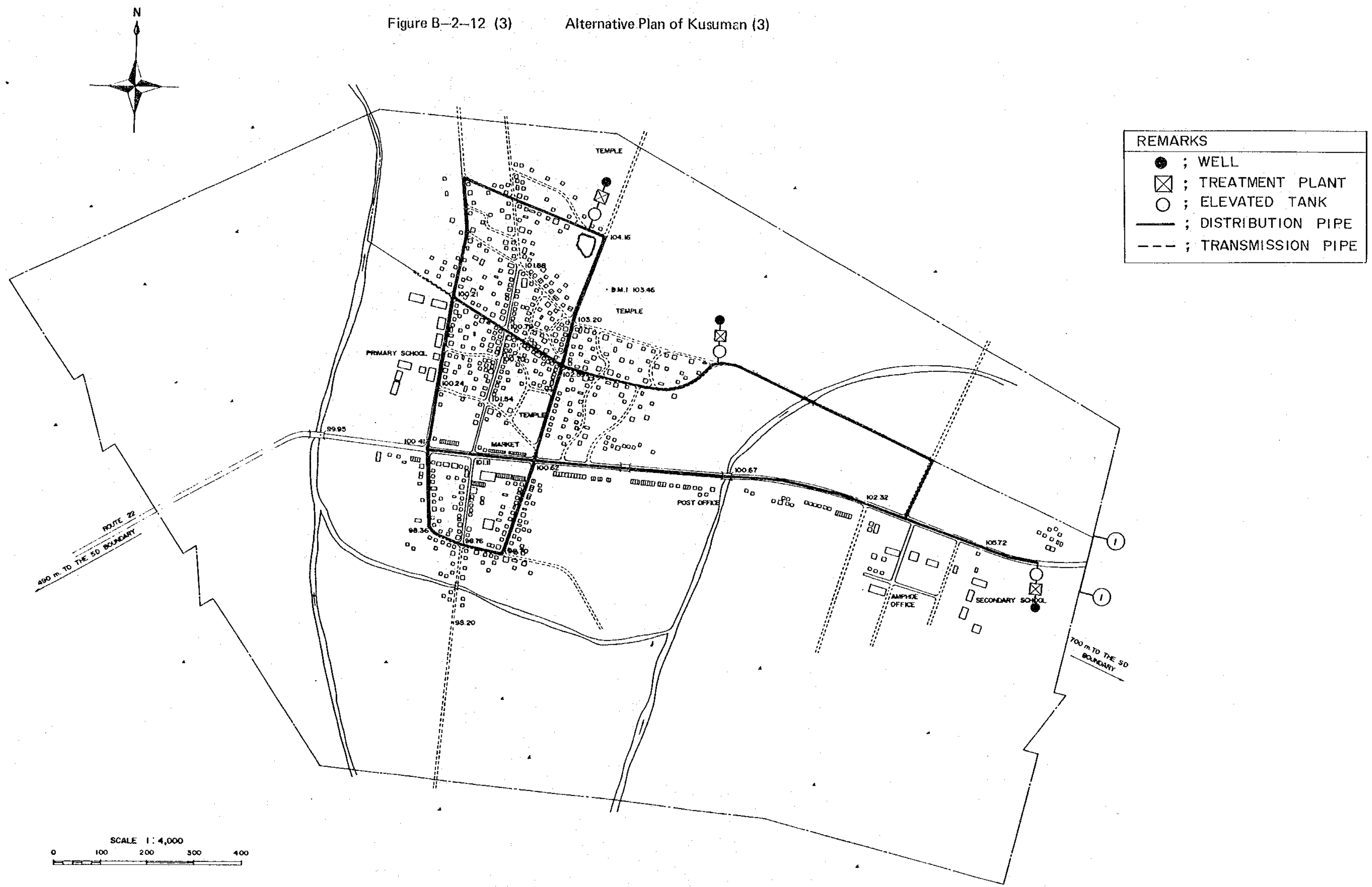
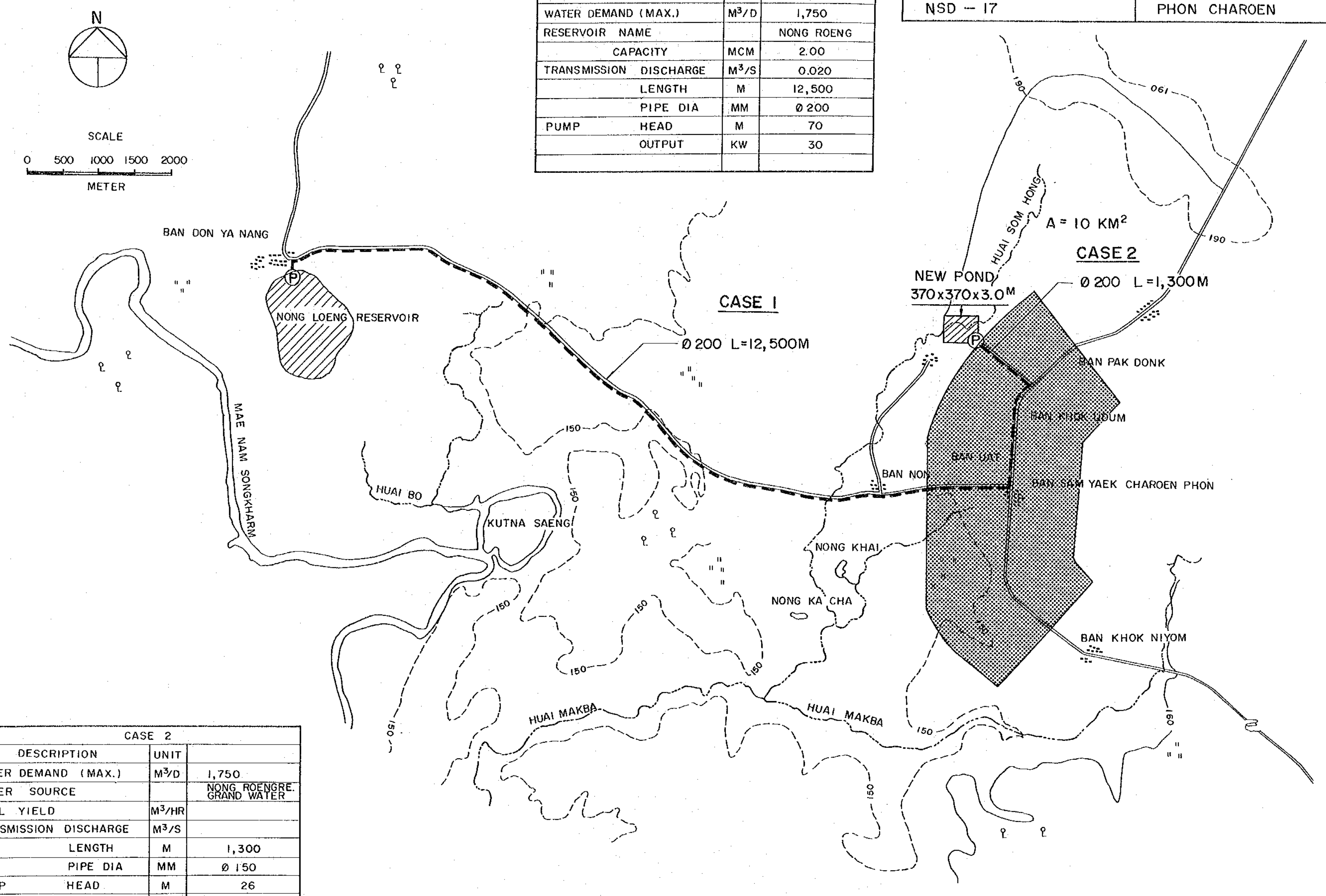


Figure B-2-13 (1) Alternative Plan of Phon Charoen (1)

9. NONG KHAI	PHON CHAROEN
NSD — 17	PHON CHAROEN

CASE 1		
DESCRIPTION	UNIT	
WATER DEMAND (MAX.)	M3/D	1,750
RESERVOIR NAME		NONG ROENG
CAPACITY	MCM	2.00
TRANSMISSION DISCHARGE	M3/S	0.020
LENGTH	M	12,500
PIPE DIA	MM	Ø 200
PUMP HEAD	M	70
OUTPUT	KW	30



CASE 2		
DESCRIPTION	UNIT	
WATER DEMAND (MAX.)	M3/D	1,750
WATER SOURCE		NONG ROENGRE. GRAND WATER
WELL YIELD	M3/HR	
TRANSMISSION DISCHARGE	M3/S	
LENGTH	M	1,300
PIPE DIA	MM	Ø 150
PUMP HEAD	M	26
OUTPUT	KW	

Figure B–2–13 (2) Alternative Plan of Phon Charoen (2)

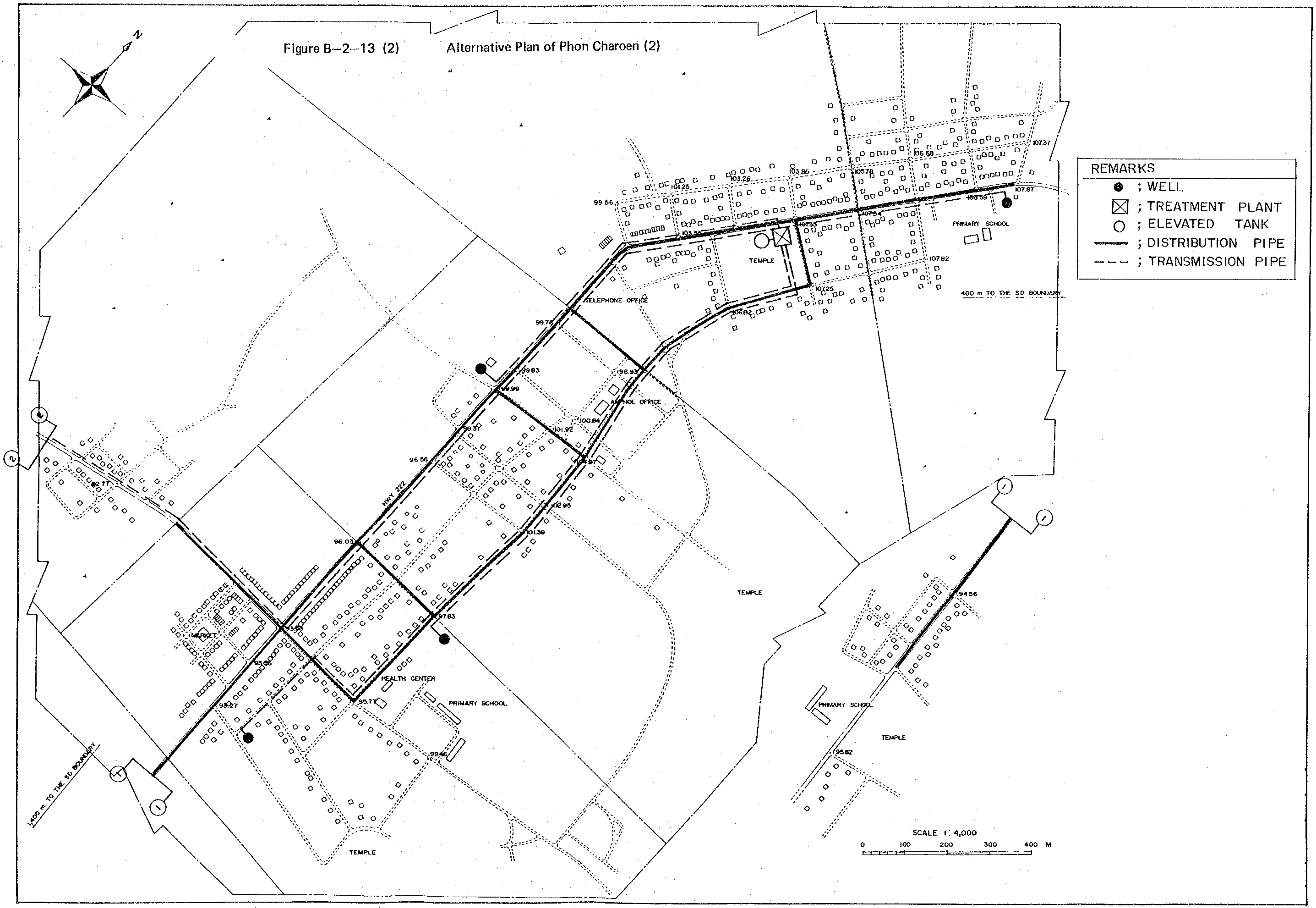


Figure B–2–13 (3) Alternative Plan of Phon Charoen (3)

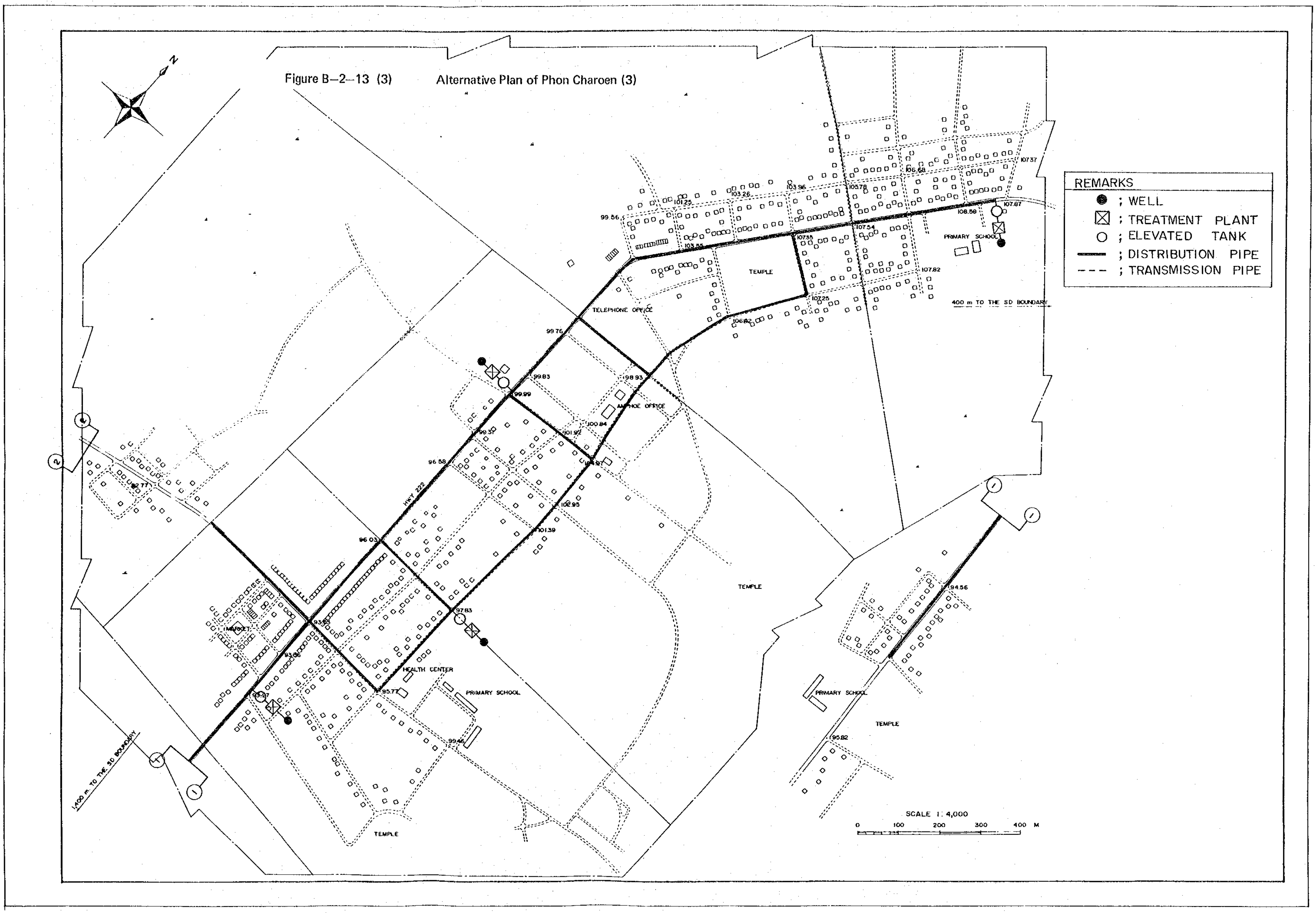


Figure B-2-14 (1) Alternative Plan of Nong Song Hong (1)

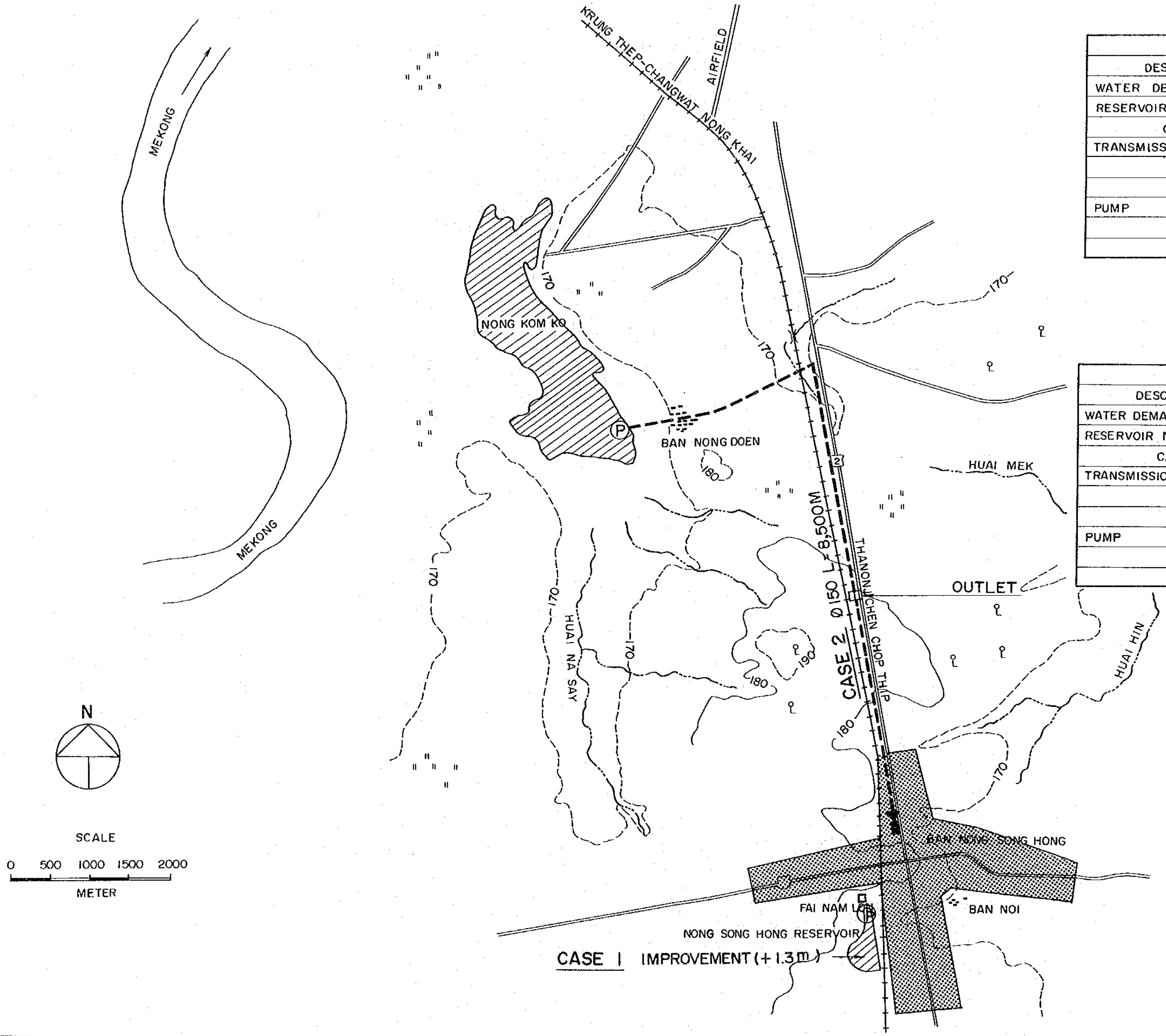
9. NONG KHAI	NONG SONG HONG
NSD – 18	NONG SONG HONG

CASE 1

DESCRIPTION		UNIT	
WATER DEMAND (MAX.)		M³/D	1,420
RESERVOIR NAME			NONG-SONG HONG
CAPACITY		MCM	0.38
TRANSMISSION	DISCHARGE	M³/S	0.016
	LENGTH	M	200
	PIPE DIA	MM	Ø 150
PUMP	HEAD	M	11
	OUTPUT	KW	3.7

CASE 2

DESCRIPTION		UNIT	
WATER DEMAND (MAX.)		M³/D	1,420
RESERVOIR NAME			NONG KOM KO
CAPACITY		MCM	10.0
TRANSMISSION	DISCHARGE	M³/S	0.016
	LENGTH	M	8,500
	PIPE DIA	MM	Ø 200
PUMP	HEAD	M	29
	OUTPUT	KW	11



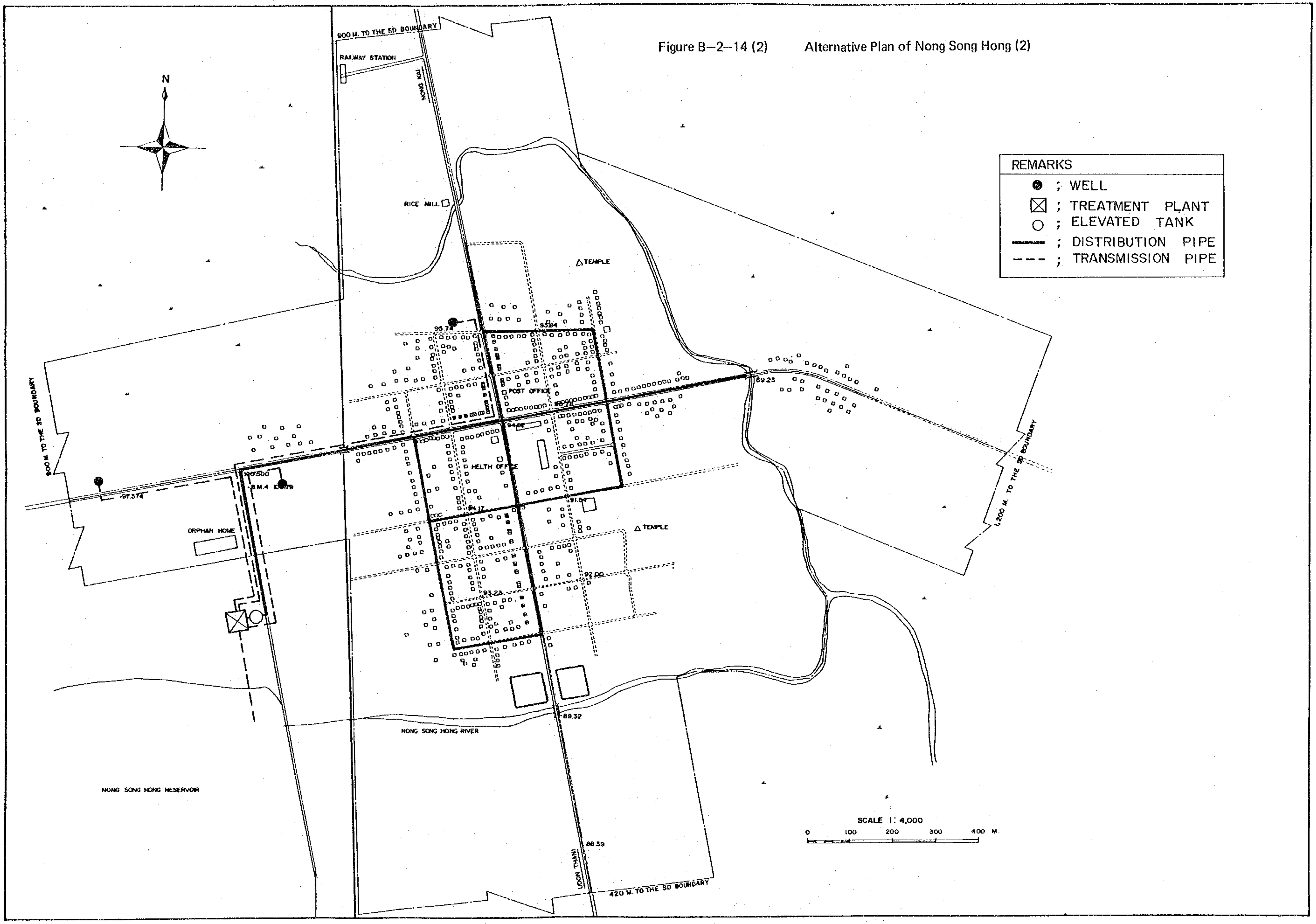
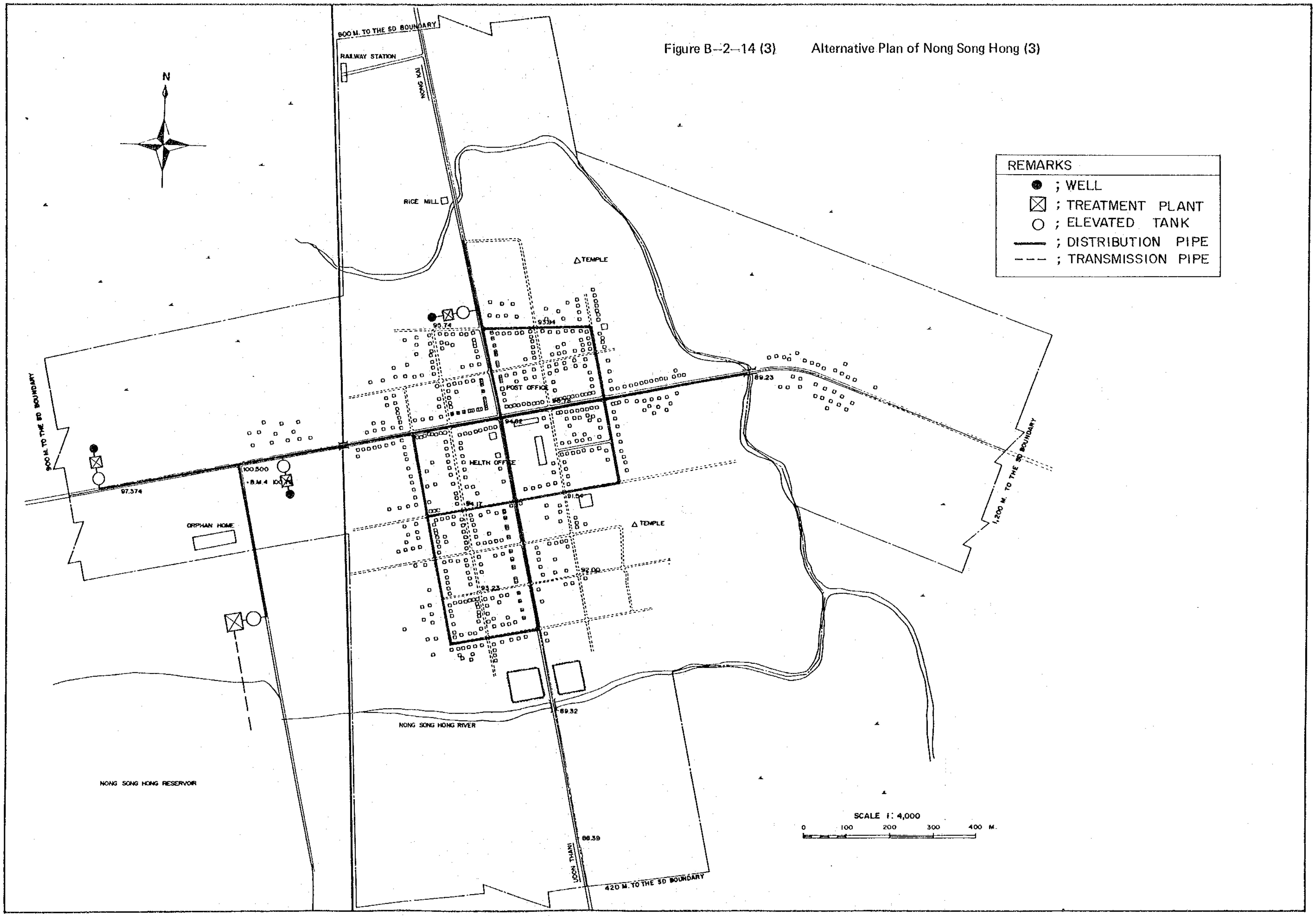


Figure B-2-14 (2) Alternative Plan of Nong Song Hong (2)

Figure B–2–14 (3) Alternative Plan of Nong Song Hong (3)



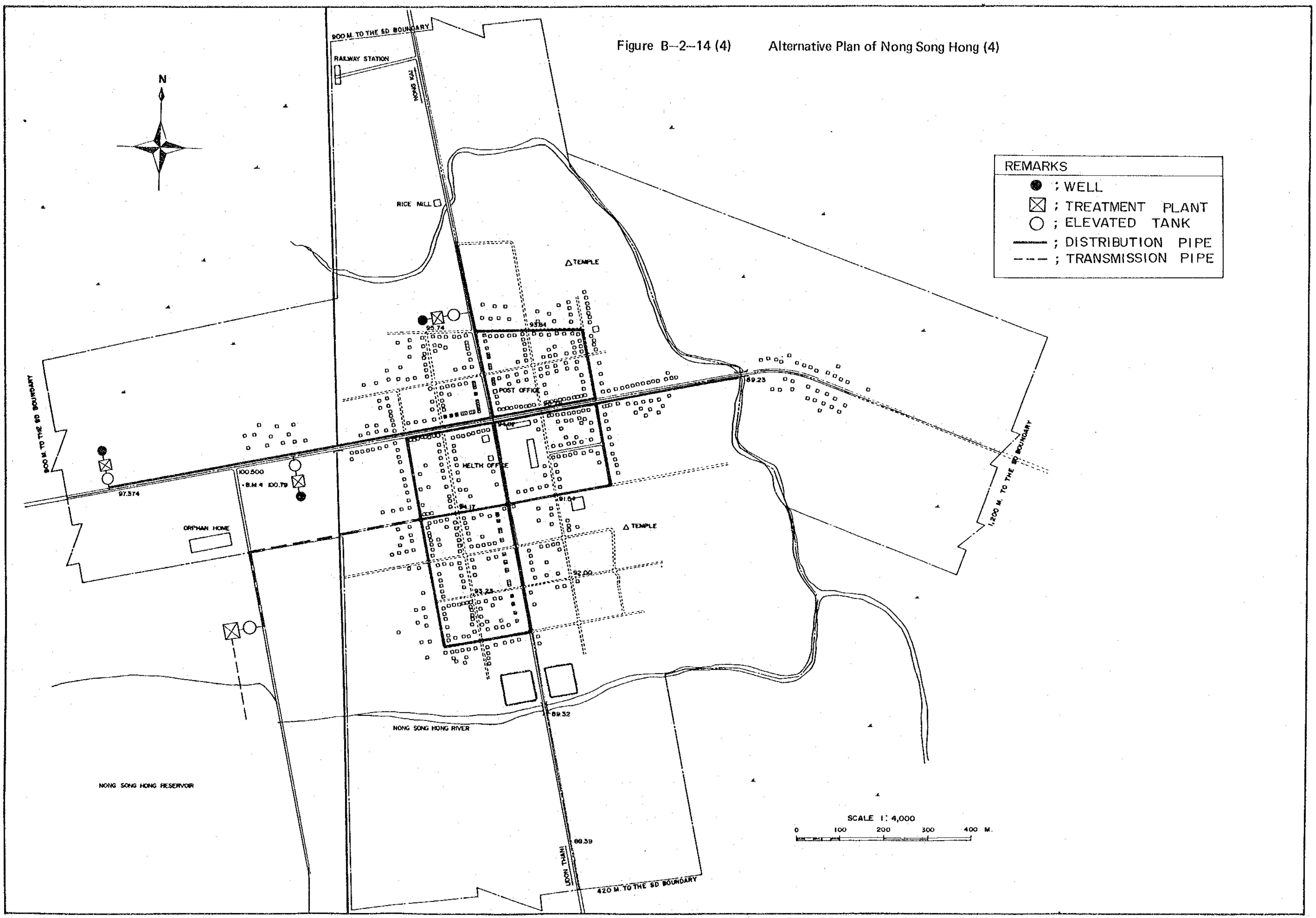
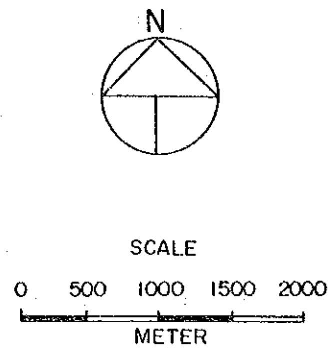


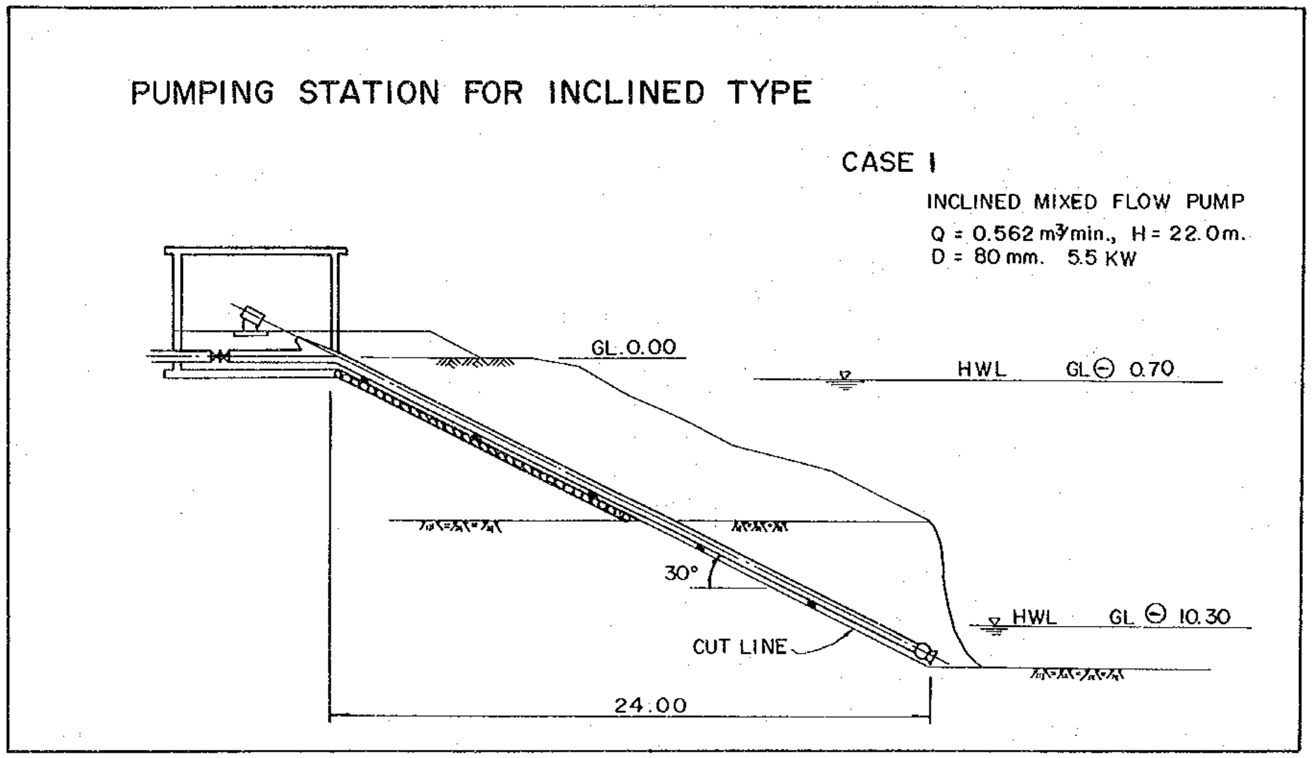
Figure B-2-14 (4) Alternative Plan of Nong Song Hong (4)

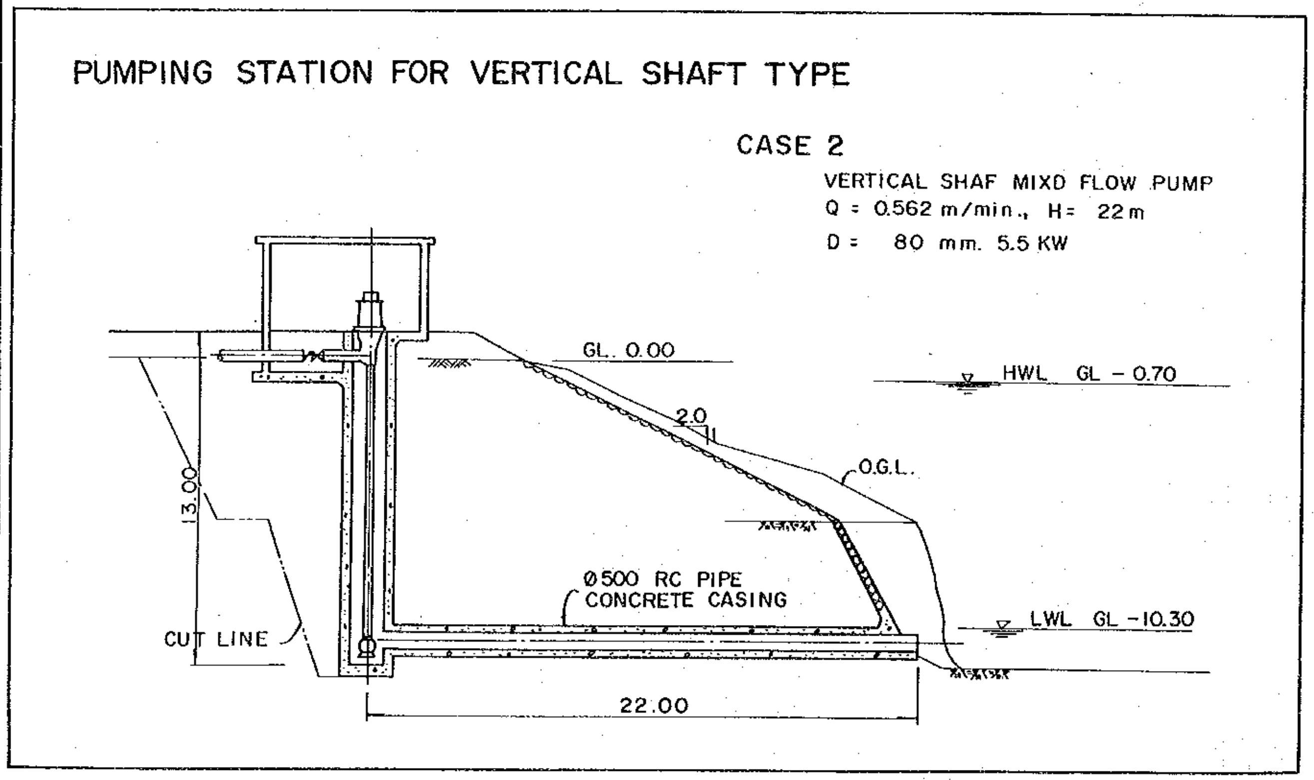
Figure B–2–15 Alternative Plan of Huai Kya Yung

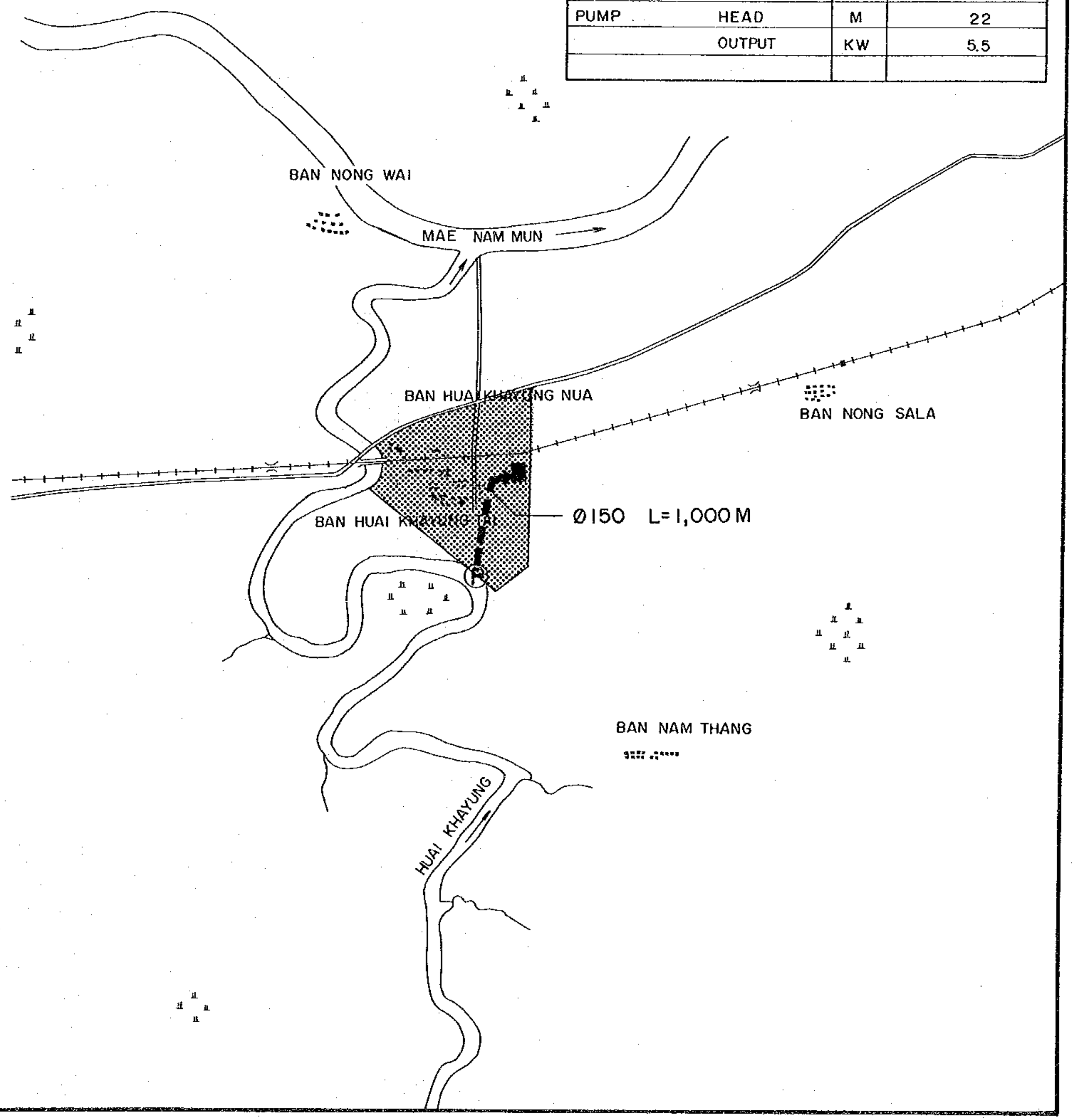
11. UBON RATCHATHANI	WARIN CHAMRAP
NSD – 20	HUAI KHA YUNG



CASE I			
DESCRIPTION		UNIT	
WATER DEMAND (MAX.)		M^3/D	810
RIVER NAME			HUAI KYA YUNG
	CAPACITY	M^3/S	11.7
TRANSMISSION	DISCHARGE	M^3/S	0.009
	LENGTH	M	1,000
	PIPE DIA	MM	Ø 150
PUMP	HEAD	M	22
	OUTPUT	KW	5.5







B.2.3. Hydraulic Calculation of Pipeline Network

Table B-2-2(1) Diameter and Effective Head of Pipeline

NAME OF SANITARY DISTRICT ; KUSUMAN (ALTERNATIVE PLAN 1)

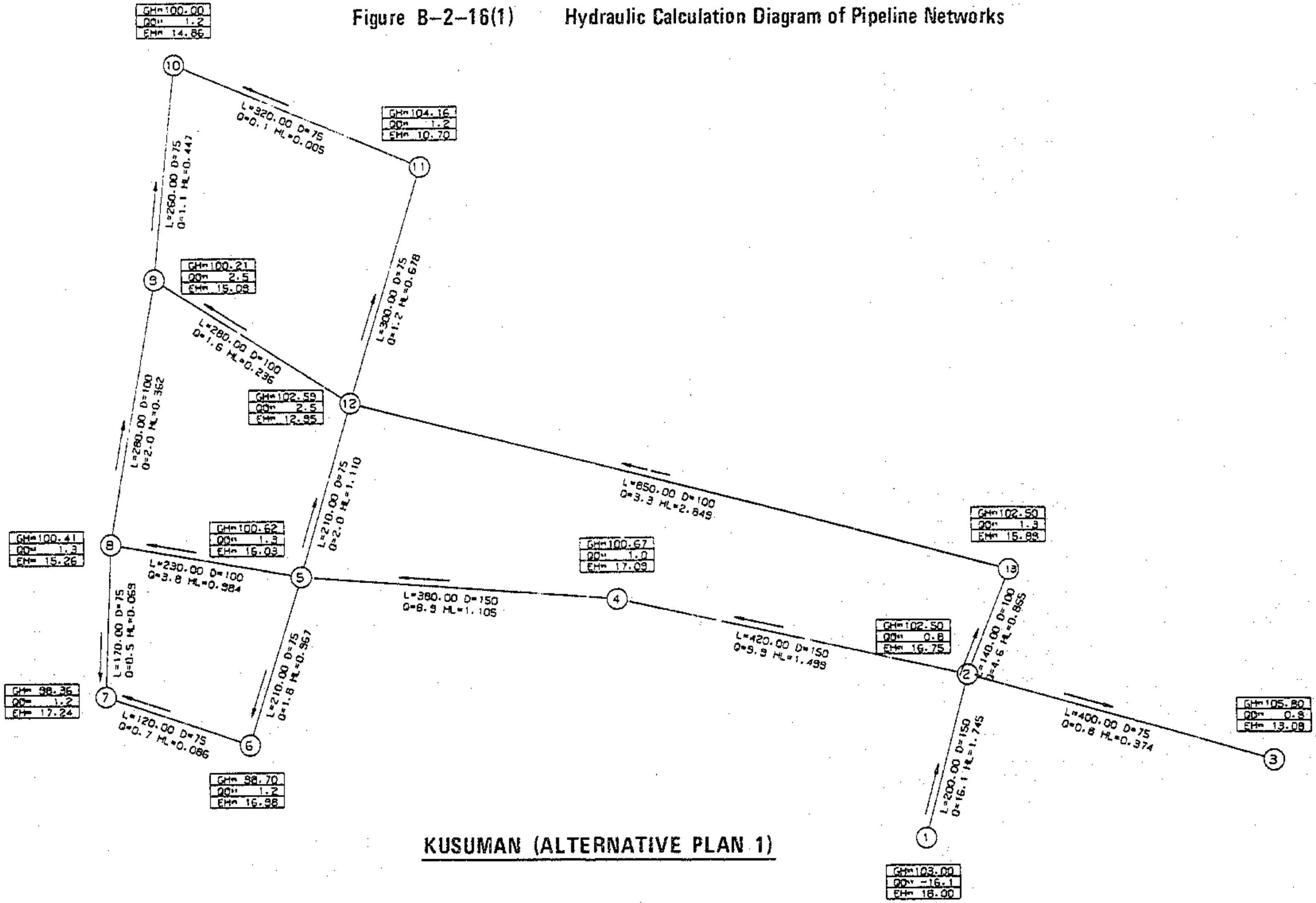
*** INPUT DATA ***

MINIMUM DIAMETER	0.075 (M)
NUMBER OF PIPELINE	16
NUMBER OF CONTACT	13
NUMBER OF CONTACT DESIGNATING WATER HEAD	1
HOURLY MAXIMUM WATER DEMAND	0.0026 (L/SEC/CAPITA)
DESIGNATED CONTACT	1
DESIGNATED WATER HEAD (M)	119.6

CONTACT NO.	DIVERTED WATER HEAD (EL.M)	GROUND ELEVATION (EL.M)	EFFECTIVE HEAD (M)	POPULATION SERVED	WATER DEMAND (L/SEC)
1	119.550	102.550	17.000	-6200.0	-16.1
2	117.114	102.500	14.614	500.0	1.3
3	116.781	102.500	14.281	300.0	0.8
4	116.689	105.800	10.889	300.0	0.8
5	116.570	100.670	15.900	400.0	1.0
6	116.566	100.620	15.946	500.0	1.3
7	116.034	98.700	17.334	450.0	1.2
8	116.028	98.360	17.668	450.0	1.2
9	116.282	100.410	15.872	500.0	1.3
10	116.299	100.210	16.089	950.0	2.5
11	116.373	100.000	16.373	450.0	1.2
12	116.812	104.160	12.652	450.0	1.2
13	117.763	102.590	15.173	950.0	2.5

PIPE NO.	CONTACT NO. FROM	CONTACT NO. TO	DIAMETER (MM)	LENGTH (M)	DISCHARGE COEFFICIENT	DISCHARGE (L/SEC)	VELOCITY (M/SEC)	HEAD LOSS (M)	HYDROURIC GRADIENT	FRICTION LOSS COEFFICIENT
1	1	2	100	500.00	110	4.1	0.516	2.436	4.871	0.03588
2	2	3	100	140.00	110	2.8	0.350	0.333	2.379	0.03800
3	3	4	100	400.00	110	0.8	0.099	0.092	0.231	0.04580
4	3	5	100	420.00	110	1.2	0.152	0.212	0.504	0.04302
5	5	6	100	380.00	110	0.2	0.019	0.004	0.011	0.05846
6	6	7	75	210.00	110	1.3	0.302	0.531	2.530	0.04075
7	7	8	75	120.00	110	0.2	0.037	0.006	0.053	0.05556
8	8	9	75	170.00	110	-1.0	-0.228	-0.255	-1.497	-0.04250
9	9	10	100	280.00	110	-0.4	-0.048	-0.017	-0.060	-0.05098
10	10	11	100	260.00	110	-0.9	-0.111	-0.074	-0.284	-0.04505
11	11	12	100	320.00	110	-2.0	-0.260	-0.439	-1.371	-0.03971
12	12	13	100	300.00	110	-3.2	-0.409	-0.951	-3.171	-0.03714
13	9	6	100	230.00	110	-1.9	-0.245	-0.283	-1.231	-0.04006
14	10	13	75	280.00	110	-2.0	-0.447	-1.464	-5.228	-0.03845
15	13	6	100	210.00	110	4.4	0.562	1.198	5.704	0.03543
16	13	1	150	350.00	110	-12.1	-0.683	-1.787	-5.105	-0.03217
TOTAL				4570.00						

Figure B-2-16(1) Hydraulic Calculation Diagram of Pipeline Networks



KUSUMAN (ALTERNATIVE PLAN 1)

Table B-2-2(2) Diameter and Effective Head of Pipeline

NAME OF SANITARY DISTRICT ; KUSUMAN (ALTERNATIVE PLAN 2)

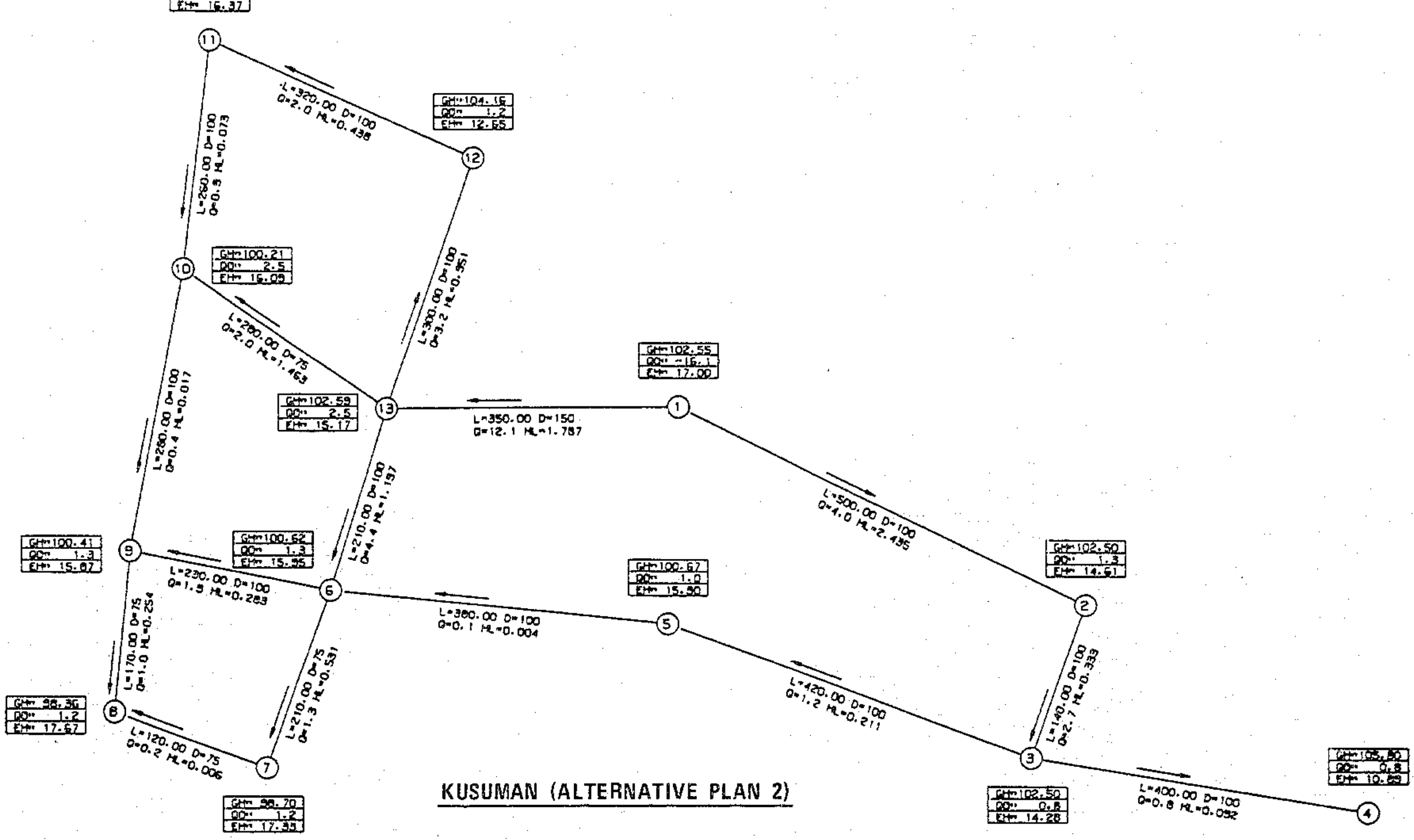
*** INPUT DATA ***

MINIMUM DIAMETER	0.075 (M)
NUMBER OF PIPELINE	16
NUMBER OF CONTACT	13
NUMBER OF CONTACT DESIGNATING WATER HEAD	1
HOURLY MAXIMUM WATER DEMAND	0.0026 (L/SEC/CAPITA)
DESIGNATED CONTACT	1
DESIGNATED WATER HEAD (M)	119.6

CONTACT NO.	DIVERTED WATER HEAD (EL.M)	GROUND ELEVATION (EL.M)	EFFECTIVE HEAD (M)	POPULATION SERVED	WATER DEMAND (L/SEC)
1	119.550	102.550	17.000	-6200.0	-16.1
2	117.114	102.500	14.614	500.0	1.3
3	116.781	102.500	14.281	300.0	0.8
4	116.689	105.800	10.889	300.0	0.8
5	116.570	100.670	15.900	400.0	1.0
6	116.566	100.620	15.946	500.0	1.3
7	116.034	98.700	17.334	450.0	1.2
8	116.028	98.360	17.668	450.0	1.2
9	116.282	100.410	15.872	500.0	1.3
10	116.299	100.210	16.089	950.0	2.5
11	116.373	100.000	16.373	450.0	1.2
12	116.812	104.160	12.652	450.0	1.2
13	117.763	102.590	15.173	950.0	2.5

PIPE NO.	CONTACT NO. FROM	TO	DIAMETER (MM)	LENGTH (M)	DISCHARGE COEFFICIENT	DISCHARGE (L/SEC)	VELOCITY (M/SEC)	HEAD LOSS (M)	HYDROURIC GRADIENT	FRICTION LOSS COEFFICIENT
1	1	2	100	500.00	110	4.1	0.516	2.436	4.871	0.03588
2	2	3	100	140.00	110	2.8	0.350	0.333	2.379	0.03800
3	3	4	100	400.00	110	0.8	0.099	0.092	0.231	0.04580
4	3	5	100	420.00	110	1.2	0.152	0.212	0.504	0.04302
5	5	6	100	380.00	110	0.2	0.019	0.004	0.011	0.05846
6	6	7	75	210.00	110	1.3	0.302	0.531	2.530	0.04075
7	7	8	75	120.00	110	0.2	0.037	0.006	0.053	0.05556
8	8	9	75	170.00	110	-1.0	-0.228	-0.255	-1.497	-0.04250
9	9	10	100	280.00	110	-0.4	-0.048	-0.017	-0.060	-0.05098
10	10	11	100	260.00	110	-0.9	-0.111	-0.074	-0.284	-0.04505
11	11	12	100	320.00	110	-2.0	-0.260	-0.439	-1.371	-0.03971
12	12	13	100	300.00	110	-3.2	-0.409	-0.951	-3.171	-0.03714
13	9	6	100	230.00	110	-1.9	-0.245	-0.283	-1.231	-0.04006
14	10	13	75	280.00	110	-2.0	-0.447	-1.464	-5.228	-0.03845
15	13	6	100	210.00	110	4.4	0.562	1.198	5.704	0.03543
16	13	1	150	350.00	110	-12.1	-0.683	-1.787	-5.105	-0.03217
TOTAL				4570.00						

Figure B-2-16(2) Hydraulic Calculation Diagram of Pipeline Networks



KUSUMAN (ALTERNATIVE PLAN 2)

Table B-2-2(3) Diameter and Effective Head of Pipeline

NAME OF SANITARY DISTRICT ; KUSUMAN (ALTERNATIVE PLAN 3)

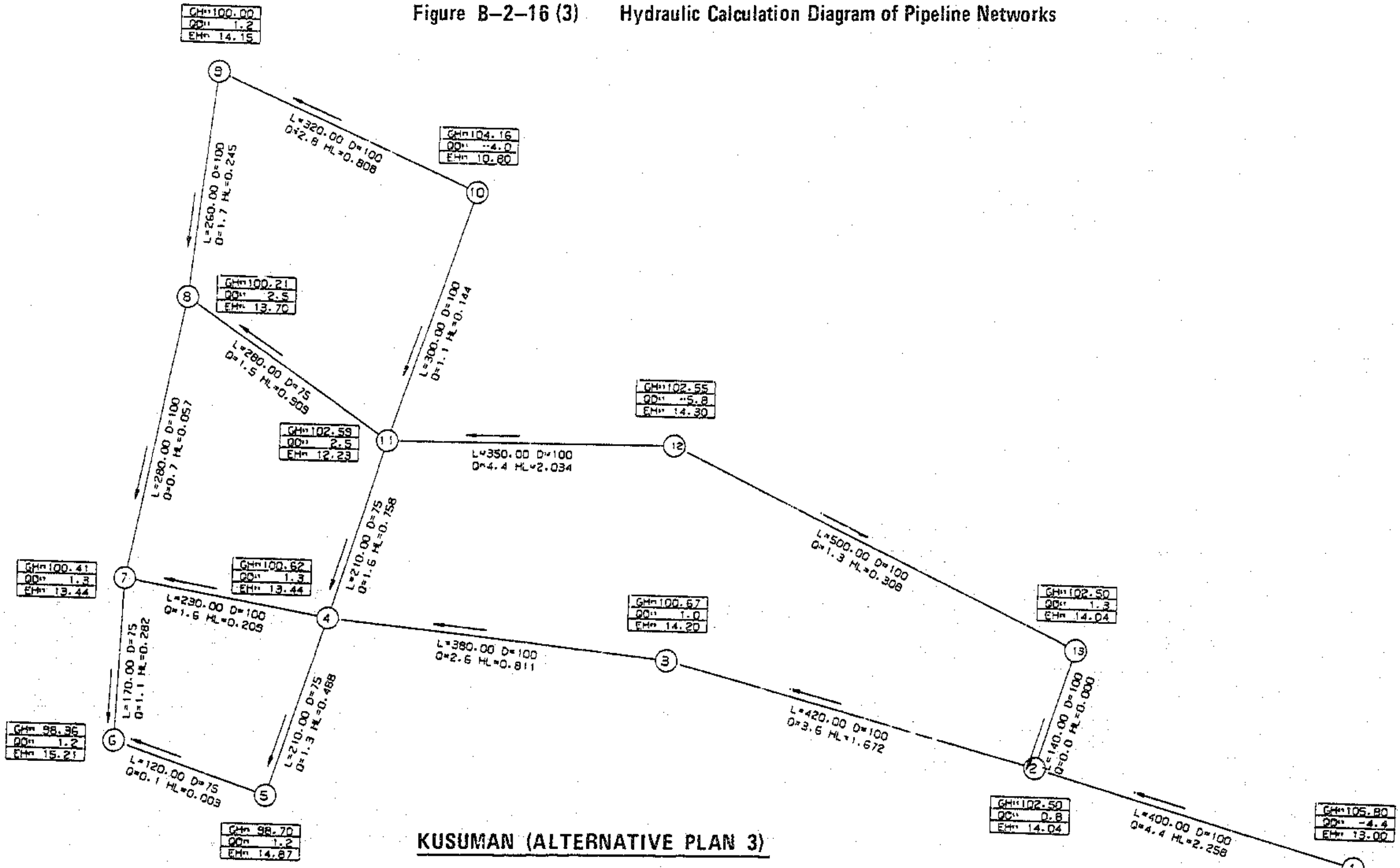
*** INPUT DATA ***

MINIMUM DIAMETER	0.075 (M)
NUMBER OF PIPELINE	16
NUMBER OF CONTACT	13
NUMBER OF CONTACT DESIGNATING WATER HEAD	1
HOURLY MAXIMUM WATER DEMAND	0.0026 (L/SEC/CAPITA)
DESIGNATED CONTACT	1
DESIGNATED WATER HEAD (M)	118.8

CONTACT NO.	DIVERTED WATER HEAD (EL.M)	GROUND ELEVATION (EL.M)	EFFECTIVE HEAD (M)	POPULATION SERVED	WATER DEMAND (L/SEC)
1	118.800	105.800	13.000	-1700.0	-4.4
2	116.513	102.500	14.013	300.0	0.8
3	114.844	100.670	14.174	400.0	1.0
4	114.036	100.620	13.416	500.0	1.3
5	113.548	98.700	14.848	450.0	1.2
6	113.545	98.360	15.185	450.0	1.2
7	113.828	100.410	13.418	500.0	1.3
8	113.886	100.210	13.676	950.0	2.5
9	114.133	100.000	14.133	450.0	1.2
10	114.944	104.160	10.784	-1550.0	-4.0
11	114.795	102.590	12.205	950.0	2.5
12	116.806	102.550	14.256	-2200.0	-5.7
13	116.513	102.500	14.013	500.0	1.3

PIPE NO.	CONTACT NO. FROM	CONTACT NO. TO	DIAMETER (MM)	LENGTH (M)	DISCHARGE COEFFICIENT	DISCHARGE (L/SEC)	VELOCITY (M/SEC)	HEAD LOSS (M)	HYDROURIC GRADIENT	FRICTION LOSS COEFFICIENT
1	1	2	100	400.00	110	4.4	0.562	2.287	5.718	0.03543
2	2	3	100	420.00	110	3.6	0.462	1.669	3.973	0.03647
3	3	4	100	380.00	110	2.6	0.330	0.808	2.126	0.03834
4	4	5	75	210.00	110	1.3	0.289	0.488	2.325	0.04103
5	5	6	75	120.00	110	0.1	0.024	0.003	0.023	0.05940
6	6	7	75	170.00	110	-1.1	-0.241	-0.283	-1.666	-0.04214
7	7	8	100	280.00	110	-0.7	-0.093	-0.058	-0.206	-0.04622
8	8	9	100	260.00	110	-1.7	-0.214	-0.247	-0.951	-0.04089
9	9	10	100	320.00	110	-2.8	-0.362	-0.811	-2.535	-0.03781
10	10	11	100	300.00	110	1.2	0.151	0.150	0.499	0.04306
11	11	4	75	210.00	110	1.6	0.366	0.758	3.612	0.03961
12	8	11	75	280.00	110	-1.5	-0.346	-0.909	-3.246	-0.03995
13	7	4	100	230.00	110	-1.6	-0.208	-0.208	-0.904	-0.04106
14	11	12	100	350.00	110	-4.4	-0.564	-2.011	-5.746	-0.03541
15	12	13	100	500.00	110	1.3	0.164	0.293	0.586	0.04251
16	13	2	100	140.00	110	-0.0	-0.002	-0.000	-0.000	-0.07995
TOTAL				4570.00						

Figure B-2-16 (3) Hydraulic Calculation Diagram of Pipeline Networks



KUSUMAN (ALTERNATIVE PLAN 3)

Table B-2-3(1) Diameter and Effective Head of Pipeline

NAME OF SANITARY DISTRICT ; PHON CHAROEN (ALTERNATIVE PLAN 1)

*** INPUT DATA ***

MINIMUM DIAMETER	0.075 (M)
NUMBER OF PIPELINE	17
NUMBER OF CONTACT	14
NUMBER OF CONTACT DESIGNATING WATER HEAD	1
HOURLY MAXIMUM WATER DEMAND	0.0026 (L/SEC/CAPITA)
DESIGNATED CONTACT	1
DESIGNATED WATER HEAD (M)	121.4

CONTACT NO.	DIVERTED WATER HEAD (EL.M)	GROUND ELEVATION (EL.M)	EFFECTIVE HEAD (M)	POPULATION SERVED	WATER DEMAND (L/SEC)
1	121.350	107.350	14.000	-10600.0	-27.6
2	118.670	107.870	10.800	1590.0	4.1
3	119.391	102.000	17.391	1000.0	2.6
4	118.774	99.800	18.974	650.0	1.7
5	118.136	99.090	19.046	220.0	0.6
6	116.835	96.030	20.805	220.0	0.6
7	115.950	93.530	22.420	2080.0	5.4
8	113.083	94.560	18.523	1430.0	3.7
9	113.597	92.770	20.827	710.0	1.8
10	116.129	95.770	20.359	1100.0	2.9
11	117.617	97.830	19.787	200.0	0.5
12	118.424	104.970	13.454	200.0	0.5
13	118.982	98.930	20.052	600.0	1.6
14	120.588	107.250	13.338	600.0	1.6

PIPE NO.	CONTACT NO. FROM	TO	DIAMETER (MM)	LENGTH (M)	DISCHARGE COEFFICIENT	DISCHARGE (L/SEC)	VELOCITY (M/SEC)	HEAD LOSS (M)	HYDROURIC GRADIENT	FRICTION LOSS COEFFICIENT
1	1	2	100	530.00	110	4.1	0.526	2.680	5.057	0.03578
2	1	3	150	400.00	110	11.8	0.668	1.959	4.897	0.03228
3	3	4	150	200.00	110	9.2	0.521	0.618	3.088	0.03349
4	4	5	150	250.00	110	8.3	0.469	0.637	2.549	0.03401
5	5	6	150	480.00	110	8.6	0.485	1.302	2.712	0.03384
6	6	7	150	270.00	110	9.5	0.538	0.885	3.278	0.03333
7	7	8	100	690.00	110	3.7	0.473	2.867	4.155	0.03634
8	9	7	75	510.00	110	-1.8	-0.418	-2.353	-4.613	-0.03884
9	7	10	100	240.00	110	-1.5	-0.187	-0.179	-0.746	-0.04169
10	10	11	100	270.00	110	-4.3	-0.551	-1.488	-5.511	-0.03553
11	11	12	150	520.00	110	-6.3	-0.359	-0.807	-1.553	-0.03539
12	12	13	150	250.00	110	-7.7	-0.437	-0.558	-2.233	-0.03437
13	13	14	150	440.00	110	-10.1	-0.570	-1.605	-3.648	-0.03305
14	6	11	75	250.00	110	-1.5	-0.339	-0.782	-3.128	-0.04006
15	5	12	75	260.00	110	-0.9	-0.193	-0.288	-1.106	-0.04354
16	4	13	75	220.00	110	-0.8	-0.178	-0.208	-0.948	-0.04408
17	1	14	150	160.00	110	11.6	0.658	0.762	4.765	0.03235
TOTAL				5940.00						

Table B-2-3(2) Diameter and Effective Head of Pipeline

NAME OF SANITARY DISTRICT ; PHON CHAROEN (ALTERNATIVE PLAN 2)

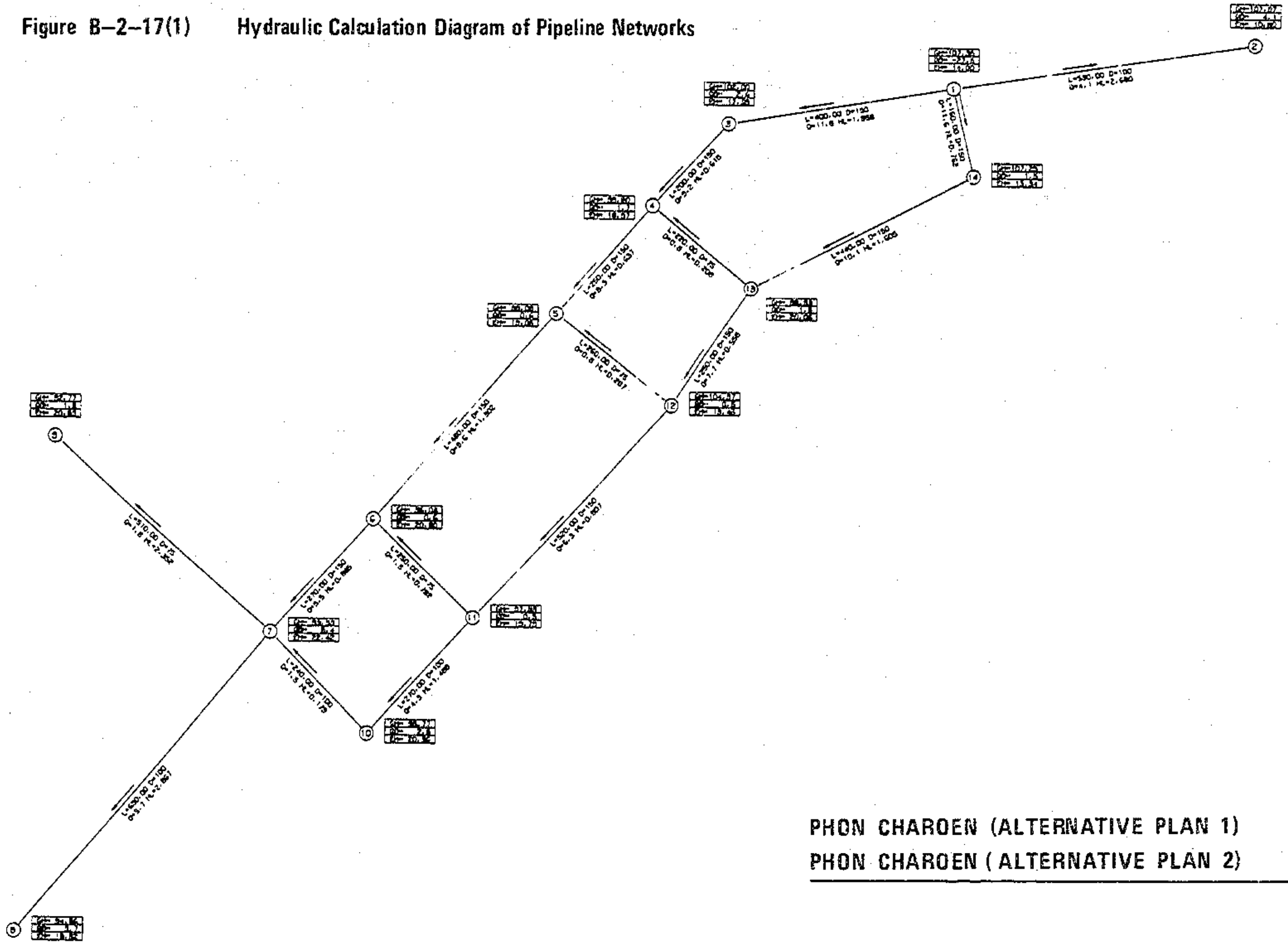
*** INPUT DATA ***

MINIMUM DIAMETER	0.075 (M)
NUMBER OF PIPELINE	17
NUMBER OF CONTACT	14
NUMBER OF CONTACT DESIGNATING WATER HEAD	1
HOURLY MAXIMUM WATER DEMAND	0.0026 (L/SEC/CAPITA)
DESIGNATED CONTACT	1
DESIGNATED WATER HEAD (M)	121.4

CONTACT NO.	DIVERTED WATER HEAD (EL.M)	GROUND ELEVATION (EL.M)	EFFECTIVE HEAD (M)	POPULATION SERVED	WATER DEMAND (L/SEC)
1	121.350	107.350	14.000	-10600.0	-27.6
2	118.670	107.870	10.800	1590.0	4.1
3	119.391	102.000	17.391	1000.0	2.6
4	118.774	99.800	18.974	650.0	1.7
5	118.136	99.090	19.046	220.0	0.6
6	116.835	96.030	20.805	220.0	0.6
7	115.950	93.530	22.420	2080.0	5.4
8	113.083	94.560	18.523	1430.0	3.7
9	113.597	92.770	20.827	710.0	1.8
10	116.129	95.770	20.359	1100.0	2.9
11	117.617	97.830	19.787	200.0	0.5
12	118.424	104.970	13.454	200.0	0.5
13	118.982	98.930	20.052	600.0	1.6
14	120.588	107.250	13.338	600.0	1.6

PIPE NO.	CONTACT NO. FROM	CONTACT NO. TO	DIAMETER (MM)	LENGTH (M)	DISCHARGE COEFFICIENT	DISCHARGE (L/SEC)	VELOCITY (M/SEC)	HEAD LOSS (M)	HYDROURIC GRADIENT	FRICTION LOSS COEFFICIENT
1	1	2	100	530.00	110	4.1	0.526	2.680	5.057	0.03578
2	1	3	150	400.00	110	11.8	0.668	1.959	4.897	0.03228
3	3	4	150	200.00	110	9.2	0.521	0.618	3.088	0.03349
4	4	5	150	250.00	110	8.3	0.469	0.637	2.549	0.03401
5	5	6	150	480.00	110	8.6	0.485	1.302	2.712	0.03384
6	6	7	150	270.00	110	9.5	0.538	0.885	3.278	0.03333
7	7	8	100	690.00	110	3.7	0.473	2.867	4.155	0.03634
8	9	7	75	510.00	110	-1.8	-0.418	-2.353	-4.613	-0.03884
9	7	10	100	240.00	110	-1.5	-0.187	-0.179	-0.746	-0.04169
10	10	11	100	270.00	110	-4.3	-0.551	-1.488	-5.511	-0.03553
11	11	12	150	520.00	110	-6.3	-0.359	-0.807	-1.553	-0.03539
12	12	13	150	250.00	110	-7.7	-0.437	-0.558	-2.233	-0.03437
13	13	14	150	440.00	110	-10.1	-0.570	-1.605	-3.648	-0.03305
14	6	11	75	250.00	110	-1.5	-0.339	-0.782	-3.128	-0.04006
15	5	12	75	260.00	110	-0.9	-0.193	-0.288	-1.106	-0.04354
16	4	13	75	220.00	110	-0.8	-0.178	-0.208	-0.948	-0.04408
17	1	14	150	160.00	110	11.6	0.658	0.762	4.765	0.03235
TOTAL				5940.00						

Figure B–2–17(1) Hydraulic Calculation Diagram of Pipeline Networks



PHON CHAROEN (ALTERNATIVE PLAN 1)
PHON CHAROEN (ALTERNATIVE PLAN 2)

Table B-2-3(3) Diameter and Effective Head of Pipeline

NAME OF SANITARY DISTRICT ; PHON CHAROEN (ALTERNATIVE PLAN 3)

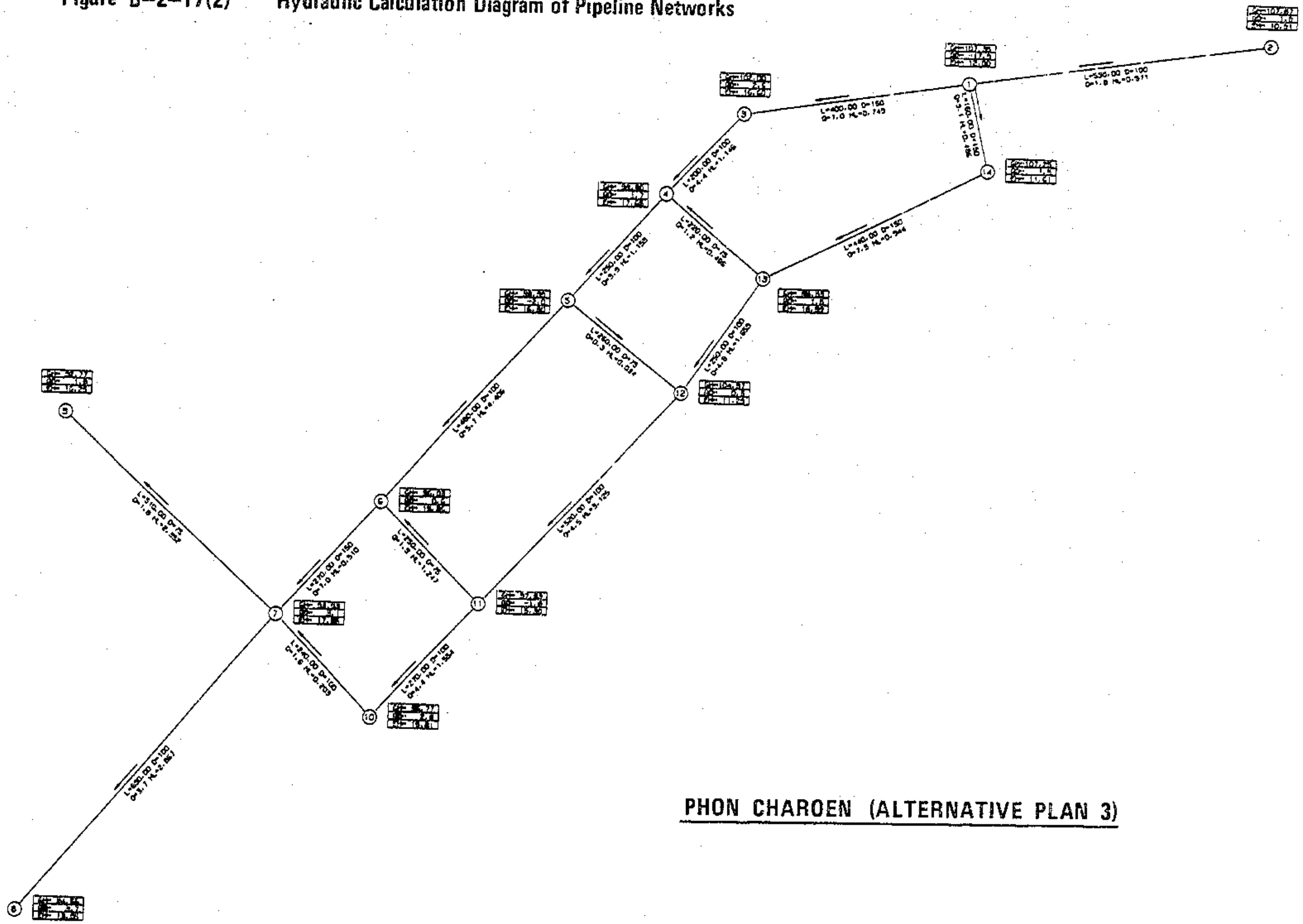
*** INPUT DATA ***

MINIMUM DIAMETER	0.075 (M)
NUMBER OF PIPELINE	17
NUMBER OF CONTACT	14
NUMBER OF CONTACT DESIGNATING WATER HEAD	1
HOURLY MAXIMUM WATER DEMAND	0.0026 (L/SEC/CAPITA)
DESIGNATED CONTACT	1
DESIGNATED WATER HEAD (M)	119.4

CONTACT NO.	DIVERTED WATER HEAD (EL.M)	GROUND ELEVATION (EL.M)	EFFECTIVE HEAD (M)	POPULATION SERVED	WATER DEMAND (L/SEC)
1	119.350	107.350	12.000	-6900.0	-17.9
2	118.779	107.870	10.909	690.0	1.8
3	118.601	102.000	16.601	1000.0	2.6
4	117.454	99.800	17.654	650.0	1.7
5	116.295	99.990	16.305	-780.0	-2.0
6	111.889	96.030	15.859	220.0	0.6
7	111.378	93.530	17.848	1180.0	3.1
8	108.511	94.560	13.951	1430.0	3.7
9	109.025	92.770	16.255	710.0	1.8
10	111.581	95.770	15.811	1100.0	2.9
11	113.136	97.830	15.306	-700.0	-1.8
12	116.261	104.970	11.291	200.0	0.5
13	117.920	98.930	18.990	600.0	1.6
14	118.864	107.250	11.614	600.0	1.6

PIPE NO.	CONTACT NO. FROM	TO	DIAMETER (MM)	LENGTH (M)	DISCHARGE COEFFICIENT	DISCHARGE (L/SEC)	VELOCITY (M/SEC)	HEAD LOSS (M)	HYDROURIC GRADIENT	FRICTION LOSS COEFFICIENT
1	1	2	100	530.00	110	1.8	0.228	0.571	1.078	0.04048
2	1	3	150	400.00	110	7.0	0.397	0.749	1.873	0.03486
3	3	4	100	200.00	110	4.4	0.563	1.146	5.731	0.03542
4	4	5	100	250.00	110	3.9	0.502	1.160	4.638	0.03602
5	5	6	100	480.00	110	5.7	0.726	4.406	9.180	0.03411
6	6	7	150	270.00	110	7.1	0.399	0.510	1.890	0.03483
7	7	8	100	690.00	110	3.7	0.473	2.867	4.155	0.03634
8	9	7	75	510.00	110	-1.8	-0.418	-2.353	-4.613	-0.03884
9	7	10	100	240.00	110	-1.6	-0.200	-0.203	-0.846	-0.04128
10	10	11	100	270.00	110	-4.4	-0.565	-1.554	-5.756	-0.03541
11	11	12	100	520.00	110	-4.5	-0.578	-3.125	-6.010	-0.03528
12	12	13	100	250.00	110	-4.8	-0.610	-1.659	-6.637	-0.03501
13	13	14	150	440.00	110	-7.6	-0.428	-0.944	-2.145	-0.03448
14	6	11	75	250.00	110	-1.9	-0.436	-1.247	-4.988	-0.03860
15	5	12	75	260.00	110	0.3	0.061	0.034	0.131	0.05165
16	4	13	75	220.00	110	-1.2	-0.274	-0.466	-2.116	-0.04134
17	1	14	150	160.00	110	9.1	0.516	0.486	3.038	0.03354
TOTAL				5940.00						

Figure B-2-17(2) Hydraulic Calculation Diagram of Pipeline Networks



PHON CHAROEN (ALTERNATIVE PLAN 3)

Table B-2-4(1) Diameter and Effective Head of Pipeline

NAME OF SANITARY DISTRICT ; NONG SONG HONG (ALTERNATIVE PLAN 1)

*** INPUT DATA ***

MINIMUM DIAMETER	0.075 (M)
NUMBER OF PIPELINE	17
NUMBER OF CONTACT	14
NUMBER OF CONTACT DESIGNATING WATER HEAD	1
HOURLY MAXIMUM WATER DEMAND	0.0026 (L/SEC/CAPITA)
DESIGNATED CONTACT	1
DESIGNATED WATER HEAD (M)	114.0

CONTACT NO.	DIVERTED WATER HEAD (EL.M)	GROUND ELEVATION (EL.M)	EFFECTIVE HEAD (M)	POPULATION SERVED	WATER DEMAND (L/SEC)
1	114.000	100.000	14.000	-8600.0	-22.4
2	112.307	100.500	11.807	250.0	0.6
3	110.779	96.000	14.779	780.0	2.0
4	109.583	94.020	15.563	1740.0	4.5
5	108.793	90.700	18.093	950.0	2.5
6	108.095	89.230	18.865	420.0	1.1
7	107.785	95.000	12.785	700.0	1.8
8	108.683	95.740	12.943	780.0	2.0
9	108.684	93.800	14.884	500.0	1.3
10	110.420	94.000	16.420	500.0	1.3
11	109.466	93.000	16.466	860.0	2.2
12	108.991	91.800	17.191	300.0	0.8
13	109.403	93.000	16.403	400.0	1.0
14	109.309	92.500	16.809	420.0	1.1

PIPE NO.	CONTACT NO. FROM	CONTACT NO. TO	DIAMETER (MM)	LENGTH (M)	DISCHARGE COEFFICIENT	DISCHARGE (L/SEC)	VELOCITY (M/SEC)	HEAD LOSS (M)	HYDROURIC GRADIENT	FRICTION LOSS COEFFICIENT
1	1	2	200	430.00	110	22.4	0.712	1.693	3.937	0.03048
2	2	3	200	410.00	110	21.7	0.691	1.528	3.727	0.03061
3	3	4	150	210.00	110	12.8	0.725	1.196	5.695	0.03189
4	4	5	100	250.00	110	3.2	0.408	0.790	3.160	0.03715
5	5	6	75	400.00	110	1.1	0.247	0.698	1.745	0.04198
6	4	8	100	210.00	110	3.8	0.481	0.900	4.284	0.03625
7	8	7	75	200.00	110	1.8	0.412	0.899	4.494	0.03892
8	8	9	100	250.00	110	-0.1	-0.007	-0.000	-0.002	-0.06781
9	9	5	100	170.00	110	-1.4	-0.173	-0.109	-0.641	-0.04220
10	10	3	150	200.00	110	-6.9	-0.389	-0.359	-1.797	-0.03497
11	11	4	100	200.00	110	-1.3	-0.165	-0.117	-0.587	-0.04250
12	12	5	100	200.00	110	1.7	0.218	0.198	0.988	0.04077
13	10	11	100	200.00	110	4.0	0.510	0.954	4.770	0.03594
14	11	12	100	240.00	110	2.5	0.317	0.475	1.980	0.03856
15	13	10	75	300.00	110	-1.6	-0.354	-1.017	-3.389	-0.03981
16	14	11	75	300.00	110	-0.6	-0.129	-0.157	-0.522	-0.04623
17	13	14	75	210.00	110	0.5	0.118	0.094	0.446	0.04682
TOTAL				4380.00						

Table B-2-4(2) Diameter and Effective Head of Pipeline

NAME OF SANITARY DISTRICT ; NONG SONG HONG (ALTERNATIVE PLAN 2)

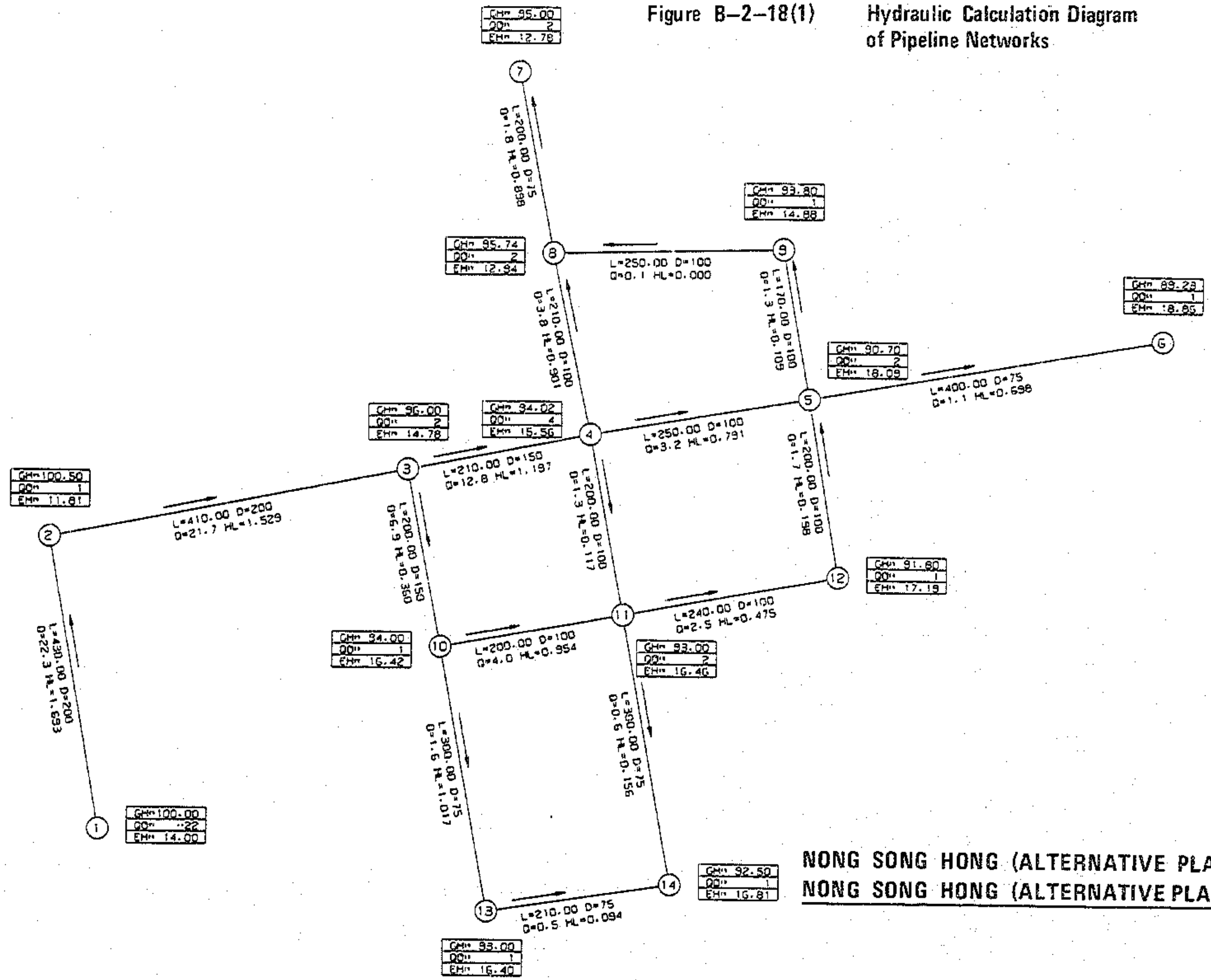
*** INPUT DATA ***

MINIMUM DIAMETER	0.075 (M)
NUMBER OF PIPELINE	17
NUMBER OF CONTACT	14
NUMBER OF CONTACT DESIGNATING WATER HEAD	1
HOURLY MAXIMUM WATER DEMAND	0.0026 (L/SEC/CAPITA)
DESIGNATED CONTACT	1
DESIGNATED WATER HEAD (M)	114.0

CONTACT NO.	DIVERTED WATER HEAD (EL.M)	GROUND ELEVATION (EL.M)	EFFECTIVE HEAD (M)	POPULATION SERVED	WATER DEMAND (L/SEC)
1	114.000	100.000	14.000	-8600.0	-22.4
2	112.307	100.500	11.807	250.0	0.6
3	110.779	96.000	14.779	780.0	2.0
4	109.583	94.020	15.563	1740.0	4.5
5	108.793	90.700	18.093	950.0	2.5
6	108.095	89.230	18.865	420.0	1.1
7	107.785	95.000	12.785	700.0	1.8
8	108.683	95.740	12.943	780.0	2.0
9	108.684	93.800	14.884	500.0	1.3
10	110.420	94.000	16.420	500.0	1.3
11	109.466	93.000	16.466	860.0	2.2
12	108.991	91.800	17.191	300.0	0.8
13	109.403	93.000	16.403	400.0	1.0
14	109.309	92.500	16.809	420.0	1.1

PIPE NO.	CONTACT NO. FROM	CONTACT NO. TO	DIAMETER (MM)	LENGTH (M)	DISCHARGE COEFFICIENT	DISCHARGE (L/SEC)	VELOCITY (M/SEC)	HEAD LOSS (M)	HYDROURIC GRADIENT	FRICTION LOSS COEFFICIENT
1	1	2	200	430.00	110	22.4	0.712	1.693	3.937	0.03048
2	2	3	200	410.00	110	21.7	0.691	1.528	3.727	0.03061
3	3	4	150	210.00	110	12.8	0.725	1.196	5.695	0.03189
4	4	5	100	250.00	110	3.2	0.408	0.790	3.160	0.03715
5	5	6	75	400.00	110	1.1	0.247	0.698	1.745	0.04198
6	4	8	100	210.00	110	3.8	0.481	0.900	4.284	0.03625
7	8	7	75	200.00	110	1.8	0.412	0.899	4.494	0.03892
8	8	9	100	250.00	110	-0.1	-0.007	-0.000	-0.002	-0.06781
9	9	5	100	170.00	110	-1.4	-0.173	-0.109	-0.641	-0.04220
10	10	3	150	200.00	110	-6.9	-0.389	-0.359	-1.797	-0.03497
11	11	4	100	200.00	110	-1.3	-0.165	-0.117	-0.587	-0.04250
12	12	5	100	200.00	110	1.7	0.218	0.198	0.988	0.04077
13	10	11	100	200.00	110	4.0	0.510	0.954	4.770	0.03594
14	11	12	100	240.00	110	2.5	0.317	0.475	1.980	0.03856
15	13	10	75	300.00	110	-1.6	-0.354	-1.017	-3.389	-0.03981
16	14	11	75	300.00	110	-0.6	-0.129	-0.157	-0.522	-0.04623
17	13	14	75	210.00	110	0.5	0.118	0.094	0.446	0.04682
TOTAL				4380.00						

Figure B-2-18(1) Hydraulic Calculation Diagram of Pipeline Networks



NONG SONG HONG (ALTERNATIVE PLAN 1)
NONG SONG HONG (ALTERNATIVE PLAN 2)

Table B-2-4(3) Diameter and Effective Head of Pipeline

NAME OF SANITARY DISTRICT ; NONG SONG HONG (ALTERNATIVE PLAN 3)

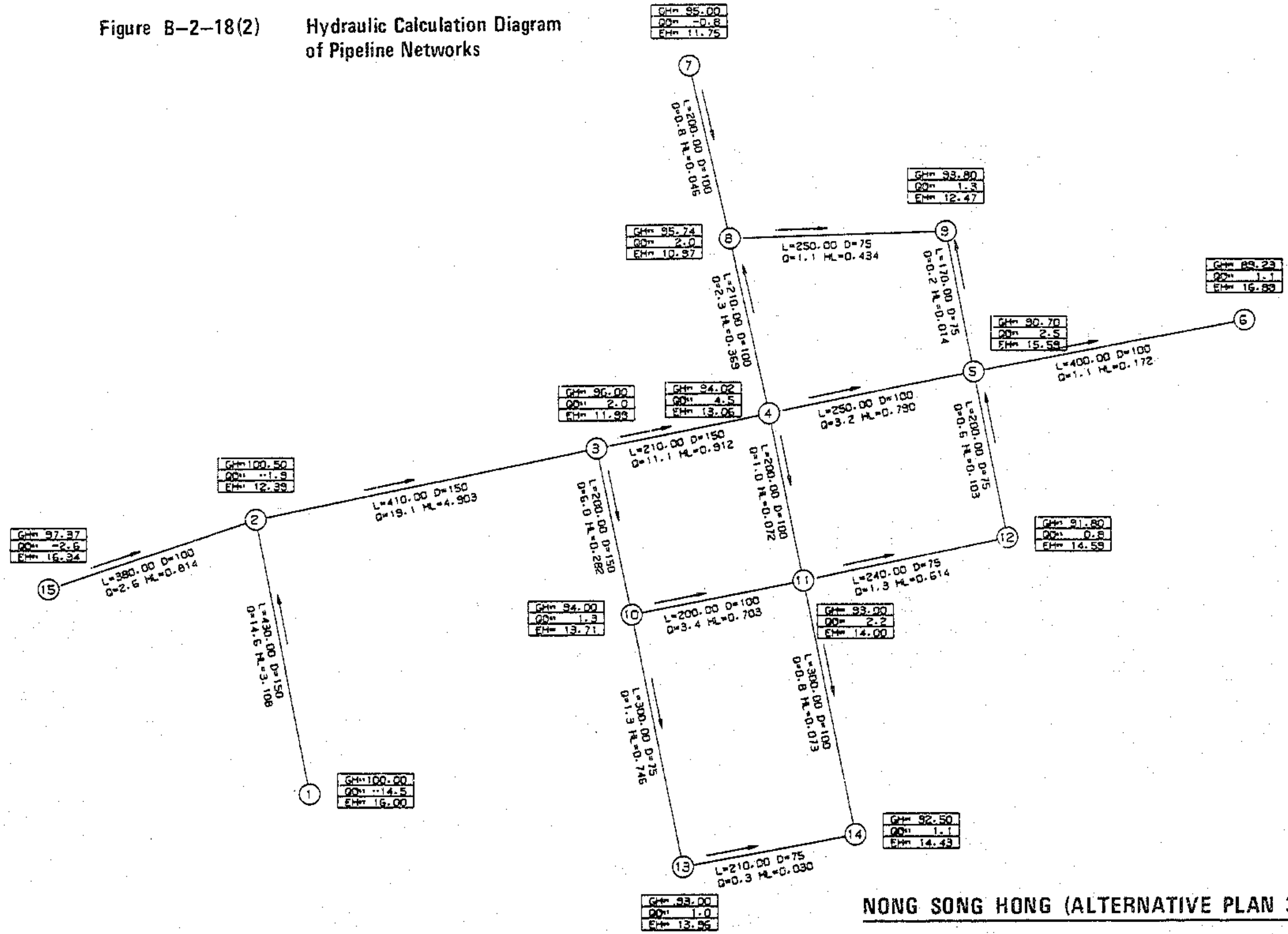
*** INPUT DATA ***

MINIMUM DIAMETER	0.075 (M)
NUMBER OF PIPELINE	18
NUMBER OF CONTACT	15
NUMBER OF CONTACT DESIGNATING WATER HEAD	1
HOURLY MAXIMUM WATER DEMAND	0.0026 (L/SEC/CAPITA)
DESIGNATED CONTACT	1
DESIGNATED WATER HEAD (M)	116.0

CONTACT NO.	DIVERTED WATER HEAD (EL.M)	GROUND ELEVATION (EL.M)	EFFECTIVE HEAD (M)	POPULATION SERVED	WATER DEMAND (L/SEC)
1	116.000	100.000	16.000	-5600.0	-14.6
2	112.892	100.500	12.392	-750.0	-1.9
3	107.989	96.000	11.989	780.0	2.0
4	107.077	94.020	13.057	1740.0	4.5
5	106.287	90.700	15.587	950.0	2.5
6	106.115	89.230	16.885	420.0	1.1
7	106.754	95.000	11.754	-300.0	-0.8
8	106.708	95.740	10.968	780.0	2.0
9	106.273	93.800	12.473	500.0	1.3
10	107.708	94.000	13.708	500.0	1.3
11	107.005	93.000	14.005	860.0	2.2
12	106.390	91.800	14.590	300.0	0.8
13	106.961	93.000	13.961	400.0	1.0
14	106.931	92.500	14.431	420.0	1.1
15	113.706	97.370	16.336	-1000.0	-2.6

PIPE NO.	CONTACT NO. FROM	CONTACT NO. TO	DIAMETER (MM)	LENGTH (M)	DISCHARGE COEFFICIENT	DISCHARGE (L/SEC)	VELOCITY (M/SEC)	HEAD LOSS (M)	HYDROURIC GRADIENT	FRICTION LOSS COEFFICIENT
1	1	2	150	430.00	110	14.6	0.824	3.108	7.228	0.03129
2	2	3	150	410.00	110	19.1	1.082	4.903	11.958	0.03005
3	3	4	150	210.00	110	11.1	0.626	0.912	4.345	0.03259
4	4	5	100	250.00	110	3.2	0.408	0.790	3.160	0.03715
5	5	6	100	400.00	110	1.1	0.139	0.172	0.430	0.04358
6	4	8	100	210.00	110	2.3	0.298	0.369	1.759	0.03893
7	8	7	100	200.00	110	-0.8	-0.099	-0.046	-0.230	-0.04580
8	8	9	75	250.00	110	1.1	0.247	0.435	1.738	0.04199
9	9	5	75	170.00	110	-0.2	-0.047	-0.014	-0.082	-0.05363
10	10	3	150	200.00	110	-6.0	-0.341	-0.282	-1.408	-0.03566
11	11	4	100	200.00	110	-1.0	-0.126	-0.072	-0.361	-0.04419
12	12	5	75	200.00	110	0.6	0.128	0.103	0.516	0.04628
13	10	11	100	200.00	110	3.4	0.432	0.703	3.514	0.03683
14	11	12	75	240.00	110	1.3	0.304	0.615	2.562	0.04071
15	13	10	75	300.00	110	-1.3	-0.299	-0.746	-2.488	-0.04080
16	14	11	100	300.00	110	-0.8	-0.103	-0.074	-0.246	-0.04557
17	13	14	75	210.00	110	0.3	0.064	0.030	0.144	0.05126
18	2	15	100	380.00	110	-2.6	-0.331	-0.814	-2.142	-0.03832
TOTAL				4760.00						

Figure B-2-18(2) Hydraulic Calculation Diagram of Pipeline Networks



NONG SONG HONG (ALTERNATIVE PLAN 3)

Table B-2-4(4) Diameter and Effective Head of Pipeline

NAME OF SANITARY DISTRICT ; NONG SONG HONG (ALTERNATIVE PLAN 4-1)

*** INPUT DATA ***

MINIMUM DIAMETER	0.075 (M)
NUMBER OF PIPELINE	12
NUMBER OF CONTACT	10
NUMBER OF CONTACT DESIGNATING WATER HEAD	1
HOURLY MAXIMUM WATER DEMAND	0.0026 (L/SEC/CAPITA)
DESIGNATED CONTACT	1
DESIGNATED WATER HEAD (M)	112.0

CONTACT NO.	DIVERTED WATER HEAD (EL.M)	GROUND ELEVATION (EL.M)	EFFECTIVE HEAD (M)	POPULATION SERVED	WATER DEMAND (L/SEC)
1	112.000	100.000	12.000	-5600.0	-14.6
2	108.245	94.000	14.245	500.0	1.3
3	106.578	96.000	10.578	700.0	1.8
4	105.758	94.020	11.738	1200.0	3.1
5	104.535	90.700	13.835	800.0	2.1
6	103.837	89.230	14.607	420.0	1.1
7	106.333	93.000	13.333	860.0	2.2
8	104.994	91.800	13.194	300.0	0.8
9	106.621	93.000	13.621	400.0	1.0
10	106.325	92.500	13.825	420.0	1.1

PIPE NO.	CONTACT NO. FROM	CONTACT NO. TO	DIAMETER (MM)	LENGTH (M)	DISCHARGE COEFFICIENT	DISCHARGE (L/SEC)	VELOCITY (M/SEC)	HEAD LOSS (M)	HYDROURIC GRADIENT	FRICTION LOSS COEFFICIENT
1	1	2	150	520.00	110	14.6	0.824	3.755	7.222	0.03129
2	2	3	100	200.00	110	5.4	0.689	1.667	8.335	0.03437
3	3	4	100	210.00	110	3.6	0.458	0.820	3.903	0.03652
4	4	5	75	250.00	110	1.9	0.431	1.223	4.892	0.03866
5	5	6	75	400.00	110	1.1	0.247	0.698	1.745	0.04198
6	2	7	100	200.00	110	5.8	0.742	1.911	9.556	0.03400
7	7	8	75	240.00	110	2.0	0.463	1.339	5.581	0.03825
8	7	4	75	200.00	110	1.4	0.324	0.575	2.877	0.04033
9	8	5	75	200.00	110	1.3	0.287	0.459	2.295	0.04107
10	9	2	75	300.00	110	-2.0	-0.455	-1.623	-5.411	-0.03835
11	10	7	75	300.00	110	-0.1	-0.027	-0.008	-0.028	-0.05839
12	9	10	75	210.00	110	1.0	0.220	0.296	1.411	0.04270
TOTAL				3230.00						

Table B-2-4(5) Diameter and Effective Head of Pipeline

NAME OF SANITARY DISTRICT ; NONG SONG HONG (ALTERNATIVE PLAN 4-2)

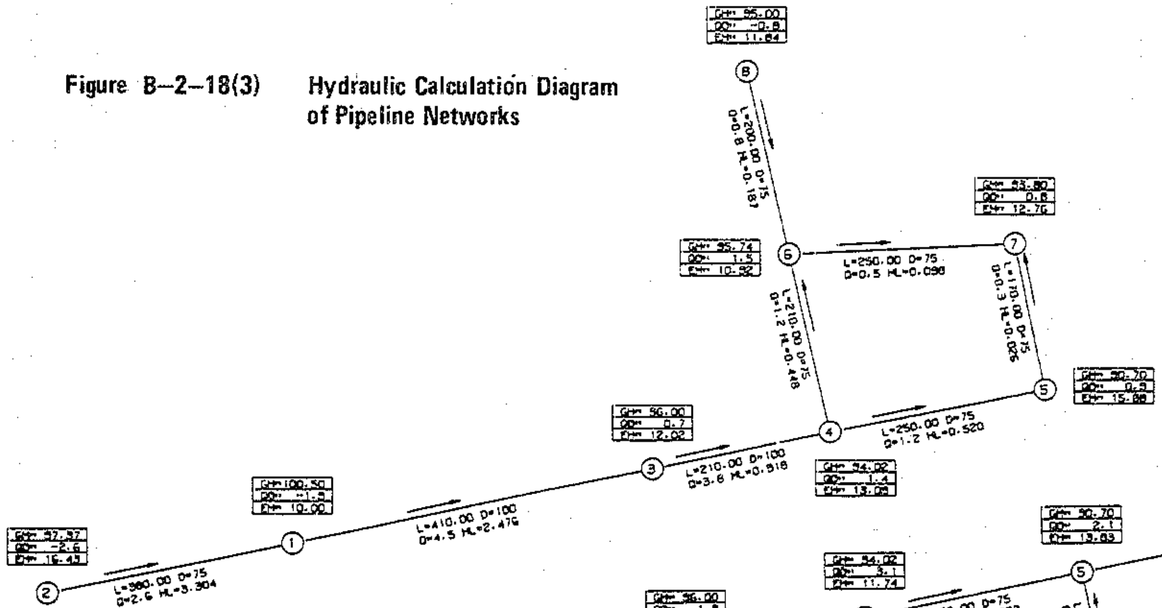
*** INPUT DATA ***

MINIMUM DIAMETER	0.075 (M)
NUMBER OF PIPELINE	8
NUMBER OF CONTACT	8
NUMBER OF CONTACT DESIGNATING WATER HEAD	1
HOURLY MAXIMUM WATER DEMAND	0.0026 (L/SEC/CAPITA)
DESIGNATED CONTACT	1
DESIGNATED WATER HEAD (M)	110.5

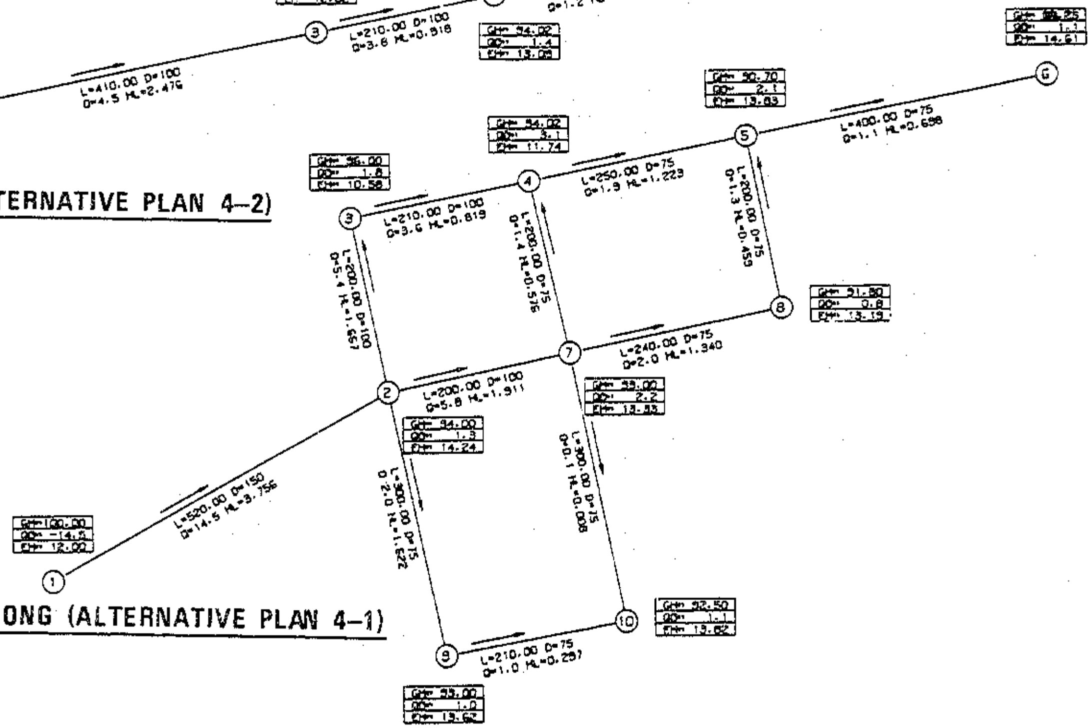
CONTACT NO.	DIVERTED WATER HEAD (EL.M)	GROUND ELEVATION (EL.M)	EFFECTIVE HEAD (M)	POPULATION SERVED	WATER DEMAND (L/SEC)
1	110.500	100.500	10.000	-750.0	-1.9
2	113.805	97.370	16.435	-1000.0	-2.6
3	108.024	96.000	12.024	280.0	0.7
4	107.105	94.020	13.085	540.0	1.4
5	106.585	90.700	15.885	350.0	0.9
6	106.658	95.740	10.918	580.0	1.5
7	106.559	93.800	12.759	300.0	0.8
8	106.845	95.000	11.845	-300.0	-0.8

PIPE NO.	CONTACT NO. FROM	TO	DIAMETER (MM)	LENGTH (M)	DISCHARGE COEFFICIENT	DISCHARGE (L/SEC)	VELOCITY (M/SEC)	HEAD LOSS (M)	HYDROURIC GRADIENT	FRICTION LOSS COEFFICIENT
1	1	2	75	380.00	110	-2.6	-0.588	-3.305	-8.697	-0.03692
2	1	3	100	410.00	110	4.5	0.579	2.476	6.040	0.03527
3	3	4	100	210.00	110	3.8	0.487	0.918	4.373	0.03619
4	4	5	75	250.00	110	1.2	0.272	0.521	2.082	0.04139
5	4	6	75	210.00	110	1.2	0.275	0.448	2.132	0.04131
6	6	8	75	200.00	110	-0.8	-0.177	-0.187	-0.936	-0.04413
7	6	7	75	250.00	110	0.5	0.111	0.098	0.394	0.04729
8	5	7	75	170.00	110	0.3	0.066	0.026	0.151	0.05105
TOTAL				2080.00						

Figure B-2-18(3) Hydraulic Calculation Diagram of Pipeline Networks



NONG SONG HONG (ALTERNATIVE PLAN 4-2)



NONG SONG HONG (ALTERNATIVE PLAN 4-1)