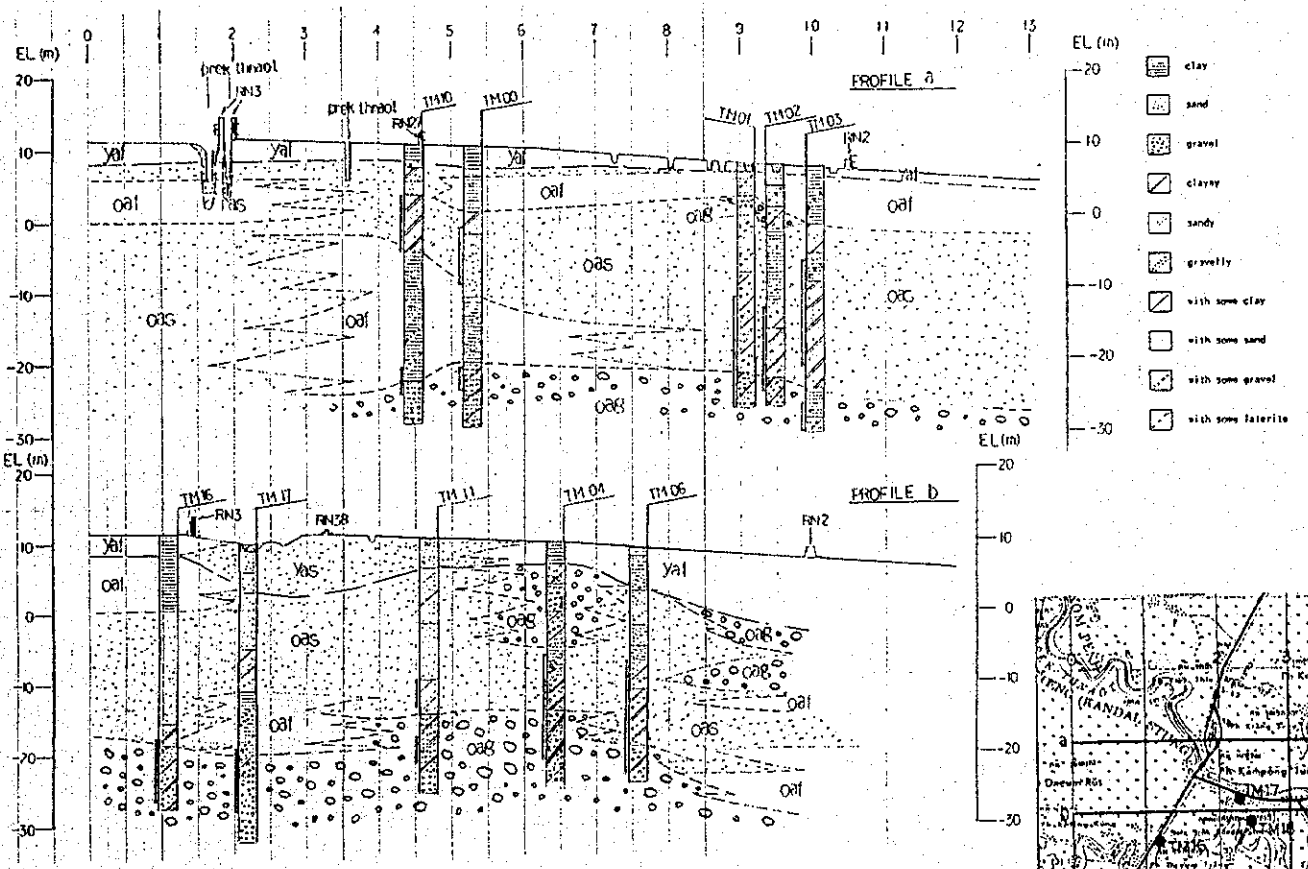


Age	Mark	Formation	Columnare Section	Mark	Soil Classification
Holocene	E	EMBANKMENT		E	
	r a	RECENT ALLUVIUM		r a f	fines
				r a s	sand
	y a	YOUNG ALLUVIUM		y a s	sand
				y a f	fines
Pleistocene	o a	OLD ALLUVIUM		o a f	fines
				o a s	sand
				o a g	gravels
				o a l	laterite

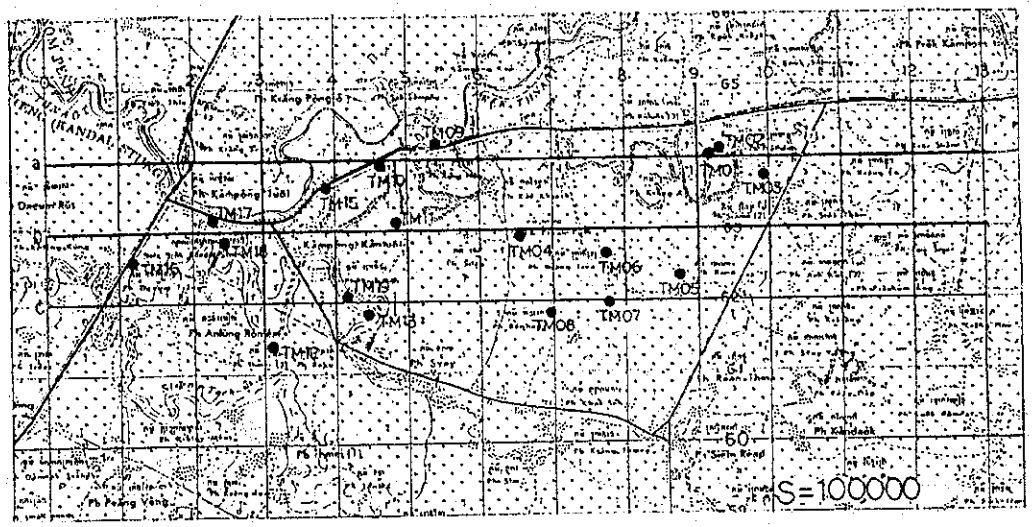
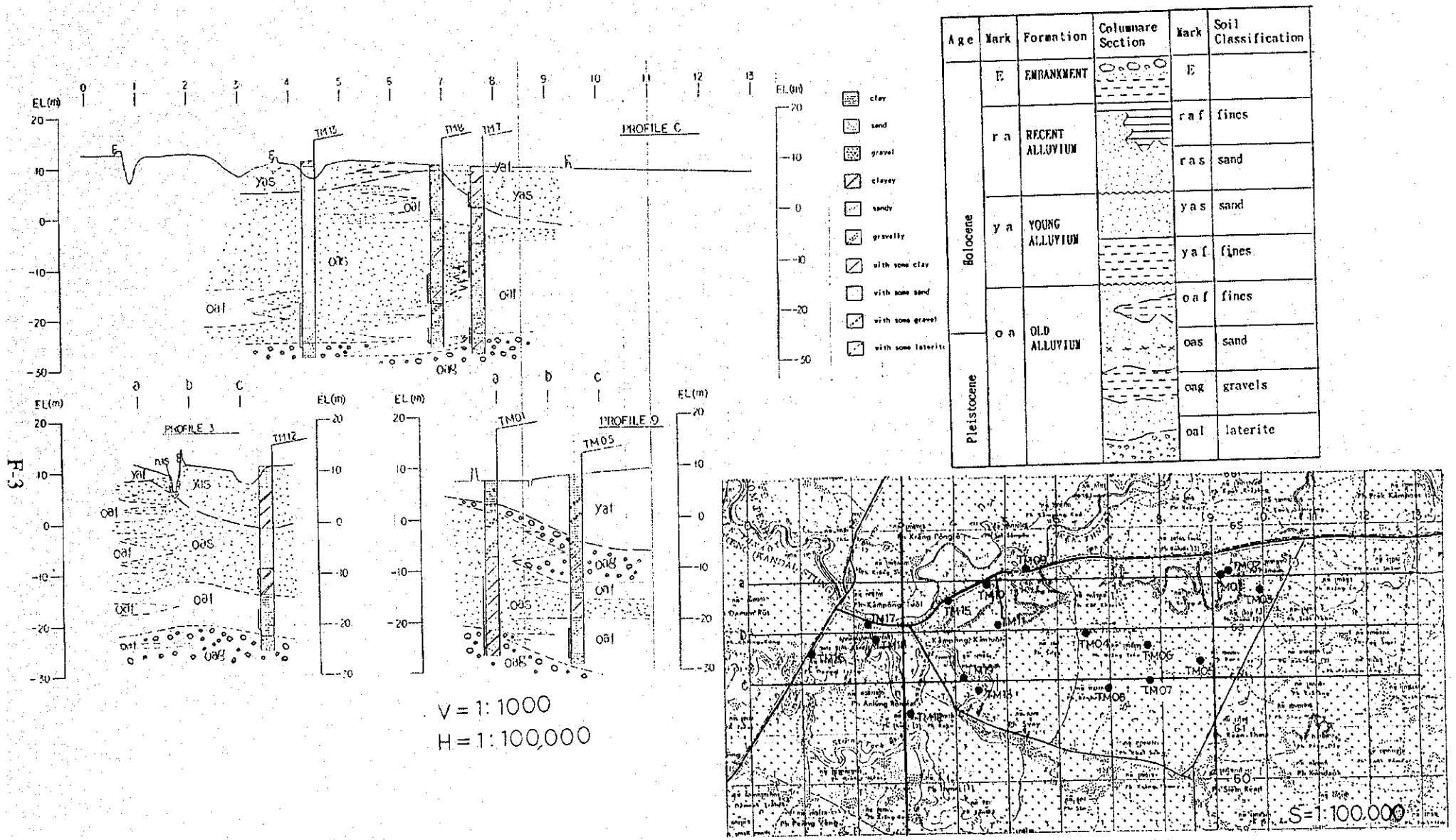


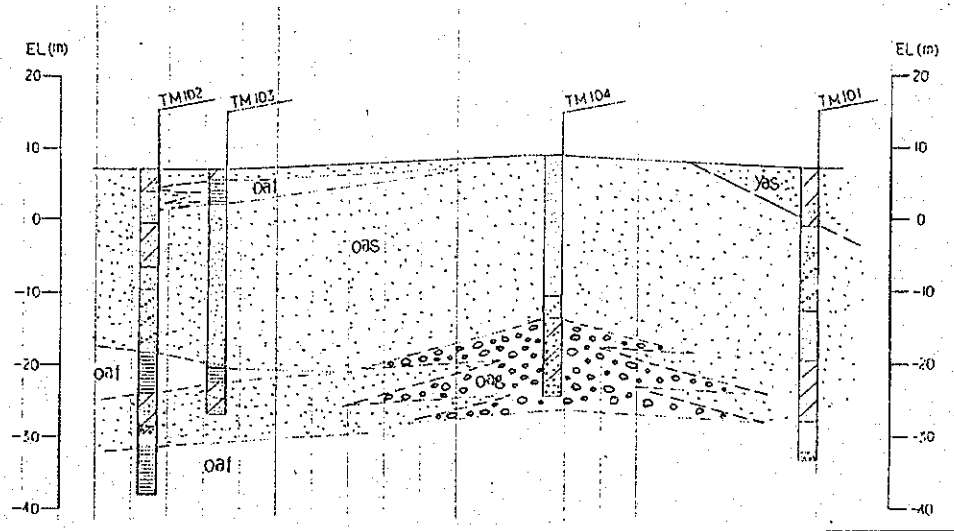
Fig. III-2 Geological Profile of Kandal Stung Irrigation Area (1/2)

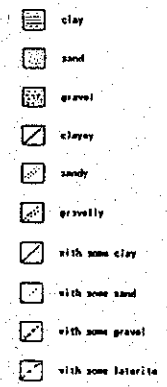
V=1:1,000
H=1:100,000



F-3

Fig. III-2 Geological Profile of Kandal Stung Irrigation Area (2/2)





Age	Mark	Formation	Columnare Section	Mark	Soil Classification
Holocene	E	EMBANKMENT		E	
	r a	RECENT ALLUVIUM		r a f	fines
				r a s	sand
	y a	YOUNG ALLUVIUM		y a s	sand
				y a f	fines
	o a	OLD ALLUVIUM		o a f	fines
Pleistocene				o a s	sand
				o a g	gravels
				o a l	laterite

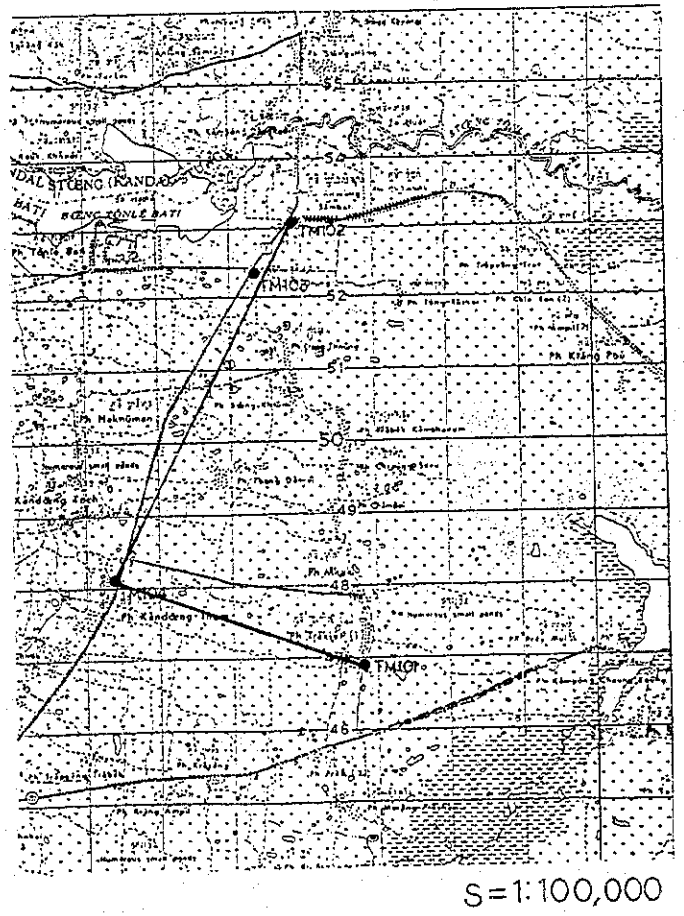


Fig. III-3 Geological Profile of Tonle Bati Irrigation Area

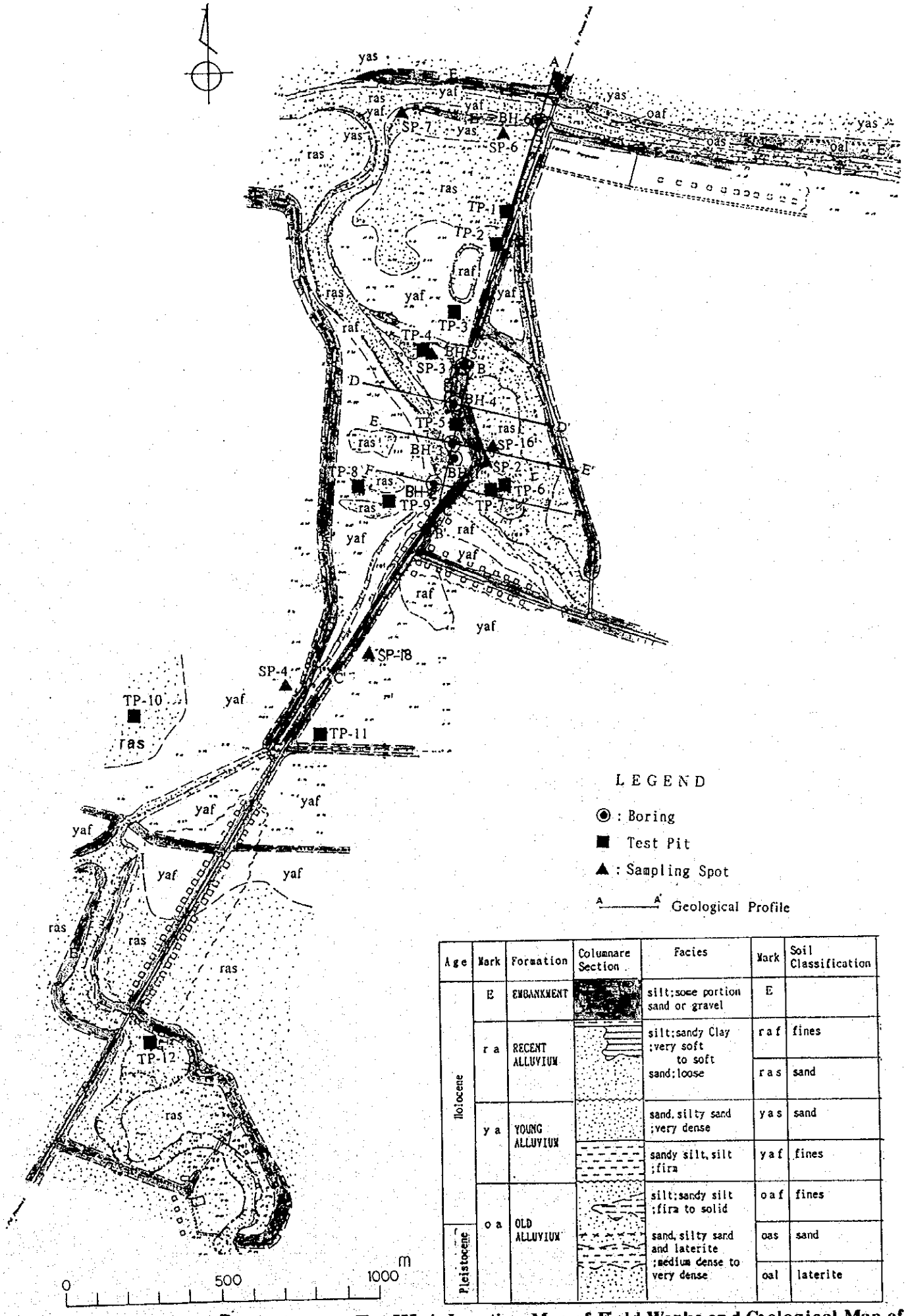
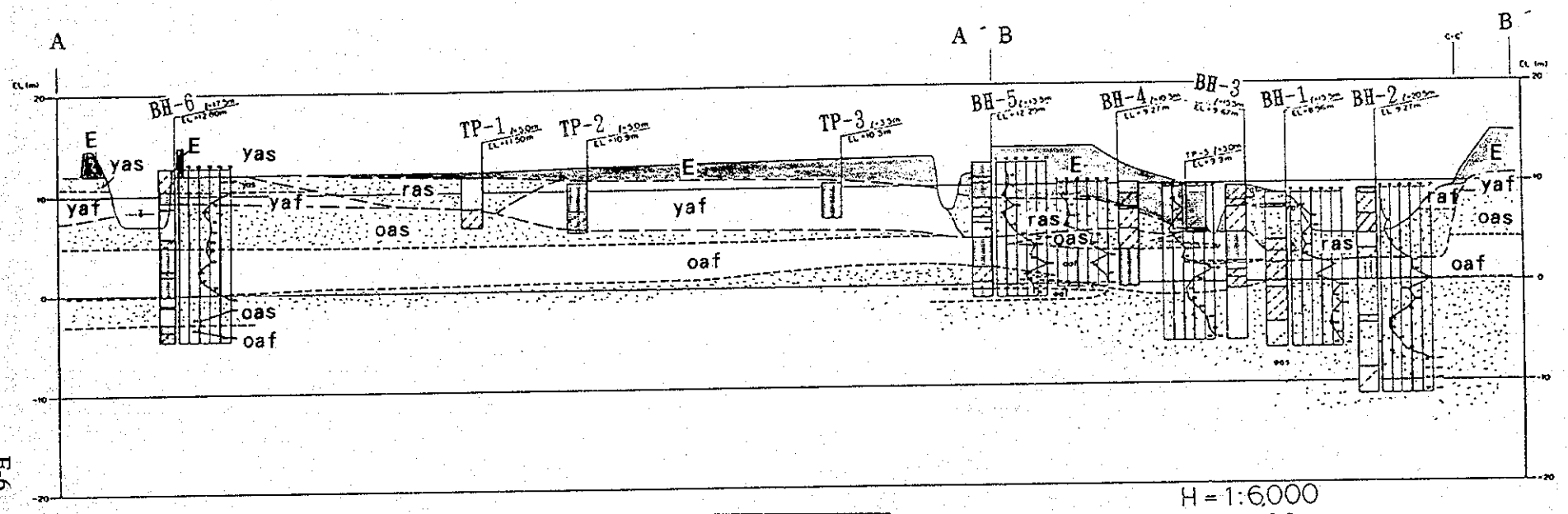


Fig. III-4 Location Map of Field Works and Geological Map of Tuk Thla and Kompong Tuol Regulators Site

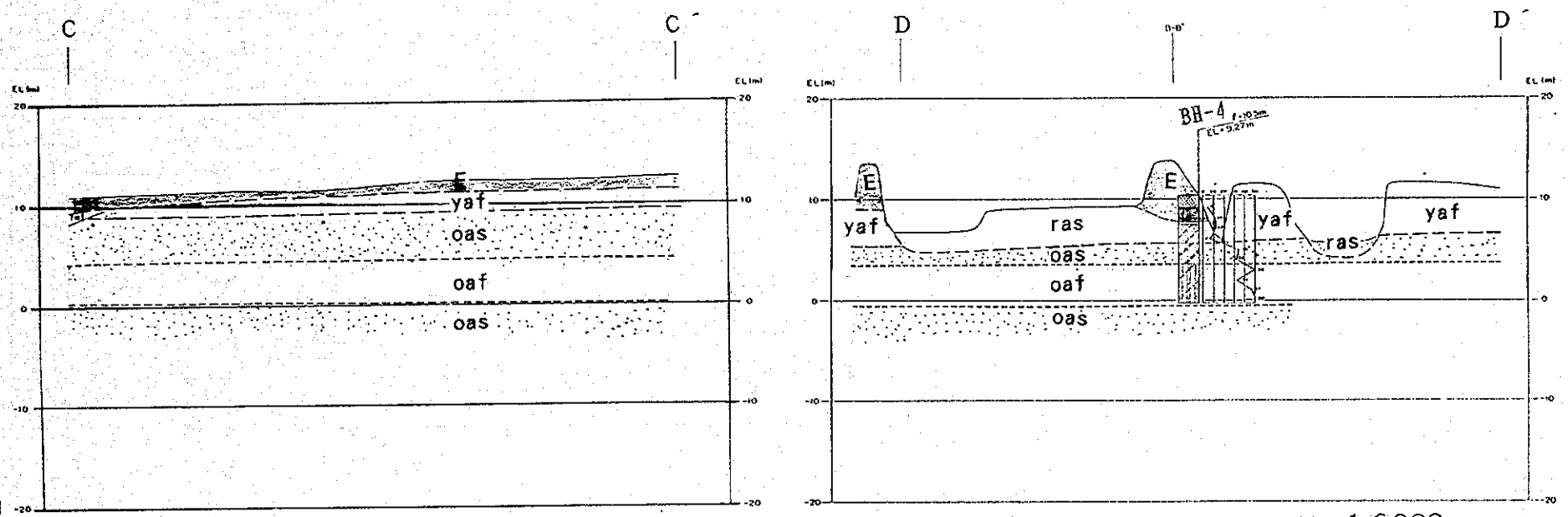


F-6

Age	Mark	Formation	Columnare Section	Facies	Mark	Soil Classification	N−value	Permeability
Holocene	E	EMBANKMENT		silt;some portion sand or gravel	E		5 to 20	
Holocene	r a	RECENT ALLUVIUM		silt;sandy Clay ;very soft to soft	r a f	fines	smaller than 1	(smaller than 2×10^{-5}cm/sec)
Holocene	r a	RECENT ALLUVIUM		sand;loose	r a s	sand	4 to 18	2×10^{-3}cm/sec
Holocene	y a	YOUNG ALLUVIUM		sand, silty sand ;very dense	y a s	sand	greaeter than 50	(2×10^{-3}cm/sec)
Holocene	y a	YOUNG ALLUVIUM		sandy silt, silt ;firm	y a f	fines	(13 to greater than 50)	(5×10^{-6}cm/sec)
Pleistocene	o a	OLD ALLUVIUM		silt;sandy silt ;firm to solid	o a f	fines	13 to greater than 50	6×10^{-6}cm/sec
Pleistocene	o a	OLD ALLUVIUM		sand, silty sand and laterite ;medium dense to very dense	oas	sand	8 to graeater than 50	6×10^{-3}cm/sec
Pleistocene	o a	OLD ALLUVIUM		sand, silty sand and laterite ;medium dense to very dense	oal	laterite	greater than 50	

clay
sand
gravel
clayey
sandy
gravelly
with some clay
with some sand
with some gravel
with some laterite

Fig. III-5 Geological Profile of National Road No. 3 New Dike Site (1/3)

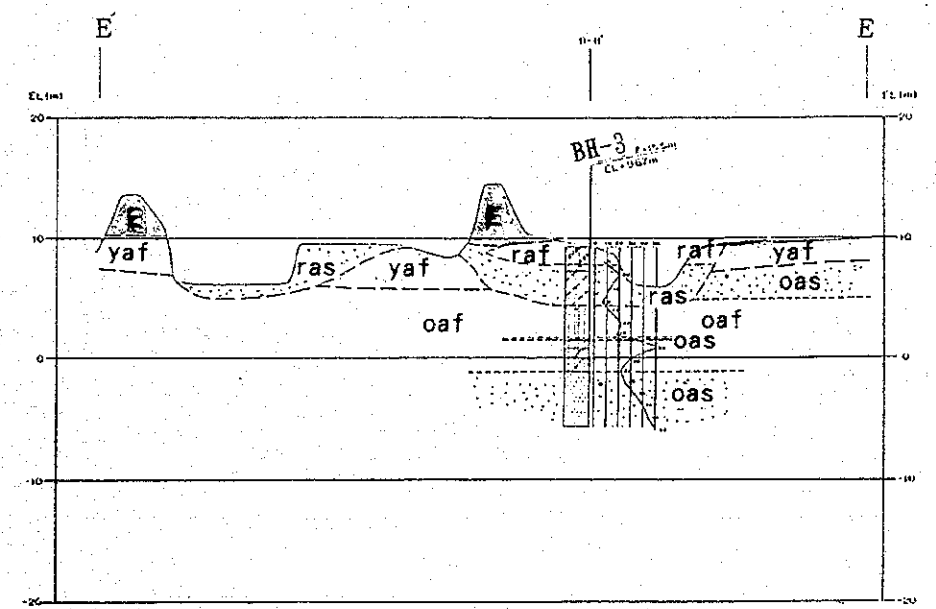


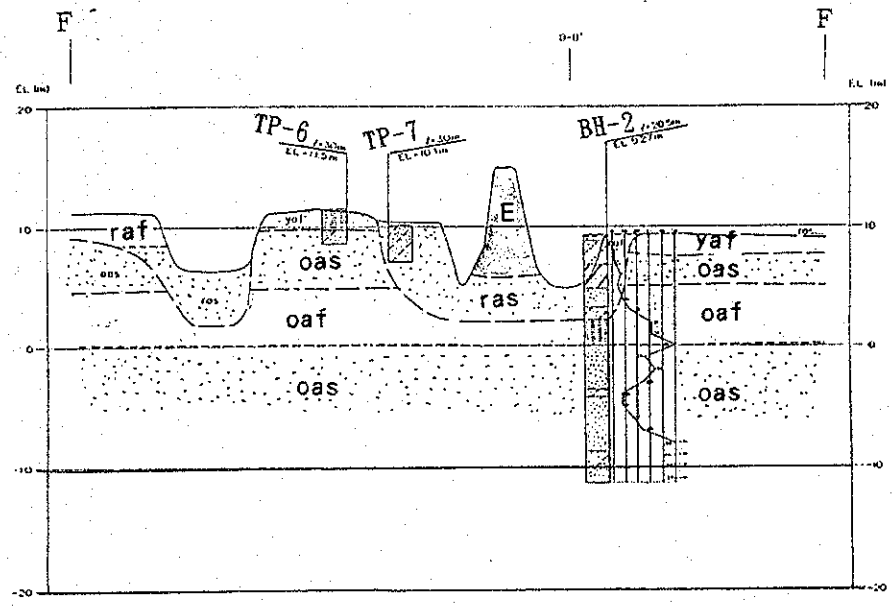
Age	Mark	Formation	Columnare Section	Facies	Mark	Soil Classification	N – value	Permeability
Holocene	E	EMBANKMENT		silt;some portion sand or gravel	E		5 to 20	
	r a	RECENT ALLUVIUM		silt;sandy Clay ;very soft to soft	r a f	fines	smaller than 1	(smaller than 2×10^{-5}cm/sec)
				sand;loose	r a s	sand	4 to 18	2×10^{-3}cm/sec
	y a	YOUNG ALLUVIUM		sand, silty sand ;very dense	y a s	sand	graeater than 50	(2×10^{-3}cm/sec)
				sandy silt, silt ;firm	y a f	fines	(13 to greater than 50)	(5×10^{-6}cm/sec)
Pleistocene	o a	OLD ALLUVIUM		silt;sandy silt ;firm to solid	o a f	fines	13 to greater than 50	6×10^{-6}cm/sec
				sand, silty sand and laterite ;medium dense to very dense	oas	sand	8 to graeater than 50	6×10^{-3}cm/sec
					oal	laterite	greater than 50	

clay
sand
gravel
clayey
sandy
gravelly
with some clay
with some sand
with some gravel
with some laterite

F-7

Fig. III-5 Geological Profile of National Road No. 3 New Dike Site (2/3)





H = 1:6000
V = 1:600

Age	Mark	Formation	Columnare Section	Facies	Mark	Soil Classification	N-value	Permeability
Holocene	E	EMBANKMENT		silt;some portion sand or gravel	E		5 to 20	
	r a	RECENT ALLUVIUM		silt;sandy Clay ;very soft to soft	r a f	fines	smaller than 1	(smaller than 2×10^{-5}cm/sec)
				sand;loose	r a s	sand	4 to 18	2×10^{-3}cm/sec
	y a	YOUNG ALLUVIUM		sand, silty sand ;very dense	y a s	sand	graeater than 50	(2×10^{-3}cm/sec)
				sandy silt, silt ;firm	y a f	fines	(13 to greater than 50)	(5×10^{-4}cm/sec)
Pleistocene	o a	OLD ALLUVIUM		silt;sandy silt ;firm to solid	o a f	fines	13 to greater than 50	6×10^{-6}cm/sec
				sand, silty sand and laterite ;medium dense to very dense	oas	sand	8 to graeater than 50	6×10^{-3}cm/sec
					oal	laterite	greater than 50	

clay
sand
gravel
clayey
sandy
gravelly
with some clay
with some sand
with some gravel
with some laterite

F-8

Fig. III.5 Geological Profile of National Road No. 3 New Dike Site (3/3)

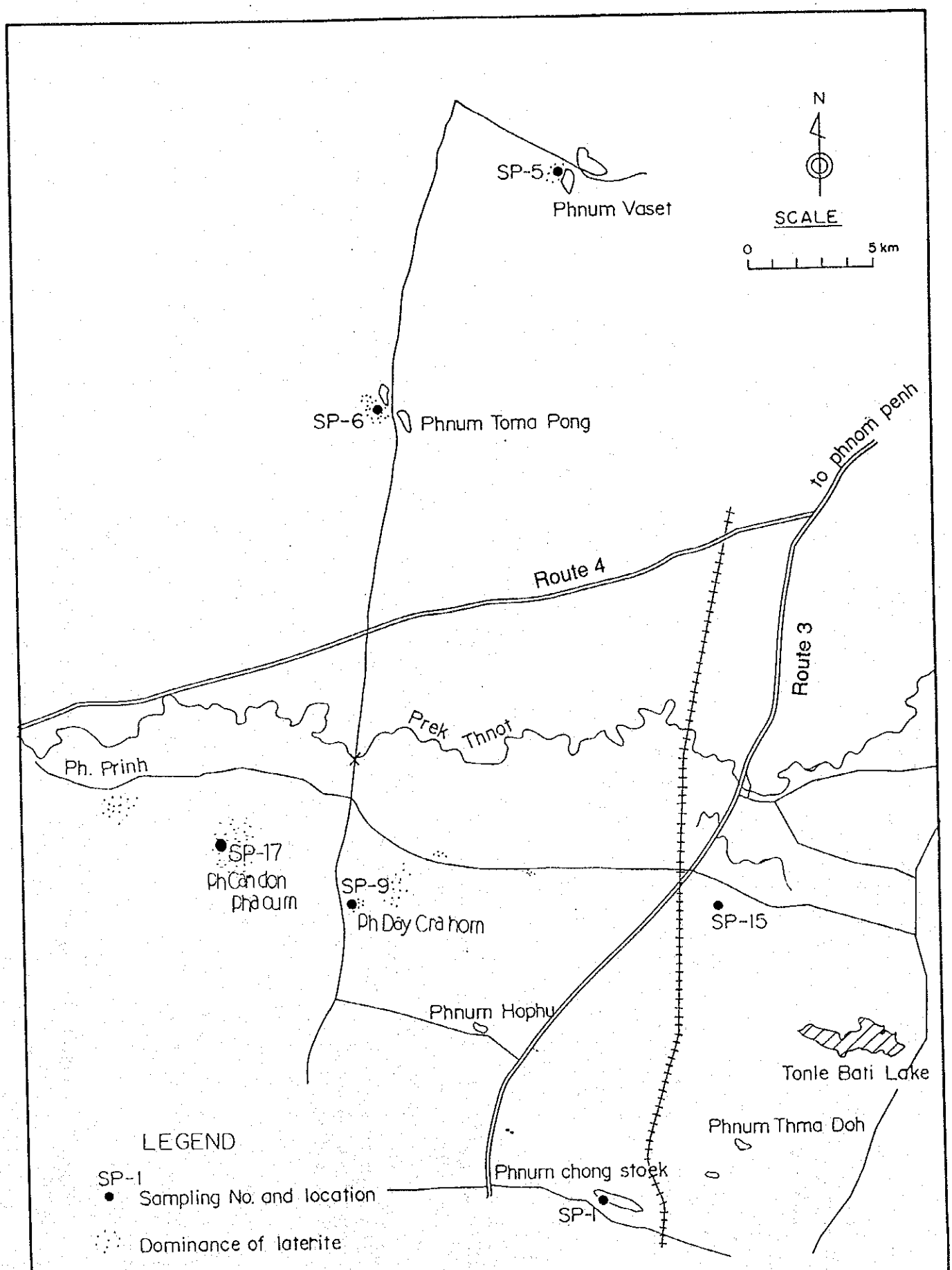


Fig. III-6 Sampling Location Map

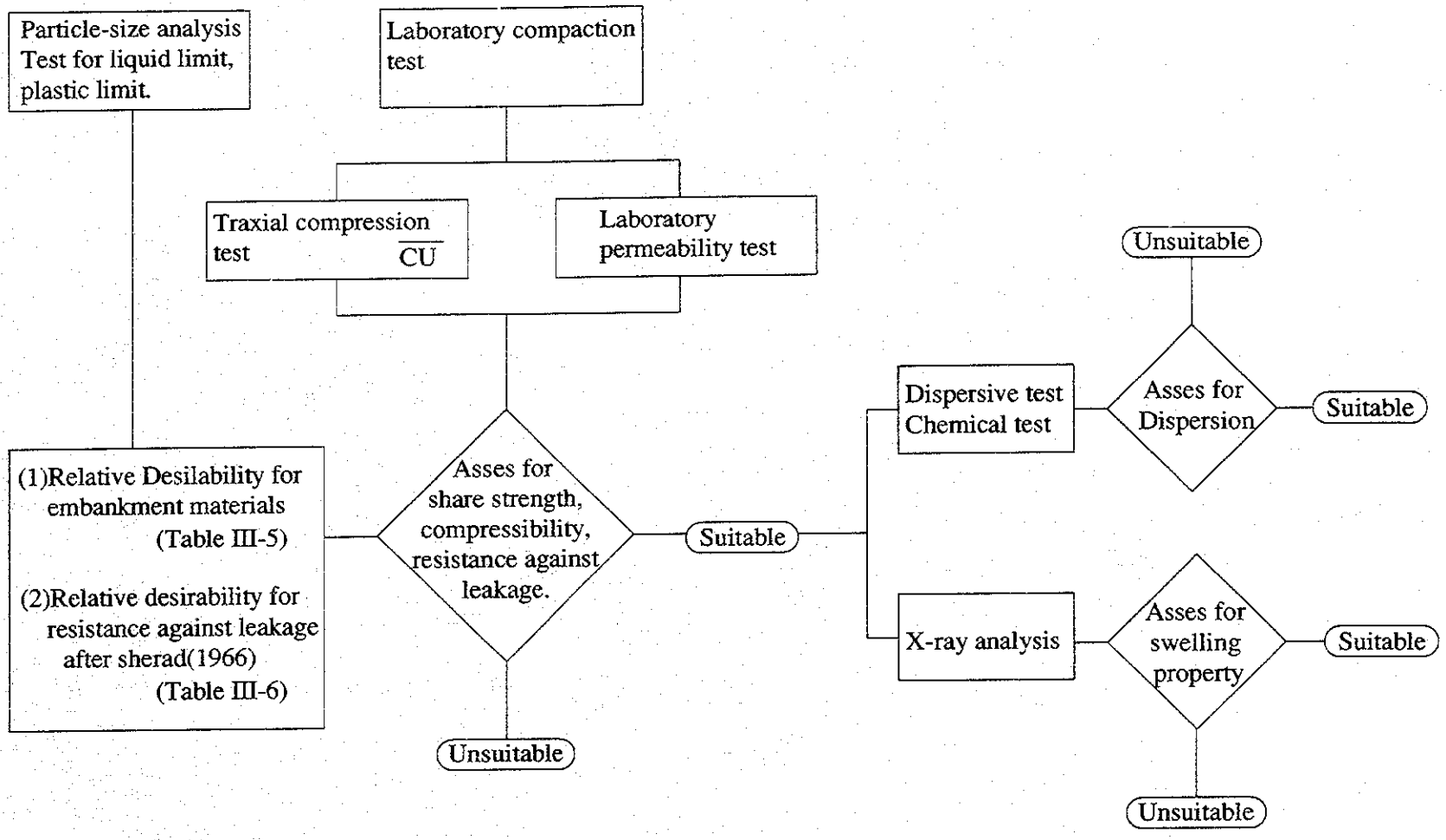


Fig. III-7 Working Flow about Investegation of Desirable Embankment Materials

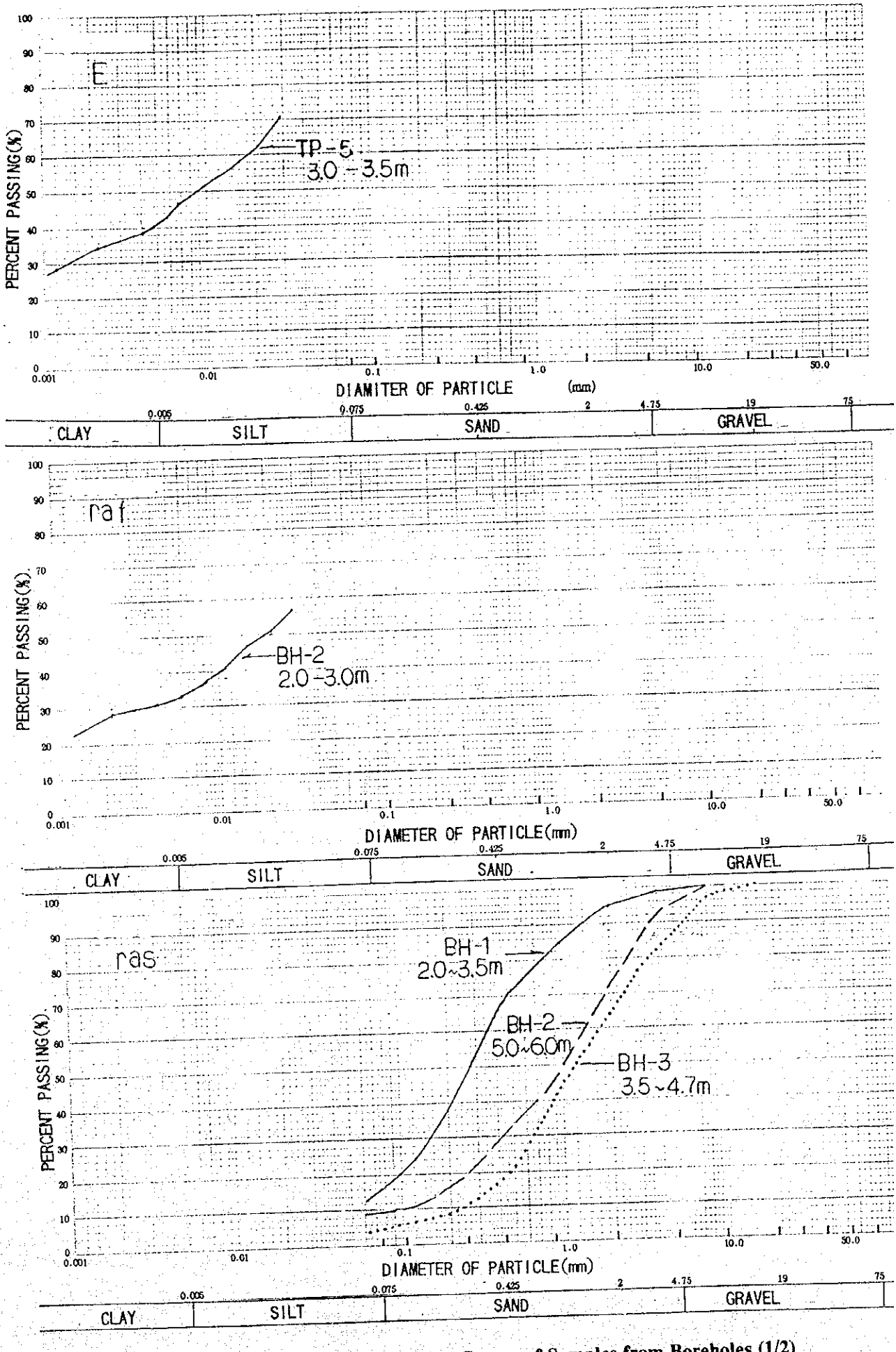


Fig. III-8 Grain Size Accumulation Curves of Samples from Boreholes (1/2)

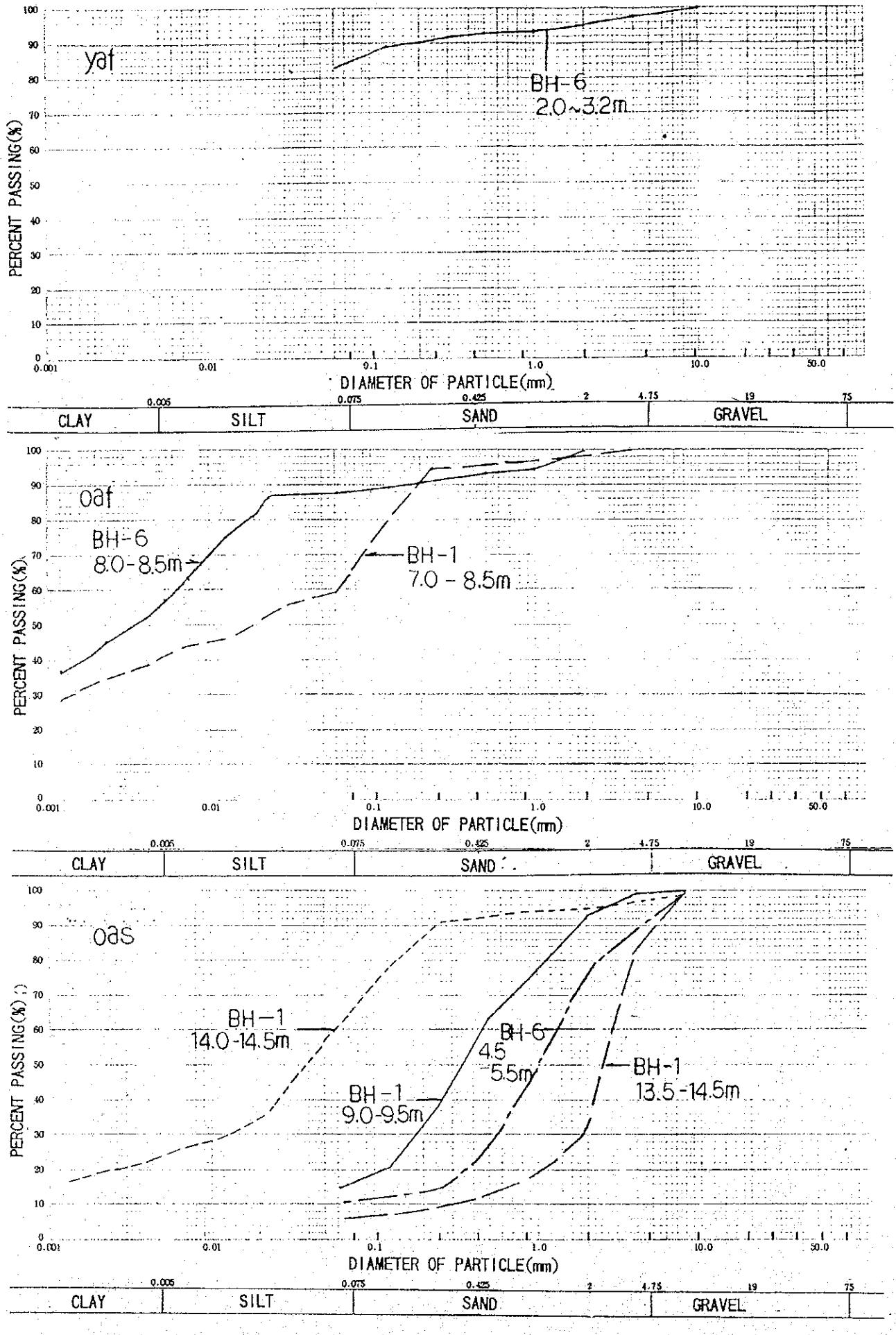


Fig. III-8 Grain Size Accumulation Curves of Samples from Boreholes (2/2)

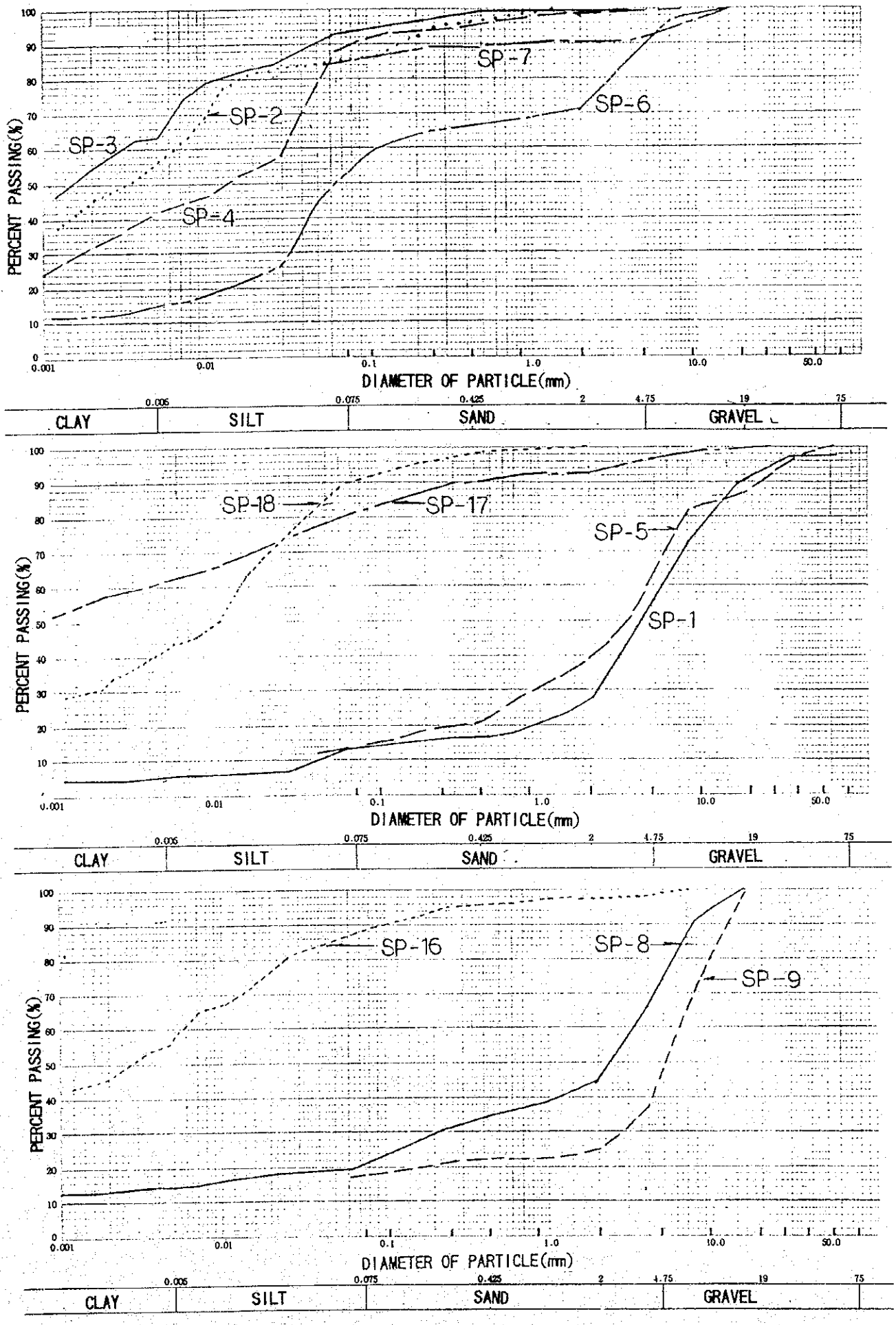
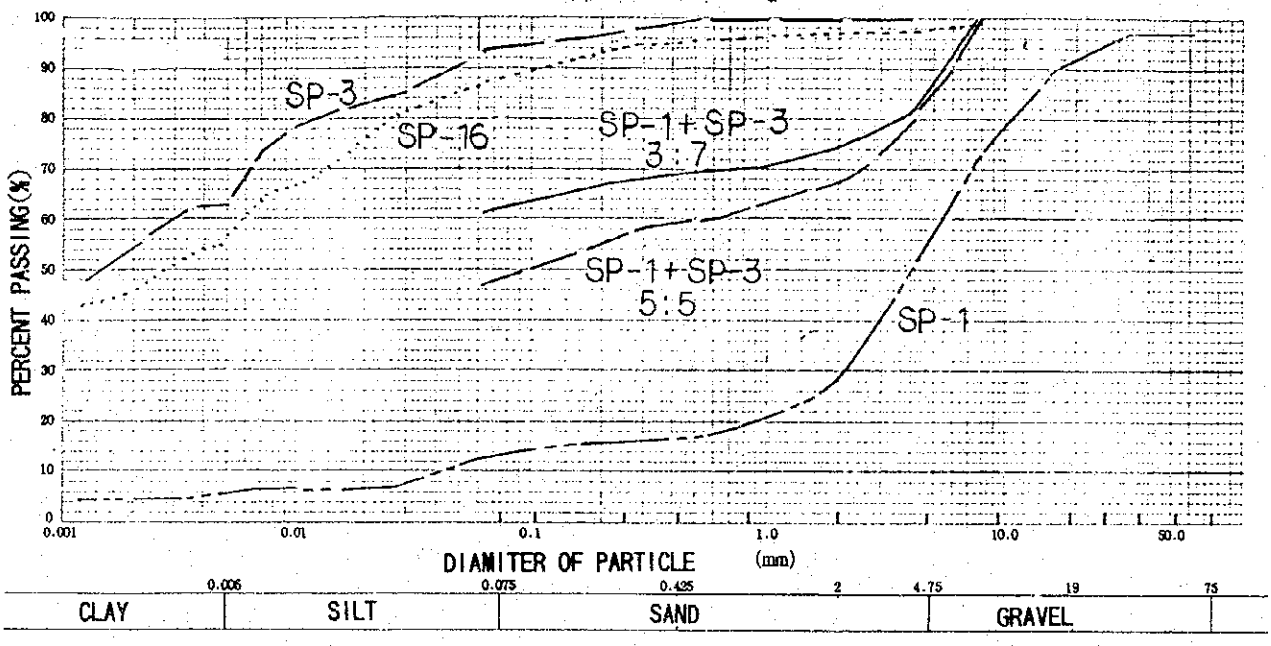


Fig. III-9 Grain Size Accumulation Curves of Embankment Materials (1/2)



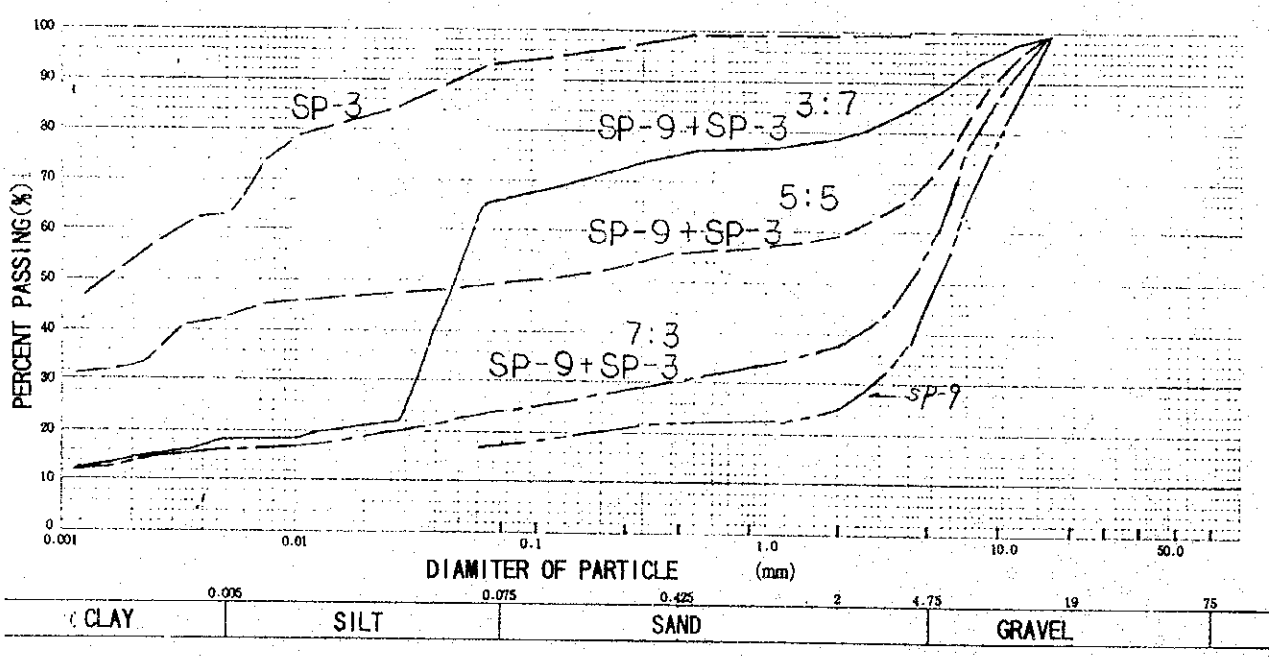
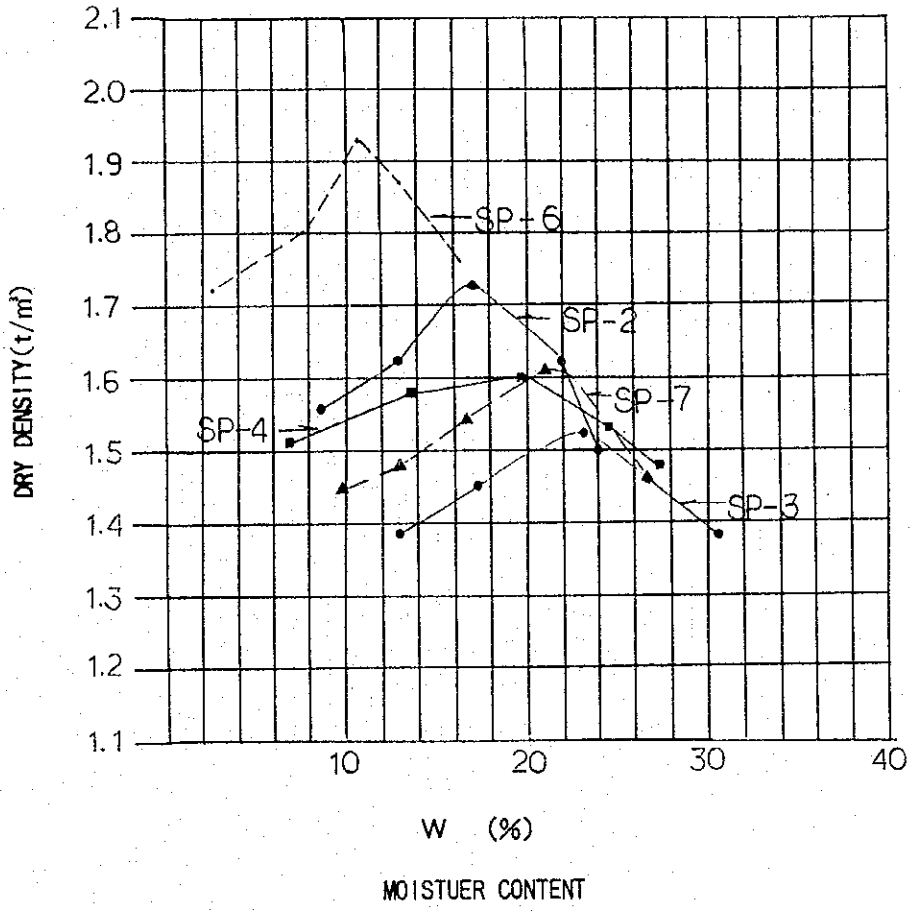
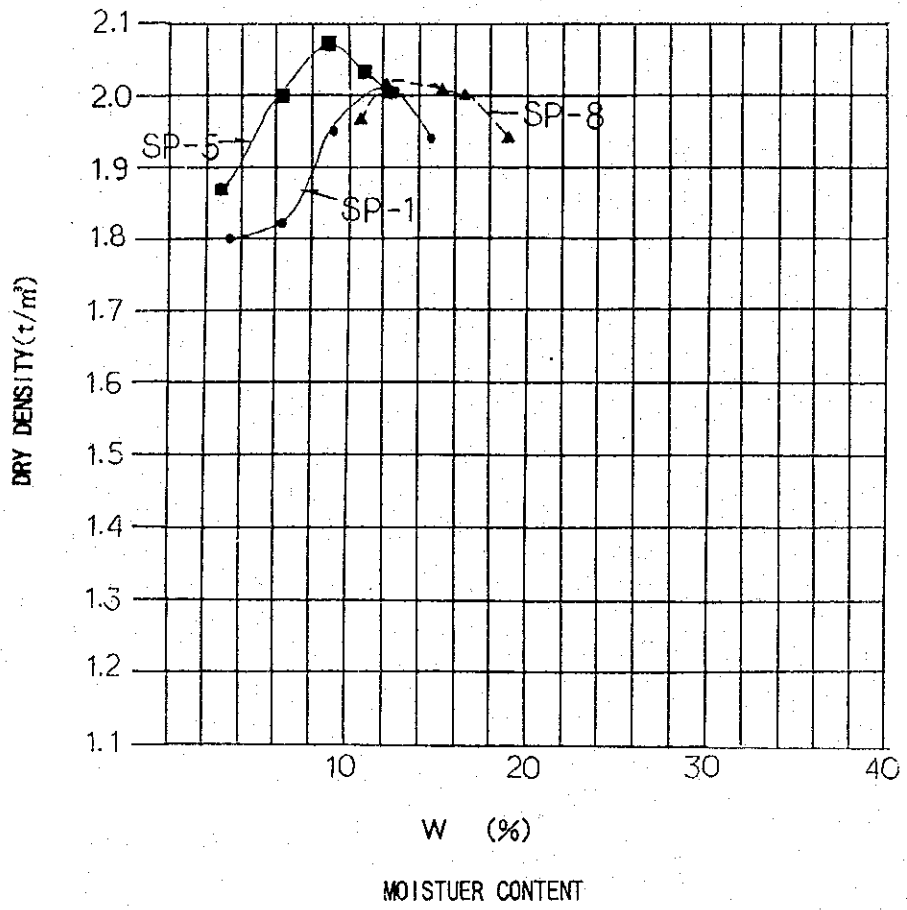


Fig. III-9 Grain Size Accumulation Curves of Embankment Materials (2/2)



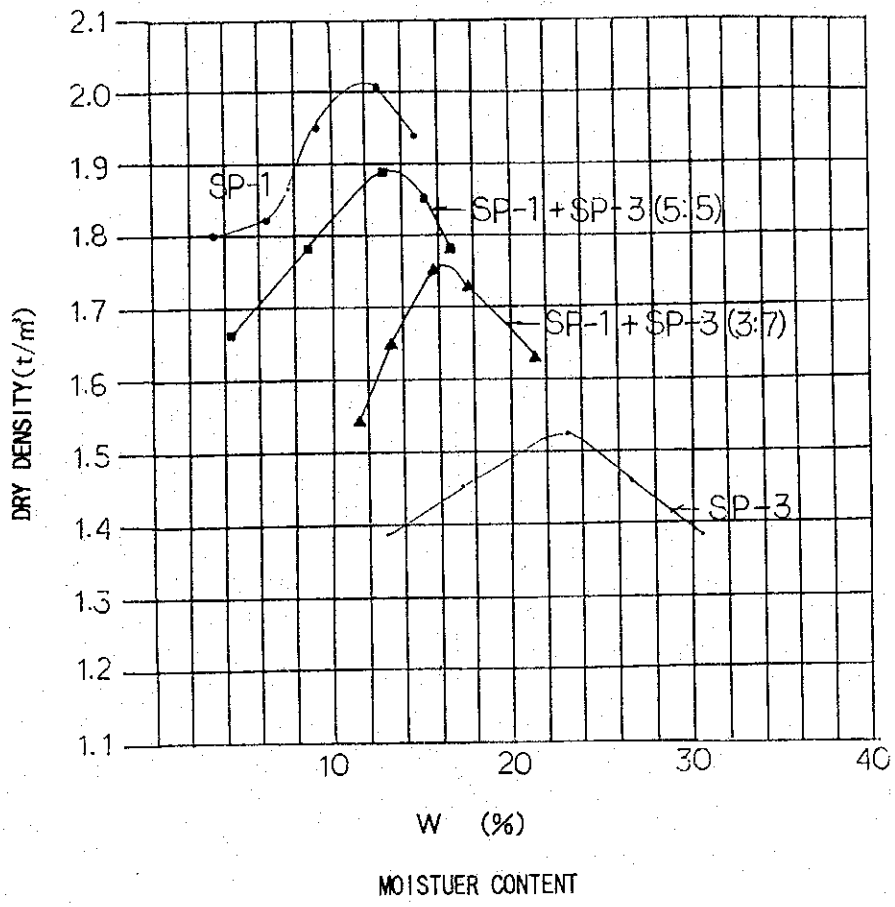
Sampling No.	Optimum moisture content (%)	Maximum dry density (t/m^3)	Soil Classification
SP-2	18	1.73	fines
SP-3	24	1.52	fines
SP-4	20	1.60	fines
SP-6	11	1.93	sands
SP-7	21	1.61	fines

Fig. III-10 (1/4) Compaction Curves (fines and sand near dike site)



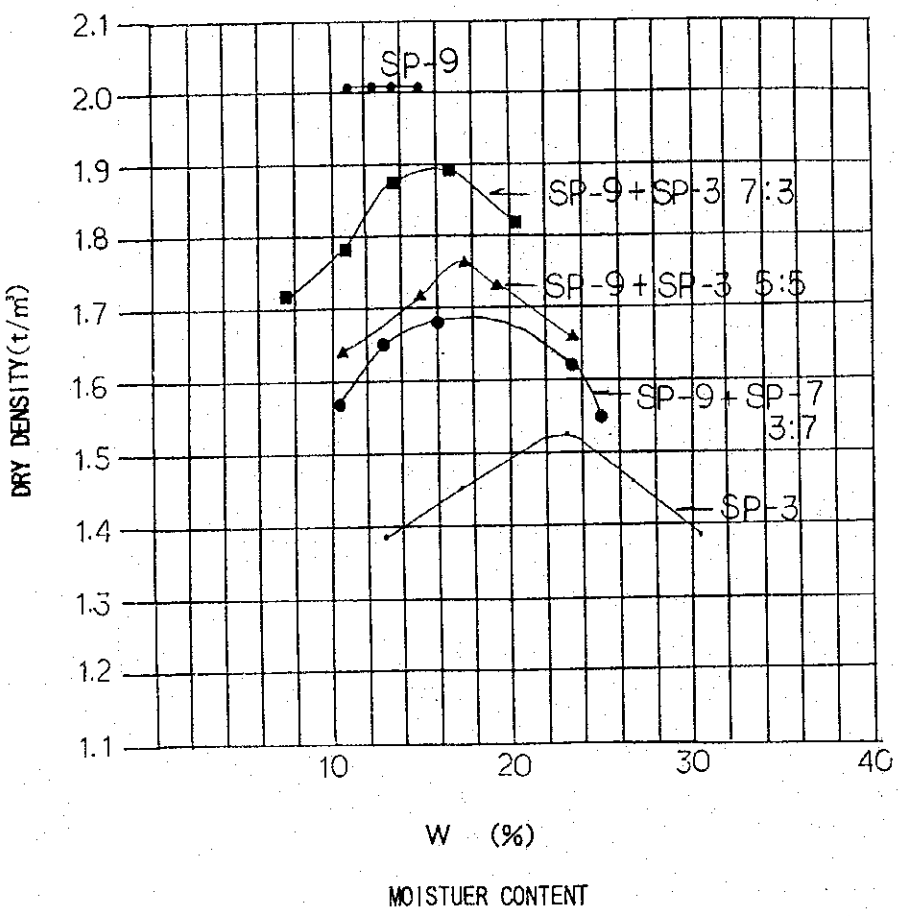
Sampling No.	Optimum moisture content (%)	Maximum dry density (t/m^3)	Soil Classification
SP-1	12	2.05	gravels
SP-5	9	2.07	laterite
SP-8	12	2.08	laterite
SP-9		2.05	laterite

Fig. III-10 (2/4) Compaction Curves (gravels and laterite)



Sampling No.	Optimum moisture content (%)	Maximum dry density (t/m^3)	Soil Classification
SP-1	12	2.05	gravels
SP-3	24	1.73	fines
SP-1+SP-3 5 : 5	13	1.88	
SP-1+SP-3 3 : 7	16	1.75	

Fig. III-10 (3/4) Compaction Curves (mixed materials of fines and gravels)



Sampling No.	Optimum moisture content (%)	Maximum dry density (t/m^3)	Soil Classification
SP-3	24	1.73	fines
SP-9	—	2.05	laterite
SP-9+SP-3 7 : 3	16	1.89	
SP-9+SP-3 5 : 5	18	1.76	
SP-9+SP-3 3 : 7	16	1.68	

Fig. III-10 (4/4) Compaction Curves (mixed materials of fines and latrite)

DRILL LOG

HOLE NO. 1 SHEET NO. OF

PROJECT	Integrated Agricultuat and Rural Development Project in the Suburbs of Phnom Penh	DEPTH	15.45m	ELEVATION	8.96
SITE	Ph Kampong Tuol	COORDINATE	: :	INCLINATION	Vertical	DRILL RIG	SAIAM TONE MODEL TOC-1G
AVERAGE CORE RECOVERY	60%	DATE	FROM June 22, 1994 TO June 27, 1994	DRILLED		LOGGED	M. Mori

DATE	DEPTH	ELEVATION	CLASSIFICATION OF SOIL	COLUMN SECTION	DESCRIPTION	SAMPLES LABORATORY TEST	GROUNDWATER LEVEL
June 22	1.20	7.76	SP		Medium SAND; loose; yellowish brown.		
	1.50	7.46	CH		CLAY with some silt particales; plastic; dark gray.		▽ GL-1.45m
					Fine to medium SAND with some silt particles; approx. 70% fine sand, approx. 25% medium sand, approx. 5% non plastic fines; saturated below water table; brownish light gray.		
June 23	4.80	4.16	SW		Coarse SAND with some grabels and some fines; approx. 90% coarse sand, approx. 5% grabel, approx. 5% non plastic fines; grabel, max φ10mm sub rounded, almost silica; light gray.		
	5.90	3.06	SW		Silty SAND; loose; approx. 60% medium sand, approx. 30% slight plasticity fines; clark green grey.		
June 24	7.00	1.96	SM		Sandy SILT; firm to hard; moist; approx. 70% slight plasticity fines, approx. 30% fine sand; lighit brownish gray.		
	9.00	-0.04	ML				
June 25	9.60	-0.64	SP		Fine SAND; dense, more than 95% fine sand, less than 5% non plastic fines; saturated; light reddish gray.		
June 26	13.0	-4.04	SW		Medium to coarse SAND; dense; approx. 50% medium sand, approx. 45% coarse sand. approx. 5% non plastic fines; saturated; light yellowish gray.		
June 27	15.45	-6.49	SW		Coarse SAND; dense; approx. 80% coarse sand; approx. 10% medium sand, approx. 5% fine gravel, approx. 5% non plastic fines; gravel max φ20mm subrounded, almost silica; light gray.		

CORE RECOVERY %	CORE RECOVERY cm	Field permeability test K: Cofficent of permeability (cm/sec)	Field penetration test with split-tube sampler N-VALUE	DEPTH
		K=5.6 X10⁻³	1.15 •9 (3/10, 5/10, 3/10) 1.45	1
			2.15 •19 (6/10, 7/10, 6/10) 2.45	2
		K=5.2 X10⁻⁴	3.15 •20 (6/10, 7/10, 6/10) 3.45	3
			4.0 •10 (4/10, 3/10, 3/10) 4.3	4
		K=9.7 X10⁻⁴	5.15 •14 (5/10, 5/10, 5/10) 5.45	5
			6.15 •10 (4/10, 3/10, 3/10) 6.45	6
		K=1.1 X10⁻³	7.15 (9/10, 16/10, 18/10) •44 7.45	7
			8.15 24 • (7/10, 8/10, 9/10) 8.45	8
		K=1.9 X10⁻⁴	9.15 (15/10, 19/10, 19/10) 49• 9.45	9
			10.15 (7/10, 14/10, 19/10) •40 10.45	10
			11.15 (10/10, 17/10, 21/10) 48• 11.45	11
			12.15 (9/10, 17/10, 29/10) •40 12.45	12
			13.15 (9/10, 19/10, 19/10) •38 13.45	13
			14.15 (10/10, 23/10, 21/10) •45 14.45	14
			15.15 (13/10, 21/10, 35/10) 69 — 15.45	15

* R.Q.D is Rock Quality Designation, R.Q.D= (Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%
* LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
* DEPTH and ELEVATION are in meter

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Fig. III-11 (1/6) Drill Log (BH-1)

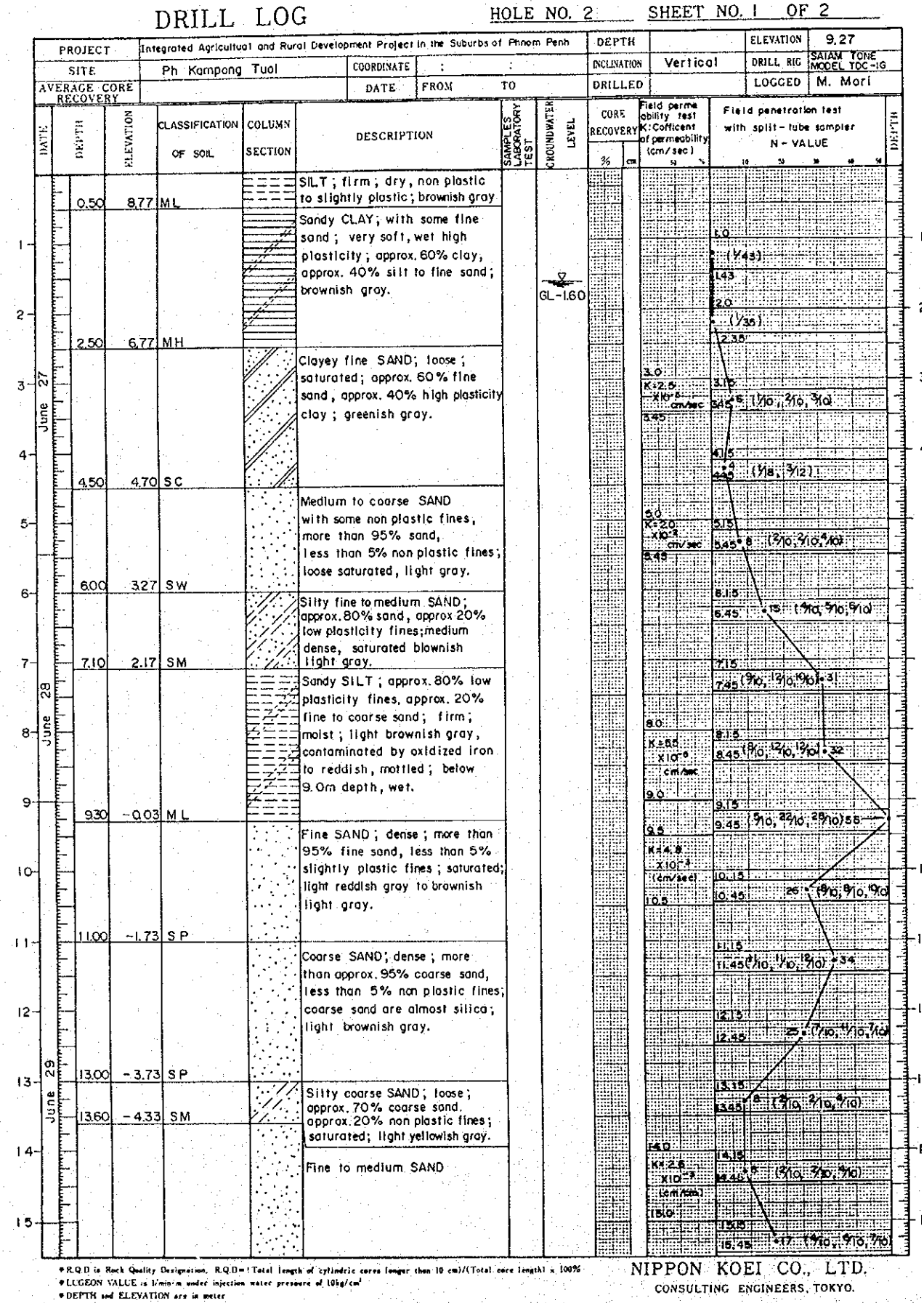

Fig. III-11 (2/6) Drill Log (BH-2) (to be continue

DRILL LOG

HOLE NO. 2 SHEET NO. 2 OF 2

PROJECT	Integrated Agricultual and Rural Development Project in the Suburbs of Phnom Penh		DEPTH	20.45	ELEVATION 9.274
SITE	Ph Kampong Tuol	COORDINATE : :	INCLINATION	Vertical	DRILL RIG SAIAM TONE MODEL TOC-1G
AVERAGE CORE RECOVERY		DATE FROM TO	DRILLED		LOGGED M. Mori

DATE	DEPTH	ELEVATION	CLASSIFICATION OF SOIL	COLUMN SECTION	DESCRIPTION	SAMPLES LABORATORY TEST	GROUNDWATER LEVEL
June 30	18.00	-8.73	SP		Fine to Medium SAND ; Medium dense ; approx. 60% fine sand , approx. 35% medium sand , approx. 5% non plastic fines ; saturated ; light gray ; below 17m depth, very dense.		
	20.45	-11.18	SP		Medium to Coarse SAND with some silt particles ; very dense ; approx 90% medium to coarse sand, approx 10% low plasticity fines ; saturated ; ligh gray.		

CORE RECOVERY % cm

Field permeability test K: Cofficent of permeability (cm/sec)

Field penetration test with split-tube sampler N - VALUE

15.15
15.45 41* (4/10, 6/10, 7/10)
16.15
16.45 24 (5/10, 9/10, 9/10)
17.15
17.45 (29/10, 32/10, 41/10) 93*
18.15
18.45 (22/10, 24/10, 29/10) 66*
19.15
19.45 (19/10, 17/10, 25/10) 52*
20.15
20.45 (29/10, 19/10, 28/10) 57*

DEPTH 16 17 18 19 20 21

* R.Q.D is Rock Quality Designation. R.Q.D = (Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%
* LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
* DEPTH and ELEVATION are in meter

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Fig. III-11 (2/6) Drill Log (BH-2)

Fig. III-11 (3/6) Drill Log (BH-3)

DRILL LOG

HOLE NO. 4 SHEET NO. OF

PROJECT	Integrated Agricultual and Rural Development Project in the Suburbs of Phnom Penh		DEPTH	10.15	ELEVATION 10.26
SITE	Ph Kampong Tuol	COORDINATE : :	INCLINATION	Vertical	DRILL RIG SATAKI TONE MODEL TOC-1G
AVERAGE CORE RECOVERY		DATE FROM TO	DRILLED		LOGGED M. Mori

DATE	DEPTH	ELEVATION	CLASSIFICATION OF SOIL	COLUMN SECTION	DESCRIPTION	SAMPLES LABORATORY TEST	GROUNDWATER LEVEL
July 6	1.20	9.06	SP		Fine SAND ; very loose ; less than 5% low plasticity fines ; light brown.		
	2.50	7.76	ML		Sandy SILT ; firm ; approx. 70% low plasticity fines; approx. 30% fine sand ; brownish gray.		
	2.70	7.56	SW		Fine SAND with some fines ; brownish gray.		
	4.60	5.66	SP		Coarse SAND ; with some silt particles ; loose ; approx. 5% non plastic fines ; saturated below water table, light gray.		▽ 3.60
July 7	6.80	3.46	SW		Silty fine SAND with some silt particles ; dense ; approx. 20~30% low Plasticity fines ; slight bluish light gray.		
	10.45	0.19	ML		SILT with some fine sand ; very firm to solid moist ; approx. 95% low plasticity fines, approx. 5% fine sand ; light brownish gray to reddish gray, mottled ; contaminated by oxidized iron.		

CORE RECOVERY %	cm	Field permeability test K: Cofficent of permeability (cm/sec)	Field penetration test with split-tube sampler N-VALUE	DEPTH
			1.15 1.45 4 (1/10, 1/10, 2/10)	1
			2.15 2.45 11 (3/10, 4/10, 4/10)	2
			3.15 3.45 12 (3/10, 3/10, 6/10)	3
			4.15 4.45 7 (2/10, 2/10, 3/10)	4
			5.15 5.45 (5/10, 11/10, 19/10) 30	5
			6.15 6.45 (6/10, 10/10, 14/10) 32	6
			7.15 7.45 (15/10, 16/10, 19/10) 50	7
			8.15 8.45 (8/10, 12/10, 15/10) 33	8
			9.15 9.45 (7/10, 17/10, 23/10) 47	9
			10.15 10.45 (29/10, 39/10, 39/10) 80	10
				11

* R.Q.D in Rock Quality Designation, R.Q.D = (Total length of cylindric cores longer than 10 cm)/(Total core length) × 100%
* LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
* DEPTH and ELEVATION are in meter

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Fig. III-11 (4/6) Drill Log (BH-4)

DRILL LOG

HOLE NO. 5 SHEET NO. OF

PROJECT	Integrated Agricultuol and Rural Development Project in the Suburbs of Phnom Penh		DEPTH		ELEVATION 12.29
SITE	Ph Kampong Tuol	COORDINATE : :	INCLINATION	Vertical	DRILL RIG SAIAM TONE MODEL TOC-1G
AVERAGE CORE RECOVERY		DATE FROM TO	DRILLED		LOGGED M. Mori

DATE	DEPTH	ELEVATION	CLASSIFICATION OF SOIL	COLUMN SECTION	DESCRIPTION
July 8	1.50	10.79	ML		SILT with some fine sand; firm; approx. 90% low plasticity fines. approx 10% fine sand; moist; light brown.
	2.00	10.29	SM		Sity SAND with some grabels appox.
	3.50	8.79	ML		Sandy SILT; medium to firm; approx. 70% to 80% low plasticity fines, approx. 20% to 30%; moist; light brownish gray.
	4.50	7.79	SP		Fine SAND; with some fines; approx. 90% fine sand, approx. 10% non plastic fines; blownish light gray.
July 9	5.40	6.89	SM		Silty fine SAND; loose; approx. 70% fine sand, approx. 30% Silght plasticity fines, saturated; dark gray.
	6.00	6.29	SP		Fine SAND with some non plastic fines; approx. more than 90% fine sand, saturated; light gray.
	7.50	4.79	SP		Medium SAND with some silt denses; medium dense; approx. more than 95% medium sand; blownish gray.
July 10	10.40	1.89	ML		SILT; very firm; moist; more than 95% low plasticity fines. less than 5% fine sand; light brownish gray to reddish brown mottled; contaminated by oxidized iron.
July 11	12.00	-0.29	SM		Fine SAND with some silt particles; medium density; approx 90% fine sand, approx. 10% low plasticity fines; saturated; light gray.
	12.70	-0.41	SM		Corse SAND with some silt particles; dense; approx. 10% low plasticity fines; light gray.
	13.50	-1.21	ML		SILT; firm; moist; more than 95% low plasticity fines. less than 5% fine sand; light brownish gray.

SAMPLES LABORATORY TEST | GROUNDWATER LEVEL: 3.78, 4.43

CORE RECOVERY (%, cm)

Field permeability test K: Cofficent of permeability (cm/sec)

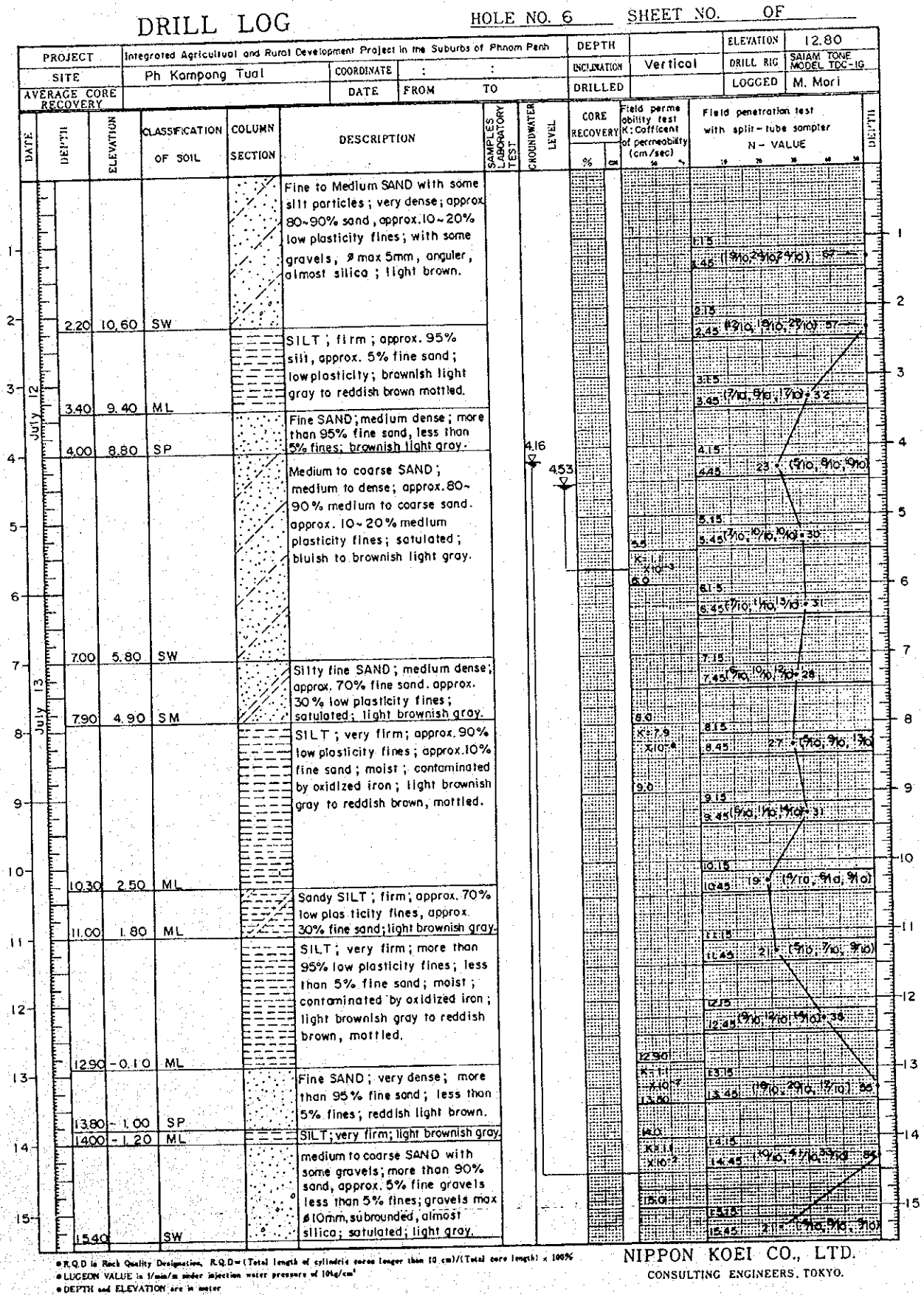
Field penetration test with split-tube sampler N-VALUE

DEPTH

*R.Q.D is Rock Quality Designation, R.Q.D=(Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%
*LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
*DEPTH and ELEVATION are in meter

NIPPON KOEI CO., LTD.
CONSULTING ENGINEERS, TOKYO.

Fig. III-11 (5/6) Drill Log (BH-5)



* R.Q.D is Rock Quality Designation, R.Q.D=(Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%
* LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
* DEPTH and ELEVATION are in meter

Fig. III-11 (6/6) Drill Log (BH-6) (to be continued)

DRILL LOG

HOLE NO. 6 SHEET NO. 2 OF 2

PROJECT	Integrated Agricultual and Rurol Development Project in the Suburbs of Phnom Penh			DEPTH	17.5m	ELEVATION	12.80
SITE	Ph Kampong Tual	COORDINATE	: :	INCLINATION	Vertical	DRILL RIG	SAIAM TONE MODEL TDC-1G
AVERAGE CORE RECOVERY		DATE	FROM TO	DRILLED		LOGGED	M. Mori

DATE	DEPTH	ELEVATION	CLASSIFICATION OF SOIL	COLUMN SECTION	DESCRIPTION	SAMPLES LABORATORY TEST	GROUNDWATER LEVEL	CORE RECOVERY %	CORE RECOVERY cm	Field permeability test K: Cofficent of permeability (cm/sec)	Field penetration test with split-tube sampler N-VALUE	DEPTH
	15.80	- 3.00	SW		medium to coarse SAND;							
	16.50	- 3.70	ML		SILT with some sand; very firm approx. 80 to 90% silt; approx. 10 to 20% fine to coarse sand; light gray.							
	17.50	- 4.70	ML		sandy SILT; solid; approx. 70 to 80 % silt; approx. 20 to 30% coarse sand; contaminated and cemented by oxidized iron; light brownish gray to reddish brown.							

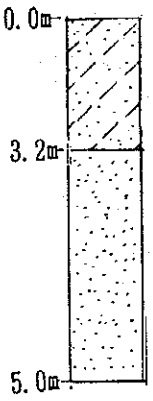
16 17 18 19

* R.Q.D is Rock Quality Designation. R.Q.D = (Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%
* LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
* DEPTH and ELEVATION are in meter

NIPPON KOEI CO., LTD.
CONSULTING ENGINEERS, TOKYO.

Fig. III-11 (6/6) Drill Log (BH-6)

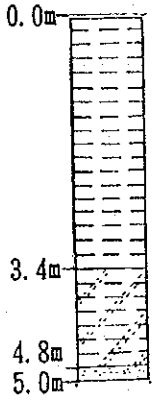
TP－1
EL＝11.5m



0.0m－3.2m
Fine to medium SAND;
approx. 5% fines;
reddish light gray

3.2m－5.0m
Medium SAND with some silt particles;
approx. 2.0% low plasticity fines;
bluish light gray

TP－2
EL＝10.9m

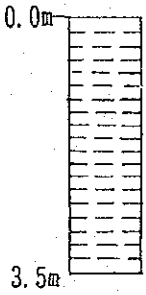


0.0m－3.4m
SILT;firm;moist;
approx. 90% low plasticity fines,
approx. 10% fine sand;
light brownish gray

3.4m－4.8m
Sandy SILT;firm; moist;
approx. 70% low plasticity fines,
approx. 30% light brownish gray

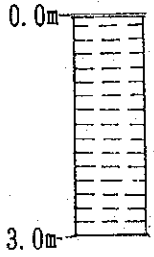
4.8m－5.0m
Fine SAND; approx100% fine sand;
reddish gray

TP－3
EL＝10.5m



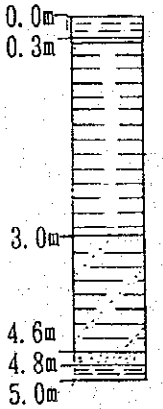
0.0m－3.5m
SILT;very firm; dry;
approx. 90% low plasticity fines;
approx. 10% fine sand;
light brownish gray

TP－4
EL－11.1m



0.0m－3.0m
SILT; firm; moist; more than 90% low plasticity fines. less than 10 % fines sand; light brownish gray.

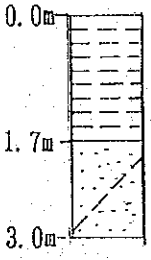
TP－5
EL＝12.3m



0.0m－0.3m
SILT;firm; moist; light blownish gray
0.3m-3.0m
SILT; soft; wet;
medium plasticity; brownish gray

3.0m－4.6m
CLAY with some fine sand;
approx. 90% clay,
approx. 10% fine sand;
bluish gray
4.6m－4.8m
Medium SAND with some silt;
approx. 90% sand, approx. 10% silt;
4.8m－5.0m
SILT;firm;borwnish gray

TP－6
EL＝11.5m

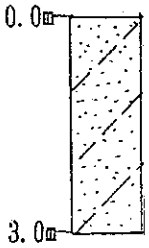


0.0m－1.7m
SILT; firm; moist; more than 90% low plasticity fines. less than 10% fine sand; light brown

1.7m－3.0m
Fine SAND with some fines;
approx. 20% low plasticity fines;
brownish gray

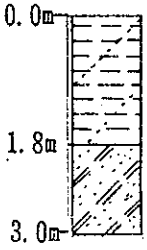
Fig. III-12 Log of Test Pit (1/2)

TP－7
EL＝10.1m



0.0m－3.0m
Medium SAND with some fines;
approx. 90%, medium sand ;
approx. 10%, low plasticity fines
yellowish gray

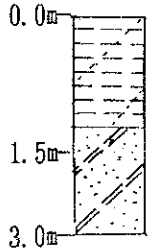
TP－8
EL＝11.0m



0.0m－1.8m
SILT with some fine sand;
approx. 8.0% low plasticity fines,
approx. 20% fine sand;very firm

1.8m－3.0m
Silty Fine SAND;dense
approx. 70% fine sand,
approx. 30% low plasticity fines;
brownish gray

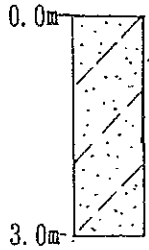
TP－9
EL＝10.6m



0.0m－1.5m
SILT with some fine sand;very firm
approx. 80% low plasticity fines
approx. 20% fine sand;
brownish gray

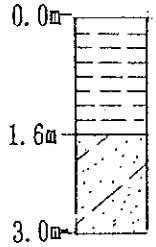
1.5m－3.0m
Silty Fine SAND;dense;
approx. 7.0% fine sand,
approx. 30% low plasticity fines;
brownishi gray

TP－10
EL＝12.3m



0.0m－3.0m
Fine SAND with some fines;
loose;
approx. 80% fine sand
approx. 20% low plasticity fines;
moist; reddish brown

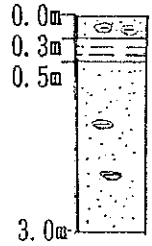
TP－11
EL＝11.2m



0.0m－1.6m
SILT;very fine;
approx. 90% low plasticity fines,
approx. 10% fine sand;brownish gray

1.6m－3.0m
FineSAND with some fines;
approx. 90% fine sand,
approx. 10% low plasticity fines;
brownish gray

TP－12
EL＝ 9.3m



0.0m－0.3m
medium SAND with some silt
lenses, reddish gray

0.3m－0.5m
SILT;soft;wet;dark gray

0.5m－3.0m
medium SAND with some silt
lenses;reddish gray

Fig. III-12 Log of Test Pit (2/2)

APPENDIX III-1

EXAMINATION OF SAFETY AGAINST UNDER SEEPAGE

Appendix III-1

Examination of Safety against Under Seepage

Method of Creep Ratio

1) Method of Bligh

$$C_c < \frac{L_c}{h}$$

C_c : Creep ratio

h : Gap of water head

L_c : line of creep $(B + \Sigma)$

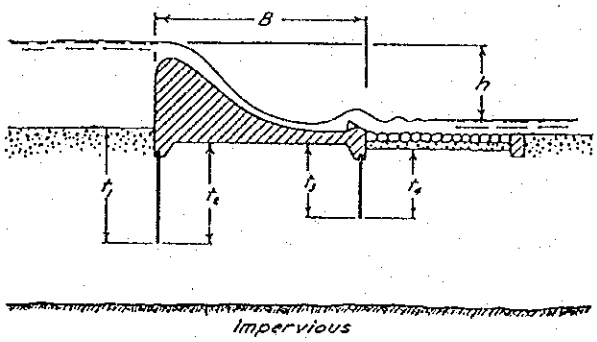


Diagram indicating dimensions used for computation of length of line of creep.

2) Method of LANE

$$C_w < \frac{L_w}{h}$$

C_w : Weighted creep ratio

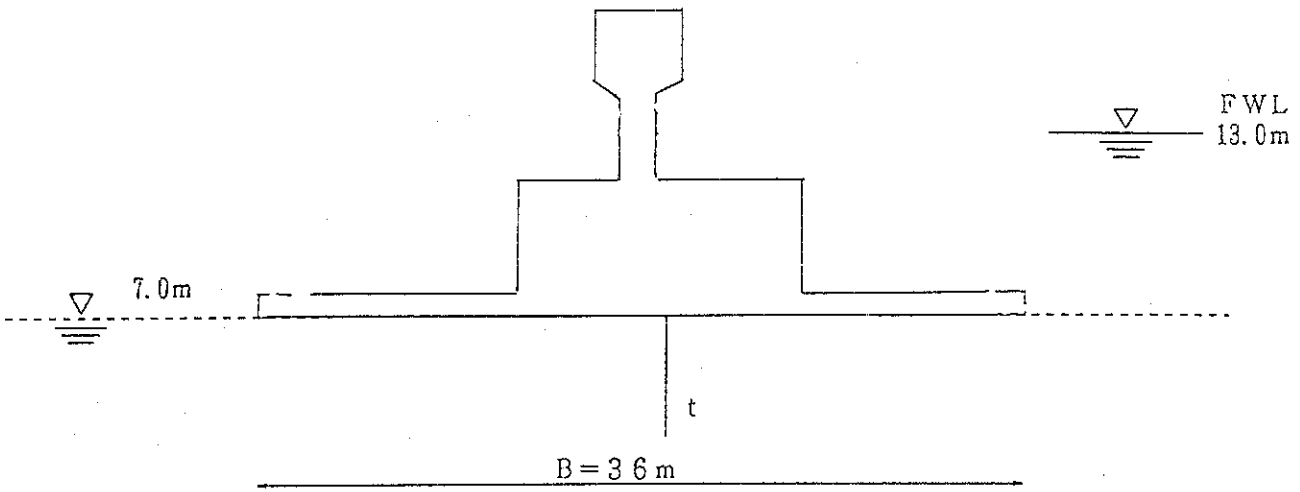
h : Gap of water head

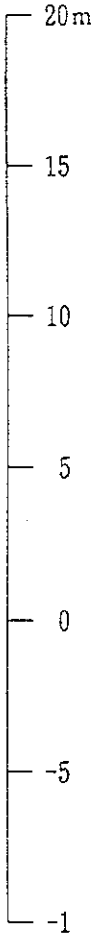
L_w : Weighted line of Creep

$(1/3B + \Sigma t)$

Creep value

	C_c	C_w
Very fine sand or silt	18	8.5
Fine sand	15	7.0
Medium sand	—	6.0
Coarse sand	12	5.0
Fine gravel	—	4.0
Medium gravel	—	3.5
Mixed sand and gravel	9	—
Coarse gravel including cobbles	4~6	3.0
Boulders with some cobbles and gravel	—	2.5





1) Method of Bligh

$$C_c < \frac{L_c}{h}$$

C_c : Creep value of fine sand 15
h : 13.0 − 7.0 = 6.0m
L_c : Line of creep $(B+2t)$

$$15 < \frac{L_c}{6.0}$$

$90 < L_c = B+2t$
$B = 36$
$27 < t$

2) Method of Lane

$$C_w < \frac{L_w}{h}$$

C_w : Creep value of fine sand 7.0
h : 6.0m
L_w : weighted line of creep $(1/3)B+2t$

$$7.0 < \frac{L_w}{6.0}$$

$42 < L_w = (1/3)\,B+2\,t$
$B = 36$
$15 < t$

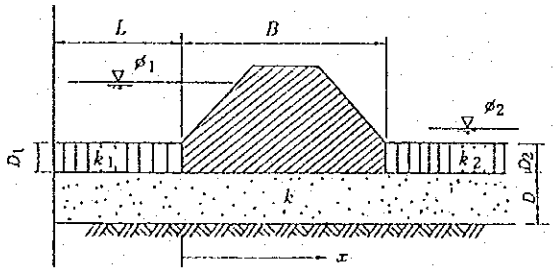
APPENDIX III-2

EXAMINATION OF SAFETY AGAINST UNDER SEEPAGE AT THE RIGHT ABUTMENT OF THE KOMPONG TUOL REGULATOR (TAKEO SIDE)

Appendix III-2 Examination of Safety against Under Seepage at the Right Abutment of the Kompong Toul Regulator (Takeo side)

Seepage pressure in the pervious layer at the toe of the downstream slope is given by the equation (Yamamura, Kutara 1974 : Study on under seepage beneath Levees).

Condition : Semi-permeable surface course extend on the river bed, and pervious layer extends infinitely.



ϕB : Head of water in the pervious layer at the downstream toe of slope

$$\phi_B = \frac{\lambda_2 \phi_1 + (\lambda_1 + L)\ \phi_2}{L + \lambda_1 + \lambda_2}$$

$$\lambda_1 = \sqrt{KD_{c1}} \quad , \quad \lambda_2 = \sqrt{KD_{c2}}$$

K_1, K_2 : coefficient of permeability

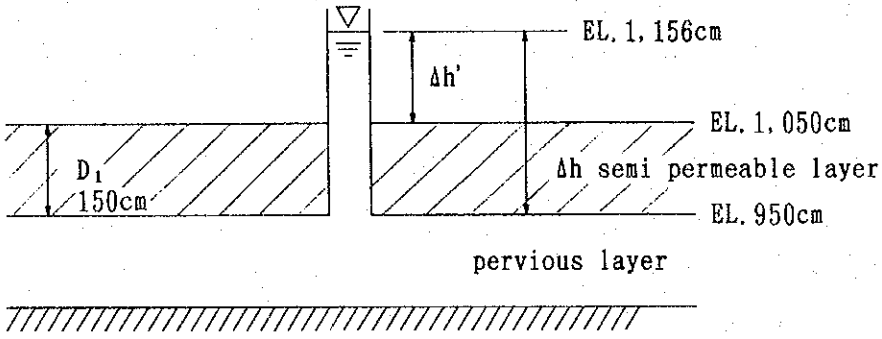
K, K1, K2 are adopted maximum value of field permeability test.

$K = 2 \times 10^{-2}$ cm/sec , $K_1, K_2 = 1 \times 10^{-5}$ cm/sec

According to section H-H', D_1=150cm, D_2=150cm, D=500cm, L=4,500cm, ϕ_1=1,300cm, ϕ_2=1,050cm

at this time ϕ_B=1,156cm

Then, seepage failure is examined by critical hydroulic gradient. Hydroaulic gradient (ic) is given by the following equation.



$$ic = \frac{\Delta h - D_1}{D_1} = \frac{\Delta h'}{D_1}$$

Δh : Head of water in the pervious layer at the downstream toe of slope

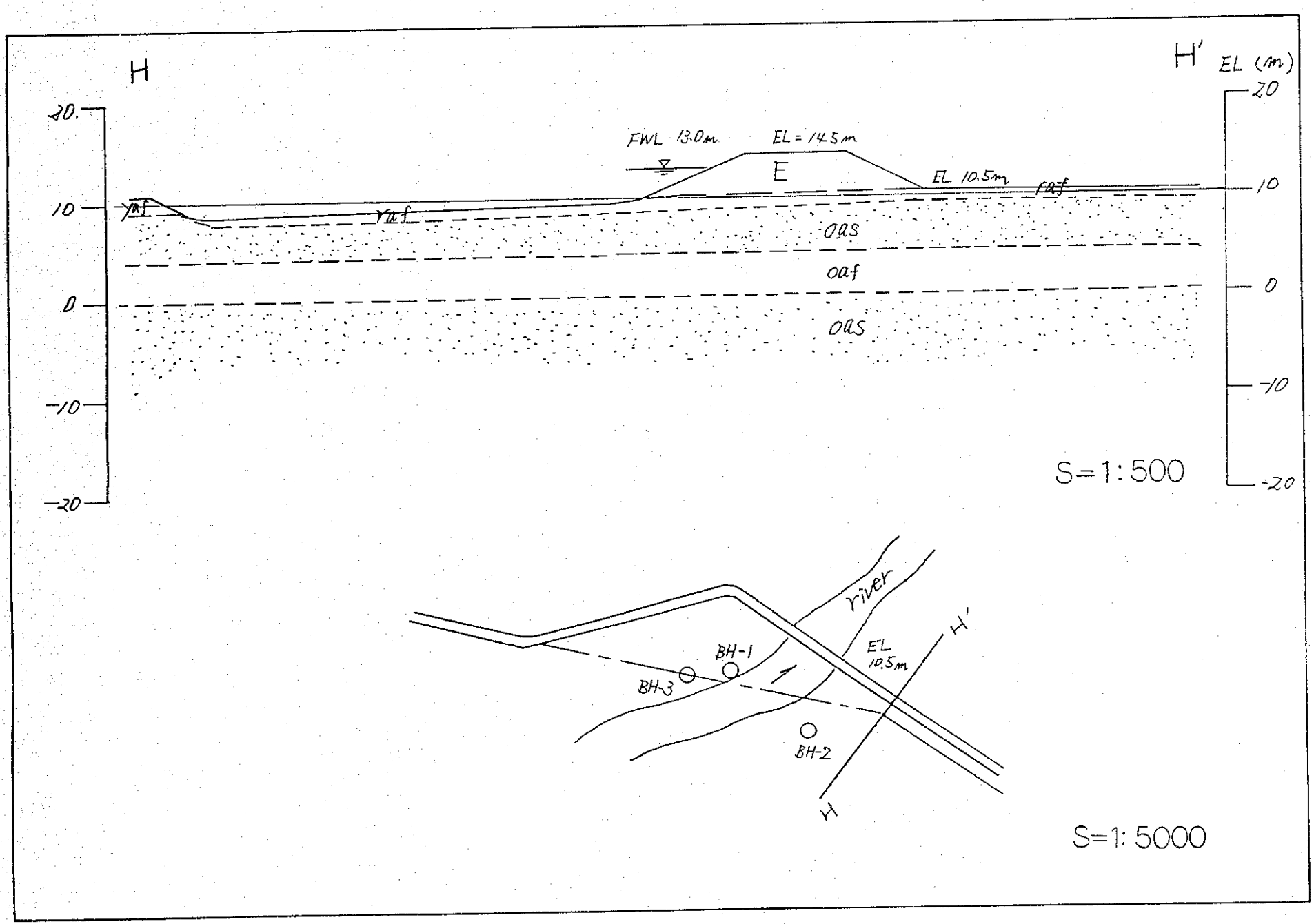
D_1 : Thickness of semi-pervious layer

Empirically, when hydraulic gradient (ic) is greater than 0.5, semi permeable layer is stable aginst seepage failure.

$$\Delta h' = EL, 1, 156cm - EL, 1, 050cm = 106cm$$

$$ic = \frac{\Delta h'}{D_1} \fallingdotseq 0.7$$

Therefor, it is stable aginst seepage at the right abutment of the proposed Kompong Tuol Regulator.


H
H'
EL (m)
20
10
0
-10
-20
FWL 13.0m
EL = 14.5m
E
EL 10.5m
raf
oas
oaf
S=1:500
river
BH-1
BH-3
BH-2
EL 10.5m
S=1:5000

ANNEX IV

AGRICULTURE AND AGRICULTRAL ECONOMY

ANNEX IV

AGRICULTURE AND AGRICULTURAL ECONOMY

Contents

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List of Appendix

1. AGRICULTURE AND AGRO-ECONOMIC BACKGROUND

1.1 Land and Population

1.1.1 Land

Cambodia covers about 181,000 km^2 of land, of which the forest and other natural vegetation are found in the north-eastern, in the northern and the south-western parts of the country and are the largest land use classes of Cambodia as summarized below:

Land categories	Area (1,000 km^2)	Share (%)
I. Natural Areas	138	76
A. Forest	123	68
a.Dense evergreen forest	63	35
b.Deciduous forest	60	33
B.Other Vegetation	15	8
II. Cultivated Areas	38	21
III. Other Land Usage	5	3
Total	181	100

Source: Agenda for Rehabilitation and Reconstruction 1992, Cambodia, World Bank.

The total forest area is about 12.3 million ha, or 68 % of the country, of which 6.3 million ha or 51 % of the total forest area are dense evergreen forest. The deciduous forest is mainly located in the north-eastern part and between the Tonle Sap Lake and Dongrek mountains in the north. As an other vegetation, about 1.5 million ha or 8 % of the total area consists of thickets, scrub, brushwood, grass savannah and grassland susceptible to flooding, and swampy vegetation is distributed over the country. The cultivated area covers about 3.8 million ha or 21 % of the total area. This includes 2.7 million ha of rice field, 1.0 million of upland crops field and 85 thousand ha of rubber plantations. This also includes settlement areas and other infrastructure. Other land usage such as bare land, sandy bank, open water areas and rivers account for about 0.5 million ha or 3 % of the total land of Cambodia. The details of land use is given in Table IV-1.

The cultivated areas are mainly concentrated in the lowland around Tonle Sap Lake and in the south of the country on both sides of the Mekong River. The upland crops are distributed over the country, while the field crops and fruit gardens are mainly located along the banks of the main rivers.

1.1.2 Population

The population by province or city are given in Table IV-2 as stated in Statistics Book (1980-1991), Ministry of Planning. The population of Cambodia in 1991 was around 8.8 million and the annual growth rate was 2.8 % . About 88 % of the total population live in the rural areas. The population density is 49 persons/km^2 on the national average and 1,840 persons/km^2 in Phnom Penh. The rate of female is about 54 % of the total population as shown in Table IV-3.

Labour force population (male from 16 to 60 years old and female from 16 to 55 years old) was 47.2 % in 1980 and demographic dependency ratio (non-labour force population to labour force population) was 1.11 (see Table IV-4). No data on the proportion of working

people at present is available. Based on the 1988 statistics, the agricultural labours was estimated at around 40% to the total population. Adult literacy rate is around 30 %.

1.2 Administration and National Economy

1.2.1 Government Administration

While Cambodia declared its independence in November 1959, the country experienced many times of scramble for political power due to civil wars. The political instability caused by civil wars has retarded the social and economic development process, and continued to create a delicate political situation. At the final meeting of the Paris Conference of Cambodia, the Agreement on a Comprehensive Political Settlement of the Cambodia Conflict were signed by Cambodia and 18 other nations in the presence of the UN Secretary General in 1991. The general elections was held from April to May 1993.

During 1980 to 1990, Cambodia was administrated by 14 Ministries, 23 governmental supervisory administrative offices with about 49,000 state cadres personnel. However, a reform of administrative structure mentioned above has been made by the Royal Government of the newly formulated Kingdom of Cambodia in September, 1993. The newly formulated Royal Government of Cambodia comprises 19 Ministries and 4 Secretariats of State as shown in Fig. IV-1.

1.2.2 National Economy

(1) GDP

Gross domestic product (GDP) by industrial origin at constant prices (Million of Riels) from 1987 to 1991 is given in Table IV-5, and summarized in the following table. GDP in terms of constant 1989 prices has experienced uneven growth in recent years, advancing by 16.2 % in 1988 and 2.4 % in 1989, falling by 0.1 % in 1990, and growing by 13.5 % in 1991.

Item	1987	1988	1989	1990	1991
1. GDP (Million of Riels in Constant 1989 Prices)	207,873	241,534	247,300	247,015	280,304
2. Real Growth Rates of GDP (%)	-	16.2	2.4	-0.1	13.5
3. Share of Real GDP (%)					
Agriculture	51.4	44.0	45.8	45.4	46.9
Industry	15.3	16.9	16.7	16.3	15.6
Services	33.4	39.1	37.5	38.3	37.5

Cambodia is weather dependent, being primarily an agricultural economy with about 85 % of the work force engaged in the agricultural sector, which account for 46.9 % of real GDP in 1991. Of total agricultural output in 1991, rice production account for 17.6 %, other crop and rubber for 11.7 %, livestock for 11.2 %, fishing for 4.8 % and forestry for 1.5 %, respectively.

The industrial and service sectors in 1991 represented 15.6 and 37.5 %, respectively. Of total industrial output in 1991, manufacturing account for 54 % and construction for 38 %: electricity, gas, and water represented 1 % and mining and quarrying account for 7 %.

Service sector increased in real terms by about 2 % in 1990 but 11 % in 1991. Wholesale and retail trade account for 48 % of 1991 services in real terms, while transportation and communications represented for about 7 %. Administration, education

and health services account for about 10 % of total services in 1991, home ownership for 15 %, hotel and restaurants for 1 %, and other services for 18 % respectively.

GDP per capita from 1987 to 1991 was estimated at 127, 170, 153, 171 and 223 US$, respectively. The average annual growth rate of GDP per capita was estimated at about 19 % for the period based on Table IV-5.

(2) Trade

From 1980 to 1987, foreign trade was conducted through a state monopoly along traditional socialist lines. In recent years, international trade has been liberalized by allowing the private sector to engage in trading activities. Official trade data covered only public sector trade, not private trade and would be low estimate as shown in Table IV-6. Most of foreign transactions take place outside the official banking sector, hence, it is impossible to estimate the balance of payment.

The principal exports are timber, rubber, soybeans, maize and fish/fish products, while the main imports are food, fuel, fertilizers, raw materials, equipment , and consumer goods. A huge influx of personal transport equipment and materials have been seen in the last two years as shown in Table IV-6.

1.3 Agricultural Production

1.3.1 General

In spite of importance of agriculture in Cambodia at the end of the 1970's, Cambodia's agricultural sector was virtually devastated. Rice production was down to 0.5 million tons in 1979, compared with 3.2 million tons in 1968. Rubber production of about 53,000 t in 1967 was drastically declined to almost nil in 1979. The number of animals recorded in 1969 was decreased to about one third in 1979. The fish catch fell to 20,000 t in 1979 from the pre-war level of 100,000-125,000 t. Table IV-7 and Table IV-8 show the planted area and production respectively, for major crops in 1967 and 13 years from 1979 to 1991.

Since 1980, the activities on agricultural sector have recovered steadily. The cultivated area and production of rice in 1991 were about 1.8 million ha and 2.5 million t respectively. Fish production in 1991 has increased six times from its 1980 level (Table IV-9). Rubber production has risen to about 30,000 t in 1989 from practically zero in 1979. The number of cattle in 1991 recovered to the level at the end of 1960s, 2.3 million heads, and pigs increased to 1.6 million heads in 1991 from 50 thousand heads in 1979, poultry increased to 8.4 million in 1991 from 870 thousand in 1979 respectively (Table IV-10). Despite these increase, agricultural economy in the country, especially self-sufficiency, still remains at a subsistence level.

1.3.2 Rice

Rice is the most important crop in the country. About 23 % of agricultural production in terms of GDP in 1991 (Table IV-5) is covered by rice. Some 85-90 % of agricultural field is under rice cultivation. The rice production area is widely divided into four regions; (i) Plain region, (ii) Tonle Sap Lake region, (iii) Coastal region, and (iv) Plateau and mountain region as shown in Table IV-11. Among these regions, about 85 % of rice area is concentrated to plains along the Mekong and Bassac rivers and Tonle Sap Lake region.

1.3.2.1 Rice Ecosystem in Cambodia

Rice ecosystems in Cambodia are broadly classified into four systems mainly depending on the condition of water availability, say, rainfed upland, rainfed lowland, deepwater land and dry season irrigated crop as described below:

The following table shows the cultivated area and yield of various types of rice and those percentage of area planted in 1990.

Rice Culture Type	Harvested area	Yield	% of total area
1. Wet season total	1,425,803	1.3	91.0
IR variety	30,569	1.9	2.0
Early rice	209,607	1.5	13.5
Medium rice	469,130	1.4	30.2
Late rice	583,058	1.4	37.5
Upland rice	24,228	1.2	1.6
Deep/Floating	109,211	1.2	7.0
2. Dry season	130,076	2.7	8.4
3. Total	1,555,879	1.5	100.0

Source : IRRI Cambodia-Project Annual Report 1990.

As seen in the above table, more than 90 % of rice cultivation is dependent on wet season while the irrigated dry season rice is less than 10 % of the total cultivated area.

(1) Rainfed upland rice

As seen in the table above approximately 24,000 ha of rainfed upland rice are grown annually mainly in small pockets in hilly areas under shifting cultivation in mostly Kampong Cham, Ratnakiri, Siem Reap, and Kandal provinces. They are usually planted at the beginning of wt season, end of May to June, and harvested in September to October. The area under rainfed upland rice cultivation is less than 2 % of the total area of rice in Cambodia. An average yield is as low as 1.2 t/ha.

(2) Rainfed lowland rice

More than 90 % of Cambodia's wet season rice area is cultivated with rainfed lowland rice. It is concentrated on the flat plains surrounding the Tonle Sap Lake and spread over along the Mekong and Tonle Bassac Rivers. The rainfed lowland rice ecosystem is divided into three categories relating to water depth.

i) Early rice (less than 30 cm depth of water)

Early duration rices are photoperiod insensitive and mature in 120 days or less and cultivated as irrigated early rice. Seeded usually by May harvested by September, or as receding water crops seeded in November to December, harvested in February and March in some areas, these varieties are also seeded in August as delayed crops during the wet season and harvested by November. Approximately 15 % of the rainfed lowland area in Cambodia is cultivated with early maturing varieties (IRRI-Cambodia Project Annual Report, 1992).

ii) Medium rice (30-40 cm depth of water)

Presently about 30 % of the total rice area is transplanted to medium maturing rainfed lowland varieties. These are usually photoperiod insensitive and have a duration of between 120 and 150 days. They are generally seeded in July, flower in October and harvested November-December. Some varieties may be photoperiod sensitive and flower during October for maturation in November and December. Medium duration

rices are cultivated exclusively in the wet season, either as rainfed lowland crops or with supplementary irrigation. All varieties presently grown are under traditional types.

iii) Late rice (40-60 cm)

These are the longest duration (more than 150 days) of the rainfed rice in Cambodia and cultivated during wet season only being seeded between May and August and harvested during December to January period. These rices are photoperiod sensitive and usually flower between mid November and mid December. Late duration rices are most important subgroup in Cambodia representing about 37 % of the total rice area. Major areas are located in Prey Veng, Kompong Chhnang, Battambang, Svay Rieng, Kompong Cham, Takeo, and Siem Reap.

(3) Deepwater/floating rice

Deep water/floating rice areas are spreaded over the edge of Tonle Sap Lake and along the both banks of rivers of the Tonle Sap, Mekong, and Tonle Bassac. They are known locally as floating rice and are directly seeded from April to June and harvested in January-February. These rices were important to Cambodia during the 1960's (371,000 ha in 1967), but substantially decreased to about 60,000 ha in 1970's and about 125,000 ha were cultivated in 1987.

(4) Dry season rice

These are grown under the following three situations: a fully irrigated crop after harvesting wet season rice seeded November to December, and harvested in March to April; partially irrigated crop grown in the field where the deep water rices could not be cultivated during the wet season; and partially irrigated crop on the banks of rivers, lakes natural depressions, etc. according as the water recedes. These rices are all photoperiod insensitive, early maturing varieties. Some modern varieties such as IR36, and IR42 are grown in these areas.

1.3.2.2 Yield of Rice in Cambodia

The average unit yield of rice in Cambodia is still stagnated at low level around 1.5 t/ha in 1990 mainly due to reasons that the most of rice is cultivated under rainfed condition and the rainfall is erratic even in the wet season, the rice varieties cultivated are mostly local ones which are usually rather suitable than the improved high-yielding varieties to be cultivated under such conditions of unstable water supply, but less respondent to fertilizers. In other words, there exists a great potential for increasing rice production by stabilization of water supply and by applying improved varieties and farming practices.

1.3.3 Other Crops

The other crops grown in the country are rubber, maize, mungbeans, soybean, sesame, tobacco, groundnuts, coconuts, sugar palm, vegetables, jute and sugar cane, etc. The total area planted for these crops was about 250 thousand ha in 1967, decreased to some 120 thousand ha in 1979, and recovered to about 150 thousand ha in 1991 (see Table IV-7). In recent years, soybean, mungbeans and maize (yellow) were exported but still in small quantity. Especially maize, the cultivated area of about 120 thousand ha in 1967 was decreased to about 75 thousand ha in 1979, and 46 thousand ha in 1991 mainly due to lack of market and problems of storage. Vegetables are also grown mainly along the river banks for about 27,000 ha in 1991. Rubber is cultivated as plantation farm and one of main agricultural products for export. The exported amount reached to 33 thousand tons in 1989.

1.3.4 Livestock

Livestock husbandry in Cambodia is mainly characterized by small scale units, mostly derived from small subsistence farms. Most of farm families keep a few cows for draught power, pigs, chickens and ducks mainly for cash income. The pigs and chickens are used for cash income. The livestock raising in Cambodia from 1961 to 1991 is shown in Table IV-10. The number of draught animals is still short for crop cultivation though substantial increase was seen after the liberalization of economy in 1980. Those livestock animals were frequently affected by diseases. Their efficiency could be greatly increased if their nutrition and health conditions are improved.

1.3.5 Fisheries

Fisheries play important protein source for the daily life of peoples in Cambodia. Main fishery resources are inland fisheries from the Tonle Sap and the Mekong, lakes and marshes along rivers, farm pond and marine fisheries. The inland water bodies in Cambodia are useful fish resources.

As seen in Table IV-9, the fishery production has substantially recovered to about 117,000 t in 1991 from 73,600 t in 1986 (1.6 times). Out of 117,000 t of product, 75,000 t were of fresh water product which increased from 64,200 t in 1986 (1.2 times).

Fish consumption in the Mekong riparian countries in 1970 estimated by the Mekong Basin-wide Fisheries Study is as shown below.

Area/Country	Per Capita Consumption(kg/year)
Laos	10.2
Northeast Thailand	11.5
Mekong Delta	20.8
Cambodia	25.5

The following Table shows the fish products, national population and fish consumption per capita per year from 1986 to 1991 in Cambodia. Per capita consumption is roughly estimated at bout 13 kg/year in 1991.

Quota	1986	1987	1988	1989	1990	1991
Total	73.60	82.10	86.80	82.00	111.40	117.3
Fresh water product	64.20	62.20	61.20	50.50	65.10	74.70
Rearing product	2.20	2.50	4.60	5.50	6.40	6.70
Sea product	7.20	17.40	21.00	20.00	39.90	36.40
Population (1,000)	7,672	7,886	8,107	8,334	8,568	8,807
Fish consumption/capita/year (kg)	9.6	10.4	10.7	9.8	13.0	13.3

Source : Department of Fisheries

1.3.6 Forestry

Cambodia still has a substantial proportion of forest coverage. According to FAO/OSRO: Report No.01/91/E, percentage of forest-covered area in the early 1960's was down to about 60 % in late 1980's summarized as follows:

unit : %

Provincial Groups	Early 1960's	End 1980's
I. Virtually Intact		
Koh Kong, Mundolkiri	90	90
Stung Treng, Preah Vihear, Kratie	90	85
Pursat, Siem Reap, Battambang, Kompong Thom	55-60	55-60
II. Moderately Severe		
Ratankiri	90	80
Svey Rieng, Prey Veng	10-15	1-5
III. Very Severe		
Kompong Chhnang	60	1-5
Kompong Cham	60	30
Kandal, Takeo	10-15	0
Total Average	74-76	58-60

The trend in forest loss in Cambodia is rapid particularly in the Southeast, where population pressure is higher and increase in timber and fuel wood consumption also exhausts the forest resources. The commercial logging officially has stood at between 200,000 and 300,000 m^3 per year over the past five years, while unofficial logging, which is not controlled by the present administration, is roughly estimated at two to three times of the official logging.

Reforestation area was only 2,100 ha from 1986 to 1990 with survival rates of 70 percent of seed. The Forest Department has an annual target for reforestation 5,000 ha for 1991 to 1995, and 7,500 ha for 1996 to 2,000.

Export of timber was about 18,000 m^3 in 1980, and increased to about 260,000 to 300,000 m^3 per annum in 1991, 1992, as seen in Table IV-6. But the new government has intention to promote forest reservation activities in connection with the environmental protection consideration.

1.4 National Agricultural Development Plan

1.4.1 Five Year Plan

Cambodia First Five Year Plan (FFYP) was inaugurated in 1985 as accomplishment for the nation's economic development covering the period of 1985 to 1990. The FFYP acknowledged a role for the state and for the private sector, and set the stage for changes in joint venture laws, price controls and foreign direct investment regulation that occurred in the late 1980's. The Second Five Year Plan (SFYP) was prepared for 1991 to 1995, which is a milestone in the transition of Cambodia's economic development. The SFYP included many positive statements for change, and calls for the need for setting sectorial priorities. The plan notes concern for the capacity of the state in guiding economic development, and identifies key sectors for emphasis as follows :

Sector	Total Investment	Distribution
	(Million Riels)/1984 Price)	(%)
Agriculture	3,318.90	30
Communication	2,765.75	25
Industry	1,106.30	10
Electrical Energy	1,659.45	15
Tourism	553.15	5
Others	1,659.45	5
Total	11,063.00	100

The SFYP makes a realistic assessment with regard to the new economic situation of Cambodia and the struggle with moving towards a market-oriented economy. In the plan, increase in food grain production is projected as one of the essential targets of the plan as follows:

Item		1986 (actual)	1990 (actual)	1991	1995
Population	(Million)	7,774	8,680	8,923	9,960
Food grains	(Thousand tons)	2,130	2,825	3,030	4,100
Production	(kg/capita/year)	275	326	340	412

According to the plan, projected per capita production and total food grain production (paddy plus maize) for 1991 was 340 kg/year, and 3,030 thousand tons, respectively. The data obtained from the Department of Planning of MAFF showed that the actual paddy and maize production in 1992 was 2,221,000 t and 60,000 t, respectively. Population in 1992 was estimated at about 9,053 thousand. Therefore, per capita annual production of food grains was estimated at 252 kg which accounts for about 74 % of the target in 1991.

1.4.2 Five Year and Two Year Agricultural Development Plan

MAFF prepared the Five Year Agricultural Development Plan titled as " Situation and Objectives of Agricultural Development Policies " to follow the SFYP (1991-1995), and under the new government MAFF has drafted up the Two Year Agricultural Development Plan for 1994-1995. The objectives of the Two Year Plan is an special urgent need of national economic strengthening included in the program of the SFYP. It is targeted in the Two Year Plan on the strengthening of national economy based on the amelioration of rural infrastructures which will be donated mostly by the international communities to the economic development priorities. The development policies incorporated in the SFYP are followed basically in the development.

1.5 Agricultural Supporting System of National Level

1.5.1 Ministry of Agriculture, Forestry and Fisheries (MAFF)

MAFF has overall responsibility for coordinating agricultural sector development activities at the central level. In addition each province has a Provincial Agriculture Department which is responsible for coordinating agricultural activities at the provincial level through Agricultural Office of each district. Although MAFF is the key institution in the sector, there are number of relevant authorities in particular Secretariats of State for Rural Development, Environment, Women's Affairs. SRD's objectives is to improve the economic and social conditions of the rural population focus on poverty stricken areas, by developing rural infrastructure such as raods and water supply, coserving natural resource, encouraging

community organizations, and integrating public and private sectors with rural populations to improve living standards. SRD is responsible for supervision and management of the rural development in the whole country, however, there will be considerable overap of responsibility between MAFF and SRD.

The government organization is still transitional under the new Government, at present the Government is improving the organization of the Ministry as shown in Fig. IV-2, but the former function and responsibility of each department and unit may be possible to be followed by new organization in principle. In the current structure 16 departments can be divided into three functional categories as follows:

i) Technical Departments

Land title and reform
Forestry and wildlife
Fisheries
Agricultural machinery
Central company of agricultural materials
Agronomy
Agricultural hydraulic and hydrometeorology
Animal production and health
Agricultural extension

ii) Support Departments

Cabinet
Planning, statistics and international cooperation
Staff and organization
Finance and accounting
Committee of inspection

iii) Technical Education

Royal University of Agriculture (ex-Chamcar Daung Agricultural Institute)
Prek Leap and Kompomg Cham Agricultural Colleges

The Department of Fisheries has four divisions (Technical Bureau, Inspection, Planning and Statistics, and Administration), four freshwater and one maritime fishing companies, two fresh water fish net factories, and two research and fish hybridisation stations. It issues licenses for artisan and industrial/export production and is responsible for the distribution of fish products to the State sector. The Department of Forestry is engaged directly in forest exploitation. It runs its own transport service and operates six saw mills and furniture shop. The Royal University of Agriculture (ex-Chamcar Daung Agricultural Institute) offers four-year Bachelors' courses in agronomy, forestry, veterinary, agricultural machinery and fisheries. The Prek Leap Agricultural College provides two and half year "Agricultural Officers" course and a one year "Agricultural Extension Officers" course.

Among the 16 departments of the Ministry, the technical departments of the Ministry which are most relevant for agriculture and rural development are: the Department of Agricultural Hydraulic and Hydro-Meteorology (ex-Department of Hydrology), the Agronomy Department, the Central Company of Agricultural Materials (ex- Department of Agricultural Materials), Department of Animal Production and Health, and the Department of Land Titles.

1.5.2 The Department of Agricultural Hydraulic and Hydro-Meteorology (DOH)

DOH is responsible for the planning, design, construction and maintenance of all water conservation, flood control, irrigation and drainage works. The organization structure is as shown in Fig. IV-3. The DOH is divided into two functional categories of administration and

technical. The administration wing comprises four offices and deals with departmental organization and management, personnel matters, preparation and control office budget. The technical wing comprises four offices of Design, Construction, Water Management, and Hydrometeorology. Technical aspects relating to large-scale (larger than 1,000 ha) and multipurpose projects are dealt with DOH centrally, while small and medium scale projects being handled at provincial level. The technical offices are responsible for research, conceptual planning, survey, design and preparation of cost estimates, implementation of designed projects, operation and maintenance of all irrigation infrastructure, installation and maintenance of a network of hydrological and climatological stations, collection and processing of data, and weather flood forecasting.

1.5.3 Department of Animal Production and Health (DAPH)

The implementation of the Government's policies and programmes for livestock production and health is the responsibility of the Department of Animal Production and Health. The Department is currently divided into 5 sections as shown Fig. IV-4, say Animal Production, Animal Health, Finance, Planning and Administration. Under Vice Director incharge of Technical Services, there are Animal Health Section and Animal Production Section. Animal Health Section is consisted of National Veterinary Diagnostic Laboratory, Veterinary Vaccine Laboratory, Veterinary Clinic and Vaccination Services. The Animal Production Section includes 3 breeding stations, i.e. Phnom Tamao Cattle Breeding Station (Takeo Province), Pig Breeding Station (KM 11), and Poultry Breeding Station (Prek Samron).

(1) Veterinary Services System

The National Veterinary Diagnostic Laboratory is staffed by 17 veterinarians and technicians who are assigned to sections of Parasitology, Bacteriology, Pathology and Serology. The first priority is to improve the skills of the technicians and to upgrade facilities. Veterinary Vaccine Laboratory produces HS vaccine. It has the capacity to produce about 800,000 doses of HS vaccine annually. Other kind of vaccine is necessary to be imported. DAPH has established a vaccination service system for cattle with cold-chain for delivery of vaccines to the field. This consists of two cold rooms at the head quarter of the department, a refrigerated van for transferring vaccines to provincial veterinary section where a cold store facilities are equipped (solar energy type refrigerator and electric refrigerators) under provincial agricultural office. The veterinarians stationed in each district office are required to prepare a vaccination programme for each commune by instruction from the provincial office and to collect the vaccines from the provincial office using ice box and motor cycle. The vaccination system is extended only to cattle free of charge for Foot and Mouth Disease, Hemorrhagic septicaemia, Anthrax and Black leg, but not covering disease of pigs and poultry. The department has drafted the strategy for reducing livestock mortality by increasing vaccination, improving facilities for delivering and stock the vaccines as the most important objectives as well as by reducing disease by external and internal parasites for short, medium and long-term strategies. The major disease of livestock identified in Cambodia is as shown in Table IV-12.

(2) The Animal Breeding Stations

The stations mentioned earlier are aiming at providing quality animals to the community and upgrading the national livestock populations. The Phnom Tamao Cattle Breeding Station is located just South of the Tonle Bati Lake. It has 380 ha of land and 440 cattle for breeding(Haryana: 13 bulls and 4 cows, Brahman: 6 bulls and 173 cows, 65 heifers, 55 bulls, 124 calves), and supplied about 600 heads of cattle to farmers since starting in 1981. Poultry Breeding Station (Prek Samrong) has an ongoing program to produce and sell Isabrown chicks to commercial egg producers, and it has also prepared proposals for a program to upgrade village chickens. Pig Breeding Station (11 km from Phnom Penh along

Road No.5) currently maintains a 50 sow breed herd for distribution of progeny, but has had no introduction of any improved stock since 1986. All these facilities are suffered from shortage of budget and trained staff.

1.5.4 Department of Agronomy (DOA)

The Department of Agronomy is responsible to formulate plan of experiment at the national level and, to monitor the food production in the country through provincial agricultural offices. And the Department manages a network of agricultural research stations and state farms, including three rice seed production farms, two rice experimental stations, a vegetable research station, a plant protection research station, two cotton farms and a pepper farm, and agricultural and rural development centres as described below and its organization structure is shown in Fig IV-5.

(1) Research Stations:

Cambodia has 10 research stations under the Department of Agronomy including agriculture research cum seed multiplication stations as follows:

Agricultural Research and Seed Stations:

Name of station	Cooperating organization	
	Province	
Prey Phdau Rice Research Station	OXFAM	Kompong Spu
Dey Eth Rice Research Station		Kandal
Bantey Dek Maize Seed Station	FAO	Kandal
Kouk Trop Rice Research Station	IRRI	Svay Rieng
Toul Krosang Rice Research,Seed Station		Pnom Penh
Samroung Thom Tobacco Research Station		Kandal
Kbal Koh Vegetable Seed Station	CWS	Kandal
Stung Men Chey Plant Protection Station		Phnom Penh
Kop Srau Rice Seed Station (120 ha)		Phnom Penh
Toul Sam Ron Rice Seed Station (250 ha)		Battambang

Beside the above stations, IRRI-Cambodia Project has been operated since 1989 in collaboration with the Ministry of Agriculture and IRRI, funded by AIDAB. The main activities are to carry out various study and experiment on rice cultivation improvement in Cambodia.

(2) Agricultural and Rural Development Centres:

There are seven agricultural/rural development centres operated under the Department of Agronomy. Each development centre has a target area to provide services on cultivation as shown below. The agricultural development centres have been established under control of the Department of Agronomy most of them receiving support from NGOs as seen in the table below. Each centre mainly provides the services for irrigation water and farm input supplies for rice cultivation. In addition to these services, Sre Ampil Centre is also providing for farm machinery services for ploughing as well. However, most of activities of the centres are compelled to scale down to limited area mainly due to shortage of manpower and budget.

Name of Centre	Target area (ha)	Staff No.	Cooperating organization	Province
Tasaang	1,000	13	CIDSE	Svay Rieng
Po Lors	2,000	26	PADEK	Prey Veng
Kbal Po	6,000	17	ACR	Takeo
Tonle Bati	6,000	10	HEKS	Takeo
Sre Ampil	2,000	24	MANITESE	Kandal
Veal Pong		2	WVI	Kompong Spu
Kandal Stung	3 communes	11	WVI	Kandal

1.5.5 Agricultural Extension System

At the national level the Department of Agronomy and the Department of Extension under the Ministry provide for agricultural extension services in small areas, the impact of which at field level is rather limited. Each department in the Ministry has it's own extension unit and executes extension works through the provincial and district agricultural offices. The Department of Extension (consists of Offices of Technical Extension and Rural Credit) established under the Ministry is executing training on the extension workers at Prek Leap Agricultural College with aiming to dispatch Community Extension Workers at commune level in each province with the support from District Extension Leaders. This activity is supported by ACR in Cambodia , Australia International Development Assistance Bureau (AIDAB) and UNDP. The Ministry has program to establish a model area of the future agricultural extension service in Treang District in Takeo Province using Kbal Po Rural Development Centre as a core station (supported by ACR). The Department of Agronomy has function for agricultural and rural development work through all the agricultural research stations and agricultural/rural development centres. But the present extension work covers very limited area due to mainly shortage of qualified manpower and budget.

1.5.6 Agricultural Inputs Supply System

There are two channels for inputs supply to the farmers, one is Government operated Central Company of Agricultural Materials (former Department of Agricultural Materials), and the other is private market. The Company under the Ministry is responsible to distribute agricultural inputs mainly fertilizers, chemicals, and some agricultural tools such as sprayers through government channels. The fertilizers mostly imported under bilateral agreements with various countries. The Company distributes at the fixed Government prices to the agricultural development centres, provincial and district offices with request. The farmers can receive at the fixed prices in cash. A small amount of fertilizers are often sold through private channels with rather high prices. Therefore, the small farmer, especially the poorest among them, are unable to obtain supplies through private channels. The most farmers complain shortage of fertilizers in time when they need for cultivation of rice. Arrival of requested fertilizers are usually delayed in case of supply by the Government. No credit sales of fertilizers is practiced at present.

2. AGRO-ECONOMIC CONDITIONS IN MASTER PLAN STUDY AREA

2.1 Administrative Jurisdiction of Master Plan Study Area

2.1.1 Administrative Jurisdiction

Cambodia is widely devided into four regions , namely, Plain region, Tonle Sap Lake region, Coastal region, and Plateau and Mountain region. The extent of area and population by region is summarized as follows:

Region	Area		Population in 1991		Population Density
	(km^2)	(%)	(' 000)	(%)	(Person/km^2)
Plain Region	25,069	14	4,763	54	190
Tonle Sap Lake Region	67,668	37	2,598	29	38
Coastal Region	17,237	10	569	7	33
Plateau and Mountain Region	68,061	38	877	10	13
Tonle Sap Lake	3,000	1	–		–
Total	181,035	100	8,807	100	49

As seen above, plain region covers only 14 % of the total area, while 54 % of total population live in the region, resulting in the highest population density of 190 persons/km^2 in the country followed by Tonle Sap Lake region of 38 persons/km^2. The population of Phnom Penh in 1991 was 491 thousand. Population density in Kandal and Takeo provinces are 248 and 196 persons/km^2, respectively. The population density in the both provinces are the second highest following that in Phnom Penh City. The detailes of area and population by province are given in Table IV-2. The Plain region produces about a half of rice production in the country followed by 33 % of Tonle Sap Lake region as seen in Table IV-11.

The Master Plan Study Area(the Study Area) is under jurisdiction of Kandal Stung District of Kandal Procvince (Kandal Stung Study Area) and Tonle Bati District of Takeo Province (Tonle Bati Study Area) as shown in Location Map. The Kandal Stung Study Area includes 72 villages (Phum in Khmer) of 13 communes (Khum in Khmer, or sub-district) out of 23 communes in the district, and the Tonle Bati Study Area includes 25 villages of 5 communes out of 11 communes.

2.1.2 Population

The Kandal Stung Study Area covers about 11,300 ha, and the Tonle Bati Study Area covers about 6,900 ha in gross. The population of the Study Area is eatimated at about 26,100 and 15,500 persons for Kandal Stung and Tonle Bati Study Area, respectively, so that the density of the both areas is estimated at 231 and 225 person/km^2, respectively, highly populated in the country. The details of the name of commune, number of family and population by commune are presented in the following table:

Commune	No.of villages	No.of families	Total Population	Average family size
Kandal Stung Area:				
Anlong Romeat	6	451	2,152	4.8
Trapeang Veng	4	354	1,895	5.4
Tbeng	2	135	717	5.3
Thmey	5	259	1,221	4.7
Trea	9	738	3,812	5.2
Prek Roka	4	645	3,069	4.8
Spean Thmar	8	512	1,875	3.7
Rolous	3	353	1,386	3.9
Preas Puth	5	356	1,604	4.5
Korng Nory	4	222	1,003	4.5
Tean	6	345	1,400	4.1
Bakou	7	612	3,040	5.0
Kok Trop	9	716	2,949	4.1
13 ommune	72	5,698	26,123	4.6
Tonle Bati Area:				
Cham Pey	7	797	4,249	5.3
Puth Sar	11	1,371	7,583	5.6
Kraing Thnung	3	356	2,067	5.8
Kandoeung	3	228	1,140	5.0
Trapeang Sap	1	97	464	5.8
5 commune	25	2,828	15,503	5.5
Study Area total	97	8,526	41,626	4.9

Source : ANNEX VII

2.2 Land Tenure System

For the purpose of increasing productivity of agriculture and thus improving living standard, the Government has taken effective efforts in the sector as adoption of granting land ownership rights, free market and decontrol of prices of products to provide more incentives to producers. The registration of land titles is on the way under the Ministry and the Ministry has a plan to complete within the 2-years development phase from 1994 to 1995. The land title registration in the Study Area is also under progress (see Appendix to this ANNEX).

2.3 Agricultural Production in Study Area

2.3.1 General

The agriculture in the Study Area is dominated by rice cultivation. Most of the agricultural land is devoted to rice field and almost all of them is in the category of rainfed lowland rice ecosystem, one crop during the wet season. Some farmers cultivate two crops a year with irrigation but in the very limited area. In addition to the rice cultivation, the farmers grow other crops like vegetables, sugar palm, and bananas, mango, guava as home garden crops. Livestock raising is also very important farming activities in the area. Most of farmers keep pig and poultry. The cattle is raised as the purpose of draught power for field preparation and cart.

The farmers grow rice as much as they can, even to the field of marginally suitable soil condition. The rice cultivation is affected by unstable distribution of rainfall and the unit yield