4.2.4. Drainage Plan

(1) Drainage from the Irrigated Paddy Field

The paddy fields in the Project Area drain excess water by natural gravity flow depending upon the topographic slope. The drained water flows into the low-lying fields, thus inundation will occur and crops suffer from damage.

Considering the above matters, drainage modulus in the irrigated paddy fields is computed by applying the following method with five-year return period and two consecutive rainfall observed at the Mae Tha station.

$$D = A\ (R\ (n,\ \max)\ t\ -\ n\ (Dc + Cu))$$

where, d: Water depth on paddy field at n-day after the first rainfall

R(n, max)t: Maximum rainfall during n-day with t-year return period (mm/day)

Dc: Drainage capacity (mm/day)

Cu: Consumptive use of paddy (mm/day)

A: Low-lying area in the Project Area; 1/A of the Area

Probable rainfall with 5-and 10-year return period which was studied at "Hydrology" in this report is given as follows:

	Consecutive Rainfall (mm)		
Return Period	1-day	2-day	3-day
5	95	117	128
10	109	128	139

Provided that little damage would not be given to paddy plants when the flood lasts less than three days and remains less than 20 cm in depth on an average, the said equation is expressed as:

$$D_1 = A \{ R(1. \max)\ T - Dc - Cu \}$$

$$D_2 = A \{ R(2, \max)\ T - 2Dc - 2Cu \}$$

$$\frac{D_1 + D_2}{2} = \frac{A}{2}\ R(1, \max)T + R(2, \mathrm{Max})T - 3Dc - 3Cu\} < 200$$

$$\therefore\ Dc > \frac{1}{3} R(1, \max)T + \frac{1}{3} R(2, \max)T - \frac{400}{3A} - Cu$$

Where, $R(1, \max)5 = 95$, $R(2, \max)5 = 117$

$A = 5$ $\quad Cu = 4.9$ mm/day

$$Dc > \frac{1}{3} \times 95 + \frac{1}{3} \times 117 - \frac{400}{3\times5} - 4.9$$

$$= 70.7 - 28.5$$

$$= 42.2 \text{ mm/day}$$

$$= 4.88\ \ell/\mathrm{s/ha}$$

On the basis of the above method, drainage modulus is obtained at 4.88 ℓ/sec/ha.

To apply this modulus for each drainage system, the following reduction rate should be considered under the Area effected by specific rainfall distribution i.e., spot rainfall in the tropical zone.

Runoff Reduction Rate

Drainage Area (km^2)	Ratio
0 - 3	1.00
3 - 8	0.90
8 - 16	0.85
16 - 30	0.80
30 - 80	0.75
80 -160	0.70
Over 160	0.65

(2) Drainage from Hilly Area

The peak discharge from the hilly area is estimated by Rational method.

$$Q = 1/3.6 \times f \times rt \times A$$

Where, Q: Drainage discharge (m^3/s)

f: Runoff ratio = 0.45

rt: Average rainfall intensity within a flood concentration hour (mm/hr)

rt: $r24/24\ (24/T)^n$

r24: Probable daily rainfall
5-year return period 95 mm/day

n: 0.5

T: Flood concentration hour
T is determined by Kerbay's and Rziha's Formula.
T = 1.0 m

Flood concentration hour (T) is obtained by the following procedure:

$$T = T1 + T2$$

Where, $T1 = (2/3 \times 3.28 \times \ell \times \frac{n}{\sqrt{s}}\quad)^{0.467}$ Kerbay's Formula

ℓ: Runoff distance at mountain sides (m) 300

s: Average slope 1/15

n: Delaying coefficient 0.60

$T2 = L/W \qquad W = 20\ (H/L)^{0.6}$ Rziha's Formula

L: Horizontal river length for flowing (m)

H: Elevation difference between upstream and downstream point (m)

In the above equation, T_1 is given at 21 minutes. On the other hand, T_2 and T is obtained as:

L	H	W	T_2		$T = T_1 + T_2$
(m)	(m)	(m/sec)	(sec)	(min)	(min)
1,000	20	1.9	526	9	30
2,000	25	1.4	1,429	24	45
3,000	30	1.3	2,308	39	60

T is obtained at less than one hour, therefore, T is given at one hour in the said equation.

Drainage modulus on the hilly Area is obtained at 24.3 ℓ/sec/ha. this value is also modified depending upon the drainage area by using the reduction rate as shown in previous paragraph.

On-farm Development Plan

Implementation of on-farm development should be carried out by farmers themselves under assistance of the Project Office and Regional Office of RID after completion of construction of the Project.

The said on-farm facilities is composed of structures to be delivered irrigation water from a turn-out of main/lateral canal up to farm lot, such as Main Farm Ditch (MFD), Supplementary Farm Ditch (SFD), Field Ditch (FD), Division Box (DB) and End Check (EC).

A Cost of the on-farm development is estimated based on a layout of typical irrigation block as shown in Fig. .

(1) Construction Cost of a Chak of On-farm Facilities

Description	Quantity (m)	Unit Cost (฿)	Amount (฿)
Construction Cost			
Main Farm Ditch	300	38	11,400
Supplementary Farm Ditch	4,100	25	102,500
Field Ditch	4,000	7	28,000
Division Box	4	1,500	6,000
End Check	5	750	3,750
Sub-total			151,650
Engineering, Administration and others (30%)			48,350
Total			200,000
Cost per rai			฿ 800
Foreign Currency			200
Local Currency			600

Total Construction Cost for Case-5 (50,600 rai)	฿ 40,480,000
Foreign Currency	10,120,000
Local Currency	30,360,000
Total Construction Cost for Case-6 (45,900 rai)	฿ 36,720,000
Foreign Currency	9,180,000
Local Currency	27,540,000

(2) Implementation Schedule and Disbursement Schedule

Implementation of the on-farm development will be carried out for a period of five years started from 1988 to 1992 and disbursement will be followed.

Case-5

Year	Total (฿'000)	Foreign Currency (฿'000)	Local Currency (฿'000)
1988	8,096	2,024	6,072
1989	8,096	2,024	6,072
1990	8,096	2,024	6,072
1991	8,096	2,024	6,072
1992	8,096	2,024	6,072
Total	40,480	10,120	30,360

Case-6

Year	Total (฿'000)	Foreign Currency (฿'000)	Local Currency (฿'000)
1988	7,344	1,836	5,508
1989	7,344	1,836	5,508
1990	7,344	1,836	5,508
1991	7,344	1,836	5,508
1992	7,344	1,836	5,508
Total	36,720	9,180	27,540

(3) Unit Construction Cost

(i) Main Farm Ditch (MFD)

$Q = 0.116\ m^3/s$, $I = 1/700$, $n = 0.030$, $V = 0.435$

Excavation 0.043 m^3 x ฿ 70 x 0.3 = ฿ 0.90
Embankment 0.866 m^3 x ฿ 70 x 0.5 = ฿ 30.31
Miscellaneous ฿ 6.24

Total Cost per linear meter ฿ 37.45
Say ฿ 38.00

(ii) Supplementary Farm Ditch (SFD)

$Q = 0.116\ m^3/s$, $I = 1/700$, $n = 0.030$, $V = 0.425$

Excavation 0.040 m^3 x ฿ 70 x 0.3 = ฿ 0.84
Embankment 0.560 m^3 x ฿ 70 x 0.5 = ฿ 19.60
Miscellaneous ฿ 4.09

Total Cost per linear meter ฿ 24.53
Say ฿ 25.00

(iii) Field Ditch (FD)

$Q = 0.012\ m^3/s$, $I = 1/500$, $n = 0.040$, $V = 0.297$

Excavation 0.068 m^3 x ฿ 70 x 0.3 = ฿ 1.43
Embankment 0.105 m^3 x ฿ 70 x 0.5 = ฿ 3.68
Miscellaneous ฿ 1.02

Total Cost per linear meter ฿ 6.13
Say ฿ 7.00

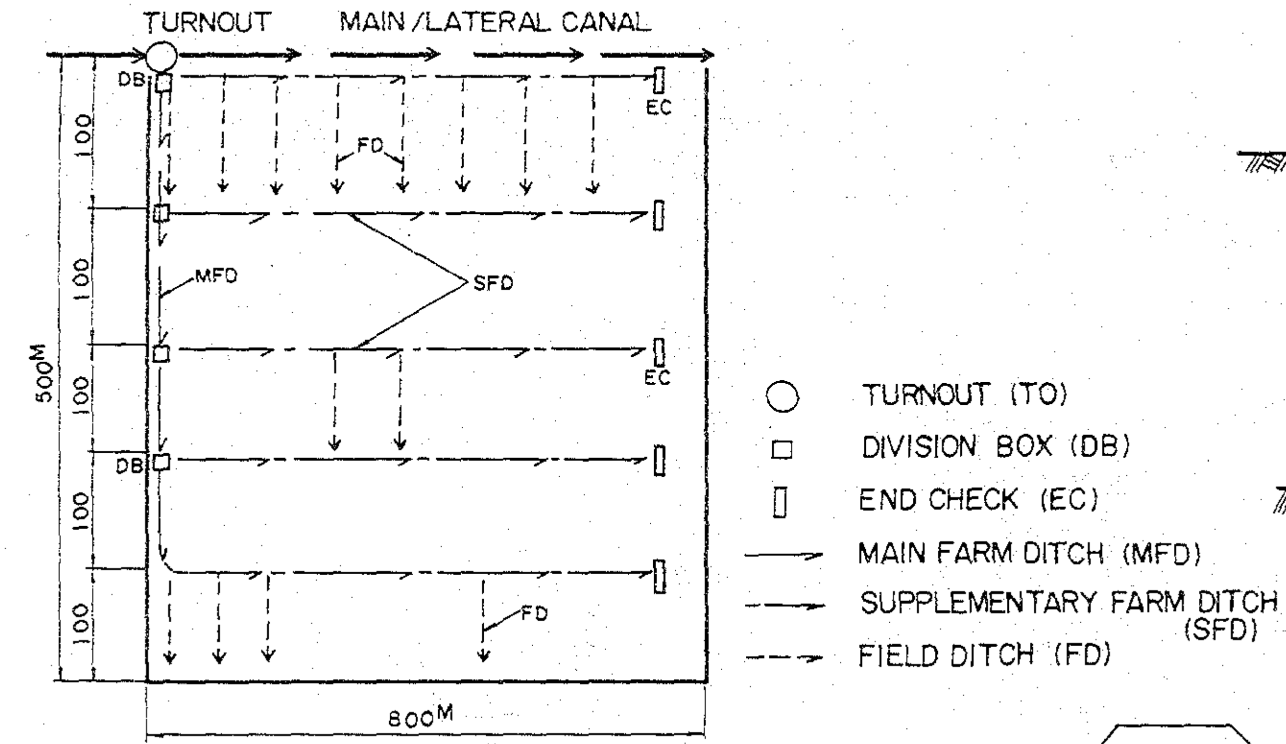
(iv) Division Box and End Check

Cost per sheet

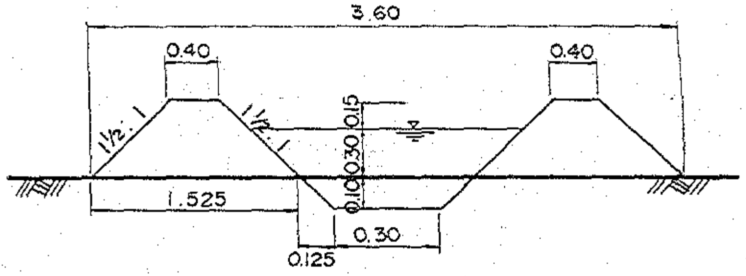
Concrete 0.077 m^3 x ฿ 6,200 = ฿ 477.40
Stop log 0.024 m^3 x ฿ 6,000 = ฿ 144.00
Others including installation cost ฿ 128.60

Total ฿ 750.00

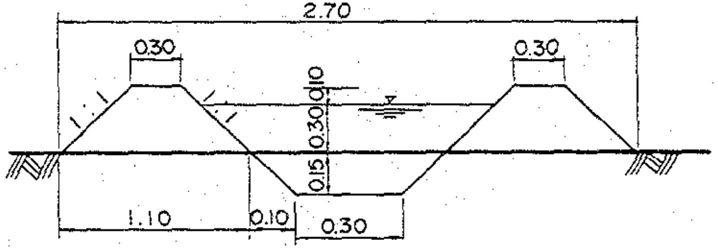
FIG 4.2-6 ON-FARM DEVELOPMENT FACILITIES



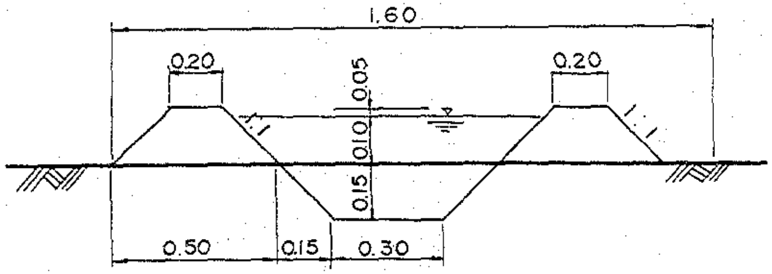
TYPICAL IRRIGATION BLOCK (CHAK)
AVERAGE ARER 250RAI (40HA)



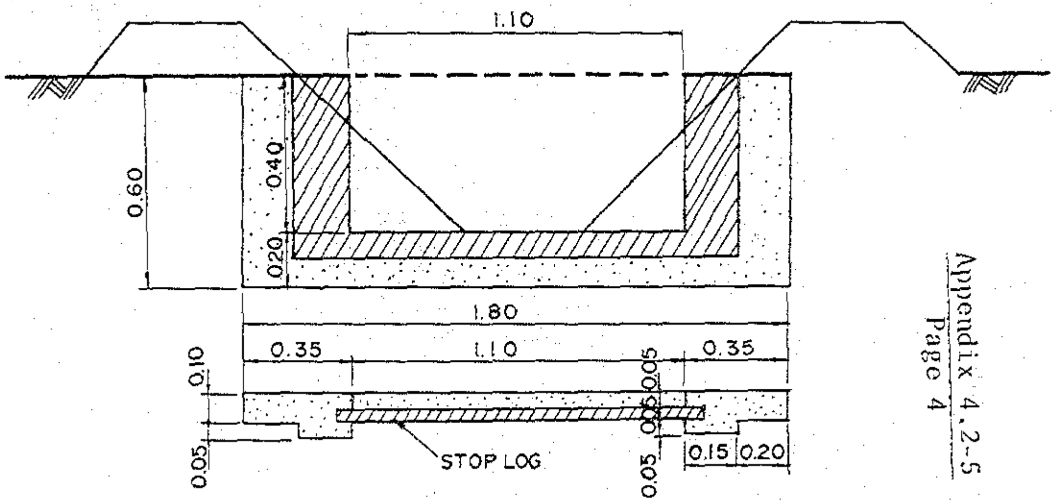
MAIN FARM DITCH (MFD)



SUPPLEMENTARY FARM DITCH (SFD)



FIELD DITCH (FD)



DIVISION BOX (DB) AND END CHECK (EC)

4.2-6 Hydropower Development Plan

1. List of Hydropower Generating Facilities

(1) 2 sets of 82 kW Horizontal Shaft Francis Turbine
(2) 2 sets of Butterfly Valve .
(3) 2 sets of Governor
(4) 1 set of Oil Pressure Supply System
(5) 1 set of 278 kVA Horizontal Shaft Synchronous Generator
(6) 1 set of Generator Panel
(7) 1 set of Control Panel
(8) 1 set of Station Service
(9) 1 set of Diesel Generator Unit
(10) 1 set of Distribution Line for 1 km
(11) Transportation and Installation

2. Cost Estimate

(Unit: ฿ '000)

2-1. Civil Works

Earth Works	1,400 m^3	100
Reinforced Concrete	150 m^3	600
Riprap	250 m^3	500
Steel Pipe (ϕ600 mm)	20 m^3	400
Building	35 m^3	175
Miscellaneous	L.S.	225
Sub-total		2,000

2-2. Hydropower Facilities

Horizontal Shaft Francis Turbine (82 kW 2 sets)	5,000
Butterfly Valve, Governor and Oil System	7,500
Horizontal Shaft Synchronous Generator (278 kVA)	3,500
Diesel Generator Unit, Panels and Station Services	8,000
Distribution Line for One Kilometer	1,000
Transportation and Installation	10,000
Sub-total	35,000

2-3. Communication and Other Facilities	5,000
2-4. Engineering and Administration	13,000
Total	55,000

3. DESIGN REQUIREMENT

3-1. HYDRAULIC TURBINE

(1) No. of Unit : 2 sets
(2) Type : Horizontal Shaft Francis
(3) Rated Output : 82 kW each
(4) Rated Speed at 50 Hz : 1000 rpm
(5) Rated Net Head : 13.0 m
(6) Rated Flow : 0.75 m^3/s each
(7) Net Head Range : 9.0 m Min. ~ 17.0 m Max.
(8) Flow Range : 0.5 m^3/s ~ 1.65 m^3/s

3-2. SYNCHRONOUS GENERATOR

(1) No. of Untis : 1 set
(2) Type : Horizontal shaft synchronous, hydraulic turbines driven at both shaft ends.
(3) Output : 278 kVA
(4) Rated Voltage : 416 V
(5) Power Factor : 80 %
(6) Frequency : 50 Hz
(7) No. of Poles : 6 P
(8) No. of Phases : 3 Phase
(9) Rated Speed : 1000 rpm
(10) Rating : Continuous
(11) Class of Insulation : Class B

FIG. 4.2-7 AVERAGE FLOW (1952 ~ 1981)

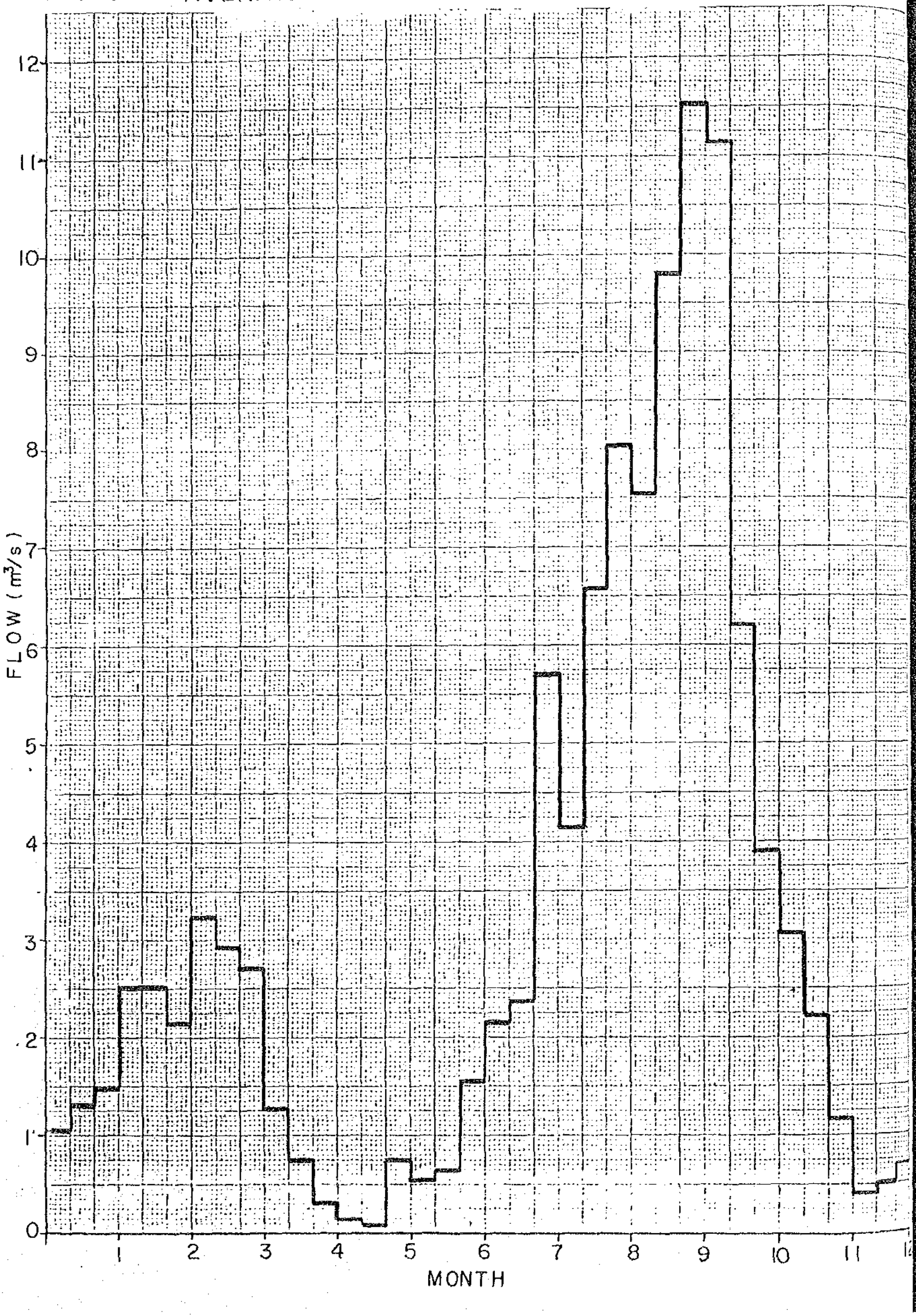
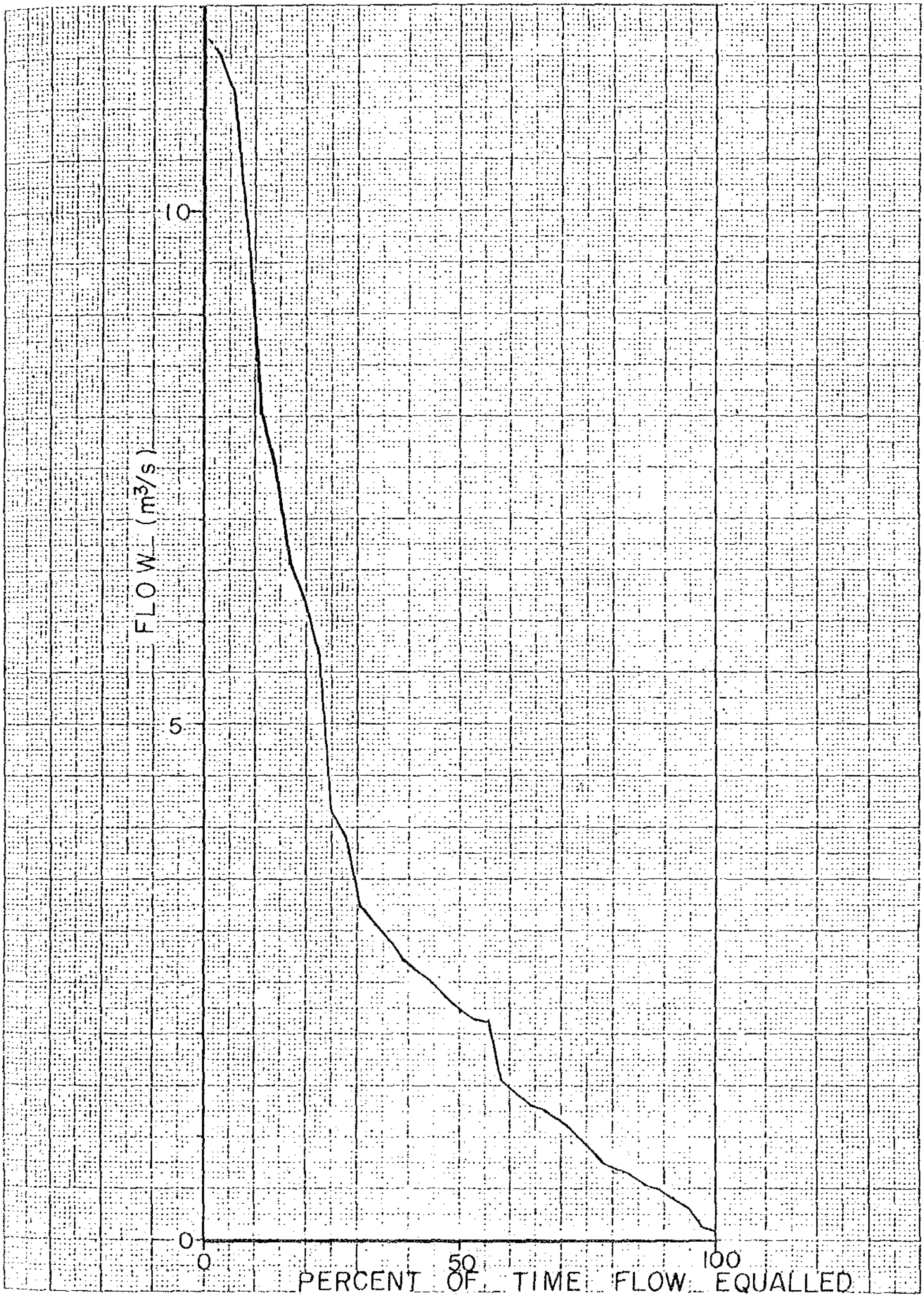


FIG. 4.2-8 FLOW DURATION CURVE (1952~ 1981)



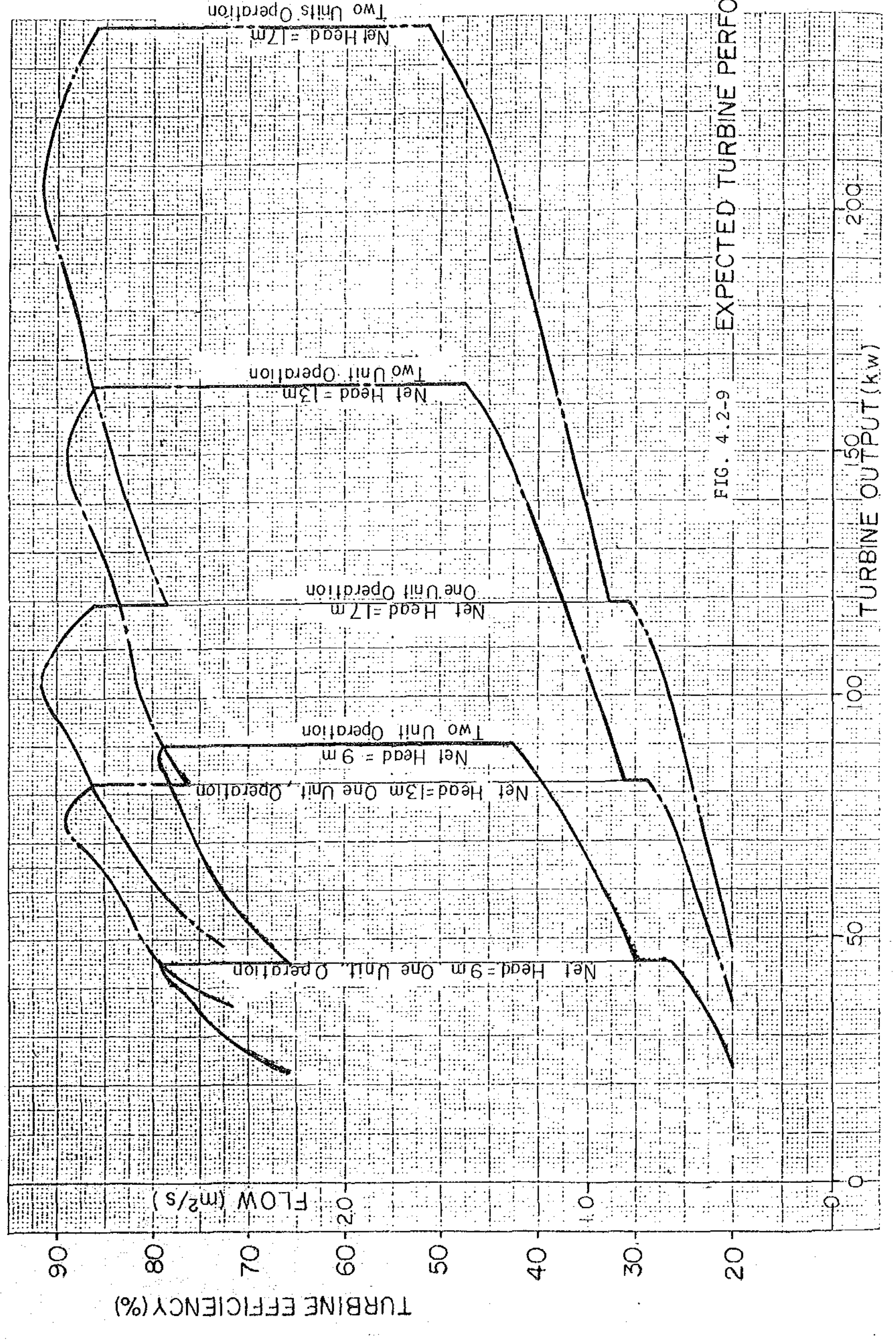


FIG. 4.2-9 EXPECTED TURBINE PERFORMANCE

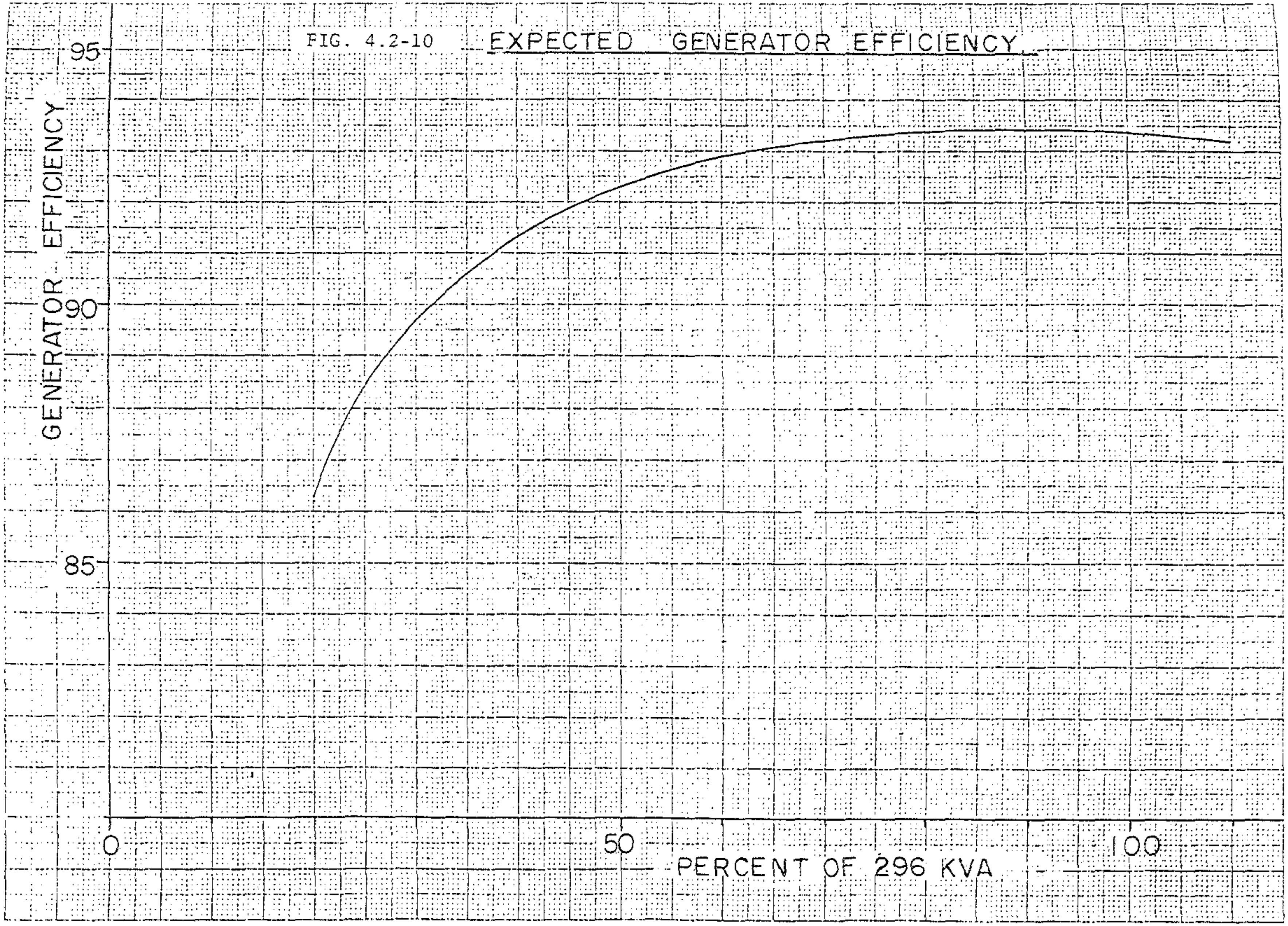
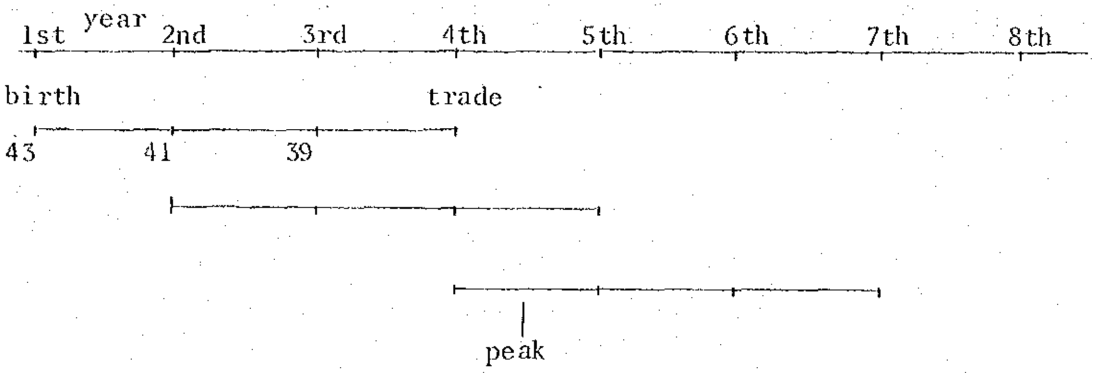


FIG. 4.2-10 EXPECTED GENERATOR EFFICIENCY

Table 4.3-1 Raising Pattern



3) Number of Feeding Cattle

Number of Raising Unit	30	$5{,}208^{t} \div 171.7^{t}$
Number of Feeding Cattle	$6{,}480^{head}$	$216^{head} \times 30$
Number of Selling Cattle	$1{,}170^{head}$	$39^{head} \times 30$

For other cases, computation has been made in the same methods.

Table 4.3-2 Program for Increasing Beef Cattle

Case 5 130%

Paddy	W.	40,500^{rai}	(NG 24,300^{rai}, G 16,200^{rai})
Soybean	W.	5,000	
	D.	4,400	

1. Paddy Rice Straw (Same Case 1)

   Available straw for feeding.

2. Soybean Shell

   W. 125$^{kg/rai}$ x 5,000 x 0.9 = 563^{t}

   D. 150 x 4,400 x 0.9 = 594

   Total 1,157

3. T.D.N.

   Rice Straw 12,533^{t} x 0.371 = 4,650^{t}

   Soybean Shell 1,157 x 0.483 = 559

   Total 5,209

4. Feeding Plan for Cattle (Same Case 1)

Number of Raising Unit	30.3	5,209 ÷ 171.7
Number of Feeding Cattle	6,545^{head}	216 x 30.3
Number of Selling Cattle	1,182^{head}	39 x 30.3

Case 6 135%

Paddy	W.	$36,400^{rai}$	(NG $21,800^{rai}$, G $14,600^{rai}$)
Soybean	W.	3,100	
	D.	4,800	

1. Paddy Rice Straw (Same Case 1)

Available straw for feeding.

2. Soybean Shell

W. $125^{kg/rai} \times 3,100 \times 0.9 = 349^{t}$

D. $150 \times 4,800 \times 0.9 = 648$

Total 997

3. T.D.N.

Rice Straw $11,208^{t} \times 0.371 = 4,158^{t}$

Soybean Shell $997 \times 0.483 = 482$

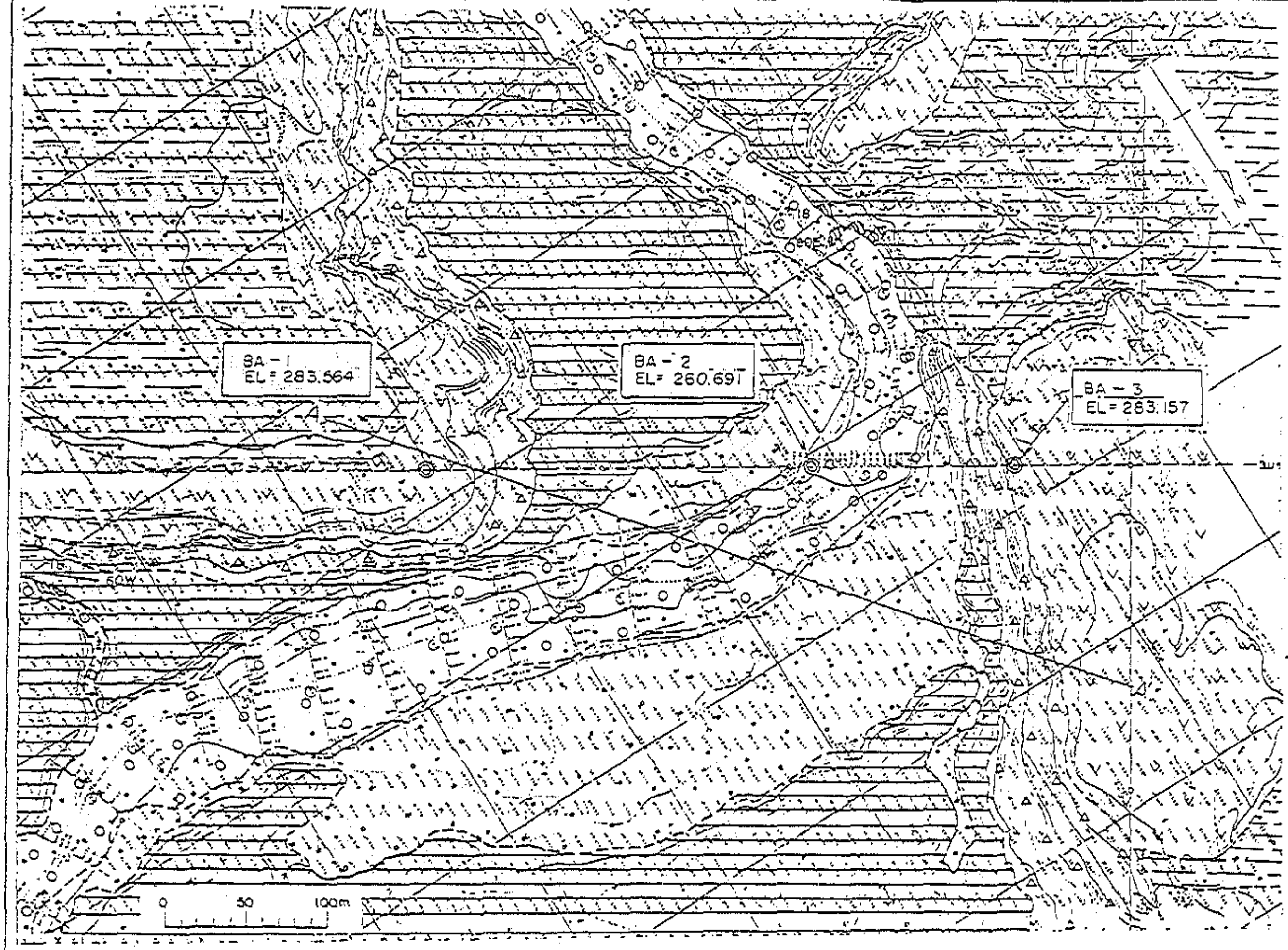
Total 4,640

4. Feeding Plan for Cattle (Same Case 1)

Number of Raising Unit	27	$4,640^{t} \div 171.7^{t}$
Number of Feeding Cattle	$5,832^{head}$	216 x 27
Number of Selling Cattle	$1,053^{head}$	39 x 27

Table 4.4-1 Rock Classification

Class	Characteristics
A	Very fresh and hard rock. Minerals particle is not weathering and change in quality. Crack and joint is hard, connecting. By hammering sound is clear. Boring core recovery is usualy 90 % over.
B	Fresh rock , but sometimes partly minerals and particle is little weathering and change in quality. Crack and joint is adhere. Hard rock by hammering sound is clear. Boring core recovery is almost 70 % over and core pieces length over 5 cm. sometimes broken pieces
CH	Minerals and particle usualy change in quality except,quartz but rock is usualy hard. By strong hammering, crack and joint separate, sometimes thin clay adhere to separated plane. By hammering sound is little dirty. Boring cere recovery is 60 − 70 %, core length 3 − 5 cm , core form is almost columnar.
CM	Minerals and particle usualy change in quality little weathering Soft to medium hard rock By strong hammering crack and joint easily seqarate, thin clay adhere to separated plane By hammering sound is not clear Boring core recovery is 5,0.−6,0. % , core length 1,−5 cm, sometimes columnar or sometimes broken pieces
CL	Minerals and particle is almost weathering and changing quality, so becomes soft rock. By soft hammering easily separate along the joint and breakes. Almost separated plane has clay,in a soft rock sometimes changing clay. Boring core recovery by using water is 30−50 %, core form almost broken pieces.
D	Minerals and particle is heavily weathered. Almost soft rock changein quality like clay. In a hard rock crack and joint is almost open, by soft hammering easily broken. Boring core by using water almost loss.



Regent

Age	Symbol	Formation	Description
Recent	° ° °	River Deposit	sand, silt, clay, gravel Maechang river deposit 6~8m thickness
Recent	△ △ △	Talus Deposit	sand, silt and basalt boulder. 1~3m thickness
Allu-vium	· · ·	Lower Terrace Deposit	mostly silty sand partly sand and pravel 4~6m thickness N 10~15
Allu-vium	☰	Middle Terrace Deposit	mostly sandy silt partly sand and gravel 4~6m thickness N 15~30
Dilu-vium	∨ ∨ ∨	Basalt	hard rock. distributed along the river 2~8m thickness
Dilu-vium	┤ ┤ ┤	Higher Terrace Deposit	silty sand and silt partly sand and gravel semiconsolidated layer N 30~50 over 15~20m thickness
Meso-zoic	⊢ ⊢ ⊢	Lampung Group Mudstone	bedrock. partly tuff-cious, sandy, and comglo-merate. low permeability soft rock. compression 80~100kg/cm(presumtion)

◎ Boring Point
----- Geological Boundary
20 30N Dip and Strike
—·—·— Fault
A———A' Geolgical Section
——— Dam axis

Boring Point
N = Penetration Test
Lu = Lugeon Test
Geological Boundary
Ground Water Table

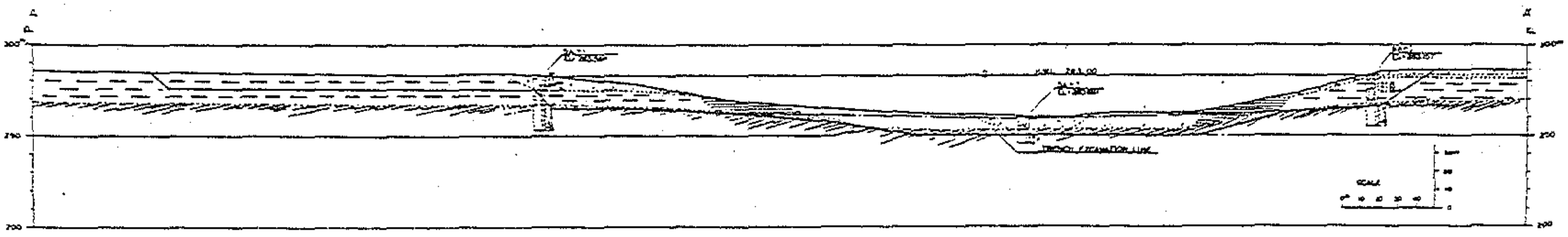
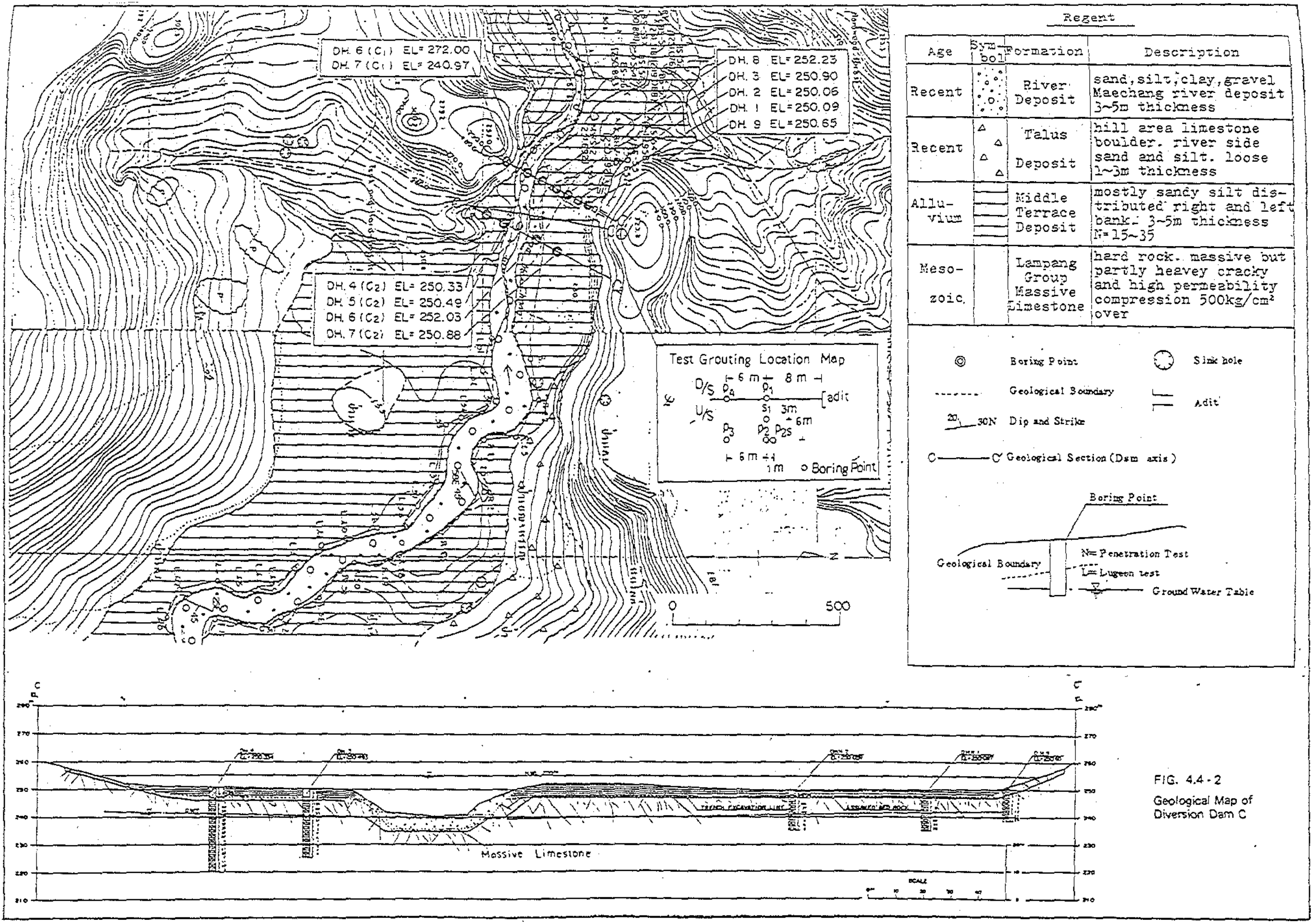


FIG. 4.4-1
Geological Map of Storage Dam A



Regent

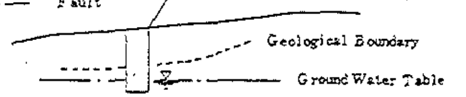
Age	Symbol	Formation	Description
Recent	∴	River Deposit	sand, silt, clay, gravel Maechang river deposit 3~5m thickness
Recent	△	Talus Deposit	hill area limestone boulder. river side sand and silt. loose 1~3m thickness
Allu-vium	☰	Middle Terrace Deposit	mostly sandy silt distributed right and left bank. 3~5m thickness N=15~35
Meso-zoic.		Lampang Group Massive Limestone	hard rock. massive but partly heavey cracky and high permeability compression 500kg/cm² over

FIG. 4.4-2
Geological Map of Diversion Dam C

Regent

Age	Symbol	Formation	Description
Re-cent	○	River Deposit	sand, silt, clay, gravel Maechang river deposit 5~7m thickness
Re-cent	△	Talus Deposit	sand, silt and limestone boulder. 2~5m thickness
Allu-vium	⁘	Lower Terrace Deposit	mostly silty sand partly sand and gravel 3~5m thickness N=10~15
Allu-vium	☰	Middle Terrace Deposit	mostly sandy silt partly sand and gravel 10~15m thickness
Dilu-vium	⊥	Higher Terrace Deposit	silty sand and silt partly sand and gravel semiconsolidated. N30~50 over 15~20m thickness
Meso-zoic	⁘	Calcarious Sandstone	hard rock. banded. distributed river and riverside. compression 200~300kg/cm² Lu=10 under fresh rock.
	≀	Shale Sandstone Conglomerate	shale, sandstone alternation partly conglomerate tuffcious. compression 150~300kg/cm² Lu=generally 20 under fresh ruck
		Massive Limestone	hard rock. distributed out of damsite. cracky

◎ Boring Point
------ Geological Boundary
20 30N Dip and Strike
—·— Fault
D——D' Geolgical Section
—— Dam axis



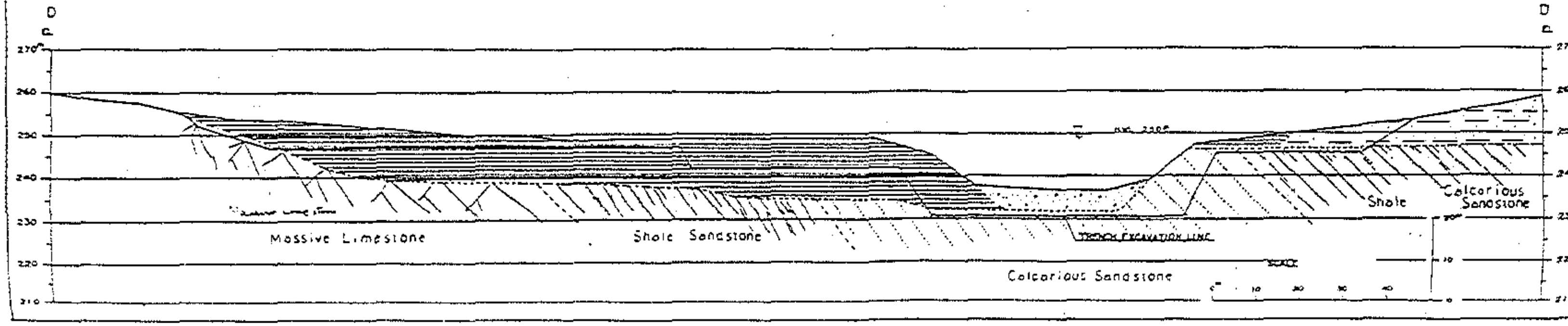
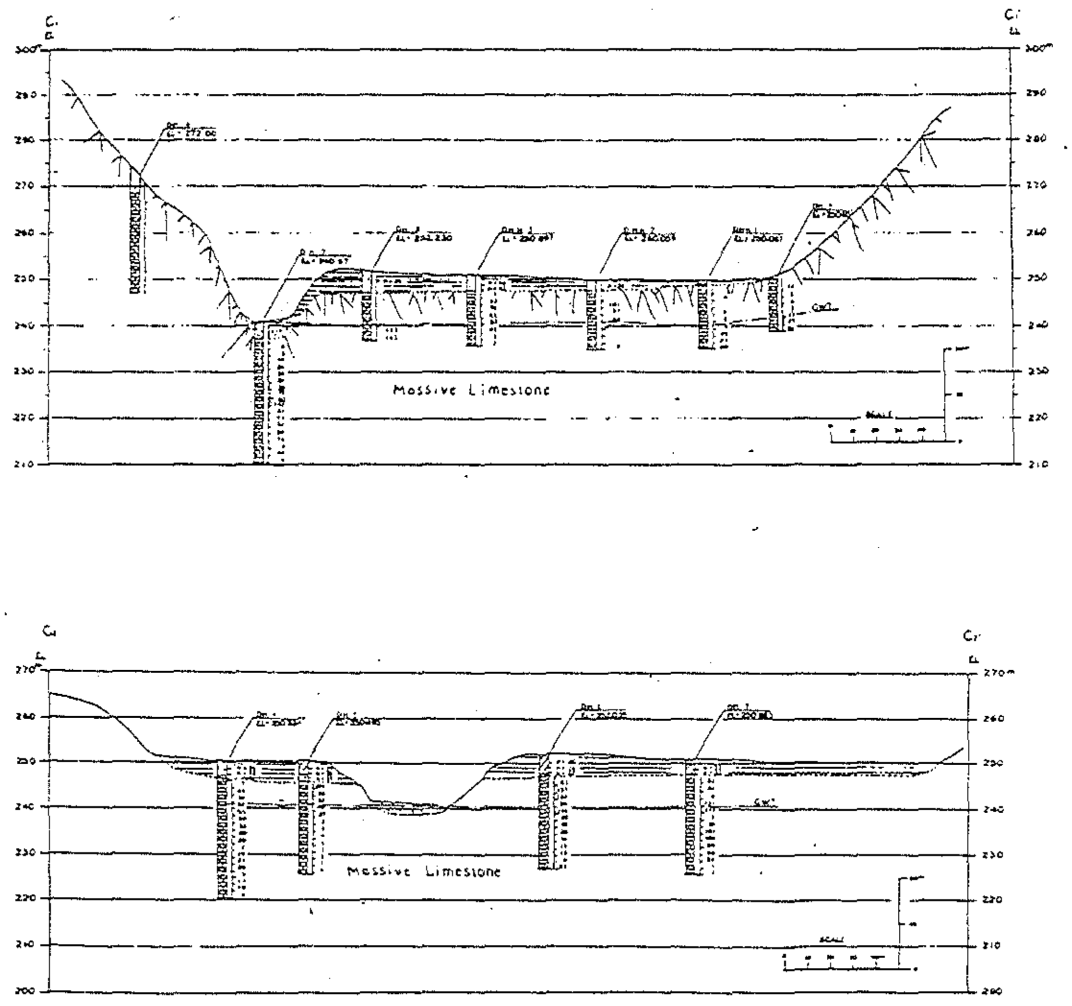


FIG. 4.4-3
Geological Map of Diversion Dam D



Regent

Age	Sym-bol	Formation	Description
Recent	∴	River Deposit	sand, silt, clay, gravel Maechang river deposit 3~5m thickness
Recent	△	Talus Deposit	hill area limestone boulder. river side sand and silt. loose 1~3m thickness
Allu-vium	≡	Middle Terrace Deposit	mostly sandy silt distributed right and left bank: 3~5m thickness N=15~35
Meso-zoic		Lampang Group Massive Limestone	hard rock. massive but partly heavey cracky and high permeability compression 500kg/cm² over

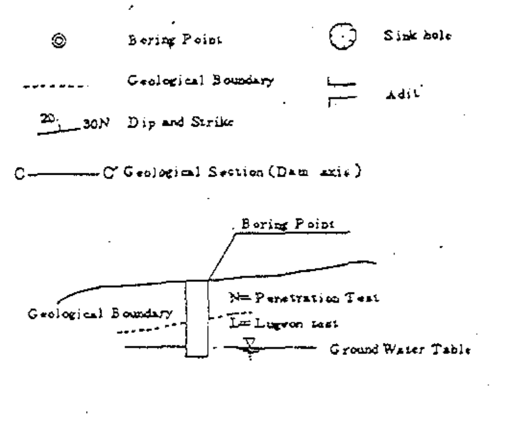
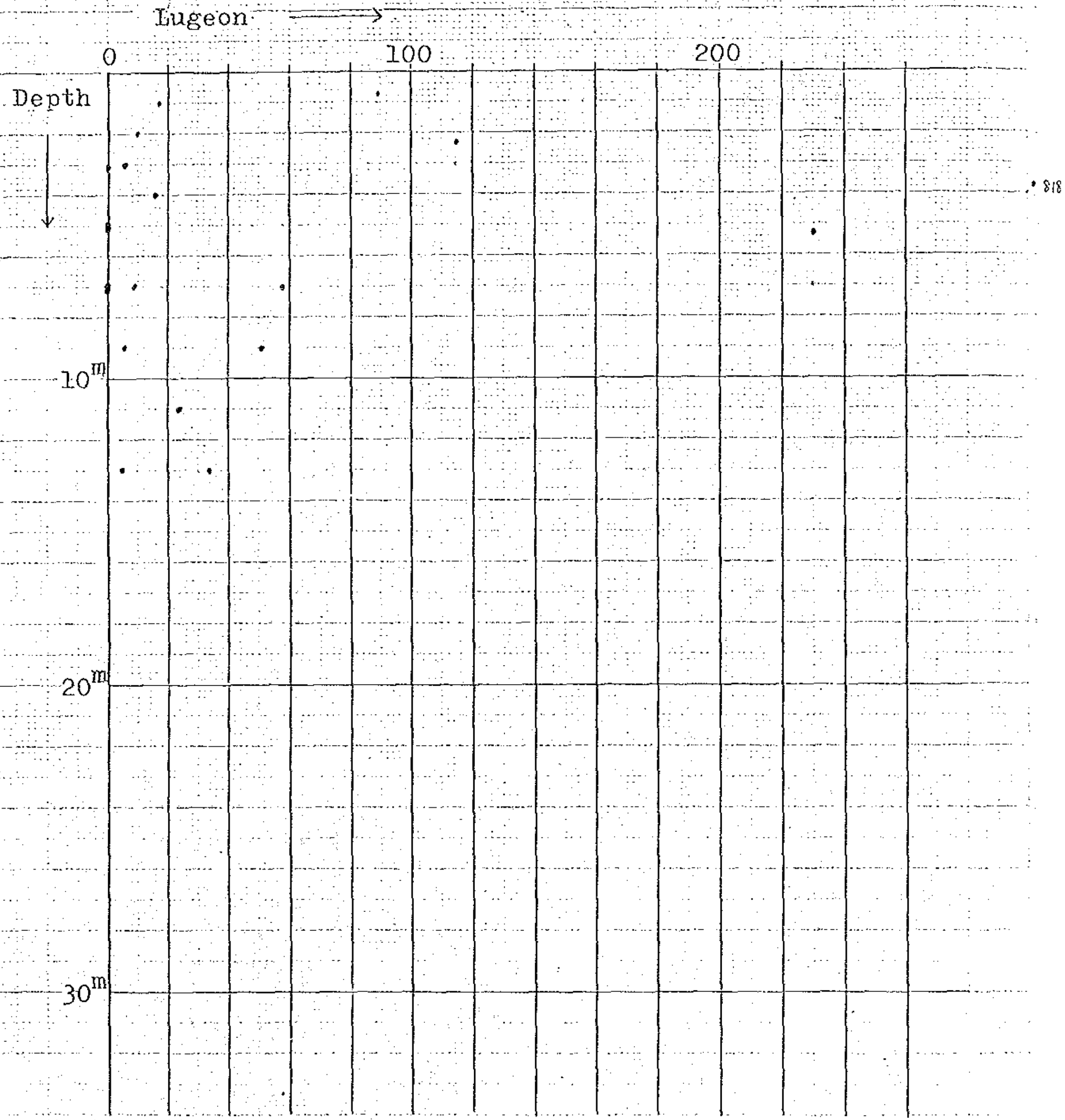


FIG. 4.4-4
Geological Cross Section of Diversion Dam C

FIG. 4.4-5 THE RELATIONSHIP BETWEEN LUGEON AND DEPTH

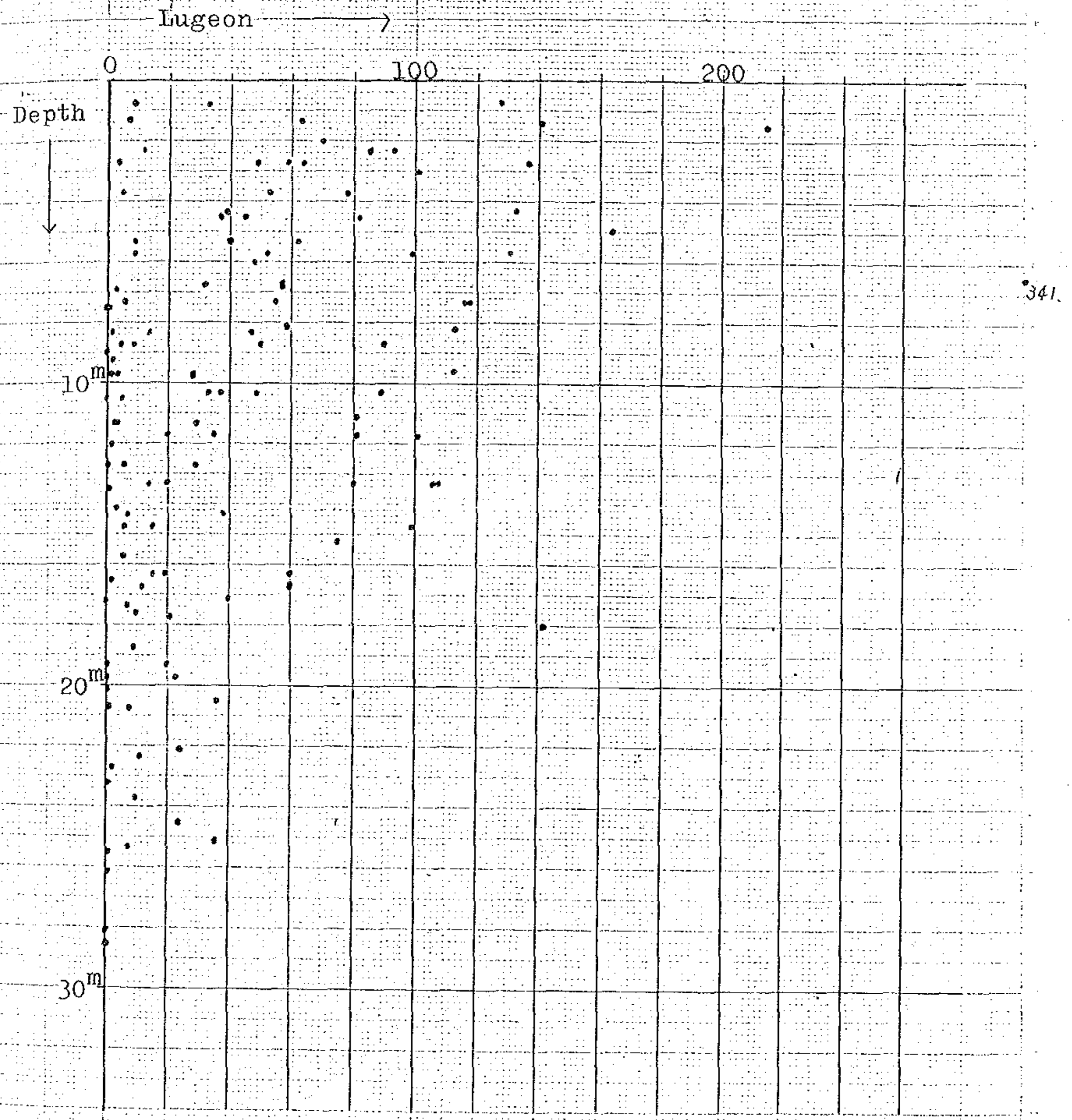
(STORAGE DAM A)



* Depth (from rocksurface to middle of Testing Lengh)

FIG. 4.4-6 THE RELATIONSHIP BETWEEN LUGEON AND DEPTH

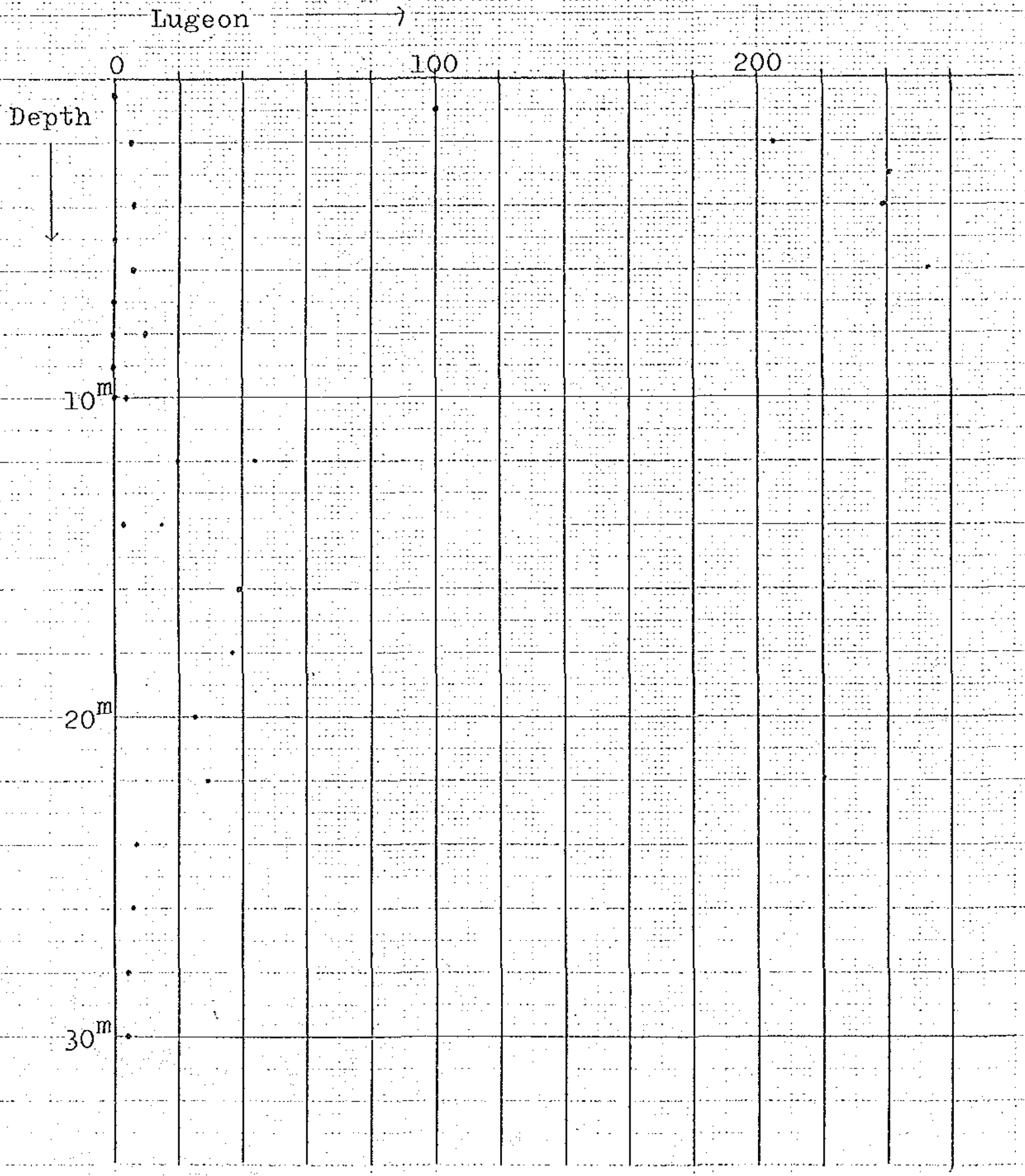
(DIVEVERSION DAM C)



* Depth (from rocksurface to middle of Testing Lengh)

FIG. 4.4-7 THE RELATIONSHIP BETWEEN LUGEON AND DEPTH

(DIVERSION DAM D)



* Depth (from rocksurface to middle of Testing Lengh)

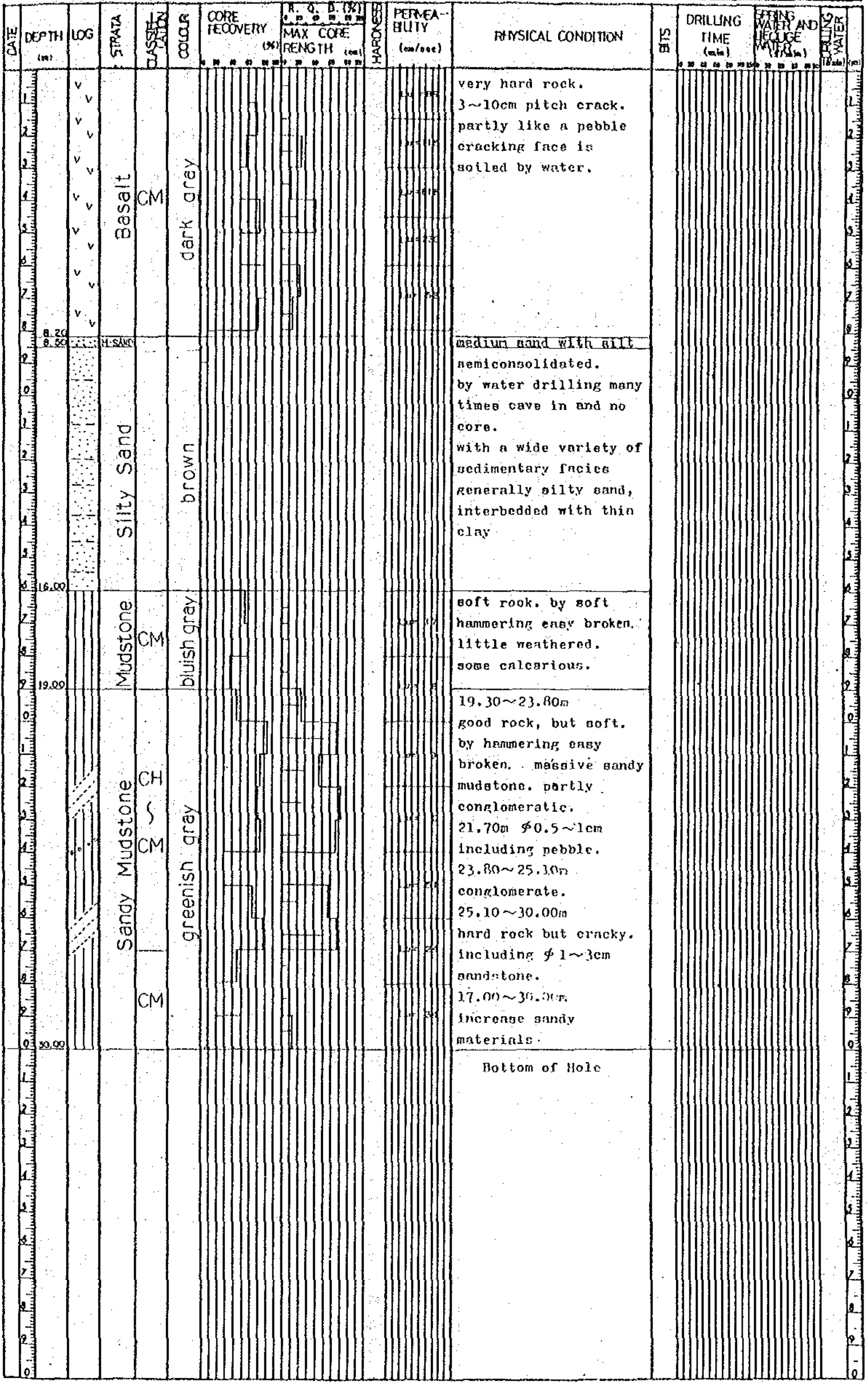
FIG. 4.4 - 8 Boring Log at Storage Dam A (1)

RQD = TOTAL CORE LENGTH (10cm OVER) / DRILLING LENGTH

BITS : MC=METAL CROWN SDB=SURFACE DIAMOND BIT IDB=IMPREGNATED DIAMOND BIT S=SINGLE W=DOUBLE

PROJECT Maechang Irrigation HOLE NO. BA - 1

BEGUN May 25 FINISHED May 27 1983	HOLE DIAMATER 59.4 ~ 75.0mm	HOLE LOGGED T. Kimura
GROUND ELEVATION 283.564	TOTAL DEPTH 30.00m	FOREMAN S. Thonglim
ANGLE FROM VERTICAL 0°	WATER TABLE GL -10.20m	



DEPTH (m)	STRATA	CLASSIFICATION	COLOUR	PHYSICAL CONDITION
8.20	Basalt	CM	dark gray	very hard rock. 3~10cm pitch crack. partly like a pebble cracking face is soiled by water.
8.50	M-SAND			medium sand with silt
16.00	Silty Sand		brown	semiconsolidated. by water drilling many times cave in and no core. with a wide variety of sedimentary facies generally silty sand, interbedded with thin clay
19.00	Mudstone	CM	bluish gray	soft rook. by soft hammering easy broken. little weathered. some calcarious.
30.00	Sandy Mudstone	CH ∫ CM CM	greenish gray	19.30~23.80m good rock, but soft. by hammering easy broken. massive sandy mudstone. partly conglomeratic. 21.70m ∮0.5~1cm including pebble. 23.80~25.10m conglomerate. 25.10~30.00m hard rock but cracky. including ∮1~3cm sandstone. 17.00~30.00m increase sandy materials.

Bottom of Hole

FIG. 4.4 - 9 Boring Log at Storage Dam A (2)

$$RQD = \frac{\text{TOTAL CORE LENGTH (10}^{cm}\text{ OVER)}}{\text{DRILLING LENGTH}}$$

BITS : MC = METAL CROWN SDB = SURFACE DIAMOND BIT IDB = IMPREGNATED DIAMOND BIT S = SINGLE W = DOUBLE

PROJECT Maechang Irrigation HOLE NO. BA - 2

BEGUN May 15 FINISHED May 15 1983	HOLE DIAMATER 59.4 ~ 75.0mm	HOLE LOGGED I. Kimura
GROUND ELEVATION 260.691	TOTAL DEPTH 15.00m	FOREMAN S. Thonglim
ANGLE FROM VERTICAL 0°	WATER TABLE GL = - 1.40m	

DATE	DEPTH (m)	LOG	STRATA	CLASSIFI-CATION	COLOUR	CORE RECOVERY (%)	R.Q.D. (%) MAX CORE LENGTH (cm)	HARDNESS	PERMEA-BILITY (cm/sec)	PHYSICAL CONDITION	BITS	DRILLING TIME (min)	FEEDING WATER AND LEAKAGE WATER (ℓ/min)	SPRING WATER (ℓ/min)
	5.00		Sand		brown					river deposits medium to corse sand with some silt. very loose				
	7.90		Sand and gravel		gray-brown					river deposit ϕ0.3~1cm small pebble sand and silt. loose				
	9.15		Sandy Mudstone	CM	reddish brown					good condition, soft rock. by soft hammering easy brocken. partly including thin fine sandstone.				
	9.25				bluish gray									
	12.00				reddish brown									
	15.00				bluish green					soft rock partly nocore by water drilling.				
										Bottom of Hole				

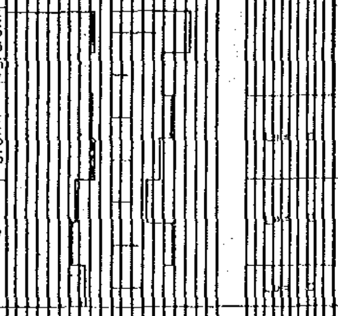


FIG. 4.4 - 10 Boring Log at Storage Dam A (3)

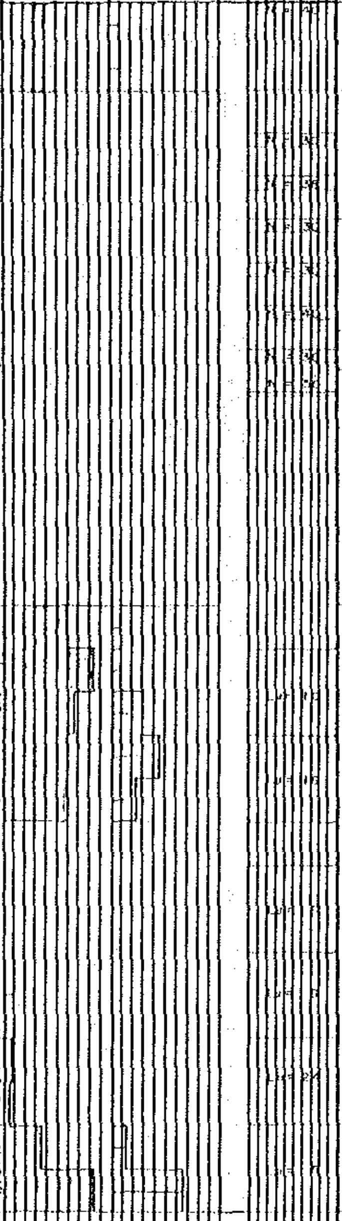
RQD = TOTAL CORE LENGTH (10cm OVER) / DRILLING LENGTH

BITS: MC=METAL CROWN SDB=SURFACE DIAMOND BIT IDD=IMPREGNATED DIAMOND BIT

S=SINGLE
W=DOUBLE

PROJECT Macchang Irrigation HOLE NO. BA – 3

BEGUN May 20 FINISHED May 22 1983	HOLE DIAMATER 59.4 ~ 75.0mm	HOLE LOGGED I. Kimura
GROUND ELEVATION 283.157	TOTAL DEPTH 28.00m	FOREMAN S. Thonglim
ANGLE FROM VERTICAL 0°	WATER TABLE GL = -18.05	



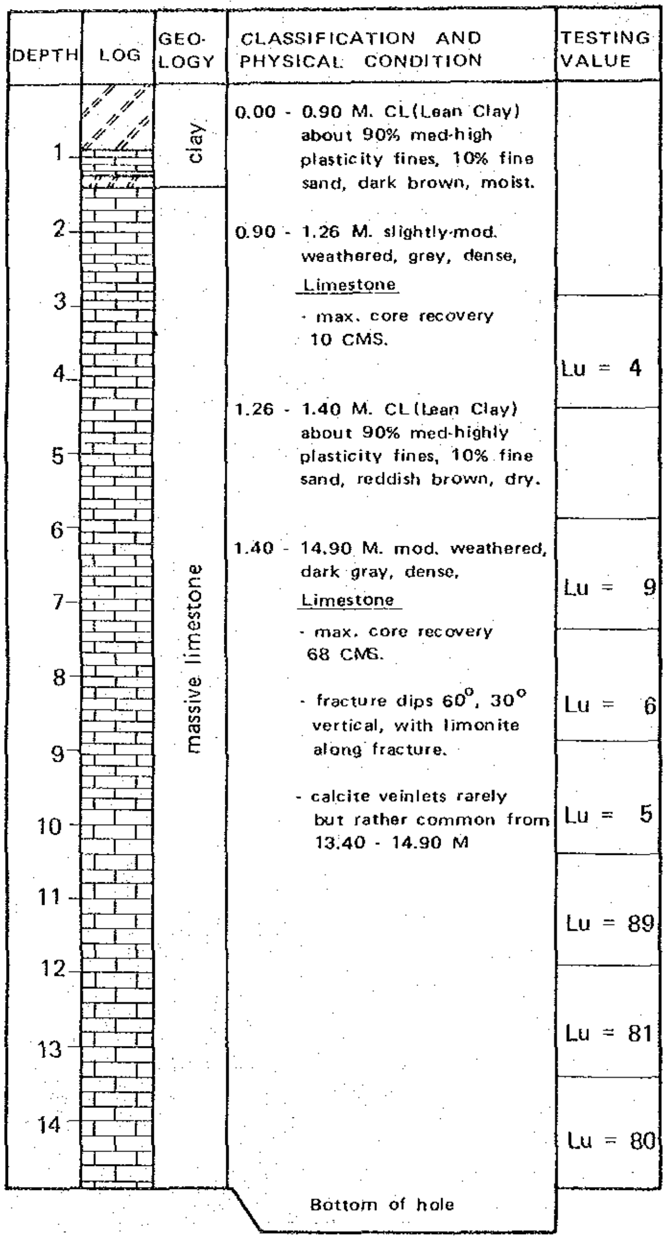
DATE	DEPTH (m)	STRATA	CLASSIFICATION	COLOUR	PHYSICAL CONDITION	BITS	DRILLING TIME (min)	SPRING WATER AND LEAKAGE WATER (ℓ/min)	DRILLING WATER (ℓ/min)
	2.00	Basalt		dark gray	0~2.00m vasalt lava flow like a boulder weathered rock.				
	5.00	Sand and Gravel with Clay		brown gray	2.00~14.00m semiconsolidated ϕ1~3cm pebble 20% matrix silty sand. very dence				
	7.60	Silty Sand		gray	very dence				
	8.50	Silt		dark gray					
	14.00	Silty Sand		pale brown	8.50~14.00m very stiff. like a soft rock. fine to medium sand with silt. 11.00~14.00m including pebble ϕ1~3cm				
		Sandy Mudstone	CL	reddish brown bluish green	14.00~18.70m soft rock. 14.00~16.00m heavey weathered soft. 16.00~18.70m fresh, partly core loss.				
	18.70		CM	reddish brown bluish gray					
	24.00	Sand Stone	CM	gray	18.70~24.00m silty~fine sandstone. almost no core by water drilling. soft rock.				
	26.00	Conglomerate	CM	reddish brown	including pebble ϕ1~3cm partly muddy				
	28.00	Sandy Mudstone	CM	reddish brown	massive				
					Bottom of Hole				

FIG. 4.4 - 11 Boring Log at Diversion Dam C (1)

HOLE NO. DHN.1

GROUND ELEVATION +250.087

WATER TABLE GL -9.80



0.00 - 0.90 M. CL(Lean Clay) about 90% med-high plasticity fines, 10% fine sand, dark brown, moist.

0.90 - 1.26 M. slightly-mod. weathered, grey, dense, Limestone
- max. core recovery 10 CMS.

1.26 - 1.40 M. CL(Lean Clay) about 90% med-highly plasticity fines, 10% fine sand, reddish brown, dry.

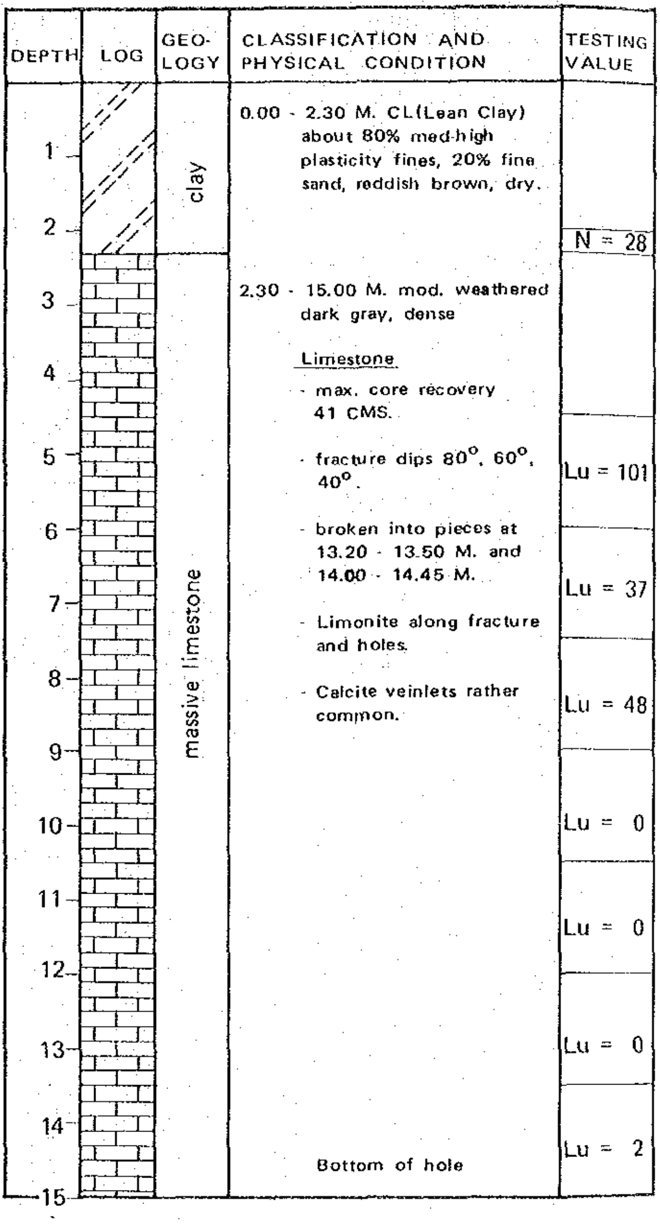
1.40 - 14.90 M. mod. weathered, dark gray, dense, Limestone
- max. core recovery 68 CMS.
- fracture dips 60°, 30° vertical, with limonite along fracture.
- calcite veinlets rarely but rather common from 13.40 - 14.90 M

Bottom of hole

HOLE NO. DHN.2

GROUND ELEVATION +250.059

WATER TABLE GL -9.00



0.00 - 2.30 M. CL(Lean Clay) about 80% med-high plasticity fines, 20% fine sand, reddish brown, dry.

2.30 - 15.00 M. mod. weathered dark gray, dense Limestone
- max. core recovery 41 CMS.
- fracture dips 80°, 60°, 40°.
- broken into pieces at 13.20 - 13.50 M. and 14.00 - 14.45 M.
- Limonite along fracture and holes.
- Calcite veinlets rather common.

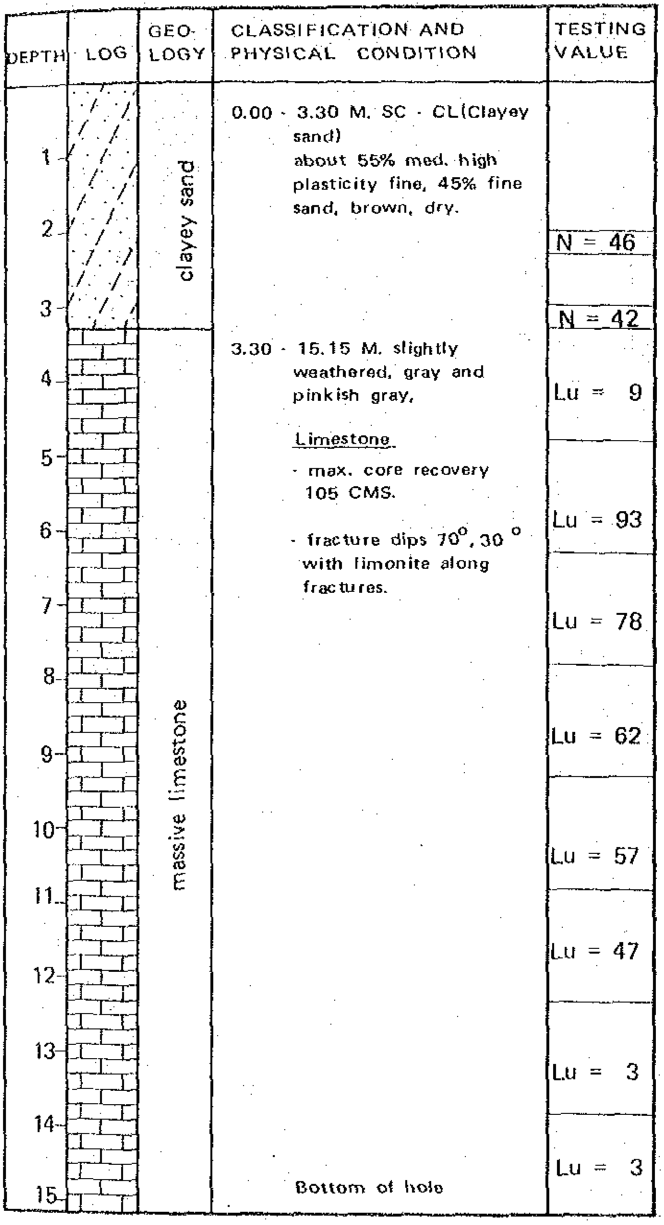
Bottom of hole

FIG. 4.4 - 12 Boring Log at Diversion Dam C (2)

HOLE NO. DHN.3

GROUND ELEVATION +250.897

WATER TABLE GL -10.30



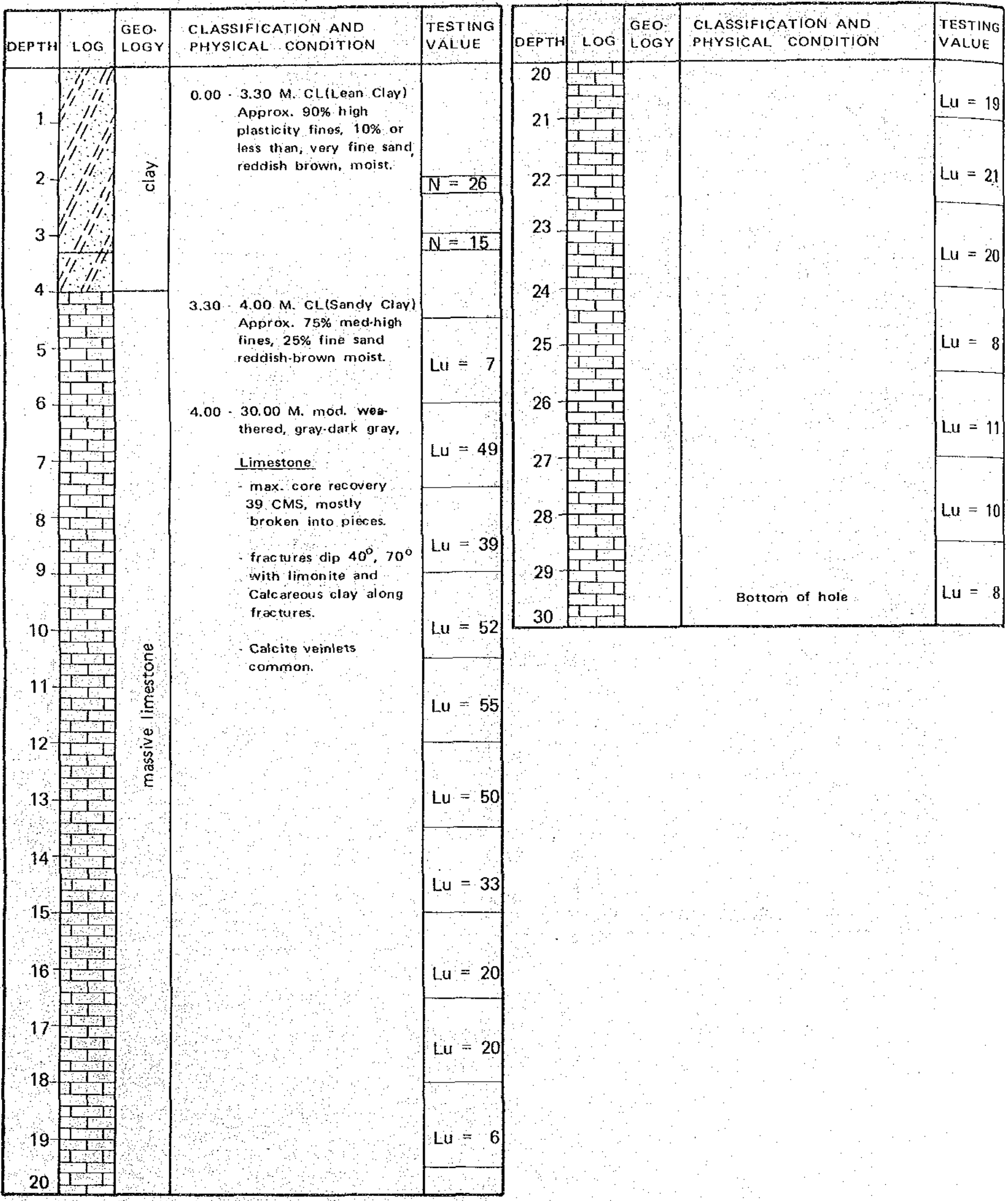
DEPTH	LOG	GEO-LOGY	CLASSIFICATION AND PHYSICAL CONDITION	TESTING VALUE
1 2 3		clayey sand	0.00 - 3.30 M. SC - CL(Clayey sand) about 55% med. high plasticity fine, 45% fine sand, brown, dry.	N = 46 N = 42
4 5 6 7 8 9 10 11 12 13 14 15		massive limestone	3.30 - 15.15 M. slightly weathered, gray and pinkish gray, Limestone - max. core recovery 105 CMS. - fracture dips 70°, 30° with limonite along fractures. Bottom of hole	Lu = 9 Lu = 93 Lu = 78 Lu = 62 Lu = 57 Lu = 47 Lu = 3 Lu = 3

FIG. 4.4 - 13 Boring Log at Diversion Dam C (3)

HOLE NO. DHN.4

GROUND ELEVATION +250.334

WATER TABLE GL -9.80



0.00 - 3.30 M. CL(Lean Clay) Approx. 90% high plasticity fines, 10% or less than, very fine sand, reddish brown, moist.

3.30 - 4.00 M. CL(Sandy Clay) Approx. 75% med-high fines, 25% fine sand reddish-brown moist.

4.00 - 30.00 M. mod. weathered, gray-dark gray,

Limestone

- max. core recovery 39 CMS, mostly broken into pieces.
- fractures dip 40°, 70° with limonite and Calcareous clay along fractures.
- Calcite veinlets common.

Bottom of hole

N = 26
N = 15
Lu = 7
Lu = 49
Lu = 39
Lu = 52
Lu = 55
Lu = 50
Lu = 33
Lu = 20
Lu = 20
Lu = 6
Lu = 19
Lu = 21
Lu = 20
Lu = 8
Lu = 11
Lu = 10
Lu = 8

FIG. 4.4 - 14 Boring Log at Diversion Dam C (4)

HOLE NO. DHN.5

GROUND ELEVATION +250.493

WATER TABLE GL -10.0

DEPTH	LOG	GEOLOGY	CLASSIFICATION AND PHYSICAL CONDITION	TESTING VALUE
1		clay	0.00 - 3.30 M. CL(Lean Clay) Approx. 85% Medium plasticity fines, 15% fine - very fine sand, brown-dark brown, dry, some roots.	
2				N = 27
3				N = 29
4			3.30 - 5.00 M. CL(Sandy Clay) Approx. 75% medium fines, 25% fine sand, reddish brown, dry.	N = 37
5		massive limestone		
6				Lu = 128
7			5.00 - 25.00 M. slightly-mod. weathered, gray-dark gray. Limestone - max. core recovery 24 CMS., most of core are broken into pieces. - fractures dips 45°, 70°, nearly vertical, with limonite and calcareous clay along fractures. - some calcite veinlets.	Lu = 85
8				
9				Lu = 53
10				Lu = 40
11				
12				Lu = 57
13				Lu = 2
14				
15				Lu = 2
16				
17				Lu = 4
18				Lu = 6
19				Lu = 7
20				

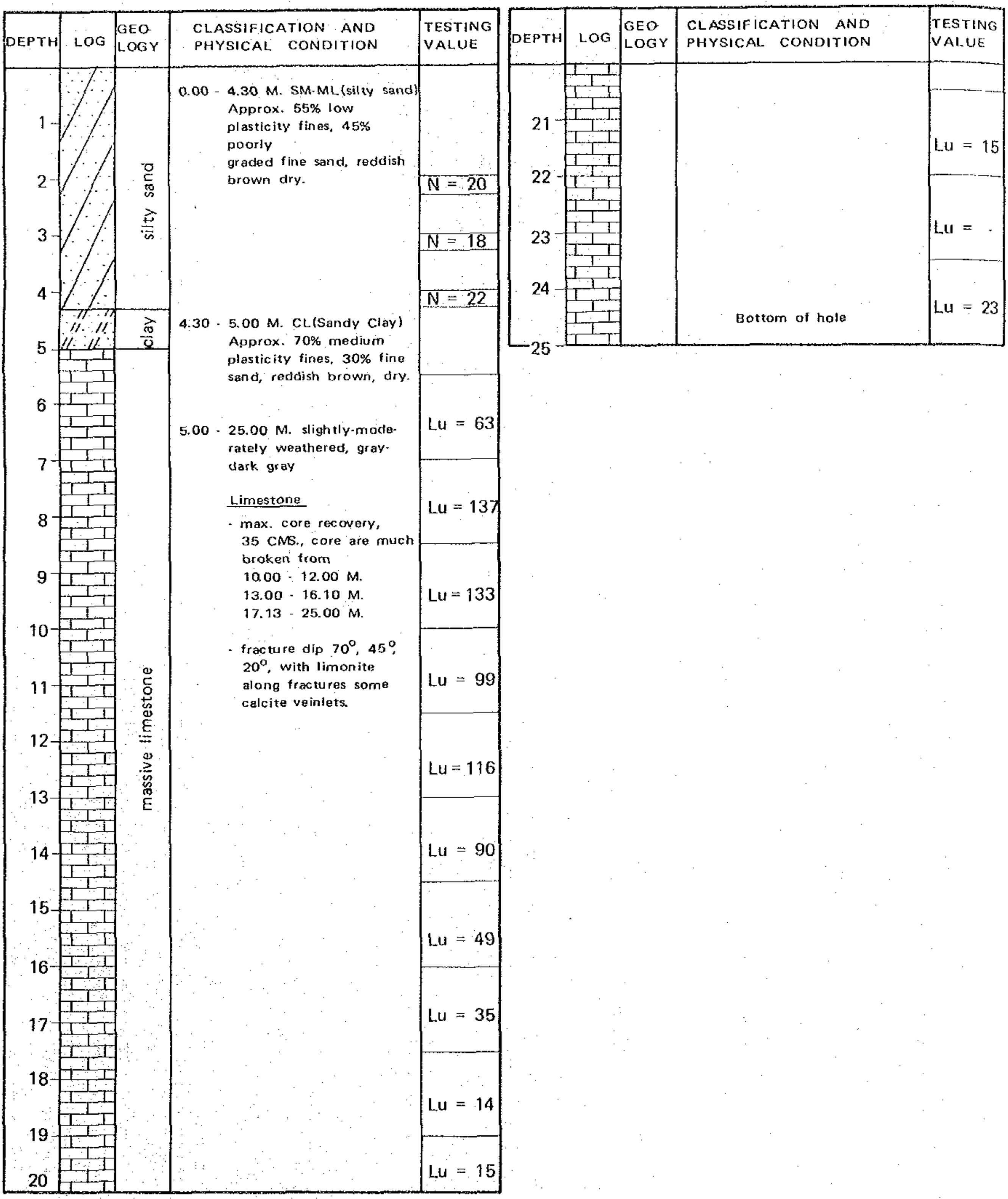
DEPTH	LOG	GEOLOGY	CLASSIFICATION AND PHYSICAL CONDITION	TESTING VALUE
21				Lu = 6
22				Lu = 7
23				
24			Bottom of hole	Lu = 9
25				

FIG. 4.4 - 15 Boring Log at Diversion Dam C (5)

HOLE NO. DHN.6

GROUND ELEVATION +252.025

WATER TABLE GL -11.80



0.00 - 4.30 M. SM-ML(silty sand) Approx. 55% low plasticity fines, 45% poorly graded fine sand, reddish brown dry.

4.30 - 5.00 M. CL(Sandy Clay) Approx. 70% medium plasticity fines, 30% fine sand, reddish brown, dry.

5.00 - 25.00 M. slightly-moderately weathered, gray-dark gray

Limestone

- max. core recovery, 35 CMS., core are much broken from
  10.00 - 12.00 M.
  13.00 - 16.10 M.
  17.13 - 25.00 M.
- fracture dip 70°, 45°, 20°, with limonite along fractures some calcite veinlets.

Bottom of hole

FIG. 4.4 - 16 Boring Log at Diversion Dam C (6)

HOLE NO. DHN.7

GROUND ELEVATION +250.883

WATER TABLE GL -10.40

DEPTH	LOG	GEOLOGY	CLASSIFICATION AND PHYSICAL CONDITION	TESTING VALUE
1		silty sand	0.00 - 1.00 M. SM-ML(Silty Sand) Approx. 55% low plasticity fines, 45% fine sand, brown, dry.	
2		clay		N = 32
3			1.00 - 3.30 M. CL(Sandy Clay) Approx. 80% med-high plasticity fines, 20% fine brown, moist.	N = 22
4		massive limestone		Lu = 33
5				
6			3.30 - 3.50 M. (Gravelly Clay) Approx. 75% med-high plasticity fines, 15% sand, subangular gravel, 10% fine sand, brown, moist.	Lu - 64
7				
8			3.50 - 25.00 M. slightly-mod. weathered, massive, gray-dark gray, Limestone - max. core recovery 75 CMS. and some are broken. - fractures dip 45°, 70°, with limonite along fracture. - Calcite veinlets rather common.	Lu = -
9				Lu = 131
10				
11				Lu = 117
12				Lu = 9
13				
14				Lu = 37
15				Lu = 101
16				
17				Lu = 106
18				
19				Lu = 99
20				Lu = 60

DEPTH	LOG	GEOLOGY	CLASSIFICATION AND PHYSICAL CONDITION	TESTING VALUE
21				Lu = 12
22				
23				Lu = 1
24			Bottom of hole	Lu = 1
25				

FIG. 4.4 - 17 Boring Log at Diversion Dam C (7)

HOLE NO. DH.8

GROUND ELEVATION +252.230

WATER TABLE GL -11.90

DEPTH	LOG	GEO-LOGY	CLASSIFICATION AND PHYSICAL CONDITION	TESTING VALUE
1		silty sand	0.00 - 4.65 M. SM-ML(Silty Sand) About 65 - 75% poor graded fine sand, 30 - 35% low plasticity fines, brown, dry, some roots.	
2				N = 29
3				
4				
5		massive limestone	4.65 - 12.00 M. $^{s}_{ss}$ Slightly-mod, weathered, pinkish gray, dense Limestone - max. core recovery 44 CMS. - fracture dips 60°, 45° with limonite along fracture. - Broken into pieces 9.45 - 10.40 M and 11.20 - 11.80 M.	
6				
7				
8				
9				
10				
11				
12				
13				Lu=113
14			Bottom of hole	Lu=113
15				

HOLE NO. DH.9

GROUND ELEVATION +250.548

WATER TABLE GL -8.80

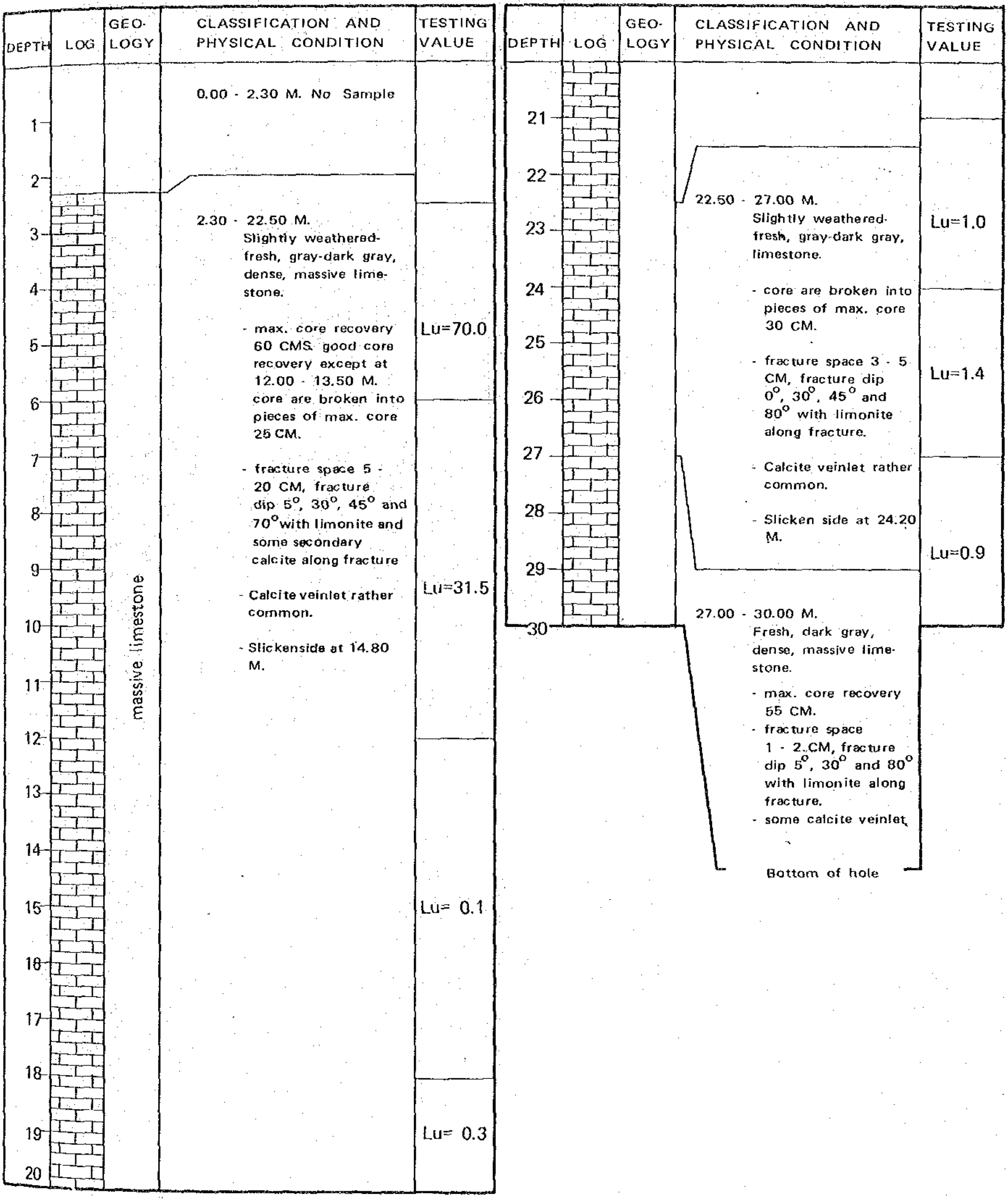
DEPTH	LOG	GEO-LOGY	CLASSIFICATION AND PHYSICAL CONDITION	TESTING VALUE
1		boulder	0.00 - 0.85 M. Slightly-mod. weathered, dark gray, dense.	
2		massive limestone	Limestone (Block insitu)	Lu = 12
3			0.85 - 1.00 M. SC-CL(Clayey Sand) About 55% fine sand, 45% low-med. plasticity fines, dark brown, moist.	
4				Lu = 5
5				Lu = 9
6			1.00 - 12.00 M. Slightly-mod. weathered, dark gray, dense Limestone - max. core recovery 32 CMS. - fracture dips 70°, 20°, 70°, 10° with limonite along fracture. - Calcite veinlets are rather common. - Broken into pieces from 3.20 - 4.05 M.	
7				Lu = 3
8				Lu = 14
9				
10				Lu = 28
11				Lu = 29
12				
13				Lu = 29
14				Lu = 38
15				Lu = 75
16				
17				Lu = 60
18			Bottom of hole	Lu=142

FIG. 4.4 - 18 Boring Log at Diversion Dam C (8)

HOLE NO. P.1

GROUND ELEVATION +250.65

WATER TABLE GL -9.60



0.00 - 2.30 M. No Sample

2.30 - 22.50 M.
Slightly weathered-fresh, gray-dark gray, dense, massive limestone.

- max. core recovery 60 CMS. good core recovery except at 12.00 - 13.50 M. core are broken into pieces of max. core 25 CM.
- fracture space 5 - 20 CM, fracture dip 5°, 30°, 45° and 70° with limonite and some secondary calcite along fracture
- Calcite veinlet rather common.
- Slickenside at 14.80 M.

22.50 - 27.00 M.
Slightly weathered-fresh, gray-dark gray, limestone.

- core are broken into pieces of max. core 30 CM.
- fracture space 3 - 5 CM, fracture dip 0°, 30°, 45° and 80° with limonite along fracture.
- Calcite veinlet rather common.
- Slicken side at 24.20 M.

27.00 - 30.00 M.
Fresh, dark gray, dense, massive limestone.

- max. core recovery 55 CM.
- fracture space 1 - 2 CM, fracture dip 5°, 30° and 80° with limonite along fracture.
- some calcite veinlet

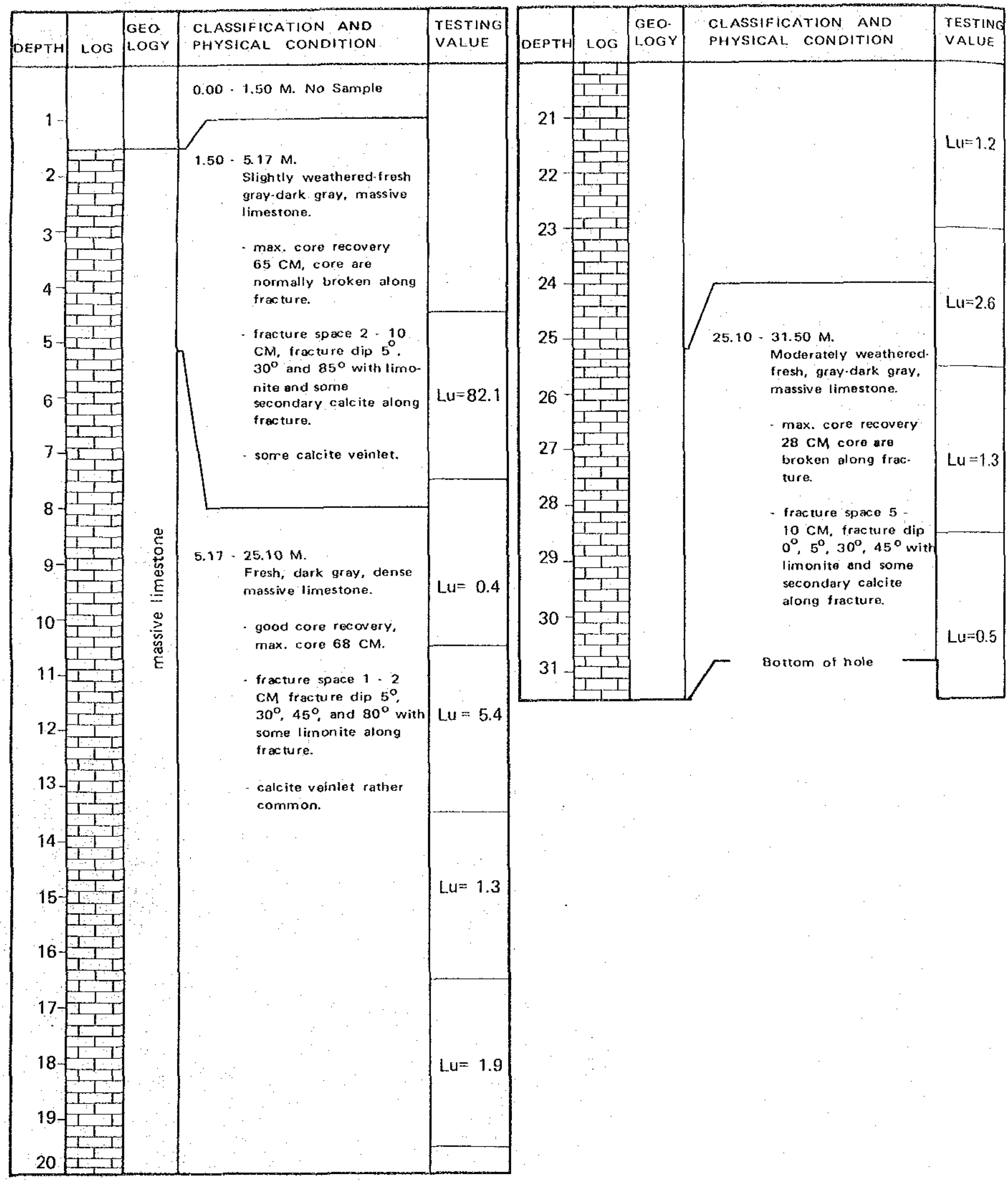
Bottom of hole

FIG. 4.4 - 19 Boring Log at Diversion Dam C (9)

HOLE NO. P.2

GROUND ELEVATION +250.65

WATER TABLE GL - 9.80



0.00 - 1.50 M. No Sample

1.50 - 5.17 M.
Slightly weathered-fresh gray-dark gray, massive limestone.

- max. core recovery 65 CM, core are normally broken along fracture.
- fracture space 2 - 10 CM, fracture dip 5°, 30° and 85° with limonite and some secondary calcite along fracture.
- some calcite veinlet.

5.17 - 25.10 M.
Fresh, dark gray, dense massive limestone.

- good core recovery, max. core 68 CM.
- fracture space 1 - 2 CM fracture dip 5°, 30°, 45°, and 80° with some limonite along fracture.
- calcite veinlet rather common.

25.10 - 31.50 M.
Moderately weathered-fresh, gray-dark gray, massive limestone.

- max. core recovery 28 CM core are broken along fracture.
- fracture space 5 - 10 CM, fracture dip 0°, 5°, 30°, 45° with limonite and some secondary calcite along fracture.

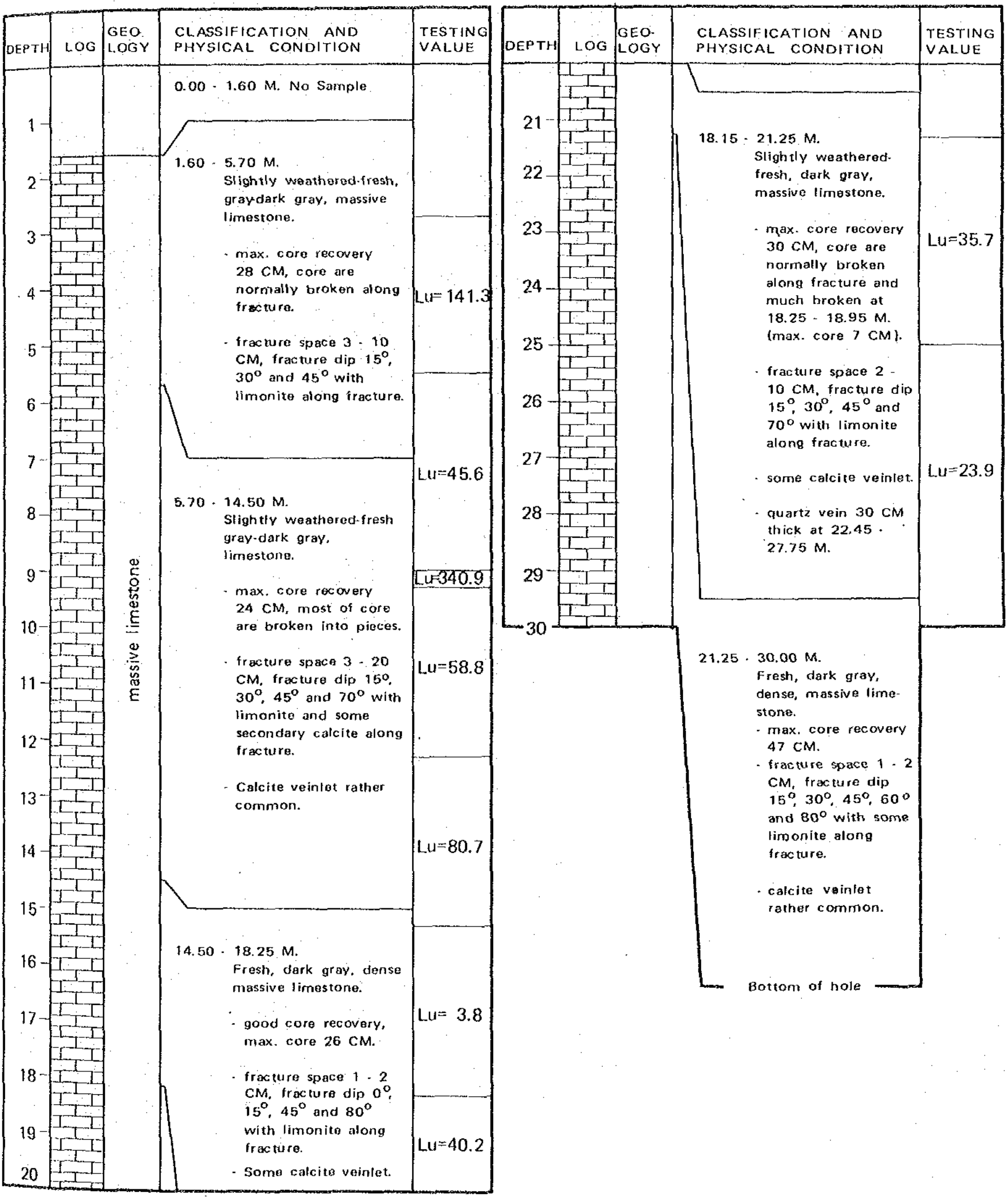
Bottom of hole

FIG. 4.4 - 20 Boring Log at Diversion Dam C (10)

HOLE NO. P.3

GROUND ELEVATION +250.65

WATER TABLE GL -9.40



0.00 - 1.60 M. No Sample

1.60 - 5.70 M.
Slightly weathered-fresh, gray-dark gray, massive limestone.

- max. core recovery 28 CM, core are normally broken along fracture.
- fracture space 3 - 10 CM, fracture dip 15°, 30° and 45° with limonite along fracture.

5.70 - 14.50 M.
Slightly weathered-fresh gray-dark gray, limestone.

- max. core recovery 24 CM, most of core are broken into pieces.
- fracture space 3 - 20 CM, fracture dip 15°, 30°, 45° and 70° with limonite and some secondary calcite along fracture.
- Calcite veinlet rather common.

14.50 - 18.25 M.
Fresh, dark gray, dense massive limestone.

- good core recovery, max. core 26 CM.
- fracture space 1 - 2 CM, fracture dip 0°, 15°, 45° and 80° with limonite along fracture.
- Some calcite veinlet.

18.15 - 21.25 M.
Slightly weathered-fresh, dark gray, massive limestone.

- max. core recovery 30 CM, core are normally broken along fracture and much broken at 18.25 - 18.95 M. (max. core 7 CM).
- fracture space 2 - 10 CM, fracture dip 15°, 30°, 45° and 70° with limonite along fracture.
- some calcite veinlet.
- quartz vein 30 CM thick at 22.45 - 27.75 M.

21.25 - 30.00 M.
Fresh, dark gray, dense, massive limestone.

- max. core recovery 47 CM.
- fracture space 1 - 2 CM, fracture dip 15°, 30°, 45°, 60° and 80° with some limonite along fracture.
- calcite veinlet rather common.

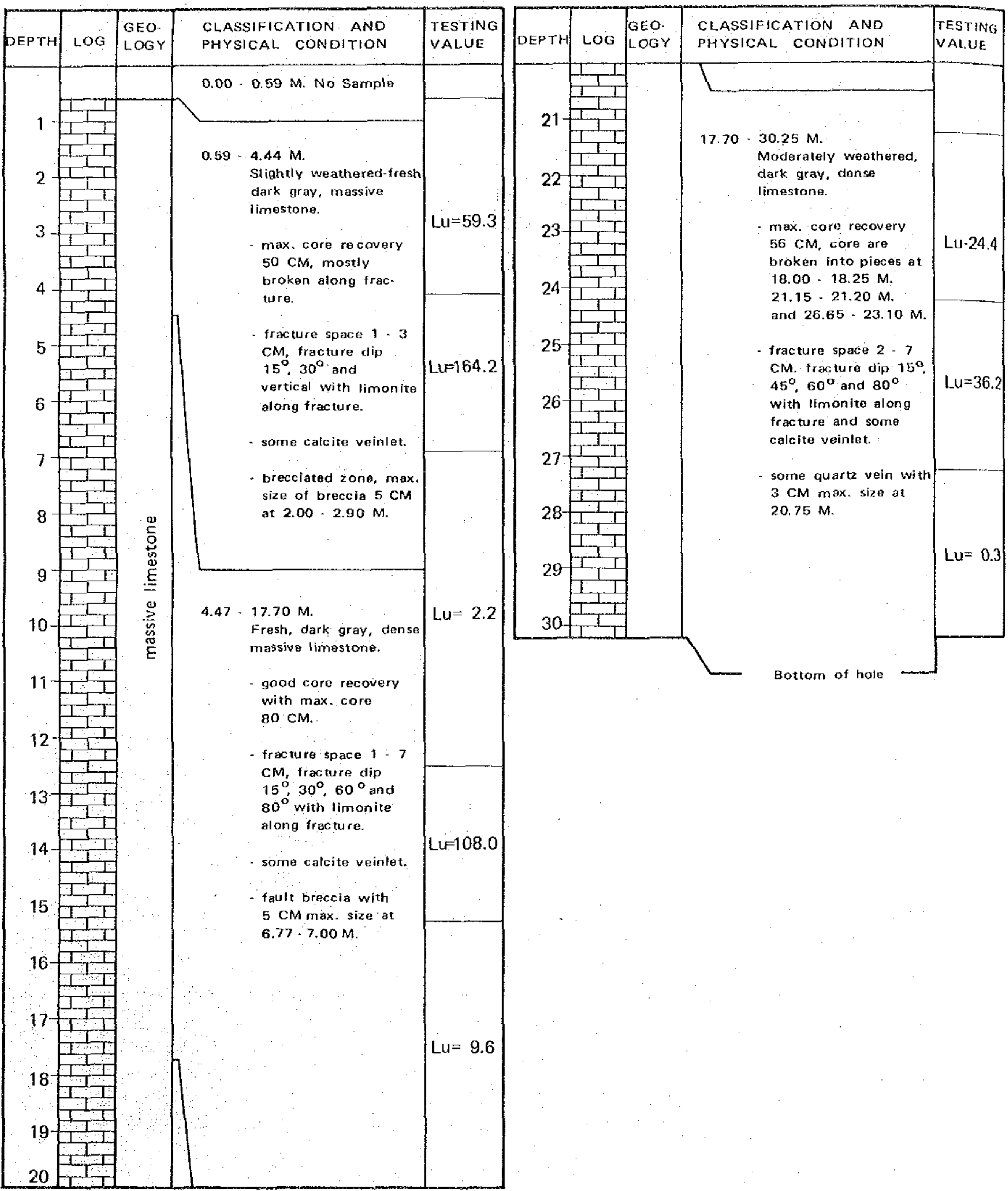
Bottom of hole

FIG. 4.4 - 21 Boring Log at Diversion Dam C (11)

HOLE NO. P.4

GROUND ELEVATION +250.65

WATER TABLE GL -6.40



0.00 - 0.59 M. No Sample

0.59 - 4.44 M.
Slightly weathered-fresh dark gray, massive limestone.

- max. core recovery 50 CM, mostly broken along fracture.
- fracture space 1 - 3 CM, fracture dip 15°, 30° and vertical with limonite along fracture.
- some calcite veinlet.
- brecciated zone, max. size of breccia 5 CM at 2.00 - 2.90 M.

4.47 - 17.70 M.
Fresh, dark gray, dense massive limestone.

- good core recovery with max. core 80 CM.
- fracture space 1 - 7 CM, fracture dip 15°, 30°, 60° and 80° with limonite along fracture.
- some calcite veinlet.
- fault breccia with 5 CM max. size at 6.77 - 7.00 M.

17.70 - 30.25 M.
Moderately weathered, dark gray, dense limestone.

- max. core recovery 56 CM, core are broken into pieces at 18.00 - 18.25 M. 21.15 - 21.20 M. and 26.65 - 23.10 M.
- fracture space 2 - 7 CM. fracture dip 15°, 45°, 60° and 80° with limonite along fracture and some calcite veinlet.
- some quartz vein with 3 CM max. size at 20.75 M.

Bottom of hole

TESTING VALUE

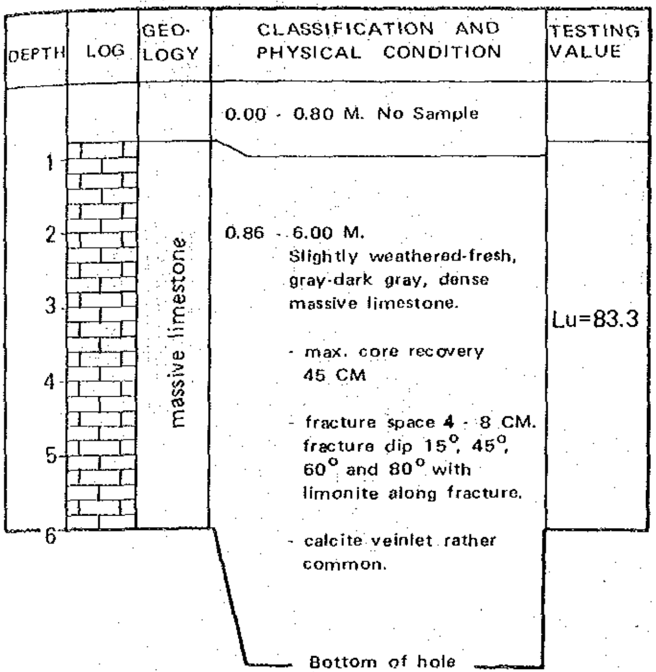
Lu=59.3
Lu=164.2
Lu= 2.2
Lu=108.0
Lu= 9.6
Lu-24.4
Lu=36.2
Lu= 0.3

FIG. 4.4 - 22 Boring Log at Diversion Dam C (12)

HOLE NO. P.25

GROUND ELEVATION +250.65

WATER TABLE



0.00 - 0.80 M. No Sample

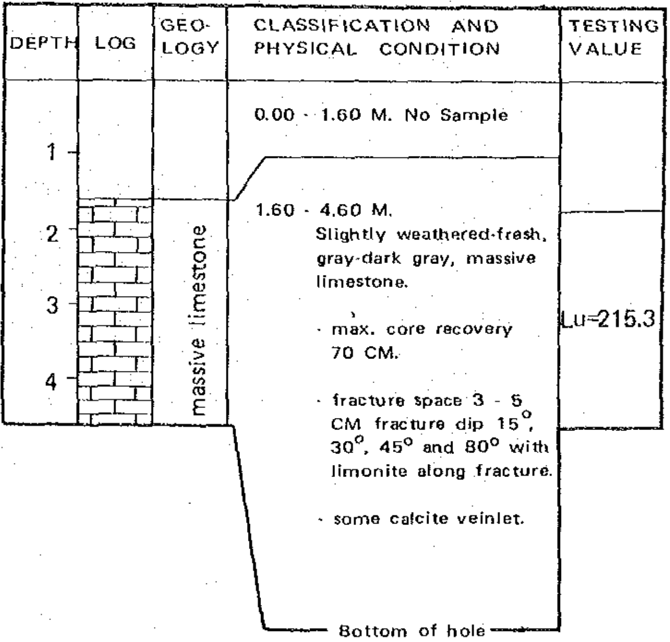
0.86 - 6.00 M.
Slightly weathered-fresh, gray-dark gray, dense massive limestone.

- max. core recovery 45 CM
- fracture space 4 - 8 CM. fracture dip 15°, 45°, 60° and 80° with limonite along fracture.
- calcite veinlet rather common.

HOLE NO. S.1

GROUND ELEVATION +250.65

WATER TABLE



0.00 - 1.60 M. No Sample

1.60 - 4.60 M.
Slightly weathered-fresh, gray-dark gray, massive limestone.

- max. core recovery 70 CM.
- fracture space 3 - 5 CM fracture dip 15°, 30°, 45° and 80° with limonite along fracture.
- some calcite veinlet.

FIG. 4.4 - 23 Boring Log at Diversion Dam D (1)

RQD = TOTAL CORE LENGTH (10cm OVER) / DRILLING LENGTH

BITS: MC=METAL CROWN SDB=SURFACE DIAMOND BIT IDB=IMPREGNATED DIAMOND BIT S=SINGLE W=DOUBLE

PROJECT Macchang Irrigation HOLE NO. BD-1

BEGUN Apr. 26 FINISHED Apr. 30 1983
GROUND ELEVATION 265.253
ANGLE FROM VERTICAL 0°
HOLE DIAMATER 59.4 ~ 57.0mm
TOTAL DEPTH 33.00m
WATER TABLE GL = - 3.50m
HOLE LOGGED I. Kimura
FOREMAN S. Thonglim

DEPTH (m)	STRATA	CLASSIFICATION	COLOUR	PHYSICAL CONDITION
2.00	Silt, Gravel		brown	0~2.0m talus deposit. mudstone weathered pebble and silt loose.
7.00	Sandy Shale	CM (CL)	pale brown	2.00~7.00m weathered rock. heavey cracky rock. partly fine sandstone bedding plane 40~43°
11.50	Sandy Shale	CH	bluish gray	7.00~11.50m fresh hard rock. good condition. 2.00~9.00m soiled by water
15.90	Calcarious Sandstone	CH	bluish gray	11.50~15.90m fresh, hard, good rock. joint pitch 5~30cm 15.30~15.90m corse sandstone
16.40	Shale	CH	blue	
18.50	Calcarious Sandstone	CH	bluish gray	partly cracky, hard and fresh. including thin shale.
19.00	Shale	CM	bluish gray	
20.00	Share zone	CL	bluish gray	fault. share zone. cracky rock,
22.20	Tuff breccia	CM	bluish gray	20.00~30.20m including many ϕ1~3cm sandstone, limestone pebble. generally hard but brittle, by hammering easy broken, partly including shale.
30.20	Tuff breccia	CM (CH)	reddish brown	
33.00	Sandstone		pale blue	medium~corse sandstone good condition

FIG. 4.4 - 24 Boring Log at Diversion Dam D (2)

RQD = $\frac{\text{TOTAL CORE LENGTH (10cm OVER)}}{\text{DRILLING LENGTH}}$

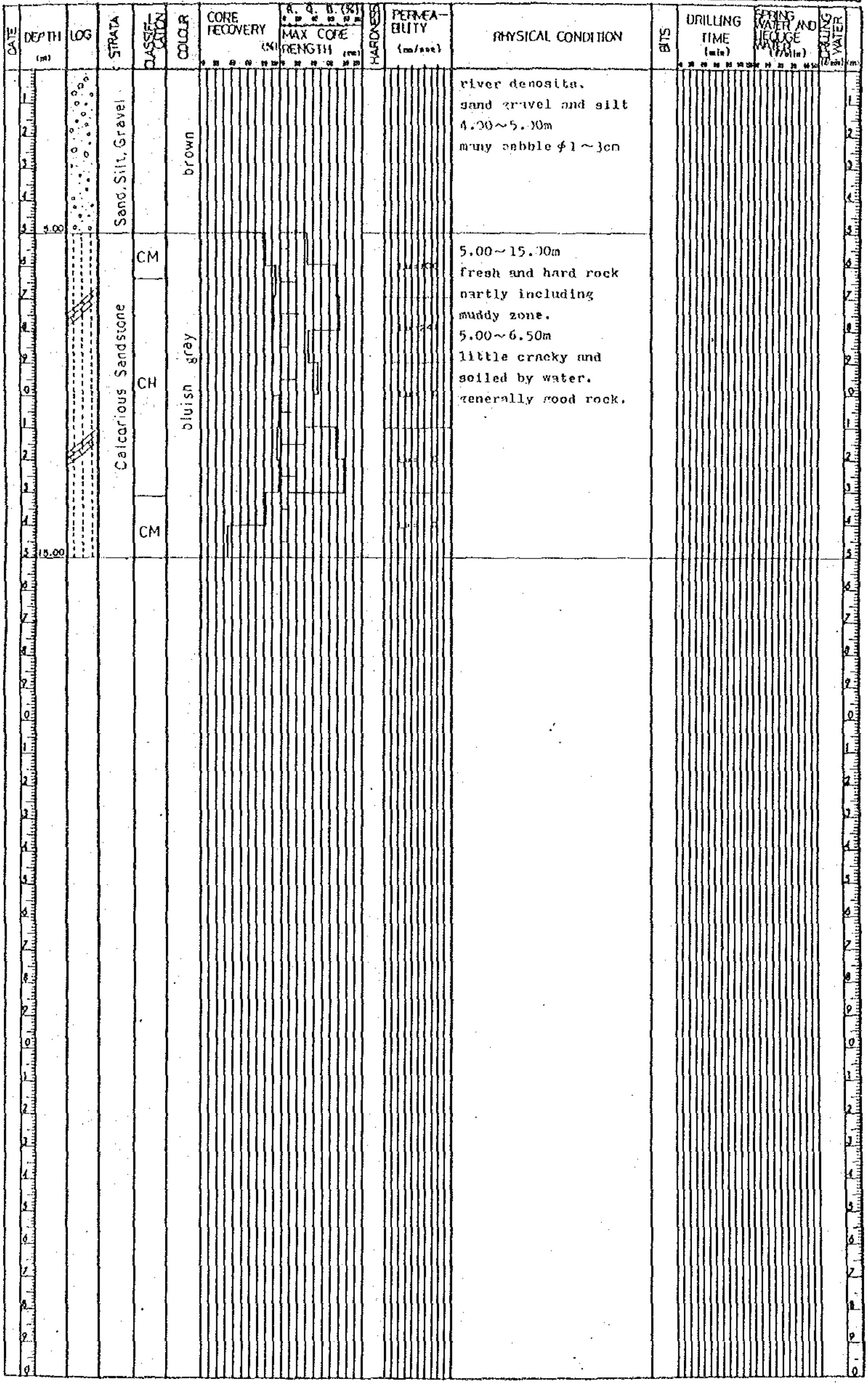
BITS: MC=METAL CROWN SDB=SURFACE DIAMOND BIT IDB=IMPREGNATED DIAMOND BIT S=SINGLE W=DOUBLE

PROJECT Macchang Irrigation HOLE NO. BD - 2

BEGUN Apr. FINISHED Apr. 23 1903
GROUND ELEVATION 237.266
ANGLE FROM VERTICAL 0°

HOLE DIAMATER 59.4 ~ 75.0mm
TOTAL DEPTH 15.00 m
WATER TABLE GL = - 1.20m

HOLE LOGGED T. Kimura
FOREMAN S. Thonglun



river deposits.
sand gravel and silt
4.00~5.00m
many pebble ϕ1~3cm

5.00~15.00m
fresh and hard rock
partly including
muddy zone.
5.00~6.50m
little cracky and
soiled by water.
generally good rock.

FIG. 4.4 - 25 Boring Log at Diversion Dam D (3)

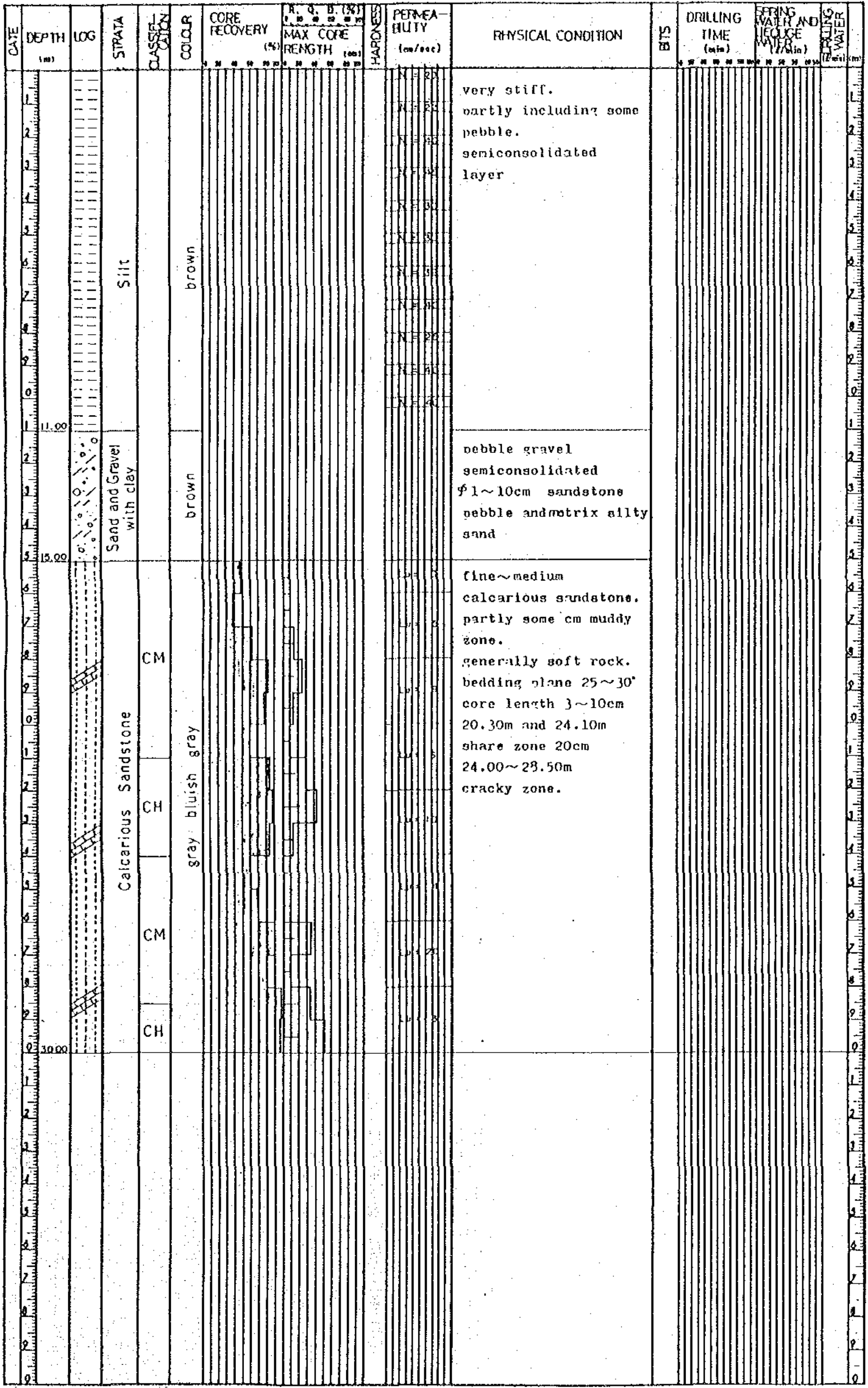
RQD = TOTAL CORE LENGTH (10cm OVER) / DRILLING LENGTH

BITS: MC=METAL CROWN SDB=SURFACE DIAMOND BIT IDB=IMPREGNATED DIAMOND BIT

S=SINGLE
W=DOUBLE

PROJECT Macchang Irrigation HOLE NO. BD - 3

BEGUN May 4 FINISHED May 10 1983	HOLE DIAMATER 59.4 ~ 75.0mm	HOLE LOGGED I. Kimura
GROUND ELEVATION 250.479	TOTAL DEPTH 30.00m	FOREMAN S. Thonglim
ANGLE FROM VERTICAL 0°	WATER TABLE GL → -12.50m	



very stiff.
partly including some pebble.
semiconsolidated layer

pebble gravel
semiconsolidated
ϕ1~10cm sandstone
pebble andmatrix silty sand

fine~medium
calcarious sandstone.
partly some cm muddy zone.
generally soft rock.
bedding plane 25~30°
core length 3~10cm
20.30m and 24.10m
share zone 20cm
24.00~28.50m
cracky zone.