

タイ王国

ユアム川

水力発電開発計画

調査報告書

〔II〕

(Appendix 1, 2, 3, 4, 5)

1984年3月

国際協力事業団

鉅計資

84-38(%)

タイ王国

ユアム川

水力発電開発計画

調査報告書

〔II〕

(Appendix 1, 2, 3, 4, 5)

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1984年3月

国際協力事業団

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A1 GEOLOGY

Micrograph and Petrographic Description of Rock

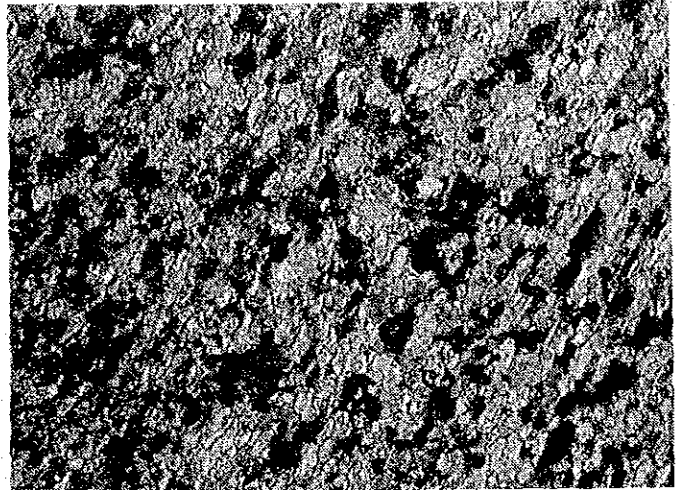
(Plate 1 of 5)

Locality: 5

600 m upstream of A dam axis,
right bank of Yuam River.

Rock name:

Limestone (massive)



Petrographic description:

0 0,3mm (crossed nicols)

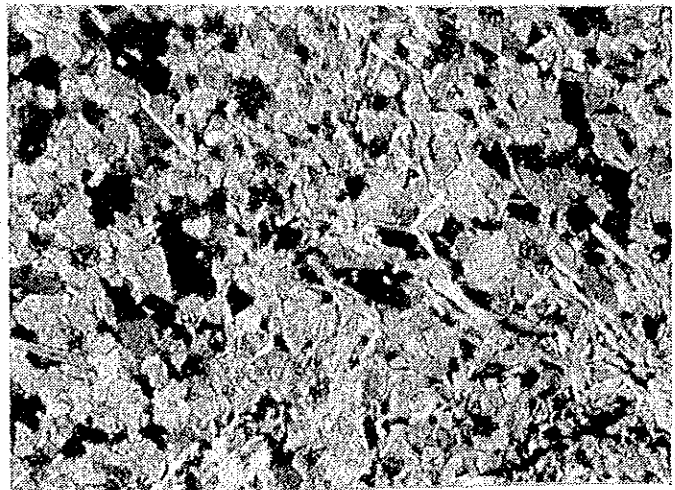
Chief consisting minerals are calcite >> muscovite, quartz and
chlorite. Dolomite and potassium feldspar are trace in amount.

Locality: 9

200 m upstream of A dam axis,
right bank of Yuam River.
(EL. 150 m)

Rock name:

Limestone (laminated)



Petrographic description:

0 0,2mm (crossed nicols)

Chief consisting minerals are calcite > white mica, quartz.
Banding texture consisting of calcite-rich and mica-rich layers is
observed.

Micrograph and Petrographic Description of Rock

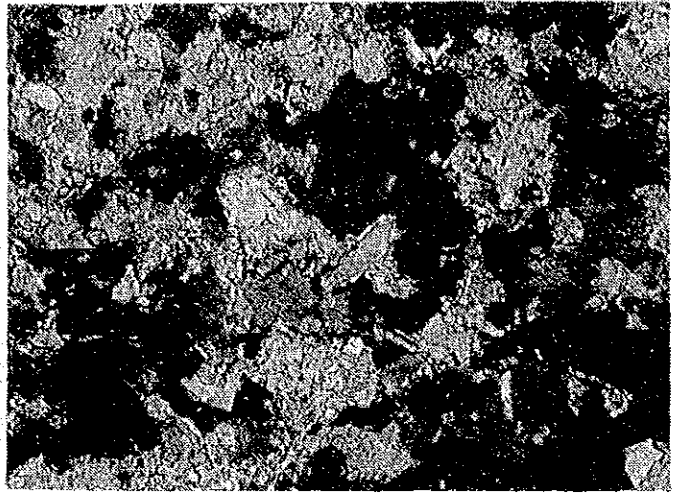
(Plate 2 of 5)

Locality: 13

1 km downstream of A dam axis,
left bank of Yuam River.

Rock name:

Sandy limestone



Petrographic description:

0 0.2 mm

(crossed nicols)

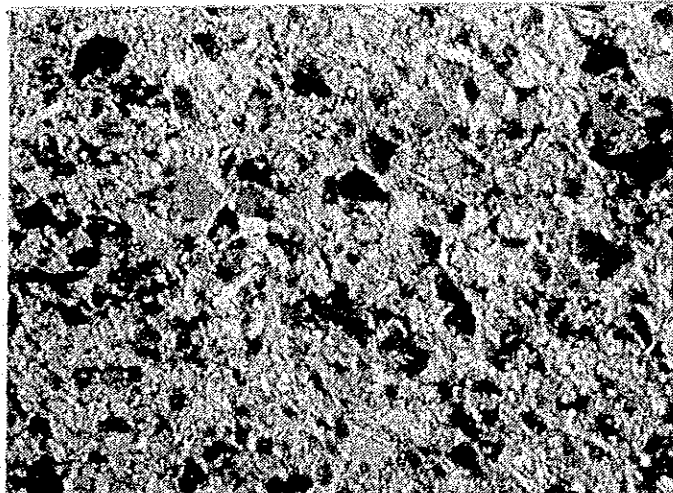
Chief consisting minerals are calcite, dolomite, quartz and
muscovite.

Locality: 16

Tributary of Huai Uya Kra
(EL. 460 m)

Rock name:

Siliceous limestone
(or calcareous sandstone)



Petrographic description:

0 0.3 mm

(crossed nicols)

Chief consisting minerals are calcite, quartz and white mica.

Clay minerals are trace in amount, less than 0.1%.

Micrograph and Petrographic Description of Rock

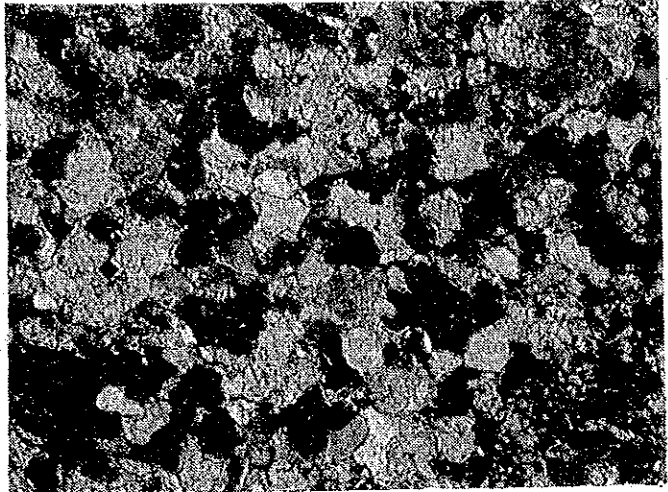
(Plate 3 of 5)

Locality: 18

Huai Uya Kra

Rock name:

Calcareous sandstone



Petrographic description:



(crossed nicols)

Chief consisting minerals are dolomite, calcite, quartz.

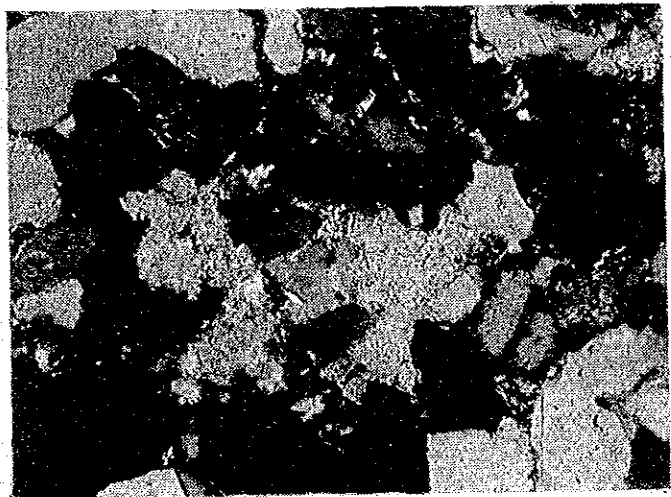
Accessory minerals are muscovite and pyrite.

Locality: 20

Huai Mae Lamu

Rock name:

Sandstone



Petrographic description:



(crossed nicols)

Chief consisting minerals are quartz, dolomite and plagioclase.

A trace amount of montmorillonite is found.

Micrograph and Petrographic Description of Rock

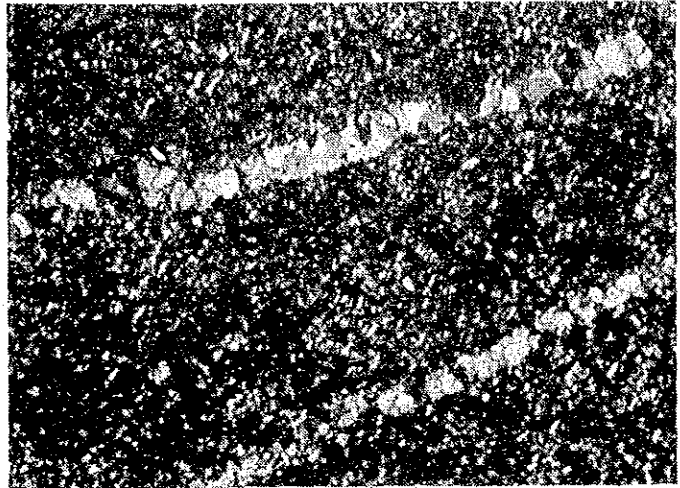
(Plate 4 of 5)

Locality: 19

Right bank of A dam axis

Rock name:

Shale



Petrographic description:

0 0.3 mm (crossed nicols)

Chief consisting minerals are quartz, white mica, graphite and plagioclase. Quartz veins are common.

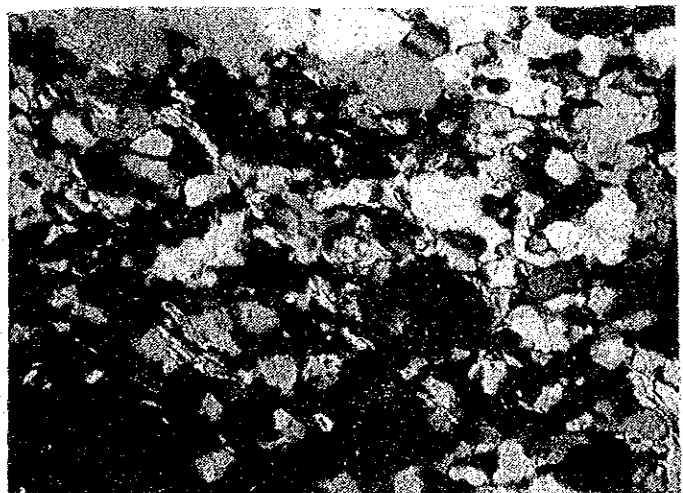
Locality:

Huai la cho Kra

(about 5 km upstream of
Damsite A)

Rock name:

Quartzose sandstone



Petrographic description:

0 0.2 mm (crossed nicols)

Chief consisting minerals are quartz, potassium feldspar and muscovite. A trace amount of tourmaline, zircon and apatite is found.

Micrograph and Petrographic Description of Rock

(Plate 5 of 5)

Locality:

Damsite C (about 12 km upstream
of Damsite A)

Rock name:

Granite



Petrographic description:

0 0.5 mm (crossed nicols)

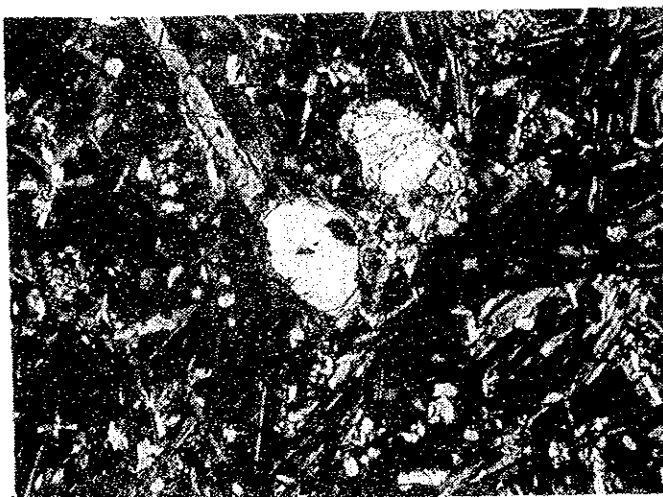
Chief consisting minerals are quartz, potassium feldspar,
plagioclase, biotite and muscovite. Mica is partly replaced by
chlorite and montmorillonite.

Locality:

Ngao river (about 3 km
upstream of junction of Yuan
river and Ngao river)

Rock name:

Basalt



Petrographic description:

0 0.5 mm (crossed nicols)

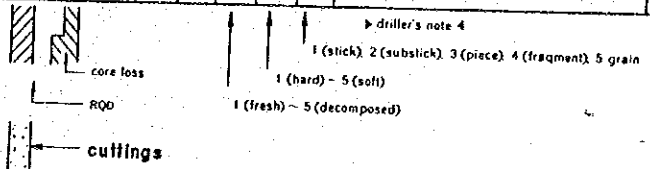
Phenocrysts are of olivine, plagioclase and clinopyroxene.
Microphenocrysts are of plagioclase, clinopyroxene and magnetite.

GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DL - 1 (SHEET 1 of 4)

LOCATION Dam left bank DEPTH OF HOLE 80.0 m COMMENCED Apr. 13 - 1983
 ELEVATION 186.6 m DEPTH OF OVERBURDEN 10.0 m COMPLETED Apr. 21 - 1983
 COORDINATE 1966 2869N 375 168.2E LENGTH OF ROCK DRILLING 70.0 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90 ° TOTAL LENGTH OF CORE 19.34 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE --- CORE RECOVERY 27.6 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE				WATER TABLE	WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING					
0.5			0 → 100 %									186.6 m	
1		△										1	
2		△										2	
3		△										3	
4		△										4	
5		△										5	
6		△										6	
7		△										7	
8		△										8	
9		△										9	
10		△										10	
11	Overburden											11	
12	Overburden											12	
13	Overburden											13	
14	Overburden											14	
15	Overburden											15	
16	Overburden											16	
17	Overburden											17	
18	Overburden											18	
19	Overburden											19	
20	Overburden											20	
21	Weathered Black shale (?)											21	
22	Weathered Black shale (?)											22	
23	Weathered Black shale (?)											23	
24	Weathered Black shale (?)											24	
25	Weathered Black shale (?)											25	
26	Weathered Black shale (?)											26	
27	Weathered Black shale (?)											27	
28	Weathered Black shale (?)											28	
29	Weathered Black shale (?)											29	
30	Weathered Black shale (?)											30	
31	Black shale											31	
32	Black shale											32	
33	Black shale											33	
34	Black shale											34	
35	Black shale											35	
36	Black shale											36	
37	Black shale											37	
38	Black shale											38	
39	Black shale											39	
40	Black shale											40	



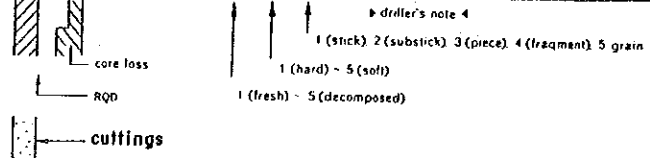
GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT

HOLE No. DL-1 (SHEET 2 OF 4)

LOCATION Dam left bank DEPTH OF HOLE 80.0 m COMMENCED Apr. 13 - 1983
 ELEVATION 186.6 m DEPTH OF OVERBURDEN 10.0 m COMPLETED Apr. 21 - 1983
 COORDINATE 1966 2869N 375 168.2E LENGTH OF ROCK DRILLING 70.0 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90° TOTAL LENGTH OF CORE 19.34 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE --- CORE RECOVERY 27.6 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT Casing	OBSERVATION OF CORE				DESCRIPTION	WATER TABLE	WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING						
20m			0 → 100 %											166.6
1	Black shale	60°			Black	2	2		Partially opened along calcite veins due to solution.					
2						3	(3)		22.1					
3						3	3~4		Generally weathered color (dark brown ~ reddish brown) along cracks and some of bedding planes.					
4		60°				2	3~4							
5	Shale				Dark grey	3	(4)		Partially gravelly cores. Small solution cavities along calcite veins.					
6						2	3							
7						3	2							
8						3	4		28.0					
9		55°				2	3		29.15					
30	(Black shale)				(Black)	3	2		29.15 - 70.0m					
1									Obtained only cuttings. All cuttings are black and non-calcareous.					
2														
3														
4														
5														
6														
7														
8														
9														
40														146.6



K = 1.65 x 10⁻⁴

Lu = 7.0

Lu = 7.6

DRILL WATER RETURN

WATER TABLE
WATER PRESSURE TEST
LEAKAGE OF DRILLING WATER

20% 50% 100%

20m 20m

166.6

1

2

3

4

5

6

7

8

9

30

1

2

3

4

5

6

7

8

9

40

146.6

1

2

3

4

5

6

7

8

9

40

146.6

GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DL-1 (SHEET 3 OF 4)

LOCATION Dam left bank DEPTH OF HOLE 80.0 m COMMENCED Apr - 13 - 1983

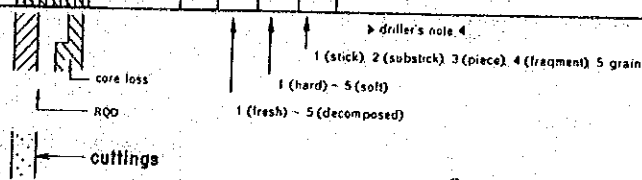
ELEVATION 186.6 m DEPTH OF OVERBURDEN 100 m COMPLETED Apr - 21 - 1983

COORDINATE 1966 286.9N 375 168.2E LENGTH OF ROCK DRILLING 70.0 m DRILLED BY ROEM

ANGLE FROM HORIZONTAL 90° TOTAL LENGTH OF CORE 19.34 m LOGGED BY M. Shibata

BEARING OF ANGLE HOLE — CORE RECOVERY 27.6%

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE					WATER TABLE	WATER PRESSURE TEST	DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION				
40m			0 → 100%										146.6
1									29.15 ^m - 70.0 m				
2									Obtained only cuttings.				
3									All cuttings are black				
4									and non-calcareous.				
5													
6													
7													
8													
9													
50													
1		(Black shale)											
2													
3													
4													
5													
6													
7													
8													
9													
60													126.6



$K = 1.10 \times 10^{-4}$
 $K = 1.72 \times 10^{-4}$
 $K = 1.98 \times 10^{-4}$
 $K = 7.23 \times 10^{-4}$

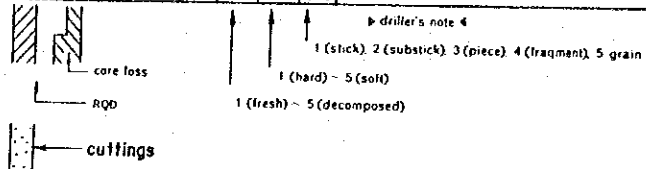
GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT

HOLE No. DL-1 (SHEET 4 of 4)

LOCATION Dam left bank DEPTH OF HOLE 80.0 m COMMENCED Apr. 13 - 1983
 ELEVATION 186.6 m DEPTH OF OVERBURDEN 10.0 m COMPLETED Apr. 21 - 1983
 COORDINATE 1966 286.9N 375 168.2E LENGTH OF ROCK DRILLING 70.0 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90 ° TOTAL LENGTH OF CORE 19.34 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE --- CORE RECOVERY 27.6 %

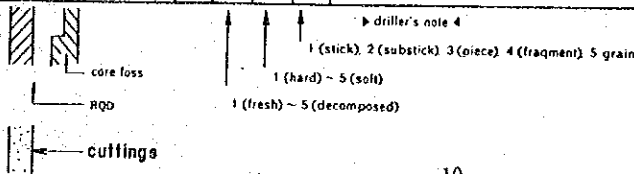
DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE				DESCRIPTION	WATER TABLE	WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING						
60m			0 + 100											
1	Black shale (Black shale)				Black (Black)	2	2 3	3 4	29.15 - 70.0 m	K = 7.55 x 10 ⁻⁴			1	126.6
2									Obtained only cuttings. All cuttings are black and non-calcareous.					
3														
4														
5														
6														
7														
8	Black shale				Black (Black)	2	2 3	3 4	70.0	K = 7.46 x 10 ⁻⁴			2	
9									Black shale, partially gravelly cores.					
10														
1	Black shale				Black (Black)	2	2 3	3 4	71.0 - 76.15 m	K = 6.43 x 10 ⁻⁴			3	
2									Obtained only cuttings. All cuttings are black and non-calcareous.					
3														
4														
5														
6														
7	Black shale				Black (Black)	2	2 3	3 4	77.0 - 79.0 m	Lu = 1.3			4	
8									Partially gravelly cores generally cores are broken into pices (less than 10 ^{cm}), Reconsolidated sheared zone at 78.7 - 79.0 m					
9														
10														



GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DL-2 (SHEET 1 of 3)
 LOCATION Dam left bank DEPTH OF HOLE 60.0 m COMMENCED May-1-1983
 ELEVATION 151.1 m DEPTH OF OVERBURDEN 3.2 m COMPLETED May-14-1983
 COORDINATE 1966 350.7N 375 194.1E LENGTH OF ROCK DRILLING 56.8 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90° TOTAL LENGTH OF CORE 53.8 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE _____ CORE RECOVERY 94.7%

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE				DESCRIPTION	WATER TABLE			DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING		WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DEPTH		
0m			0 → 100%							DRILL WATER RETURN		0m	151.1	
0-3.2	Overburden	△							Topsoil and talus deposits. (Some gravel and soil)					
3.2-5.8					Brown ~ brownish gray	4	3	4	Weathered black shale mostly flaky and brittle cores.					
5.8-12.7						3	3	3	Weathered along cracks and some of bedding planes, but most of cores are 15~20cm long.					
12.7-13.0						3	3	3	Clay seam at 12.7m					
13.0-13.5						3	3	3	Cracky and weathered at 12.3m - 13.0m					
13.5-20.0					Black, partially pale grey thin bands.	2	2	2	Generally fresh, partially weathered along cracks. Some small solution cavities along bedding planes (calcite veins along bedding planes)					

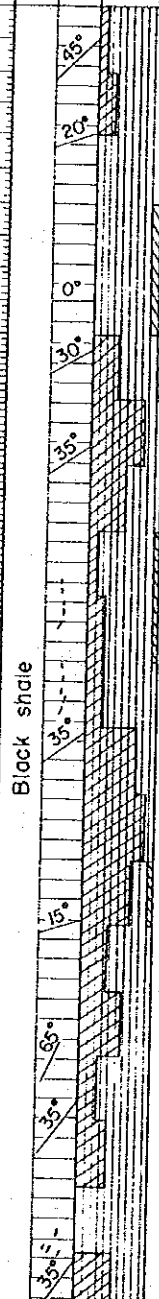


GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DL-2 (SHEET 2 OF 3)

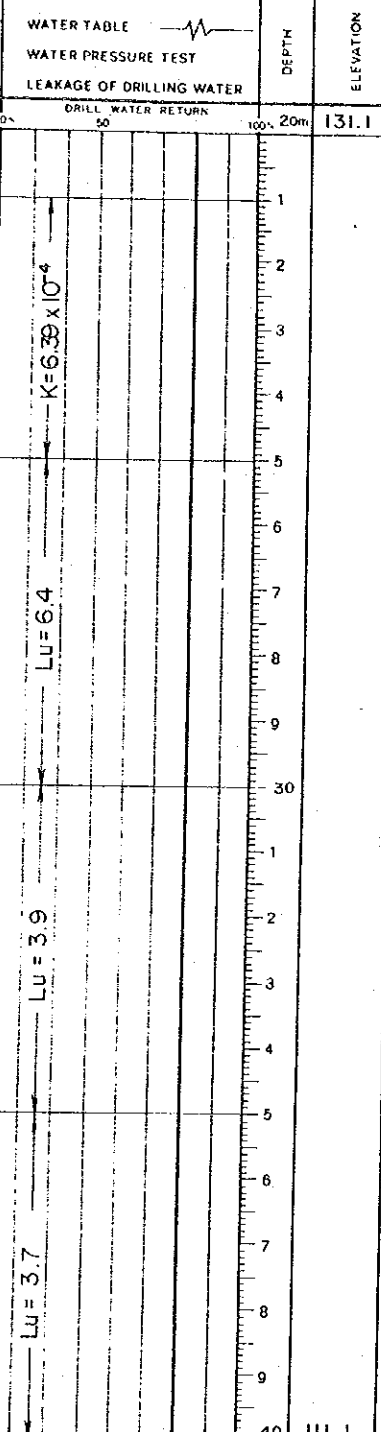
LOCATION Dam left bank DEPTH OF HOLE 60.0 m COMMENCED May - 1 - 1983
 ELEVATION 151.1 m DEPTH OF OVERBURDEN 3.2 m COMPLETED May - 14 - 1983
 COORDINATE 1966 350.7N 375 194.1E LENGTH OF ROCK DRILLING 56.8 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90 ° TOTAL LENGTH OF CORE 53.8 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE _____ CORE RECOVERY 94.7 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE			DESCRIPTION	WATER TABLE			DEPTH	ELEVATION	
					COLOR	WEATHERING	HARDNESS		WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DEPTH			ELEVATION
20m			0 → 100											
1		25°					3	Generally cracky and somewhat brittle.						
2		20°					3 3 (4)	Partially black shale changes into pale gray due to weathering.						
3							3 3							
4		0°					(4) (4) 4							
5		30°					25.2							
6		35°					3 3 3	Partially pale gray stripes in black shale.						
7							(2) (2) 2							
8							3 3 3	Some longitudinal cracks sustained by oxidation and solution. (with small cavities)						
9							(4)							
30							31.0							
1		35°					3 2	Generally somewhat cracky. All planes of cracks are sustained by oxidation.						
2							3 3							
3							2 3	Partially weathered (reddish brown) cracks.						
4		15°					3 4							
5							3 3							
6		65°					3 2	Black clayey material at 36.1m (dip=65°)						
7		35°					3 3							
8							(2)	Partially small solution cavities along calcite veins.						
9		35°												
40													151.1	



* driller's note 4
 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain
 1 (hard) - 5 (soft)
 1 (fresh) - 5 (decomposed)

core loss
 RQD
 cuttings



GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DL-2 (SHEET 3 of 3)

LOCATION Dam left bank DEPTH OF HOLE 60.0 m COMMENCED May - 1 - 1983

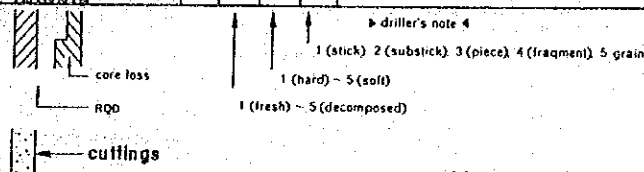
ELEVATION 151.1 m DEPTH OF OVERBURDEN 3.2 m COMPLETED May - 14 - 1983

COORDINATE 1966 350.7N 375 194.1E LENGTH OF ROCK DRILLING 56.8 m DRILLED BY ROEM

ANGLE FROM HORIZONTAL 90° TOTAL LENGTH OF CORE 53.8 m LOGGED BY M. Shibata

BEARING OF ANGLE HOLE _____ CORE RECOVERY 94.7 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE			DESCRIPTION	WATER TABLE	WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS						
40m			0 → 100										111.1
1		35°			3	3	3	Less weathering along cracks or bedding planes below 40.7 m					
2													
3					2	(2)	2	Partially cross joints with calcite veins.					
4					2		3	Slightly sheared					
5		30°					3	Partially gravelly cores, but less weathering.					
6							2	(2)					
7					(3)		3	4					
8		35°					3	3	Quartz veins at 48.5m, 48.8m. Slightly disturbed around quartz veins.				
9							2	(2)					
50													
1	Black shale	10°					3	3	Partially gravelly cores, but less weathering. (Rocks may be not loosened)				
2							3						
3							4						
4													
5		35°					3	2	Rather clear pale grey thin bands at 55.0m, 56.0m				
6							2	3					
7		35°					3						
8								4					
9	(Black shale ?)												
60													91.1

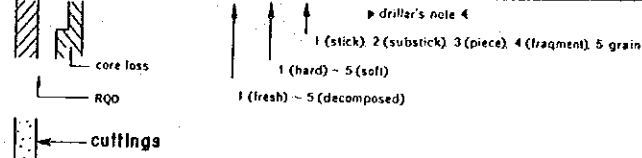


GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DL-3 (SHEET 1 OF 6)

LOCATION Dam left bank DEPTH OF HOLE 120.0 m COMMENCED May-18-1983
 ELEVATION 90.7 m DEPTH OF OVERBURDEN 0.35 m COMPLETED Jun-24-1983
 COORDINATE 1966 430.9N 375 229.3E LENGTH OF ROCK DRILLING 119.65 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90 ° TOTAL LENGTH OF CORE 58.9 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE _____ CORE RECOVERY 49.2 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE			DESCRIPTION	WATER TABLE			DEPTH	ELEVATION	
					COLOR	WEATHERING	HARDNESS		CORE CUTTING	WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER			DRILL WATER RETURN
0m		△	0 → 100 %					0.35 Topsoil, dark brown				0m	90.7 m	
1					Brownish grey ~ black	3	3	3	Weathered black shale. Cracky and weathered along cracks.				1	
2								Cuttings				2		
3								Partially solution cavities along calcite veins.				3		
4								4.6				4		
5								Bedding planes not so obvious. Sound shale but weathered along cracks.				5		
6												6		
7												7		
8					Black	3	3	3				8		
9								Sheared and black soft materials at 8.3 - 8.5m				9		
10								Sheared and black soft materials at 10.85 - 10.95m				10		
1								11.0 - 20.0m				1		
2								Cuttings.				2		
3								Cutting materials are mostly medium or coarse grained rock fragments of black shale.				3		
4								(No reaction with acid)				4		
5												5		
6												6		
7												7		
8												8		
9												9		
20												20	70.7	

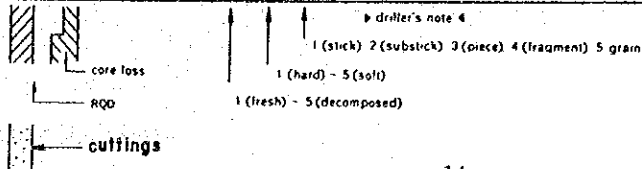


GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DL-3 (SHEET 2 OF 6)

LOCATION Dam left bank DEPTH OF HOLE 1200 m COMMENCED May - 18 - 1983
 ELEVATION 90.7 m DEPTH OF OVERBURDEN 0.35 m COMPLETED Jun - 24 - 1983
 COORDINATE 1966 430.9N 375 229.3E LENGTH OF ROCK DRILLING 119.65 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90 ° TOTAL LENGTH OF CORE 58.9 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE _____ CORE RECOVERY 49.2 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE				DESCRIPTION	WATER TABLE			DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING		WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER			
20m			0 - 100 %						20.0 - 22.35m				20m	70.7
1					(Black)				Cuttings				1	
2									22.35				2	
3					Black	2	2	3	Weathered cracks. Somewhat brittle, bedding planes are not so clear.				3	
4									23.7				4	
5					Black	2	3	4	Black gravelish cores slightly weathered along cracks.				5	
6									Black cuttings.				6	
7					(Black)								7	
8													8	
9						2-3	3	4	Small gravelly cores some cores with weathered colour.				9	
30					(Black)								30	
1	Black shale												1	
2					Blk.	2	3	4	With some quartz veins				2	
3									gravelly cores of black shale.				3	
4					Blk.	2	3	4	Minor foldings observable.				4	
5									33.7 - 40.0m				5	
6									Black shale cuttings.				6	
7					(Black)								7	
8													8	
9													9	
40													40	50.7

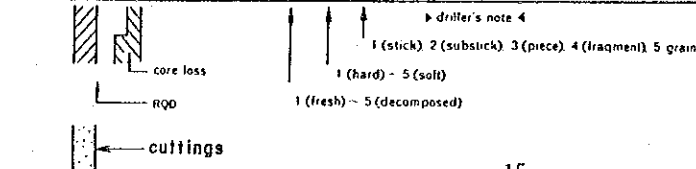


GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DL-3 (SHEET 3 of 6)

LOCATION Dam left bank DEPTH OF HOLE 120.0 m COMMENCED May-18-1983
 ELEVATION 90.7 m DEPTH OF OVERBURDEN 0.35 m COMPLETED Jun-24-1983
 COORDINATE 1966 430.9N 375 229.3E LENGTH OF ROCK DRILLING 119.65 m DRILLED BY RO EM
 ANGLE FROM HORIZONTAL 90 ° TOTAL LENGTH OF CORE 58.9 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE _____ CORE RECOVERY 49.2 %

DEPTH	ROCK NAME	L.O.G.	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE				DESCRIPTION	WATER TABLE			DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING		WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DRILL WATER RETURN		
40m			0 ~ 100 %										40m	50.7
1													1	
2													2	
3					Black	2	3	4	42.7	Minor folding with thin quartz veins.			3	
4									Partially weathered planes at cracks				4	
5													5	
6									Black shale cuttings from 43.4 to 60.0m				6	
7													7	
8									Cuttings are mostly medium or coarse				8	
9									Grained black-shale particles.				9	
50													50	
1									Very slightly including of whitish quartz grains.				1	
2													2	
3													3	
4													4	
5													5	
6													6	
7													7	
8													8	
9													9	
60													60	30.7



GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DL-3 (SHEET 4 OF 6)

LOCATION Dam left bank DEPTH OF HOLE 120.0 m COMMENCED May - 18 - 1983

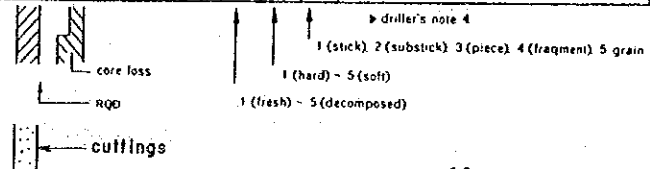
ELEVATION 90.7 m DEPTH OF OVERBURDEN 0.35 m COMPLETED Jun - 24 - 1983

COORDINATE 1966 4309N 375 229.3E LENGTH OF ROCK DRILLING 119.65 m DRILLED BY ROEM

ANGLE FROM HORIZONTAL 90° TOTAL LENGTH OF CORE 58.9 m LOGGED BY M. Shibata

BEARING OF ANGLE HOLE _____ CORE RECOVERY 49.2 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE					WATER TABLE	WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION					
60m			0 → 100											30.7
1					Black (Black)				Cuttings					
2					Black (Black)	2 3	3	4	Black shale, slightly weathered along cracks. Only gravelly cores.					
3					Black (Black)				Cuttings					
4					Black and white	2 3	1 3	3 4	Very hard quartz veins and gravelly black shale.					
5					Black and white	2 3	1 3	3 4	Cuttings					
6					Black (Black)				Cuttings					
7					Black (Black)				67.5					
8					Black (Black)	2 3	3	4 3	Generally gravelly cores. Minor folding with thin quartz veins.					
9					Black (Black)				Cuttings					
10					Black (Black)	2 3	3	4 3	Partially weathered along cracks.					
11					Black (Black)	2 3	3	4 3	Cuttings					
12					Black and white	2 3	3	4 3	Cuttings					
13					Black and white	2 3	3	4 3	Somewhat long cores are recovered.					
14					Black and white	2 3	3	4 3	Cuttings					
15					Black and white	2 3	3	4 3	Cuttings Mostly gravelly cores.					
16					Black and white	2 3	3	4 3	Cuttings					
17					Black and white	2 3	3	4 3	Calc shale, bedding planes are not so clear. Partially flaky.					
18					Black and white	2 3	3	4 3	Sheared at 77.95 ~ 78.3m					
19					Black and white	2 3	3	4 3	Somewhat whitish (whitish means rather calcareous)					
20					Black and white	2 3	3	4 3						

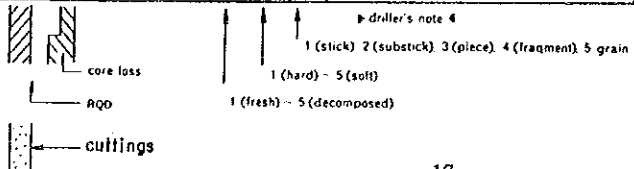


GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DL-3 (SHEET 5 of 6)

LOCATION Dam left bank DEPTH OF HOLE 120.0 m COMMENCED May - 18 - 1983
 ELEVATION 90.7 m DEPTH OF OVERBURDEN 0.35 m COMPLETED Jun - 24 - 1983
 COORDINATE 9664309N 3752293E LENGTH OF ROCK DRILLING 119.65 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90° TOTAL LENGTH OF CORE 58.9 m LOGGED BY M. Shlbata
 BEARING OF ANGLE HOLE _____ CORE RECOVERY 49.2 %

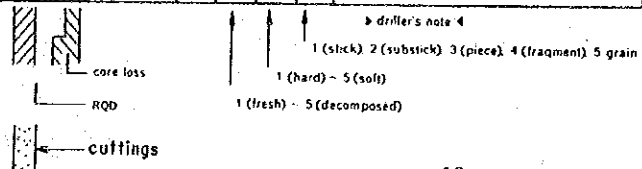
DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE			DESCRIPTION	WATER TABLE		DEPTH	ELEVATION		
					COLOR	WEATHERING	HARDNESS		CORE CUTTING	WATER PRESSURE TEST			LEAKAGE OF DRILLING WATER	
80m			0 - 100%								80m	10.7 m		
1	Calcareous shale	30°	2	Whity greenish grey	2	3	2	Partially slightly sheared and slightly flaky.	20%	50	100%	80m	10.7 m	
2						5	3							
3						2	(3)							
4														
5						3	2							Rock color gradually change rather pale greenish.
6						5	3							The more greenish the less calcareous.
7						2	(3)							
8						3	3							Generally sheared partially clayey.
9						(4)	(4)							
90						4	4							Sheared part
1	Calcareous shale	30°	2	Pale greyish light green	2	3	3	Most of cores are broken into small pieces.	20%	50	100%	80m	10.7 m	
2						(4)	3							
3						4	4							Sheared part
4						(4)	(3)							
5						3	3							Sheared at 94.5 m
6						(4)	(3)							Pale greenish clay at 95.6 m
7						3	3							Somewhat sheared at 96.9 - 97.4 m
8						3	2							
9						4	3							
100														



GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DL-3 (SHEET 6 of 6)
 LOCATION Dam left bank DEPTH OF HOLE 120.0 m COMMENCED May-18-1983
 ELEVATION 90.7 m DEPTH OF OVERBURDEN 0.35 m COMPLETED Jun-24-1983
 COORDINATE 1966 4309N 375 229.3E LENGTH OF ROCK DRILLING 119.65 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90° TOTAL LENGTH OF CORE 58.9 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE _____ CORE RECOVERY 49.2%

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE			DESCRIPTION	WATER TABLE		DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS		CORE CUTTING	WATER PRESSURE TEST		
100m			0-100%						20%	50	100m	-10.7
1	Calcareous shale	20°			Greyish pale - green	N	3	3	Sheared at 101.2 ~ 101.4 m	Lu = 1.5		
2							3	3				
3							2	2				
4							4-5	4-5				
5							4-3	4	Core loss at 104.3-104.7m	Lu = 2.2		
6					Greyish pale - green		3	3	Generally somewhat flaky:			
7							4	3	Reconsolidated sheared zone	Lu = 0.4		
8							3	4	Flaky cores.			
9							4	3		Lu = 0.8		
10					Whity greenish grey		2	2	Somewhat whitish and slightly massive clay seam at 111.4 m			
11							3	(3)		Lu = 0.4		
12							3	3	Clay seam at 111.7 m and 111.9 m			
13	Calcareous shale	20°			Greyish pale - green	2	2	3	Generally fresh slightly exfoliative along bedding planes.	Lu = 0.8		
14							3	2				
15							2	2	Clay seam at 114.7 m	Lu = 0.8		
16							3	(3)	Somewhat clayey at 116.0 m			
17							3-2	3		Lu = 0.8		
18							2	2				
19							3	3		Lu = 0.8		
20							3	3				



GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DL-4 (SHEET 1 of 4)

LOCATION Dam left bank DEPTH OF HOLE 80.0 m COMMENCED Jul. 23 1983

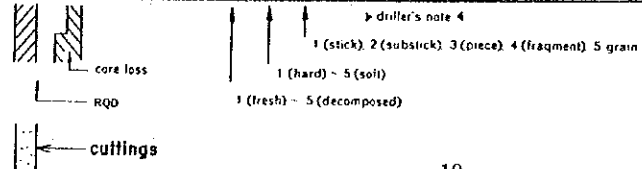
ELEVATION 191.4 m DEPTH OF OVERBURDEN 1.5 m COMPLETED Aug. 22 1983

COORDINATE 1965 774.5N 375 425.7E LENGTH OF ROCK DRILLING 78.5 m DRILLED BY ROEM

ANGLE FROM HORIZONTAL 90 ° TOTAL LENGTH OF CORE 77.0 m LOGGED BY M. Shibata

BEARING OF ANGLE HOLE _____ CORE RECOVERY 98.1 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE			WATER TABLE	WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS					
0m			0 - 100%								0m	191.4 m
0-1.5	Overburden	△			(Reddish brown)							
1.5-3.0	Limestone				Dark grey (Reddish brown at planes of cracks)	2	1	3	Lu = 0.2			
3.0-5.5												
5.5-10.0	Limestone				Dark grey (Reddish brown at planes of cracks)	5	5	2	Lu = 0.1			
10.0-10.4												
10.4-10.8	Limestone				Dark grey (Reddish brown at planes of cracks)	3	2	95	Lu = 0.3			
10.8-11.2												
11.2-11.3	Limestone				Dark grey with white veins	2	2	2	Lu = 0.3			
11.3-11.4												
11.4-12.0	Limestone				Dark grey with white veins	2	3	2	Lu = 0.3			
12.0-16.0												
16.0-16.8	Limestone				Dark grey with white veins	3	3	16.0	Lu = 0.3			
16.8-17.0												
17.0-18.5	Sandy limestone				Dark grey with white veins	2	3	3	Lu = 0.3			
18.5-18.6												
18.6-19.3	Sandy limestone				Dark grey with white veins	2	3	3	Lu = 0.3			
19.3-20.0												
20.0											20m	171.4 m



GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DL-4 (SHEET 2 of 4)

LOCATION Dam left bank DEPTH OF HOLE 80.0 m COMMENCED Jul. - 23 - 1983

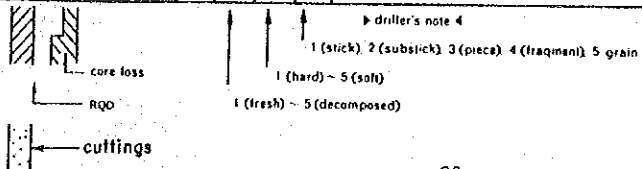
ELEVATION 191.4 m DEPTH OF OVERBURDEN 1.5 m COMPLETED Aug - 22 - 1983

COORDINATE 1965 774.5N 375 425.7E LENGTH OF ROCK DRILLING 78.5 m DRILLED BY ROEM

ANGLE FROM HORIZONTAL 90 ° TOTAL LENGTH OF CORE 77.0 m LOGGED BY M. Shibata

BEARING OF ANGLE HOLE _____ CORE RECOVERY 98.1 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE				DESCRIPTION	WATER TABLE			DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING		WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER			
20m			0 → 100%											171.4 m
1	Sandy limestone				Dark grey partially reddish brown	3	2	2	Slightly soluble along most of cracks.					
2						3	3	3	Slightly disturbed and brittle at 21.5 m					
3	Limestone				Light brown	3	3	3	23.0					
4						3	3	3	Slightly brecciated and reconsolidated limestone, partially cracky and brittle.					
5	Calcareous breccia				Light brownish	3	3	3	25.1					
6						3	3	3	Somewhat weathered breccia (inclusions of sandy and shaly breccias). Partially small solution cavities. Slightly brittle as a whole.					
7						(4)	(4)	(4)	28.1					
8	Calcareous shale with sandy part				Light yellowish ~ greenish grey	3	3	3	2	Calcareous shale with sandy part.				
9						3	3	3	3	Somewhat calcareous as a whole.				
30						3	3	3	5	Partially small solution cavities along bedding planes.				
1						3	3	3	2	Sheared and brownish clay at 32.5 m				
2						3	3	3	(2)	Partially flaky (at shaly part)				
3						3	3	3	(3)	Cracky and weathered along cracks.				
4						3	3	3	(4)	36.5				
5						3	3	3	2	Very slightly calcareous medium grained sandstone partially shaly in bands.				
6						3	3	3	3	Partially cracky.				
7						3	3	3	3					
8						3	3	3	3					
9						3	3	3	3					
40						3	3	3	3					151.4



GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DL-4 (SHEET 3 OF 4)

LOCATION Dam left bank DEPTH OF HOLE 80.0 m COMMENCED Jul. - 23 - 1983

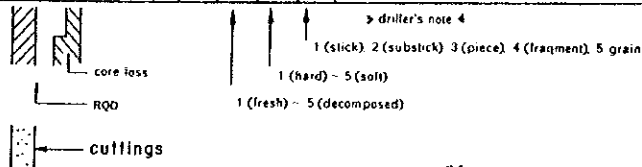
ELEVATION 191.4 m DEPTH OF OVERBURDEN 1.5 m COMPLETED Aug. - 22 - 1983

COORDINATE 1965 774.5N 375 425.7E LENGTH OF ROCK DRILLING 78.5 m DRILLED BY ROEM

ANGLE FROM HORIZONTAL 90 ° TOTAL LENGTH OF CORE 77.0 m LOGGED BY M. Shibata

BEARING OF ANGLE HOLE _____ CORE RECOVERY 98.1 %

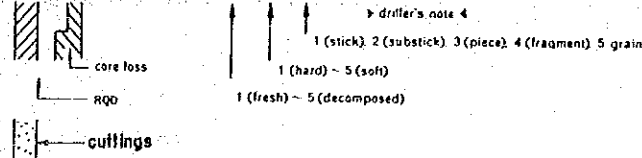
DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF CASING	OBSERVATION OF CORE				DESCRIPTION	WATER TABLE WATER PRESSURE TEST LEAKAGE OF DRILLING WATER	DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING				
40m			0 → 100 %								40m	151.4 m
1	Shaly Limestone	[Pattern]	[Pattern]	[Pattern]	Whity grey with pale greenish thin band	2	1	2	Gradually changes. Limestone banded with a few greenish shale.	[Graph]	[Scale]	[Scale]
2							2					
3							3					
4	Shaly Limestone	[Pattern]	[Pattern]	[Pattern]	Whity grey with pale greenish thin band	2	2	2	Partially rather massive. Slightly weathered along cracks.	[Graph]	[Scale]	[Scale]
5							5					
6							5					
7	Shaly Limestone	[Pattern]	[Pattern]	[Pattern]	Whity grey with pale greenish thin band	2	2	2	Small solution cavities at 46.9 ^m , 47.8 ^m	[Graph]	[Scale]	[Scale]
8							5					
9							1					
50	Calcareous sandstone	[Pattern]	[Pattern]	[Pattern]	Light grey	2	3	3	49.5 ^m Gradually changes slightly calcareous sandstone (fine grained) massive.	[Graph]	[Scale]	[Scale]
1							3					
2							3					
3	Limestone	[Pattern]	[Pattern]	[Pattern]	Grey	2	2	2	52.5 Gradually changes Limestone banded with calcareous shale.	[Graph]	[Scale]	[Scale]
4							2					
5							2					
6	Limestone	[Pattern]	[Pattern]	[Pattern]	Grey	2	(1)	3	Most of cores broken along their bands.	[Graph]	[Scale]	[Scale]
7							3					
8							3					
9	Limestone	[Pattern]	[Pattern]	[Pattern]	Grey	2	3	3	Some cracks with weathered color.	[Graph]	[Scale]	[Scale]
1							3					
2							3					
60											60	131.4



GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DL-4 (SHEET 4 of 4)
 LOCATION Dam left bank DEPTH OF HOLE 80.0 m COMMENCED Jul. - 23 - 1983
 ELEVATION 191.4 m DEPTH OF OVERBURDEN 1.5 m COMPLETED Aug. - 22 - 1983
 COORDINATE 1965 774.5N 375 425.7E LENGTH OF ROCK DRILLING 78.5 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90° TOTAL LENGTH OF CORE 77.0 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE _____ CORE RECOVERY 98.1 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE				DESCRIPTION	WATER TABLE			DEPTH	ELEVATION									
					COLOR	WEATHERING	HARDNESS	CORE CUTTING		WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER												
60m			0 → 100%							DRILL WATER RETURN			60m	131.4									
1	(Slightly shaly) Limestone				Grey, partially yellowish brown at cracks	2	2	2	Hard banded or shaly limestone with some weathered planes of cracks.	Lu=2.2													
2															A few solution small cavities in part.								
3																							
4																							
5																							
6																							
7																							
8																							
9																3	3	3	Some small solution cavities at 68.5m - 69.5m	Lu=1.7			
10																							
11																							
12																							
13																							
14																							
15																							
16																							
17																							
18	2	2	3	Banded limestone hard but partially weathered along cracks	Lu=2.0																		
19	(3)	1	2	72.2																			
20	3	3	3	Fault																			
21	3	2	3	Somewhat cracky due to faulting.																			
22	(3)	2	3	75.0																			
23	3	4-5	4-5	75.5 Fault.																			
24	3	3	3	Small fault at 76.2m (dip 50°)					Lu=2.5														
25	2	2	2	Weathered crack at 77.3m																			
26	(3)	(3)	(3)																				
27																							
28																							
29																							
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GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. S-1 (SHEET 1 of 3)

LOCATION Spillway DEPTH OF HOLE 43.5 m COMMENCED Mar. 24 - 1983

ELEVATION 126.2 m DEPTH OF OVERBURDEN 1.0 m COMPLETED Apr. 2 - 1983

COORDINATE 066 353N 375 014.2E LENGTH OF ROCK DRILLING 42.5 m DRILLED BY ROEM

ANGLE FROM HORIZONTAL 90 ° TOTAL LENGTH OF CORE 6.9 m LOGGED BY M. Shibata

BEARING OF ANGLE HOLE _____ CORE RECOVERY 19.2 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	COLOR	WEATHERING	HARDNESS	CORE CUTTING	OBSERVATION OF CORE		WATER TABLE	DEPTH	ELEVATION
									DESCRIPTION	WATER PRESSURE TEST			
0m	Top-soil	△	0 → 100 %		(Light brn)				1.0	Brown silt~clay (Maybe overburden)		0m	126.2
1										Cuttings (?)		1	
2										Materials are mixture of grey and yellowish brown particles.		2	
3												3	
4												4	
5												5	
6												6	
7												7	
8												8	
9												9	
10												10	
11												11	
12												12	
13												13	
14												14	
15												15	
16												16	
17												17	
18												18	
19												19	
20												20	106.2

Soft materials (Strongly weathered rocks?)

(Yellowish brown and grey)

(Brownish yellow)

$K = 3.48 \times 10^{-3}$

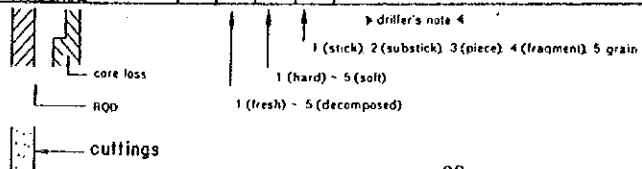
$K = 9.83 \times 10^{-3}$

$K = 6.24 \times 10^{-3}$

$K = 5.35 \times 10^{-3}$

$K = 4.04 \times 10^{-3}$

$K = 1.26 \times 10^{-3}$

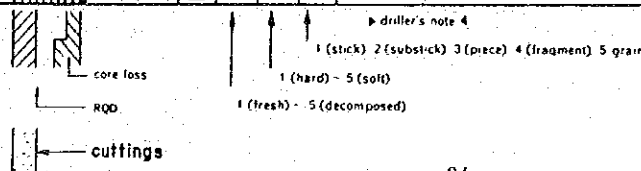


GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. S-1 (SHEET 2 OF 3)

LOCATION Spillway DEPTH OF HOLE 43.5 m COMMENCED Mar - 24 - 1983
 ELEVATION 126.2 m DEPTH OF OVERBURDEN 1.0 m COMPLETED Apr - 2 - 1983
 COORDINATE 1966 395.3N 375 04.2E LENGTH OF ROCK DRILLING 42.5 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90 ° TOTAL LENGTH OF CORE 6.9 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE _____ CORE RECOVERY 19.2 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE					WATER TABLE	WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION					
20m			0 ~ 100 %									20m	106.2 m	
1	Soft materials				(Brownish yellow)				22.0			1		
2									Black cuttings, non-calcareous			2		
3									Carbonized (?)			3		
4									Probably soft or brittle part of black shale rocks.			4		
5												5		
6												6		
7												7		
8												8		
9									Bedding planes are not so clear. Black shale, graphite rich. Some rock fragments and cuttings.			9		
30												30		
1									31.0			1		
2									Many thin calcite veins. Brittle in general.			2		
3												3		
4									Sheared and clayey at 32.7 ~ 33.5m			4		
5									Mostly gravelish cores.			5		
6												6		
7												7		
8												8		
9									35.5			9		
6									Black cuttings.			6		
7												7		
8												8		
9												9		
40									39.2			40	86.2	
									Sheared black clayey materials at 39.3 ~ 39.4m					



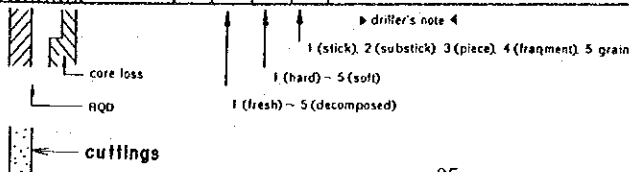
GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT

HOLE No. S-1 (SHEET 3 OF 3)

LOCATION Spillway DEPTH OF HOLE 43.5 m COMMENCED Mar. 24 - 1983
 ELEVATION 126.2 m DEPTH OF OVERBURDEN 1.0 m COMPLETED Apr. 2 - 1983
 COORDINATE 966 395.3N 375 014.2E LENGTH OF ROCK DRILLING 42.5 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90 ° TOTAL LENGTH OF CORE 6.9 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE --- CORE RECOVERY 19.2 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE			DESCRIPTION	WATER TABLE			DEPTH	ELEVATION			
					COLOR	WEATHERING	HARDNESS		WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DEPTH			ELEVATION		
40m	Black shale		0 → 100 %		Black	N	3	4	Generally brittle. Partially calcite veins.	20%	50	100%	40m	86.2 m		
1								3							5	(3)
2								4-5							4-5	5
2							4	Sheared black clayey materials at 41.3 - 41.4m								
3							3	Black clayey materials at bottom of hole. Bottom of hole at 43.5m						82.7		
4																
5																
6																
7																
8																
9																
0																

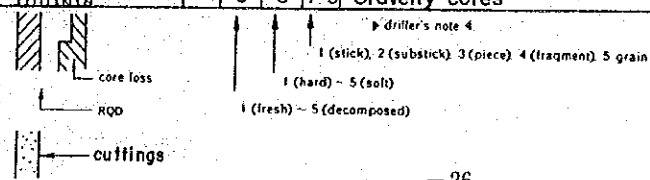


GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. I-1 (SHEET 1 OF 2)

LOCATION Intake DEPTH OF HOLE 40.0 m COMMENCED May-18-1983
 ELEVATION 143.6 m DEPTH OF OVERBURDEN 4.0 m COMPLETED Jul-27-1983
 COORDINATE 9665162N 375 4836E LENGTH OF ROCK DRILLING 36.0 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90° TOTAL LENGTH OF CORE 13.4 m LOGGED BY M. Shlbata
 BEARING OF ANGLE HOLE _____ CORE RECOVERY 31.5%

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE				DESCRIPTION	WATER TABLE	WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING						
0m			0 → 100%										0m	143.6 m
0 - 4.0	Overburden	△			(Brown)				Overburden from 0 to 4.0m				1	
4.0 - 8.0	Black shale (Weathered black shale?)	△			(Grey ~ brownish grey)				Brown lateritic soil.				2	
8.0 - 8.5	Black shale (Weathered black shale?)	△			(Brownish grey)				4.0				3	
8.5 - 9.5	Black shale (Weathered black shale?)	△			(Brownish grey)				Brownish grey Cuttings (Non-calcareous)				4	
9.5 - 10.0	Black shale (Weathered black shale?)	△			(Brownish grey)				8.0				5	
10.0 - 11.0	Black shale (Weathered black shale?)	△			(Brownish grey)				Weathered black shale Fault breccia at 8.3m-8.5m Dip of fault=60° (Thickness 5~6cm) Generally cracky				6	
11.0 - 12.0	Black shale (Weathered black shale?)	△			(Brownish grey)				Core loss				7	
12.0 - 13.4	Black shale (Weathered black shale?)	△			(Brownish grey)				9.5				8	
13.4 - 14.0	Black shale (Weathered black shale?)	△			(Brownish grey)				10.0				9	
14.0 - 15.0	Black shale (Weathered black shale?)	△			(Brownish grey)				Brownish grey Cuttings (as same as at 4.0m-8.0m) (Non-calcareous)				10	
15.0 - 16.0	Black shale (Weathered black shale?)	△			(Brownish grey)				15.0				11	
16.0 - 17.0	Black shale (Weathered black shale?)	△			(Brownish grey)				Gravelly cores				12	
17.0 - 18.0	Black shale (Weathered black shale?)	△			(Brownish grey)				Brownish grey cuttings (Non-calcareous)				13	
18.0 - 19.65	Black shale (Weathered black shale?)	△			(Brownish grey)				16.0				14	
19.65 - 20.0	Black shale (Weathered black shale?)	△			(Brownish grey)				Gravelly cores				15	
20.0									19.65				16	

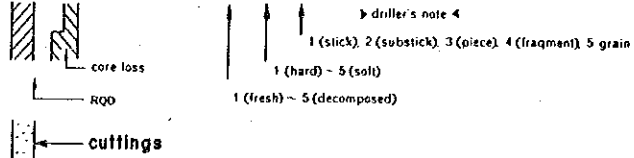


GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. I-1 (SHEET 2 OF 2)

LOCATION Intake DEPTH OF HOLE 40.0 m COMMENCED May-18-1983
 ELEVATION 143.6 m DEPTH OF OVERBURDEN 4.0 m COMPLETED Jul.-27-1983
 COORDINATE 1966516.2N 375483.6E LENGTH OF ROCK DRILLING 36.0 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90° TOTAL LENGTH OF CORE 13.4 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE _____ CORE RECOVERY 31.5%

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE					WATER TABLE	WATER PRESSURE TEST	DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION				
20m			0 → 100%										123.6
1	(Black shale?)				Light grey	3	3	4	20.0 Cuttings				
2	(Black shale?)				Light grey	3	3	4	21.15 Gravelly cores of weathered black shale				
3	(Black shale?)				(Black)				Black cuttings				
4	(Black shale?)				(Black)				24.0 Weathered black shale. Partially and slightly brittle.				
5	Black shale				Brownish grey	3	3	3	Weathered along some bedding planes and cracks.				
6	Black shale				Brownish grey	3	3	3	27.4 Black cuttings				
7	Black shale				(Black)				Black shale weathered along cracks and some bedding planes.				
8	Black shale				(Black)				Cores are generally broken into small pieces.				
9	Black shale				(Black)				Partially minorfolding. (With quartz veins)				
30	Black shale				Grey ~ black, Partially brown (along cracks)	3	3	3	Generally somewhat cracky rocks.				
1	Black shale				Grey ~ black, Partially brown (along cracks)	3	3	3	Small solution cavities along calcite veins at 37.4m ~ 37.5m				
2	Black shale				Grey ~ black, Partially brown (along cracks)	3	3	3					
3	Black shale				Grey ~ black, Partially brown (along cracks)	3	3	3					
4	Black shale				Grey ~ black, Partially brown (along cracks)	3	3	3					
5	Black shale				Grey ~ black, Partially brown (along cracks)	3	3	3					
6	Black shale				Grey ~ black, Partially brown (along cracks)	3	3	3					
7	Black shale				Grey ~ black, Partially brown (along cracks)	3	3	3					
8	Black shale				Grey ~ black, Partially brown (along cracks)	3	3	3					
9	Black shale				Grey ~ black, Partially brown (along cracks)	3	3	3					
40													103.6

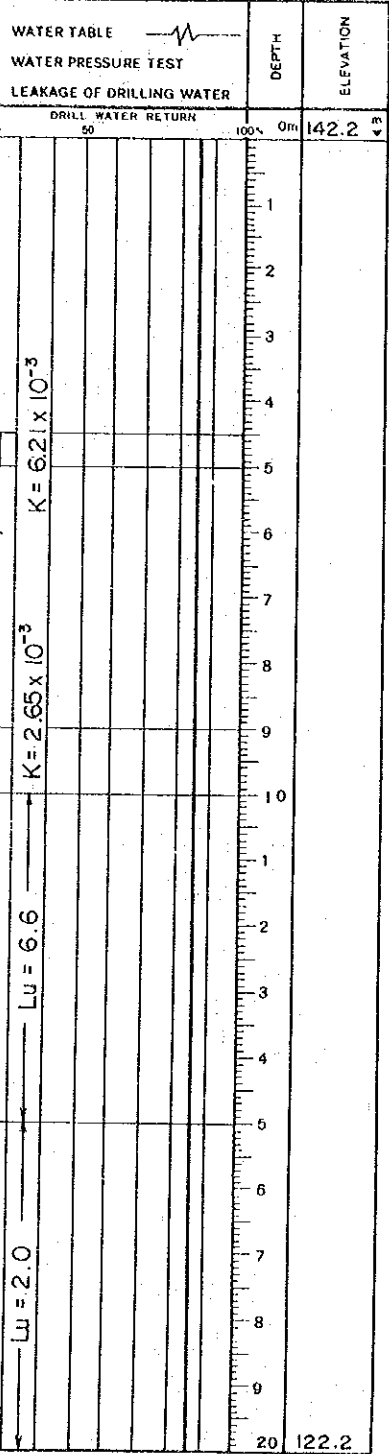
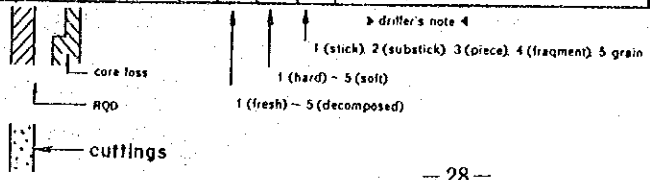


GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DR-1 (SHEET 1 OF 3)

LOCATION Dam right bank DEPTH OF HOLE 60.0 m COMMENCED Aug-18-1983
 ELEVATION 142.2 m DEPTH OF OVERBURDEN 6.0 m COMPLETED Sep-1-1983
 COORDINATE 966551.8N 375447.3E LENGTH OF ROCK DRILLING 54.0 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90° TOTAL LENGTH OF CORE 34.8 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE _____ CORE RECOVERY 64.4 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE				DESCRIPTION	WATER TABLE			DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING		WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DEPTH		
0.0			0 → 100%							DRILL WATER RETURN	20%	100%	0m	142.2
0.0 - 6.0	Overburden	△							Reddish brown laterite soil 1.0 Yellowish brown soil.					
6.0 - 10.0	Weathered shale	△			Brownish grey	3	3	3	6.0 Black shale? Rock color is changed to brownish grey due to weathering. Generally gravelly cores.					
10.0 - 19.5	Black shale	△			Black, partially brown	3	3	3	Somewhat weathered as a whole. Generally cores broken along bedding planes.					
19.5 - 20.5	Black shale	△			Black, partially brown	3-4	3	3	6.5 Partially weathered along bedding planes. Most of cores are less than 10cm long. Longitudinal crack with red plane at 19.5-20.5m					

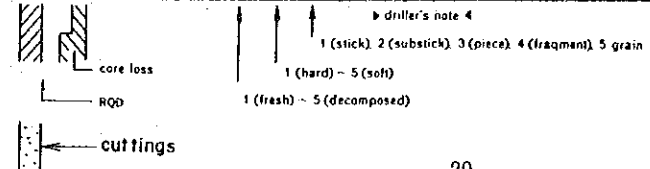


GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DR-1 (SHEET 2 OF 3)

LOCATION Dam right bank DEPTH OF HOLE 60.0 m COMMENCED Aug-18-1983
 ELEVATION 142.2 m DEPTH OF OVERBURDEN 6.0 m COMPLETED Sep-1-1983
 COORDINATE 1966551.8N 375447.3E LENGTH OF ROCK DRILLING 54.0 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90° TOTAL LENGTH OF CORE 34.8 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE _____ CORE RECOVERY 64.4 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE				DESCRIPTION	WATER TABLE			DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING		WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DRILL WATER RETURN		
20m			0 → 100%											122.2
1				(Dark grey)	Black	3-2	2-3	3-4	Sheared at 20.6 - 20.8m					
2								Cuttings	Somewhat weathered, generally cracky.					
3					Brimish Dark grey	3	2-3	3	Cuttings					
4				(Dark grey)		3	2-3	3	Cuttings					
5						3	3	3-4	24.8					
6						2	2	3	Slightly weathered along bedding planes.					
7						3	3	(2)	Partially flaky.					
8						3	3	3						
9								4	28.9					
30						3	3	4	Cuttings	Generally brittle.				
1						3	3	4	31.0					
2					Black	3	3	3	Some cracks reddish at its planes.					
3						3	3	3	Graphite rich at 32.5m-32.7m					
4						2	2	(4)	Cores generally broken into small pices.					
5									35.2					
6									35.8	Cuttings				
7						3		3	Slightly weathered along some cracks.					
8						3	3	3	Generally brittle					
9						2		(4)	Minorfolding at part, B.P not clear.					
40														102.2

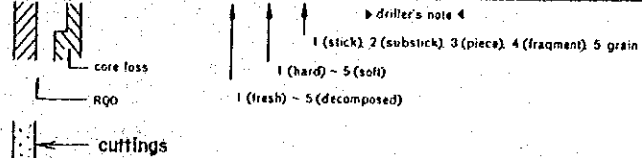


GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DR-1 (SHEET 3 OF 3)

LOCATION Dam right bank DEPTH OF HOLE 60.0 m COMMENCED Aug-18-1983
 ELEVATION 142.2 m DEPTH OF OVERBURDEN 6.0 m COMPLETED Sep-1-1983
 COORDINATE 966 551.8N 375 447.3E LENGTH OF ROCK DRILLING 54.0 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90° TOTAL LENGTH OF CORE 34.8 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE _____ CORE RECOVERY 64.4 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BITTING CASING	OBSERVATION OF CORE				DESCRIPTION	WATER TABLE		DEPTH	ELEVATION					
					COLOR	WEATHERING	HARDNESS	CORE CUTTING		WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER							
40m			0 → 100							DRILL WATER RETURN			102.2					
1	Black shale	30°	0 → 100						Most of cores are gravelly. B.P not clear.	Lu = 1.3	20%	100%	40m					
2														3	3	4	60%	
3														2	3	44.0		
4																Cuttings		
5																45.6		
6																Minorfolding at 46.5m cores generally broken into small pices.		GL 45.3
7														3	3	3		
8																Cuttings		
9														3	3	3		
50																Cuttings		
1			Cuttings															
2				Lu = 0.4														
3																		
4			Black shaly part with calcifeveins.															
5	3	3	4															
6			54.9															
7			Somewhat shaly limestone, rather massive.															
8			58.3															
9			Black shaly part at 58.3 - 58.5m															
60			(Very slightly sheared)															

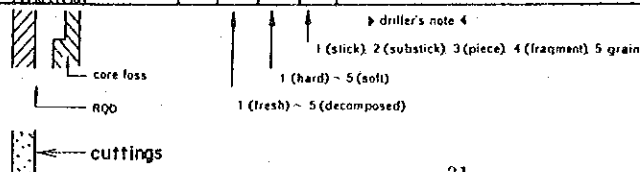


GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DR-2 (SHEET 1 OF 4)

LOCATION Dam right bank DEPTH OF HOLE 80.0 m COMMENCED Sep - 10 - 1983
 ELEVATION 103.9 m DEPTH OF OVERBURDEN 2.0 m COMPLETED Oct. - 14 - 1983
 COORDINATE 1966 502.2N 375 412.9E LENGTH OF ROCK DRILLING 78.0 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90° TOTAL LENGTH OF CORE 52.95 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE _____ CORE RECOVERY 67.9 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE					WATER TABLE	WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION					
0m			0 → 100 %											103.9 m
0 - 1.0	Overburden	△			Dark grey, Yell. brn.				0 - 1.0 m Silt, sand, small gravels and rock fragments					
1.0 - 2.0		△			Dark grey, Yell. brn.				1.0 - 2.0 m Silt, sand, small rock fragments					
2.0 - 3.0					Dark grey, Yell. brn.				2.0 - 3.0 m Dark grey cuttings (non-calcareous)					
3.0 - 4.0					Dark grey, Yell. brn.				3.0 - 4.0 m Dark grey cuttings (non-calcareous)					
4.0 - 6.4	Black shale				Dark grey black	3	3	4	Black shale, weathered along cracks and some bedding planes generally cracks					
6.4 - 7.9					Black	3	2	3	Hard shale, some cracks are sustained by oxidation in reddish colour.					
7.9 - 21.90					(Black)			(4)	Obtained only cuttings. Black cuttings at 7.9m - 20.0m					
20														83.9



GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DR-2 (SHEET 2 OF 4)

LOCATION Dam right bank DEPTH OF HOLE 80.0 m COMMENCED Sep-10-1983

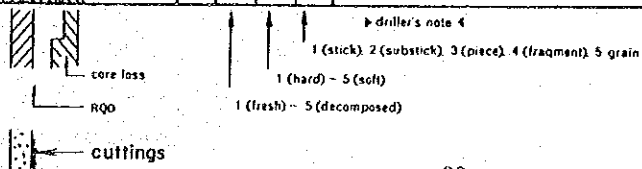
ELEVATION 103.9 m DEPTH OF OVERBURDEN 2.0 m COMPLETED Oct-14-1983

COORDINATE 1966 502.2N 35412.9E LENGTH OF ROCK DRILLING 78.0 m DRILLED BY ROEM

ANGLE FROM HORIZONTAL 90° TOTAL LENGTH OF CORE 52.95 m LOGGED BY M. Shibata

BEARING OF ANGLE HOLE _____ CORE RECOVERY 67.9 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE				DESCRIPTION	WATER TABLE	WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING						
20m			0 → 100											83.9
1	Calcareous (Calc. shale)				Whitish greenish (Pale green)				Pale green cuttings, (no reaction with acid)				1	
2									21.9				2	
3	Calcareous shale				Whitish greenish grey	2	2	2	Weakly schistose, bedding not so clear.				3	
4									24.0 - 24.5 m Core loss.				4	
5							3-2	3-4	Upper part is somewhat whitish.				5	
6					Whitish greenish grey			2	Whitish part is rather calcareous than greenish part.				6	
7						1		3					7	
8													8	
9					Whitish greenish grey		3-2	3-4	Slightly sheared around 28.5m somewhat brittle in part.				9	
30						2							30	
1	Calcareous shale								Rather greenish shale.				1	
2									Somewhat flaky due to shearing at 31.7m-32.4m				2	
3					Pale greenish grey				Generally slightly schistose				3	
4									Little weathered cracks or bedding planes.				4	
5													5	
6								3 (2)					6	
7													7	
8									Weathered crack at 37.2m				8	
9	Calcareous shale				(Greenish grey)				Cuttings at 38.2m-41.0m				9	
40													40	63.9



GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DR-2 (SHEET 3 of 4)

LOCATION Dam right bank DEPTH OF HOLE 80 m COMMENCED Sep-10-1983

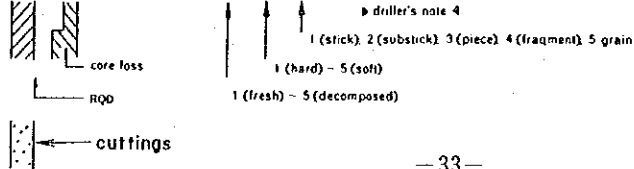
ELEVATION 103.9 m DEPTH OF OVERBURDEN 2.0 m COMPLETED Oct-14-1983

COORDINATE 9665022N 3754129E LENGTH OF ROCK DRILLING 78.0 m DRILLED BY ROEM

ANGLE FROM HORIZONTAL 90° TOTAL LENGTH OF CORE 52.95 m LOGGED BY M. Shibata

BEARING OF ANGLE HOLE _____ CORE RECOVERY 67.9 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE					WATER TABLE	WATER PRESSURE TEST	DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION				
4.0m			0-100									63.9	
1	Calc. shale				Pale greenish grey	2	3	3	Cuttings. 41.0				
2	Calc. shale				Pale greenish grey	2	3	3	Slightly flaky due to steep foliation.				
3					Pale greenish grey	2	3	3	42.7				
4	Calc. shale				Pale greenish grey	2	3	3	Cuttings (Reaction with acid)				
5	Calc. shale				Pale greenish grey	2	3	3	44.0				
6					Pale greenish grey	2	3	3	Somewhat brittle due to shearing.				
7					Pale greenish grey	2	3	3	45.0				
8	Calcareous shale				Pale greenish grey	2	3	3	Cuttings. (Reaction with acid)				
9					Pale greenish grey	2	3	3	46.0				
50	Calcareous shale				Pale greenish grey	2	3	3	Somewhat sheared as a whole.				
51					Pale greenish grey	2	3	3	47.0				
52					Pale greenish grey	2	3	3	Clayed at 49.4m				
53					Pale greenish grey	2	3	3	Clay seam along bedding plane at 50.5m				
54					Pale greenish grey	2	3	3	48.0				
55					Pale greenish grey	2	3	3	Somewhat more calcareous (whitish)				
56					Pale greenish grey	2	3	3	49.0				
57					Pale greenish grey	2	3	3	Cuttings (Reaction with acid)				
58					Pale greenish grey	2	3	3	50.0				
59					Pale greenish grey	2	3	3	Longitudinal crack with rough plane at 54.5m				
60					Pale greenish grey	2	3	3	51.0				
61					Pale greenish grey	2	3	3	Colcite veins are perpendicular to bedding planes.				
62					Pale greenish grey	2	3	3	52.0				
63					Pale greenish grey	2	3	3	53.0				
64					Pale greenish grey	2	3	3	54.0				
65					Pale greenish grey	2	3	3	55.0				
66					Pale greenish grey	2	3	3	56.0				
67					Pale greenish grey	2	3	3	57.0				
68					Pale greenish grey	2	3	3	58.0				
69					Pale greenish grey	2	3	3	59.0				
70					Pale greenish grey	2	3	3	60.0			43.9	



GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DR-2 (SHEET 4 of 4)

LOCATION Dam right bank DEPTH OF HOLE 80.0 m COMMENCED Sep-10-1983

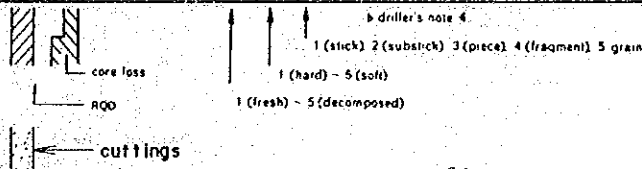
ELEVATION 103.9 m DEPTH OF OVERBURDEN 2.0 m COMPLETED Oct-14-1983

COORDINATE 966 5022N 375 412.9E LENGTH OF ROCK DRILLING 78.0 m DRILLED BY ROEM

ANGLE FROM HORIZONTAL 90° TOTAL LENGTH OF CORE 52.95 m LOGGED BY M. Shibata

BEARING OF ANGLE HOLE _____ CORE RECOVERY 67.9 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE					DESCRIPTION	WATER TABLE			DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING	WATER PRESSURE TEST		LEAKAGE OF DRILLING WATER	DEPTH	ELEVATION		
60m			0 → 100												43.9
1	Shaly Cdc. shale				Pale greenish grey	1	2	1		Partially sheared and slightly brittle.					
2	Shaly limestone				Pale grey	2	2	3		62.3					
3	Shaly limestone				Pale grey	1	2	2		Shaly limestone somewhat brittle due to shearing					
4					Pale greenish grey	2	3	4		63.4					
5					Pale greenish grey	3	3	3							
6					Pale greenish grey	4	4	3		Sheared and reconsolidated at 65.4 ~ 65.6 m					
7					Pale greenish grey	3	3	3		67.6					
8					Whity greenish grey	1	1	1		Somewhat whitish more calcareous shale. B.P is not so clear. Clay seam at 69.0m					
9					Whity greenish grey	5	5	5		Core recovery is good in general.					
10	Calcareous shale				Whity greenish grey	2	2	2		Weathering is very few.					
11					Whity greenish grey	2	2	2							
12					Whity greenish grey	2	2	2							
13					Whity greenish grey	2	2	2							
14					Whity greenish grey	2	2	2							
15					Whity greenish grey	2	2	2							
16					Whity greenish grey	2	2	2							
17					Whity greenish grey	2	2	2							
18					Whity greenish grey	2	2	2							
19					Whity greenish grey	2	2	2							
20					Whity greenish grey	2	2	2							
21					Whity greenish grey	2	2	2							
22					Whity greenish grey	2	2	2							
23					Whity greenish grey	2	2	2							
24					Whity greenish grey	2	2	2							
25					Whity greenish grey	2	2	2							
26					Whity greenish grey	2	2	2							
27					Whity greenish grey	2	2	2							
28					Whity greenish grey	2	2	2							
29					Whity greenish grey	2	2	2							
30					Whity greenish grey	2	2	2							
31					Whity greenish grey	2	2	2							
32					Whity greenish grey	2	2	2							
33					Whity greenish grey	2	2	2							
34					Whity greenish grey	2	2	2							
35					Whity greenish grey	2	2	2							
36					Whity greenish grey	2	2	2							
37					Whity greenish grey	2	2	2							
38					Whity greenish grey	2	2	2							
39					Whity greenish grey	2	2	2							
40					Whity greenish grey	2	2	2							
41					Whity greenish grey	2	2	2							
42					Whity greenish grey	2	2	2							
43					Whity greenish grey	2	2	2							
44					Whity greenish grey	2	2	2							
45					Whity greenish grey	2	2	2							
46					Whity greenish grey	2	2	2							
47					Whity greenish grey	2	2	2							
48					Whity greenish grey	2	2	2							
49					Whity greenish grey	2	2	2							
50					Whity greenish grey	2	2	2							
51					Whity greenish grey	2	2	2							
52					Whity greenish grey	2	2	2							
53					Whity greenish grey	2	2	2							
54					Whity greenish grey	2	2	2							
55					Whity greenish grey	2	2	2							
56					Whity greenish grey	2	2	2							
57					Whity greenish grey	2	2	2							
58					Whity greenish grey	2	2	2							
59					Whity greenish grey	2	2	2							
60					Whity greenish grey	2	2	2							

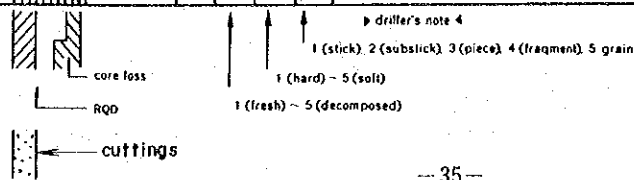


GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DU-1 (SHEET 1 of 2)

LOCATION Dam upstream DEPTH OF HOLE 22.0 m COMMENCED - -
 ELEVATION 74.5 m DEPTH OF OVERBURDEN 9.8 m COMPLETED - -
 COORDINATE 1966 424.9N 375 397.6E LENGTH OF ROCK DRILLING 12.2 m DRILLED BY - -
 ANGLE FROM HORIZONTAL 60° TOTAL LENGTH OF CORE 10.6 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE S59°W CORE RECOVERY 86.9 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF PIPING CASING	OBSERVATION OF CORE					WATER TABLE WATER PRESSURE TEST LEAKAGE OF DRILLING WATER	DEPTH	ELEVATION
					COLOR	WEATHER- ING	HARD- NESS	CORE CUTTING	DESCRIPTION			
0m			0-100%							20% 50% 100%	0m	74.5 m
0-1.5m	Sand and gravel (Riverbed Deposits)								0-1.5m Medium grained sand			
1.5-3.5m									1.5-3.5m Sand and gravels Sand; Medium grained Gravels; L=10~15cm sandstone			
3.5-4.7m									4.7-5.5m Gravels; hard L=3~10cm			
4.7-5.5m									5.5-6.8m Medium grained sand			
5.5-6.8m									6.8-8.8m Gravelly			
8.8-9.8m								9.8-10.6m Calcareous shale.				
10.6-14.2m	Calcareous shale								10.6-14.2m Partially recovered only cuttings. Slightly sheared in general, all cores are flaky.			
14.2-16.2m									14.2-16.2m Partially flaky, exfoliative along bedding plane. Somewhat schistose.			
16.2-18.2m									18.2-20.2m Only cutting is recovered			
18.2-20.2m									20.2-22.0m Partially flaky			
22.0m												20m



GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DU-1 (SHEET 2 OF 2)

LOCATION Dam upstream DEPTH OF HOLE 22.0 m COMMENCED _____

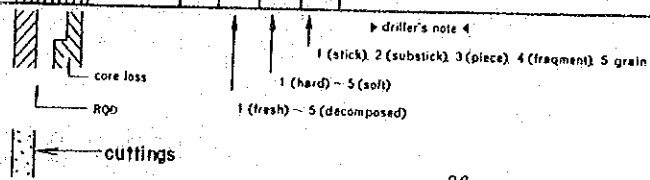
ELEVATION 74.5 m DEPTH OF OVERBURDEN 9.8 m COMPLETED _____

COORDINATE _____ LENGTH OF ROCK DRILLING 12.2 m DRILLED BY _____

ANGLE FROM HORIZONTAL 60 ° TOTAL LENGTH OF CORE 10.6 m LOGGED BY M. Shibata

BEARING OF ANGLE HOLE S59°W CORE RECOVERY 86.9 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE					DESCRIPTION	WATER TABLE			DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING	WATER PRESSURE TEST		LEAKAGE OF DRILLING WATER				
20m			0 → 100 %								DRILL WATER RETURN			20m	57.2 m
1	Calcareous shale	50	50		Pale greenish grey	2	3	3	3	Partially minorfolding with calcite veins					
2															
22m										End of hole at 22m					55.5
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															

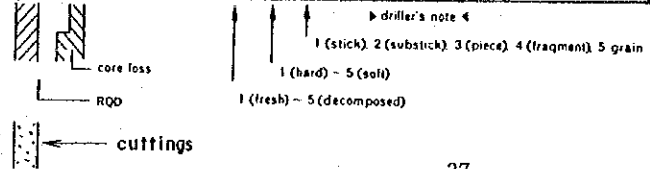


GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DU-2 (SHEET 1 of 6)

LOCATION Dam upstream DEPTH OF HOLE 120.0 m COMMENCED Sep - 3 - 1983
 ELEVATION 91.3 m DEPTH OF OVERBURDEN 6.0 m COMPLETED Oct. - 21 - 1983
 COORDINATE 1966 3333N 375 398.2E LENGTH OF ROCK DRILLING 114.0 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 60 ° TOTAL LENGTH OF CORE 79.9 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE N31°E CORE RECOVERY 70.1 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE				DESCRIPTION	WATER TABLE			DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING		WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER			
0m			0 → 100%									0m	91.3	
0 - 6.0	Overburden	△							Brown or yellowish brown silt ~ fine grained sand.					
6.0 - 9.0	Core loss								Core loss					
9.0 - 10.0	(Weathered) shale								Cuttings Some of cuttings are of overburden and some cuttings are black.					
10.0 - 15.5	Black shale								Black shale with thin quartz veins. Partially minor folding somewhat brittle.					
15.5 - 17.2	Black shale								Rather clear bedding at 15.5m - 17.2m Somewhat exfoliative in general.					
17.2 - 18.0	Black shale								Core loss					
18.0 - 31.5									Core loss from 18.0m to 31.5m (Casing drilling)					
31.5 - 120.0													74.0	



GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DU-2 (SHEET 2 of 6)

LOCATION Dam upstream DEPTH OF HOLE 120.0 m COMMENCED Sep - 3 - 1983

ELEVATION 91.3 m DEPTH OF OVERBURDEN 6.0 m COMPLETED Oct - 21 - 1983

COORDINATE E66 333.3N 375 38.2E LENGTH OF ROCK DRILLING 114.0 m DRILLED BY ROEM

ANGLE FROM HORIZONTAL 60° TOTAL LENGTH OF CORE 79.9 m LOGGED BY M. Shibata

BEARING OF ANGLE HOLE N 31° E CORE RECOVERY 70.1%

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE					DESCRIPTION	WATER TABLE			DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING	WATER PRESSURE TEST		LEAKAGE OF DRILLING WATER	DRILL WATER RETURN			
20m			0 → 100%										20m	74.0 m	
1										Casing drilling from 18.0 ^m - 31.5 ^m core loss			1		
2													2		
3										Lithologic boundary of black shale and calcareous shale exists between 8.0 ^m and 31.5 ^m			3		
4													4		
5													5		
6													6		
7													7		
8													8		
9													9		
30													30		
1													1		
2										31.5m			2		
3										Weathered calcareous shale. Mostly gravelly cores. 3425			3		
4										Very slightly schistose shale, somewhat exfoliative. (Very thin stripes)			4		
5													5		
6													6		
7													7		
8													8		
9													9		
40													40	56.7	

Calcareous shale

Pale yellowish grey

Pale greenish grey

Greenish part is less calcareous
Whitish or grey part is rather calcareous.

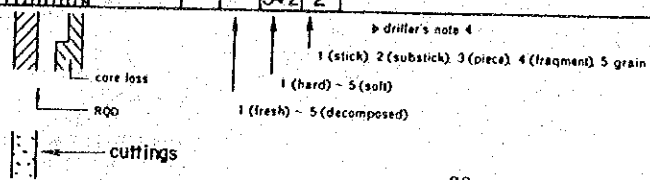
$K = 3.06 \times 10^{-3}$

$K = 2.49 \times 10^{-3}$

$K = 7.96 \times 10^{-4}$

$K = 2.18 \times 10^{-4}$

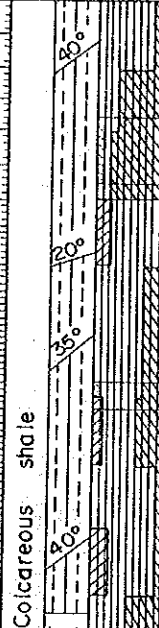
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GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DU-2 (SHEET 3 of 6)
 LOCATION Dam upstream DEPTH OF HOLE 120.0 m COMMENCED Sep - 3 - 1983
 ELEVATION 91.3 m DEPTH OF OVERBURDEN 6.0 m COMPLETED Oct. - 21 - 1983
 COORDINATE 966333.3N 375398.2E LENGTH OF ROCK DRILLING 114.0 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 60° TOTAL LENGTH OF CORE 79.9 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE N31E CORE RECOVERY 70.1%

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE					DESCRIPTION	WATER TABLE			DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING	WATER PRESSURE TEST		LEAKAGE OF DRILLING WATER	DRILL WATER RETURN			
40m			0 - 100%		Greenish grey	2	3	3	3	Flaky at 41.0 ^m - 41.5 ^m				39.4	
1					Greenish grey	2	3	3	3	Greenish grey cuttings					
2															
3					Pale greenish grey	2	3	3	3	Partially quartz veins slightly exfoliative as a whole					
4															
5															
6															
7					Pale greenish grey	2	3	3	3	45.8 ^m -46.2 ^m Cuttings					
8															
9					Pale greenish grey	2	3	3	3	Sheared clay at 49.5~49.7m					
50										49.7 Core loss } Brittle partially quartz veins					
1										50.2 Core loss					
2										51.05 Core loss					
3					Pale greenish grey	2	3	3	3	Partially weathered cracks or bedding planes					
4															
5					Pale greenish grey	3	2	2	(2)	Very hard quartz vein at 55.2 ^m -55.3 ^m					
6															
7															
8															
9															
60														22.1	

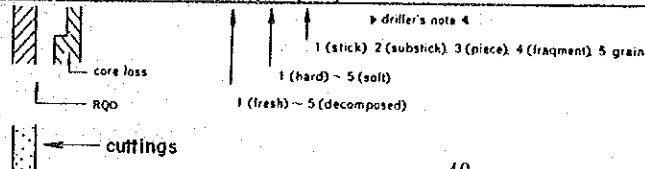


driller's note 4
 1 (stick) 2 (substick) 3 (piece) 4 (fragment) 5 grain
 1 (hard) - 5 (soft)
 1 (fresh) - 5 (decomposed)
 core loss
 RQP
 cuttings

GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DU-2 (SHEET 4 of 6)
 LOCATION Dam upstream DEPTH OF HOLE 120.0 m COMMENCED Sep. 3 - 1983
 ELEVATION 91.3 m DEPTH OF OVERBURDEN 6.0 m COMPLETED Oct. 21 - 1983
 COORDINATE 1966 333.3N 375 398.2E LENGTH OF ROCK DRILLING 114.0 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 60° TOTAL LENGTH OF CORE 79.9 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE N31E CORE RECOVERY 70.1 %

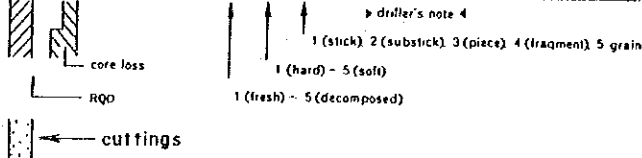
DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE				WATER TABLE	WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DEPTH	ELEVATION	
					COLOR	WEATHERING	HARDNESS	CORE CUTTING						DESCRIPTION
6.0m			0 → 100 %										22.1 m	
1	Calcareous shale				Pall greenish grey		3	3	Quartz veins at 60.6 ^m - 60.7 ^m and 61.55 - 61.65 ^m				1	
2				2				Somewhat brecciated in part and brittle.					2	
3				(4)	(4)									3
4									64.6m					4
5	Fault zone				Pale greenish grey		4	3	Fault zone with clay and breccia and sheared rocks. Generally brittle. (Sheared at shaly part)				5	
6				3	3			Not sheared at limestone					6	
7				2	3			67.6m					7	
8				4	3								8	
9	Very slightly weathered as a whole. Most of cracks somewhat weathered. Slightly banded and shaly.						2	2					9	
70													70	
1														1
2														2
3	Shaly limestone						3	3					3	
4													4	
5														5
6														6
7	Grey with thin grey, partially light yellowish grey						2	3	Sheared and brecciated at 73.4 - 73.5 m (reconsolidated) Weathered along cracks.				7	
8													8	
9														9
80														80
													4.8	



GEOLOGIC LOG OF DRILL HOLE

Nam. Yuam PROJECT HOLE No. DU-2 (SHEET 5 OF 6)
 LOCATION Dam upstream DEPTH OF HOLE 120.0 m COMMENCED Sep. 3 - 1983
 ELEVATION 91.3 m DEPTH OF OVERBURDEN 6.0 m COMPLETED Oct. 21 - 1983
 COORDINATE 1966 333.3N 375 398.2E LENGTH OF ROCK DRILLING 114.0 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 60° TOTAL LENGTH OF CORE 79.9 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE N31E CORE RECOVERY 70.1%

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE				DESCRIPTION	WATER TABLE			DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING		WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DRILL WATER RETURN		
80m			0 - 100%											4.8
1	Shaly limestone	[Log symbols]			Pate grey partially slightly yellowish	2	2	2	Generally cracky and weathered color along planes of cracks. (No solution phenomena) (Bedding planes not clear) Clay seam at 84.1m	Lu = 1.8				
2						1	(3)							
3						3	4							
4						2	3							
5	Shaly limestone	[Log symbols]			Grey	1	2	2	Fresh slightly shaly limestone. Partially slightly flaky along bands (One kind of sheared planes?) Generally massive. (Calcareous contents are rather high)	Lu = 2.3				
6						1	3							
7						1	3							
8	Shaly limestone	[Log symbols]			Yellowish grey	3	2	3	Weathered part somewhat shaly	Lu = 1.0				
9						2	3							
10	Shaly limestone	[Log symbols]			Dark grey	1	2	2	94.0 Shaly limestone ; (Difinition) Rather exfoliative along bedding planes, and rocks color is rather dark grey than the rocks called slightly shaly limestone. Partically somewhat exfoliative. (Calc. contents are rather high)	Lu = 0.6				
11						1	2							
12						1	2							
13						2	(3)							

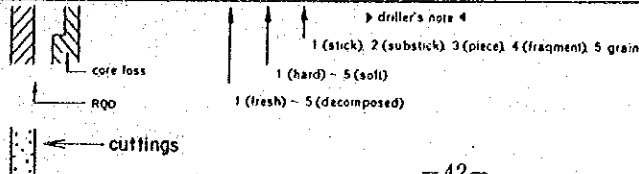


GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. DU-2 (SHEET 6 OF 6)

LOCATION Dam upstream DEPTH OF HOLE 120.0 m COMMENCED Sep - 3 - 1983
 ELEVATION 91.3 m DEPTH OF OVERBURDEN 6.0 m COMPLETED Oct - 21 - 1983
 COORDINATE 1966 333.3N 375 398.2E LENGTH OF ROCK DRILLING 114.0 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 60° TOTAL LENGTH OF CORE 79.9 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE N31E CORE RECOVERY 70.1 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE				DESCRIPTION	WATER TABLE		DEPTH	ELEVATION				
					COLOR	WEATHERING	HARDNESS	CORE CUTTING		WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER						
100m			0 → 100%										-12.5 m				
1	Shaly limestone	15°	100%	Dark grey	1	2	2	102.5m	Exfoliated along bedding planes (sliced cores)	Somewhat weathered at 104.0m ~ 105.0m Small solution cavities at 104.6m	LU = 1.2	1					
2					2	(3)	(3)					2					
3												3	1		3		
4												3	4		4		
5												(2)	3		5		
6												Dark grey	3	4	3	6	
7													2	3	7		
8															8		
9													1	2	2	9	
10																10	
1	Shaly limestone	15°	100%	Grey				(Partially very slightly exfoliate along bedding planes)	Generally shaly or slightly shaly limestone. No solution cavities.	LU = 0.8	1						
2													2				
3												3		3			
4											(2)	1		4			
5												2		5			
6														6			
7														7			
8												3		8			
9												2		9			
120					(3)			120	-29.8								

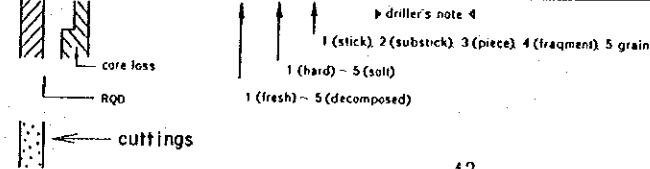


GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. P-1 (SHEET 1 OF 2)

LOCATION Power house DEPTH OF HOLE 40.0 m COMMENCED Oct. 19 -1983
 ELEVATION 90.8 m DEPTH OF OVERBURDEN 7.4 m COMPLETED Oct. 23 -1983
 COORDINATE 1966 669.5N 375 088.3E LENGTH OF ROCK DRILLING 32.6 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90 ° TOTAL LENGTH OF CORE 31.5 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE _____ CORE RECOVERY 96.6 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE					WATER TABLE	WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DEPTH	ELEVATION
					COLOR	WEATHERING	HARDNESS	CORE CUTTING	DESCRIPTION					
0m			0 ~ 100%										90.8	
0 ~ 3.0	Overburden	△							0 ~ 3.0 Yellowish brown lateritic soil. (clay, silt, sand).					
3.0	River bed deposits	△							3.0 Coarse and medium grained sand.					
6.0	River bed deposits	○							6.0 Gravel cores (Sandstone, quartzite) 7.4 φ 1cm ~ 15cm					
6.0 - 13.4	Fine grained sandstone	●							6.0 - 13.4 Fine grained sandstone. Very hard, but cracky and weathered along crack. Bedding not clear.					
13.4 - 14.3	Fine grained sandstone	●							13.4 - 14.3 Dark grey (Crack plane: Yellowish brown)					
14.3 - 18.7	Black shale	■							14.3 - 18.7 Black shale with very thin calcite veins. Partially cracky and weathered.					
18.7 - 20.0	Black shale	■							18.7 - 20.0 Black shale with very thin calcite veins. Slightly weathered along cracks.					

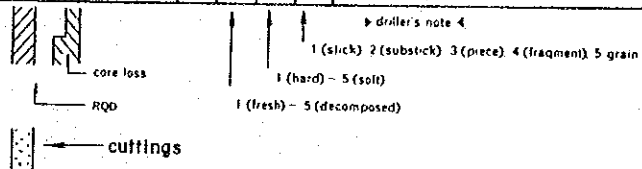


GEOLOGIC LOG OF DRILL HOLE

Nam Yuam PROJECT HOLE No. P-1 (SHEET 2 of 2)

LOCATION Power house DEPTH OF HOLE 40.0 m COMMENCED Oct - 19 - 1983
 ELEVATION 90.8 m DEPTH OF OVERBURDEN 7.4 m COMPLETED Oct - 23 - 1983
 COORDINATE 966 6695N 375 088.3E LENGTH OF ROCK DRILLING 32.6 m DRILLED BY ROEM
 ANGLE FROM HORIZONTAL 90° TOTAL LENGTH OF CORE 31.5 m LOGGED BY M. Shibata
 BEARING OF ANGLE HOLE _____ CORE RECOVERY 96.6 %

DEPTH	ROCK NAME	LOG	CORE RECOVERY	CEMENTATION KIND OF BIT CASING	OBSERVATION OF CORE				DESCRIPTION	WATER TABLE			DEPTH	ELEVATION						
					COLOR	WEATHERING	HARDNESS	CORE CUTTING		WATER PRESSURE TEST	LEAKAGE OF DRILLING WATER	DRILL WATER RETURN								
20m			0 → 100											70.8 m						
1	Black shale	30°	100		Black	2	2	2	2	Small solution cavities along 20.7 calcite veins at 20.7m	Lu = 1.3				1					
2									3	Very slightly weathered along bedding planes or joints.					2					
3									2	Partially exfoliative along bedding planes.					3					
4									{	Some planes of cross joints are smooth. (with dark greenish mineral - chlorite ?)					4					
5									2						5					
6									1 (3)						6					
7														3					7	
8														{	290	Lu = 4.2				8
9										(4)										
30															Generally few cracks, partially cross joints with calcite veins.	Lu = 2.5				30
1				1	2	2	2	No weathering at 29.0 - 33.5m					1							
2								Cores separated along cross joints in parts.					2							
3														3						
4								1	Many calcite veins and somewhat folding.	Lu = 2.3				4						
5					{	2	{	Partially small solution cavities along calcite veins.							5					
6					2		3				Slightly brittle in general.					6				
7								2							7					
8								{						8						
9								(3)						9						
40								(3)						40						



A 2 HYDROLOGY

1. Catchment Area of the Damsites

In this study, two damsites, i.e. site A and B were proposed for investigation. Catchment areas of both sites were measured with the available topographical maps (scale: 1/250,000, "Chiangwat Chiang Mai" and "Amphoe Li") published by U.S. Army Map Service, Far East.

Catchment area of Ban Tha Rua G.S. was also measured with the said map.

The catchment areas employed in the study were as follows.

Damsite A	:	5,920 km ²
Damsite B	:	5,810 km ²
Ban Tha Rua G.S.:		5,770 km ²

2. Evapotranspiration

Evapotranspiration was calculated by the following two methods.

(1) Thornthwaite Method

$$E_{pT} = 0.533 D_o \left(\frac{10t_j}{J} \right)^a$$

where $a = 6.75 \times 10^{-7} J^3 - 7.71 \times 10^{-5} J^2 + 1.79 \times 10^{-2} J + 0.49$

$$J = \frac{12}{\sum_{j=1}^{12} \left(\frac{t_j}{5} \right)^{1.514}}$$

E_{pT} = Monthly average of daily evapotranspiration [mm/day]

D_o = Daytime ratio i.e.
daily daytime/12 hrs

t = Monthly average temperature [$^{\circ}C$]

j = Month (1 - 12)

J = Indicator of Month

(2) Blaney and Criddle Method

$$E_{pT} = K C t$$

where E_{pT} = Monthly average evaporation [inch/month]

C = Ratio of monthly daytime to annual daytime

t = Monthly average temperature [$^{\circ}F$]

K = Coefficient corresponding to kind of flora

When units are converted to metric system, the equation becomes:

$$E_{pT} = K \cdot C \cdot (45.72^t + 812.8)$$

In these equations, daytime ratios D_o and C were obtained by the following way.

D_o ; based on the table below, the value at latitude 18° North was interpolated.

C; given by the following figure.

Coefficient for flora (K) is 0.7 corresponding to deciduous forest in semi-dry region⁽¹⁾.

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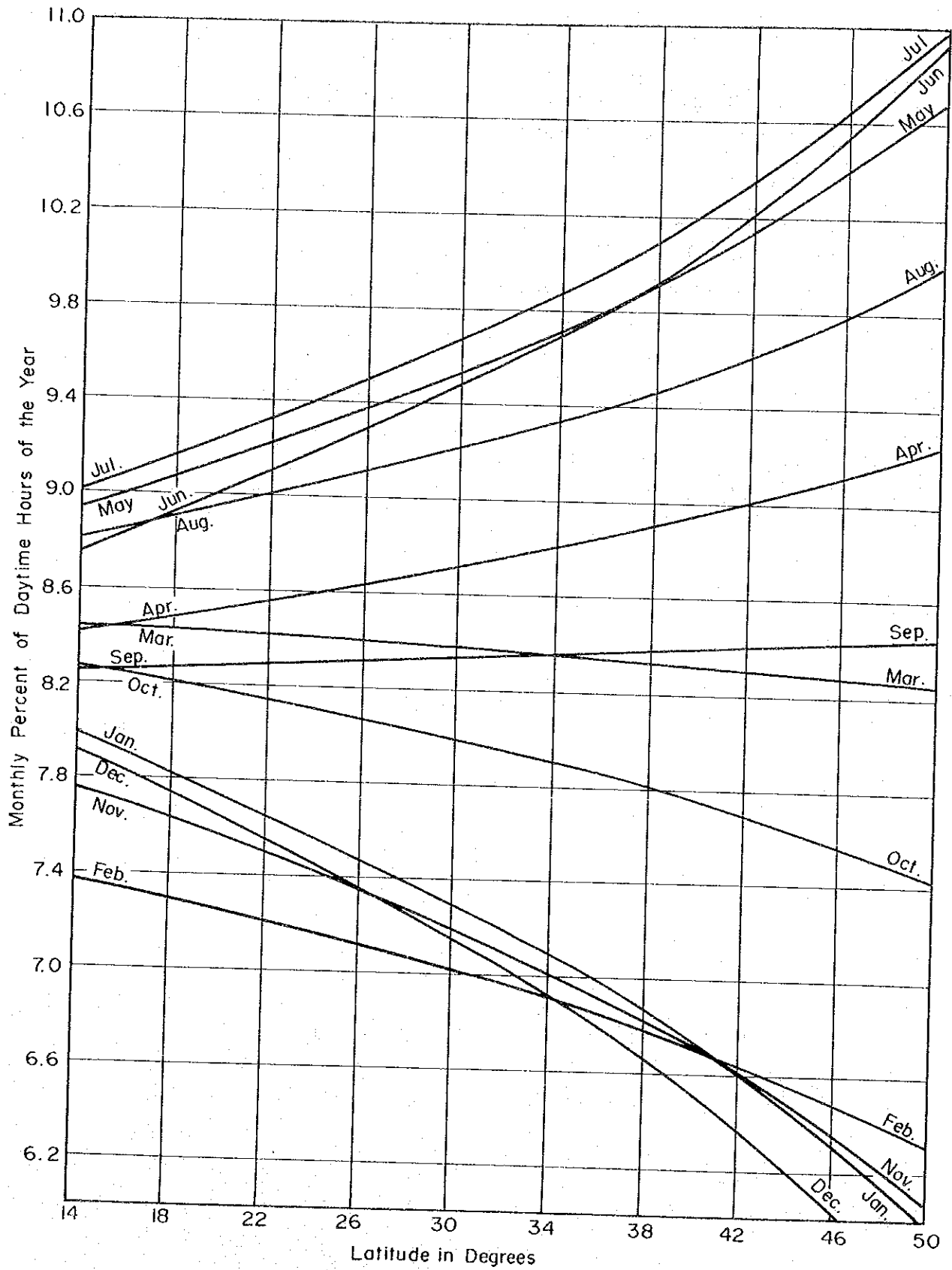


Fig. 2.1 Percent of Annual Sunshine Hours Occurring During the Indicated Month

Table 2.1 Daytime Ratio, ref. (1)

(Unit: 12 hr/day)

Mon.	Lat. N.	10	18*	20	24	26	28	30	32	34	36	38	40	42	44	46
JAN		0.965	0.929	0.920	0.899	0.889	0.878	0.867	0.855	0.843	0.830	0.817	0.802	0.787	0.770	0.752
FEB (28)		0.982	0.961	0.956	0.941	0.935	0.929	0.922	0.915	0.908	0.900	0.893	0.884	0.875	0.865	0.855
FEB (29)		0.982	0.961	0.956	0.942	0.936	0.930	0.923	0.916	0.909	0.902	0.894	0.885	0.877	0.867	0.857
MAR		1.003	1.001	1.000	0.997	0.996	0.996	0.995	0.994	0.993	0.992	0.991	0.990	0.989	0.988	0.986
APR		1.026	1.044	1.048	1.055	1.060	1.065	1.070	1.076	1.081	1.087	1.093	1.100	1.107	1.115	1.123
MAY		1.045	1.079	1.087	1.104	1.114	1.123	1.134	1.144	1.156	1.167	1.180	1.193	1.208	1.223	1.240
JUN		1.055	1.096	1.106	1.129	1.141	1.153	1.166	1.180	1.194	1.209	1.225	1.242	1.261	1.280	1.302
JUL		1.051	1.088	1.097	1.118	1.129	1.140	1.152	1.164	1.177	1.191	1.206	1.221	1.237	1.255	1.274
AUG		1.034	1.057	1.063	1.077	1.084	1.091	1.098	1.106	1.114	1.123	1.132	1.141	1.151	1.162	1.174
SEP		1.012	1.017	1.018	1.022	1.024	1.025	1.027	1.029	1.031	1.033	1.035	1.037	1.039	1.041	1.045
OCT		0.990	0.975	0.971	0.964	0.960	0.956	0.952	0.947	0.942	0.938	0.932	0.927	0.921	0.915	0.909
NOV		0.970	0.937	0.929	0.913	0.904	0.895	0.885	0.875	0.865	0.854	0.842	0.830	0.817	0.803	0.787
DEC		0.960	0.919	0.909	0.887	0.875	0.863	0.850	0.838	0.824	0.809	0.794	0.778	0.760	0.742	0.721

Note: *; Lat. 18°N. was interpolated

3. Sedimentation

3.1 Geology in the project area

The project area stretches from North to South with distance of 160 km while from West to East with 30 to 50 km width, covering catchment of 6,000 km². In the area, rugged topography in youthfulness is widely seen.

The area is mainly composed of sedimentary rock of Paleozoic and Mesozoic age, and granite of Mesozoic age. The ground is covered in most area by laterite which is generally formed by weathering in humid and high temperature region.

3.2 Sediment

Due to the laterite covering the ground, eroded and flowing material in the river is very fine. In other words, the river flow contains suspended load. On the other hand, since the river gradient is rather mild and river flow is relatively slow, bed material would not be very involved in the flow. Measurement of suspended load has been conducted at three gaging stations along the river. But one gaging station was omitted because it measures on a tributary. Instead, a measurement on the Moei river was taken into account.

(1) Density of sediment deposit

The following equation gives an average density of sediment deposit after t years.

$$W_{av.} = W_1 + 0.434 K \left[\frac{t}{t-1} (1 - e^{-Kt}) \right] \quad \text{ref. (1)}$$

where $W_{av.}$ = Average density of sediment deposit after t years.

W_1 = Initial density of sediment deposit shown in the table below.

K = Coefficient

t = Years

Table 3.1 Initial Density and Coefficient

(Unit: lb/ft³)

Reservoir Operation	Sand (>0.05 mm)		Silt (0.005 to 0.05 mm)		Clay (0.005 mm)	
	W ₁	K	W ₁	K	W ₁	K
Sediment always submerged or nearly submerged	93	0	65	5.7	30	16.0
Normally a moderate reservoir drawdown	93	0	74	2.7	46	10.7
Normally a considerable reservoir drawdown	93	0	79	1.0	60	6.0
Reservoir normally empty	93	0	82	0.0	78	0.0

For a hundred year sedimentation, the following densities were derived

Table 3.2 Average Density after 100 years

(Unit: gr/cm³)

Reservoir Operation	Sand	Silt	Clay
	W ₁₀₀	W ₁₀₀	W ₁₀₀
Sediment always submerged or nearly submerged	1.490	1.185	0.886
Normally a moderate reservoir drawdown	1.490	1.254	1.008
Normally a considerable reservoir drawdown	1.490	1.291	1.113
Reservoir normally empty	1.490	1.313	1.249

In this study stage, no information is available for composition of sediment deposit in Nam Yuam reservoir. Therefore, an average figure of the said densities could be employed, i.e. 1.30 gr/cm³.

(2) Estimation of sediment

Using the average density derived above, the suspended load measured in weight at gaging stations was converted to load in volume. At the same time the amount of load was expressed by form of specific discharge.

In addition, bed load was considered, referring other report. The report of Lower Quae Yai Environmental and Ecological Invistigation mentiones 10% of bed load against suspended load in terms of volume, while the Feasibility Study Report of Upper Quae Yai mentiones 20% thereof. In this report, thus, it is decided to consider 20% of bed load against suspended load in terms of volume.

Consequently, following sediments are estimated at each gaging stations.

Sop Han	(C.A. = 2,496 km ²)	136.2 m ³ /km ² /yr
Ban Tha Rua	(C.A. = 5,770 km ²)	109.6 m ³ /km ² /yr
Tha Song Yang	(C.A. = 8,360 km ²)	196.9 m ³ /km ² /yr

Finally the specific sediment discharge of 140 m³/km²/yr which is conservatively obtained by enlarging the figure at Sop Han has been adopted in this study.

Therefore, the total amount of sediment deposit is estimated to be 82.9x10⁶ m³

$$140 \times 5,920 \times 100 = 82.9 \times 10^6$$

This sediment occupies only 18.6% of total storage volume of the reservoir. Assuming horizontal surface of deposit, sediment level becomes EL.129.0 m.

References

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4. Generation of Runoff Data by Tank Model

4.1 Purpose

Generation of runoff data of Yuam river aimed to examine reasonability of the runoff data which was actually observed and employed as a basic information in energy computation.

4.2 Observed data utilized in the generation

The observed daily runoff data collected at Ban Tha Rua was available for eleven years from 1970 to 1980, while daily rainfall was observed at Mae Saviang for thirty-one years from 1950 to 1980 and other four observatories, i.e. Ban Tha Rua, Chom Chaeng, Sop Han and Mae La Luang for fourteen years or so.

In the generating process, however, those four rainfall observatories were not taken into consideration because the observing periods are much shorter than of Mae Saviang, and most of the periods are overlapping with the period of runoff data at Ban Tha Rua, thus no point to be used in generating the runoff of Yuam river. Consequently runoff data was generated on the basis of the thirty-one year daily rainfall at Mae Sariang which overlaps for the full period of eleven years of daily runoff at Ban Tha Rua and, in addition, extends twenty years more to the past till 1950.

The generating model, i.e. the tank model, was first adjusted during the overlapping period and then generated the runoff of the river taking the daily rainfall as input.

4.3 Tank model

1) General

Tank model is one method of runoff analysis, being widely adopted in the world. Tank model applicable to both flood and daily runoff analysis can estimate runoff of a river by taking rainfall as input. Basically the model is composed of several tanks combined each other in series or parallel, each tank of which has outlets in the bottom or side corresponding to seepage to the ground or discharge to a river. The conceptual illustration is given Fig. 4.1(a).

Function of tank model is explained as follows, taking simplest component (one tank with two outlets in the bottom and side) as an example. See Fig. 4.1(b).

In the model, section of all tanks is 1, thus storage volume can be simply expressed by height of the water stored in the tank. All the inputs and outputs are considered in time series and expressed by unit of millimeter (mm).

Rainfall	$\{x_n\}$	
Storage	$\{X_n\}$	
Discharge	$\{y_n\}$	
Seepage	$\{z_n\}$	$n = 1, 2, 3, \dots$

The outlets equipped in the side and bottom have respective coefficient α and β adjusting the discharge or seepage rate. The side outlet is usually equipped above the bottom with certain distance H which also enables to adjust the discharge and seepage rate.

The output from the tank can be expressed as follows.

$$y_n = \begin{cases} 0 & \text{if } 0 \leq X_n \leq H \\ \alpha(X_n - H) & \text{if } H < X_n \end{cases}$$

$$z_n = \beta X_n$$

Considering the process in time series, time n and $n+1$, as shown Fig. 4.1(c), outputs are then expressed in the following way.

time n ;

$$y_n = \alpha(X_n - H), \text{ since } X_n > H \text{ in the figure}$$

$$z_n = \beta X_n$$

then

$$X'_n = X_n - y_n - z_n$$

time $n+1$;

$$X_{n+1} = X'_n + x_{n+1}$$

$$y_{n+1} = \alpha(X_{n+1} - H)$$

$$z_{n+1} = \beta X_{n+1}$$

then

$$X'_{n+1} = X_{n+1} - y_{n+1} - z_{n+1}$$

This process is repeated afterwards as time proceeds.

In ordinary tank model shown in Fig. 4.1(a), the said tanks are combined each other vertically in series. In such case, discharge to a river is summation of all the output from the side outlets, while output from the bottom outlet is regarded as seepage to the ground, which is trapped in the lower tank.

Structure of the ordinary tank model is also understood on the analogy of real structure of the ground. Fig. 4.2 shows the correspondence between them.

Rainfall falls into the top tank. Lower tanks receive the water coming out of the upper tank through the bottom outlet. On the other hand, a part of water stored in each tank is discharged to a river through the side outlet. This process is seemed resemble to the real structure of the ground shown in left-hand side, figure (a).

Rainfall falling on the surface of the ground is partially discharged immediately, while the rest seepages to the ground. Outflow from the side outlet of each tank shown in the figure (b) can be considered discharge from each permeable layer of the ground as shown in the figure (a). On the other hand outflow from the bottom outlet of each tank can be thought infiltration from upper permeable layer to lower permeable layer. In the model, outlets of lower tanks are made narrower, i.e. smaller coefficient α or β , because discharge rates in real situation are smaller in lower layers.

This model can well reflect variety of discharge pattern resulted from rainfall pattern. For example, continuous rainfall could cause floods, even if the rainfall is less intensified, while highly intensified rainfall could cause floods even if the whole amount of precipitation is small. In this tank model, if the rainfall continues at a rate exceeding the infiltration rate of the bottom outlet of the top tank, storage in the top tank increases gradually and it causes a large amount of discharge from the top tank where side outlet is wide and enables to release water quickly. If the rainfall occurred in short period with high intensity, it also causes a large amount of discharge because storage in the top tank increases rapidly and most of the water trapped in the tank is released from the side outlet.

Generally speaking, if the tank model is composed of three or four tanks combined vertically in series, the top tank is considered corresponding to surface runoff, the second tank is to be subsurface flow and the third and fourth tanks are to be base flow. The tank model where each tank has different discharge rate, α and β , is, thus, considered to represent the actual physical characteristics of the phenomenon.

Problem of the tank model is to decide the parameters of the model. As seen in the previous figures, the model

consists of several tanks and each tank has parameters of outflow rate α and β and the distance of the side outlet from the bottom. These parameters have to be decided by trial and error, namely taking rainfall data as input, the parameters are so adjusted that the model as a whole can generate runoff well-matched to the observed runoff.

2) Tank model considered in the study

Tank model has variety in its structure, reflecting basin condition. Following three types were considered in this study.

- (i) Ordinary series combination of four tanks
(ab. ordinary model, see Fig. 4.3(a))
- (ii) Ordinary model equipped with soil moisture function in the top tank
(ab. soil moisture model, see Fig. 4.3(b))
- (iii) Parallel combination of four soil moisture models
(ab. 4 x 4 model, see Fig. 4.3(c))

It is generally said that the ordinary model is suitable for such region that climate is mild and there is moderate rainfall throughout a year rendering the ground always wet. On the other hand, the soil moisture model is said appropriate for such region where long dry season exists and thus the ground becomes dry for certain period in a year. If the dry condition of climate is much severer, the 4x4 model is considered suitable.

All the simulation by these three models had been conducted by computer and the soil moisture model was eventually employed in analysis in this study.

3) Soil moisture model

Fig. 4.4 shows detail of the soil moisture function equipped in the top tank.

The soil moisture function consists of two components, the primary and the secondary, which have saturation capacity of S1 and S2, respectively. Symbols appearing in the figure have the following meanings.

S1: Saturation Capacity of the primary soil moisture function

S2: Saturation Capacity of the secondary soil moisture function

XP: Actual Storage in the primary soil moisture function

XS: Actual Storage in the secondary soil moisture function

XF: Free Water stored above the primary soil moisture function, leaving the primary function full.

$$XA = XP + XF$$

$$T1 = K1 \left(1 - \frac{XP}{S1} \right)$$

$$T2 = K2 \left(\frac{XP}{S1} - \frac{XS}{S2} \right)$$

Rainfall is accumulated into XA. If XA is less than S1, whole XA is considered XP. If XA is greater than S1, XP is saturated (XP=S1) and the rest is considered free water (XF=XA-S1). Thus, seepage and discharge from the top tank is caused by the free water XF.

In addition to the ordinary process of the tank model, this model allows water to move between S1 and S2, and between the top tank and the second tank. It is shown in Fig. 4.4 (3). If S1 portion is not saturated and there is free water left in the second tank, water is supplied to the S1 portion from the second tank. This water movement is expressed by the equation below.

$$T1 = K1(1 - \frac{XP}{S1})$$

where K1 is a coefficient.

As seen in the equation, water moves only from the second tank to the S1 portion in proportion to XP/S1 which is relative humidity of the S1 portion.

On the other hand, water moves between S1 and S2 portions in a manner expressed by the following equation;

$$T2 = K2(\frac{XP}{S1} - \frac{XS}{S2})$$

If T2 is positive, water moves from the second to the top tank, on the contrary if T2 is negative, water moves from the top to the second tank. This means, in other words, water moves from dry portion to wet portion in proportion to the difference of relative humidities between the two portions.

As described above, the soil moisture function can be controlled by the four parameters, i.e. S1, S2, K1, K2.

Fig. 4.5 shows the soil moisture model with the parameters which were finally employed in the analysis. As seen in the figure, there are totally eighteen (18) parameters to be decided. These parameters were decided by trial and error. That is, under certain value of parameters given, runoff was generated by taking Mae Saviang rainfall as input, and hydrograph was then synthesized. Comparing these synthetic hydrograph with the observed hydrograph at Ban Tha Rua, parameters had been adjusted little by little so as to make the synthetic hydrograph more fit to observed.

Fig. 4.6 gives the result, where solid line in the observed hydrograph and dot line is the synthetic one.

Based on the synthetic hydrograph, periodic feature of Yuam river was studied by spectrum analysis.

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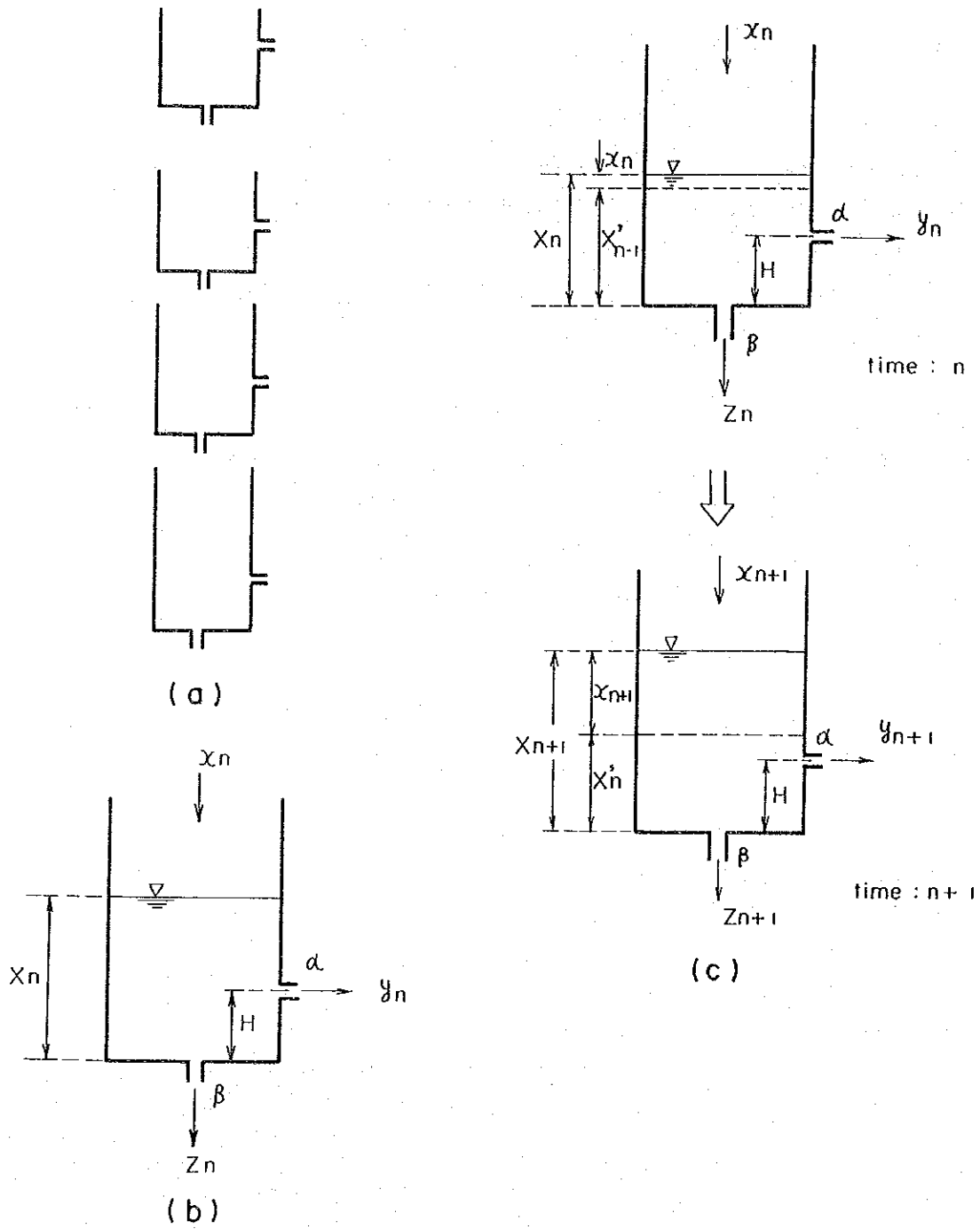


Fig. 4.1 Tank Model, Conceptual Illustration

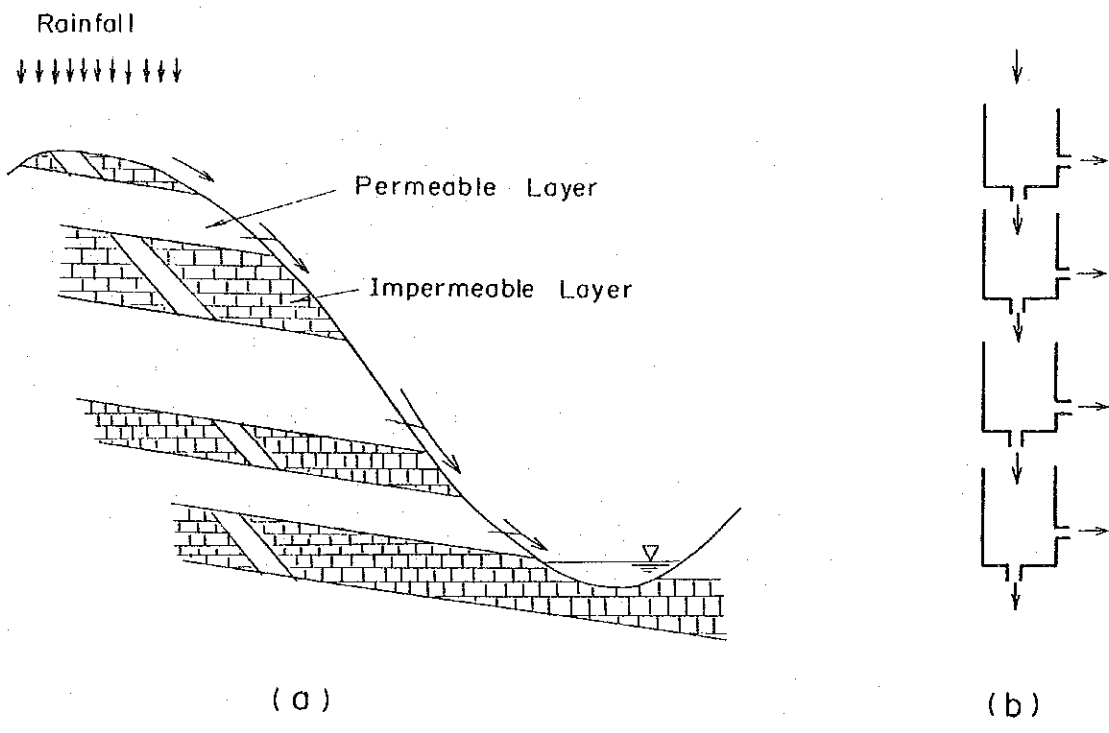


Fig. 4.2 Tank Model, Analogy to the Ground

Fig. 4-3 Estimated and Observed Runoff of Yuam River

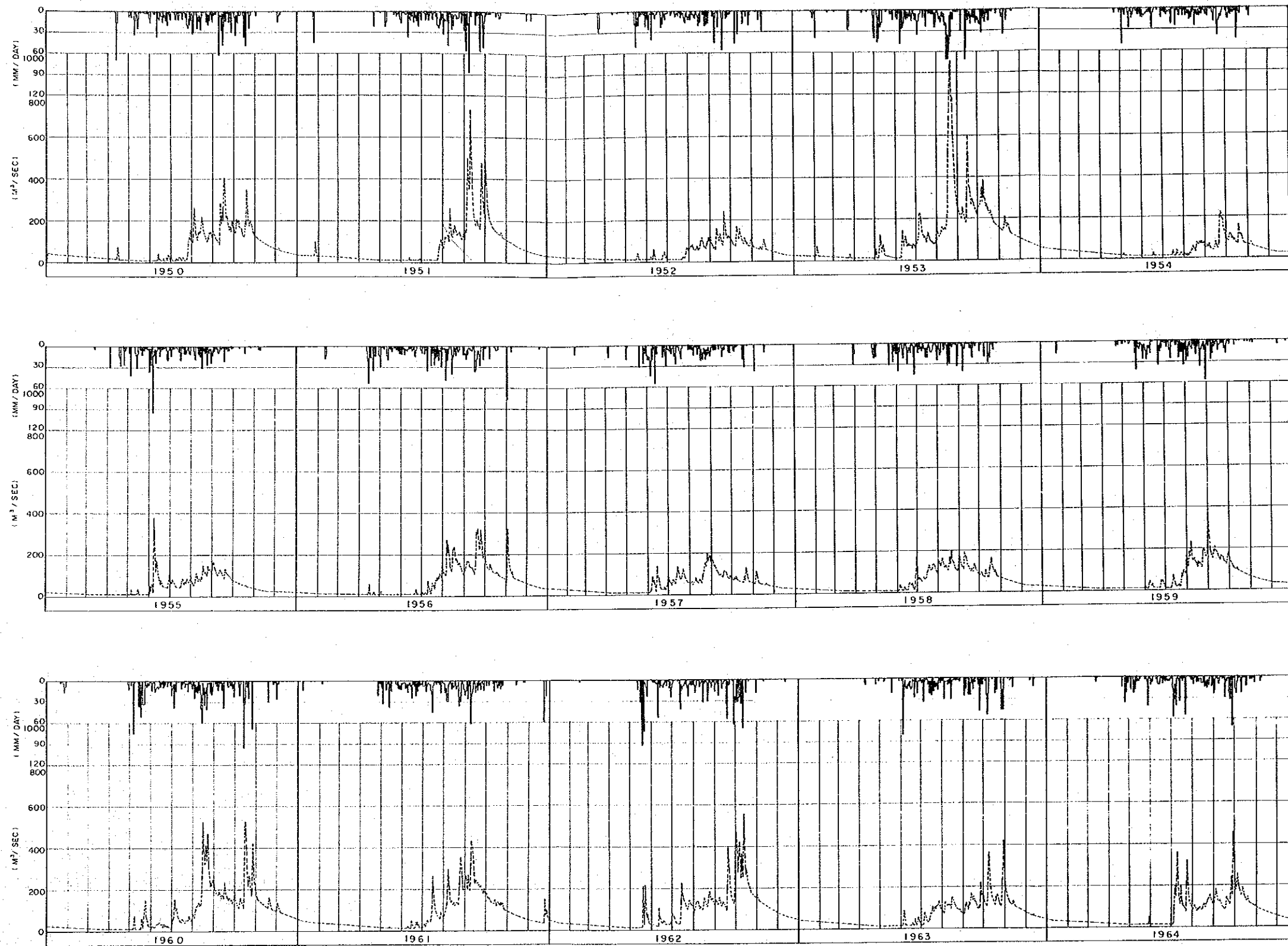
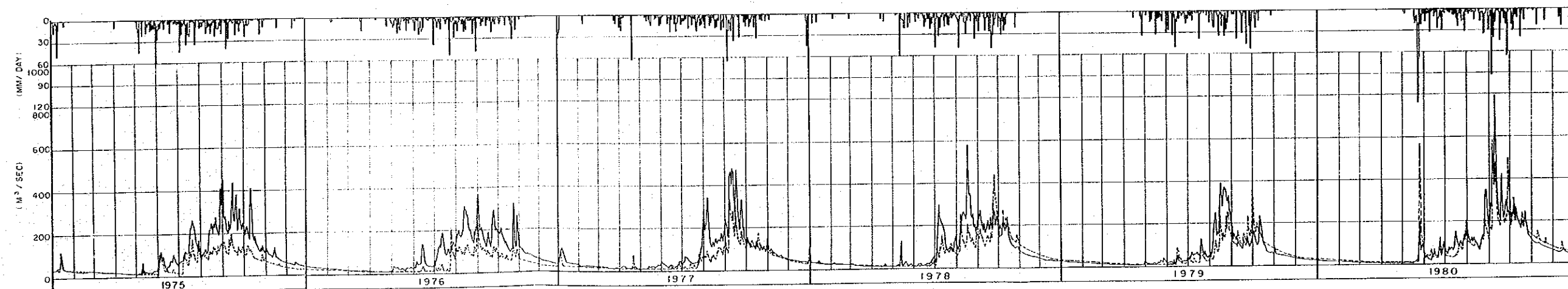
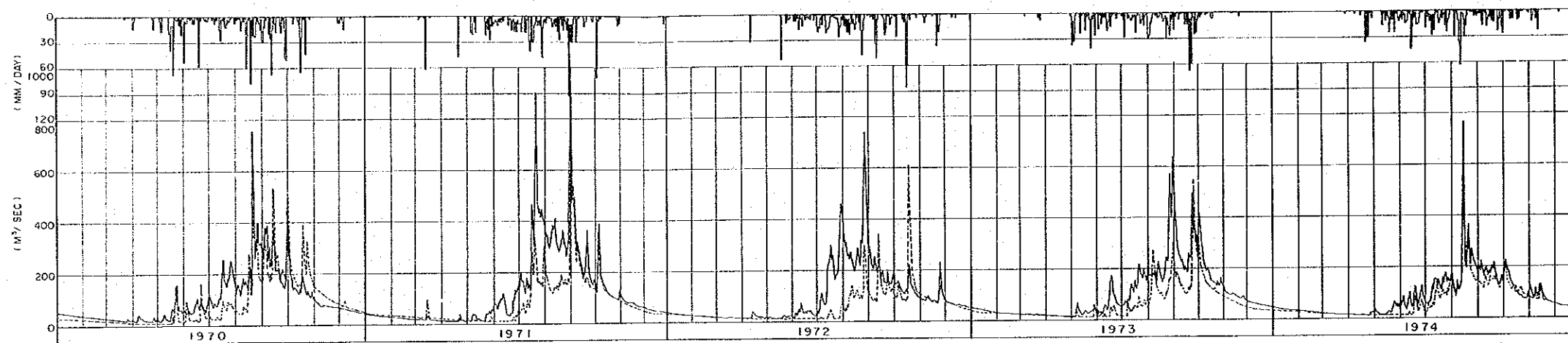
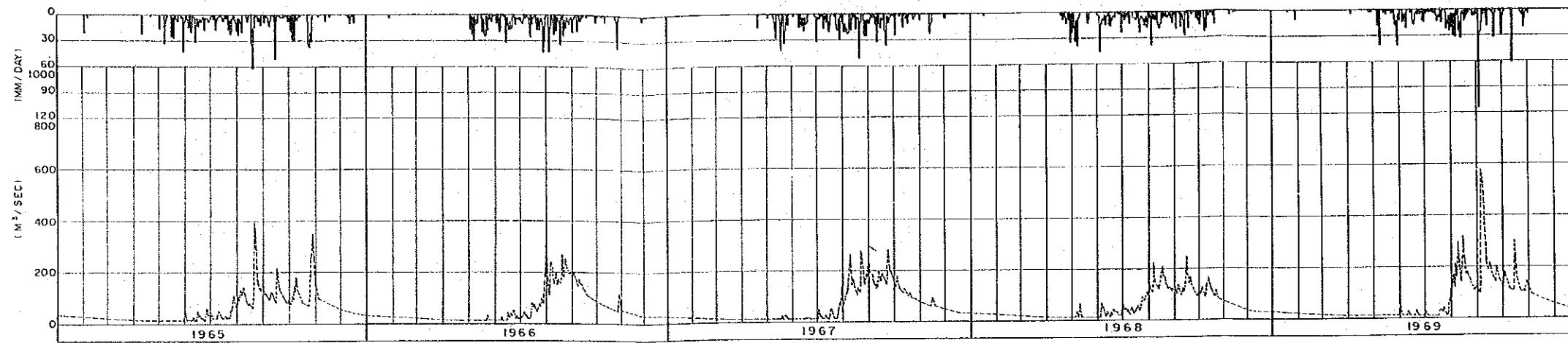
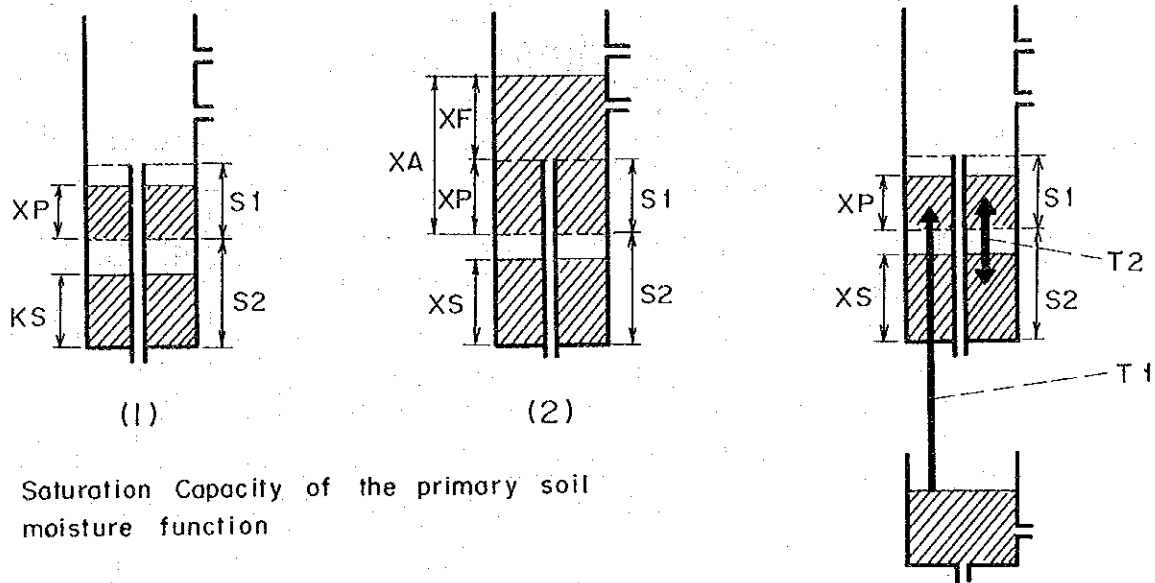


Fig. 4 -3 Estimated and Observed Runoff of Yuam River (cont'd.)





S1 : Saturation Capacity of the primary soil moisture function

S2 : Saturation Capacity of the secondary soil moisture function

XP : Actual Storage in the primary soil moisture function

XS : Actual Storage in the secondary soil moisture function

XF : Free Water stored above the primary soil moisture function, leaving the primary function full.

$XA = XP + XF$

$$T1 = K1 \left(1 - \frac{XP}{S1} \right)$$

$$T2 = K2 \left(\frac{XP}{S1} - \frac{XS}{S2} \right)$$

(3)

Fig. 4.4 Detail of Soil Moisture Function

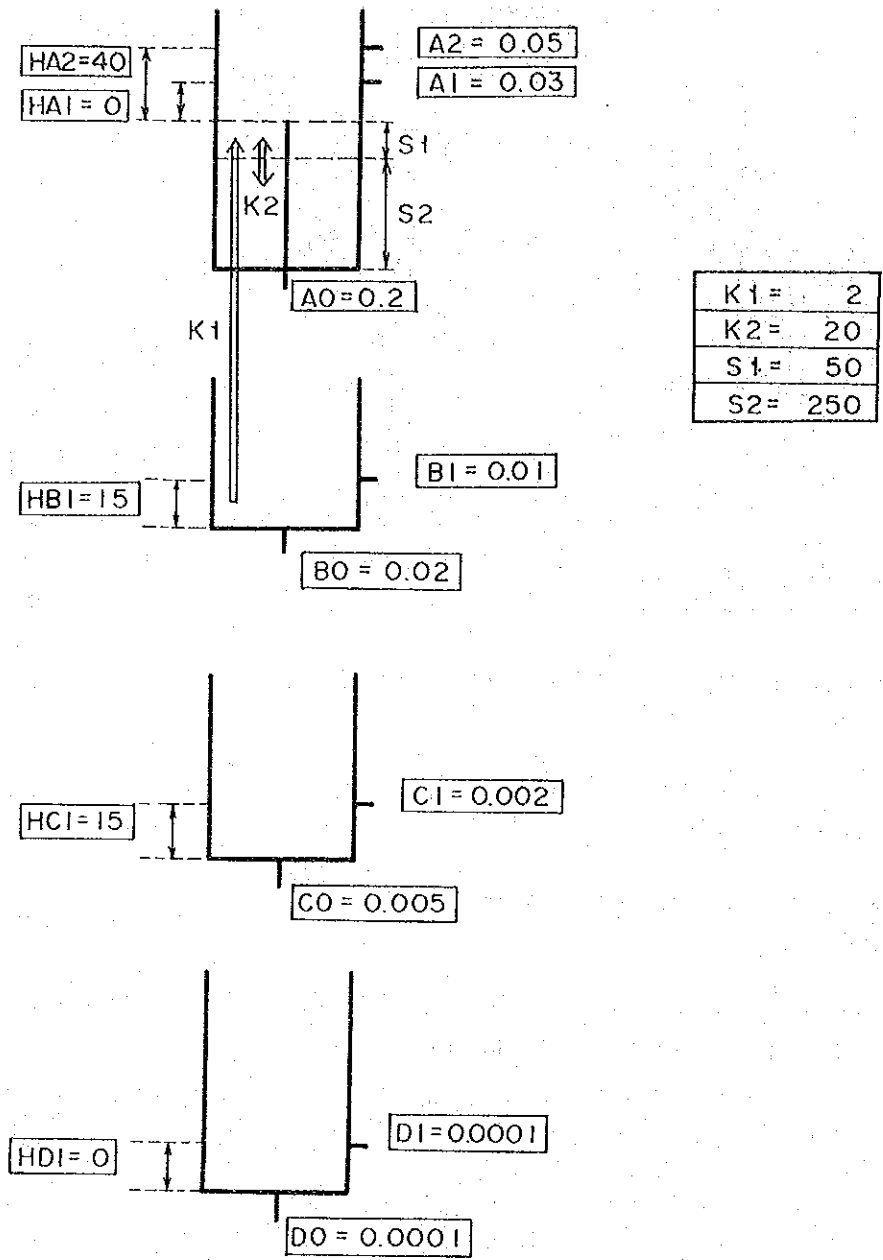


Fig. 4.5 Tank Model Eventually Employed in the Study