

Feature Small-Scale Hydroelectric project Xe Katam

Country Lao P.D.R

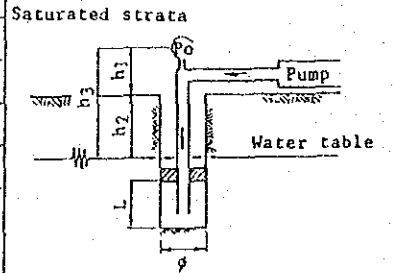
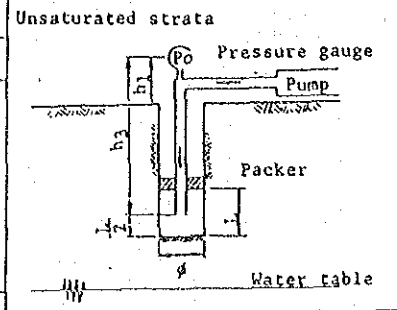
Location Intake Dam Coordinates

Reporter THONGSAY

Date of test 3-11-1971

Firm name (HEC)

Bore hole	Elevation of top	468.0 m	Diameter (φ) 66 mm; Size
	Dip	90°	Bearing
Test section	Stage NO.	1	Geology Basalt lava
	Depth of packer & hole bottom	1.00 m - 6.00 m	
	Elev. of packer & hole bottom	m - m	
	Length (L)	5 m	
Height of gauge (h ₁)	1.1 m		
Water table (h ₂)	0.3 m		Temperature of injected water °C
Pump	Mfr. model	MG-5A	Type
	Max. discharge	70 l/min	Min. graduation
	Max. pressure	60 kg/cm ²	Min.
Type of packer		kg/cm ²	Max.



* Effective pressure (kg/cm²) : $P = P_0 + 1/(10(h_3 - h_4))$, h₄ = head loss

** Lugeon value (Lu) to be calculated by following equation
Lugeon value (l/min/m/10kg/cm²) : $Lu = 10 Q/(P \cdot L)$

Time	Elapsed	Gauge pressure	Effective pressure	Water pumped-in			Lugeon value	Remarks
				Integrated	Sectional	Const. rate		
hr	min	Po (kg/cm ²)	P (kg/cm ²)	(l)	Flow (l/min)	Q (l/min)	(Lu)	
10	22	0	1.14					
	23	1		0				
	24	2		0				
	25	3		0				
	26	4		0				
	27	5		0				
	28	6		0				
	29	7		0				
	30	8		0				
	31	9		0				
	32	10		0		0.0		
10	34	0	3.14					} It should be better not to extend time interval.
	35	1		0				
	36	2		2				
	37	3		3				
	38	4		5				
	39	5		6				
	40	6		8				
	41	7		9				

Stage NO.		1		Depth of packer & hole bottom	1.0 m - 6.0 m		Test length	5 m		Reporter
Time		Gauge pressure P ₀ (kg/cm ²)	Effective pressure P (kg/cm ²)	Water pumped-in			Lugeon value (Lu)	Remarks		
hr	min			Elapsed min	Integrated (L)	Sectional flow (l/min)			Const. rate of flow Q (l/min)	
10	42	8	3	3.14	11					
	43	9			12					
	44	10			14		1.4			
10	46	0	5	5.14						
	47	1			16					
	48	2			21					
	49	3			24					
	50	4			26					
	51	5			28					
	52	6			31					
	53	7			34					
	54	8			37					
	55	9			40					
	56	10			43		2.9			
									Don't set 1 time interval	
11	7	0	3	3.14						
	8	1			44					
	9	2			45					
	10	3			46					
	11	4			47					
	12	5			48					
	13	6			49					
	14	7			50					
	15	8			51					
	16	9			52					
	17	10			53		1.0			
11	18	0	1	1.14						
	19	1			53					
	20	2			"					
	21	3			"					
	22	4			"					
	23	5			"		0.0			

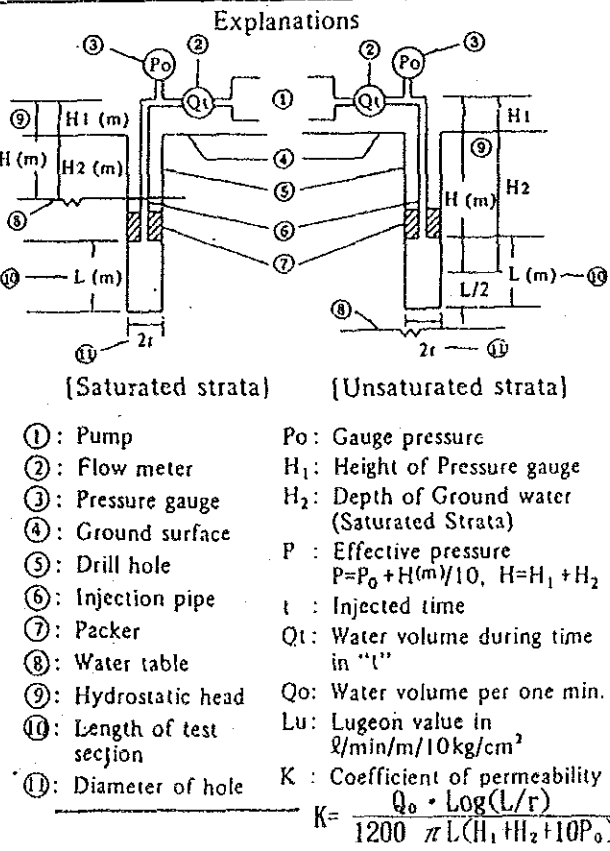
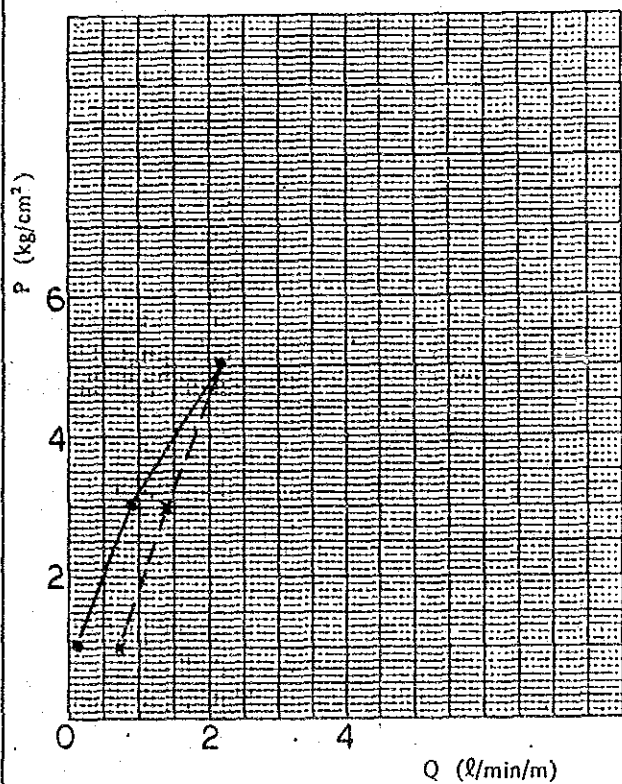
Stage NO.		Depth of packer & hole bottom		Test length		Reporter			
1		1.0 m- 6.0 m		5.0 m					
Time			Gauge pressure P _o (kg/cm ²)	Effective pressure P(kg/cm ²)	Water pumped-in			Lugeon value (Lu)	Remarks
hr	min	Elapsed min			Integrated (ℓ)	Sectional flow (ℓ/min)	Const. rate of flow Q (ℓ/min)		
11	24	6	1	1.14	53				
	25	7	"	"	"				
	26	8	"	"	"				
	27	9	"	"	"				
	28	10	"	"	"		0.0		

PERMEABILITY TEST IN DRILL HOLE (SHEET / OF /)

XE KATAM PROJECT HOLE No. KI-1

LOCATION INTAKE DAM DEPTH OF HOLE 15.0 m TEST DATE Mar. 12, '91
 ELEVATION 468.0m DIAMETER OF HOLE 6.6 cm TESTED BY H. WATANABE
 COORDINATE _____ DRILLED DEPTH 10.0 m DRILLED BY THONGSAY
 ANGLE FROM HORIZONTAL 90° LEVEL OF WATER TABLE _____ CHECKED BY I. SHIMIZU
 BEARING OF ANGLE HOLE _____ BEFORE T. 2.3 m AFTER T. _____ m
 TEST SECTION FROM 5.0 m TO 10.0 m

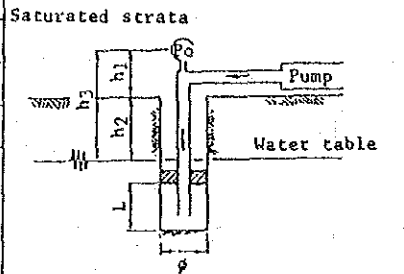
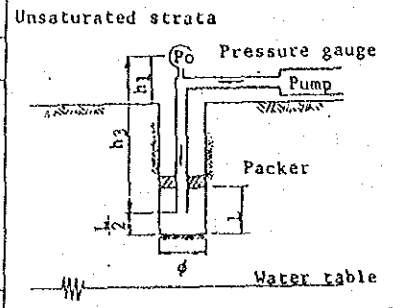
L (m)	H ₁ (m)	H ₂ (m)	P ₀ (kg/cm ²)	P (kg/cm ²)	t (min)	Q _t (ℓ)	Q ₀ (ℓ/min)	Q (ℓ/min/m)	Lu (Lugeon)	K (cm/sec)
1	0.1	0.3	1.0	1.04	10	6	0.6	0.12	1.15	0.67 × 10 ⁻⁵
1	"	"	3.0	3.04	10	45	4.5	0.90	2.96	1.71 × 10 ⁻⁵
1	"	"	5.0	5.04	10	109	10.9	2.18	4.33	2.50 × 10 ⁻⁵
1	"	"	3.0	3.04	10	70	7.0	1.40	4.61	2.67 × 10 ⁻⁵
1	"	"	1.0	1.04	10	36	3.6	0.72	6.92	4.00 × 10 ⁻⁵



Feature project **Xe Katam**
 Location **Intake Dam** Coordinates
 Date of test **3-12-1991**

Country **Lao P.D.R**
 Reporter **THONGSAY**
 Firm name (**HEC**)

Bore hole	Elevation of top	488.0 m	Diameter(φ) 60 mm; Size
	Dip	90°	Bearing
Test section	Stage NO.	2	Geology Basalt lava
	Depth of packer & hole bottom	5.00 m - 10.00 m	
	Elev. of packer & hole bottom	m - m	
	Length (L)	5 m	
Height of gauge (h ₁)	0.1 m		
Water table (h ₂)	0.3 m	Temperature of infected water	°C
Pump	Mfr. model	MG-5A	Type
	Max. discharge	70 l/min	Min. graduation
	Max. pressure	60 kg/cm ²	Min.
	Type of packer	kg/cm ²	Max.



* Effective pressure (kg/cm²) : $P = P_0 + 1/10(h_3 - h_4)$, $h_4 =$ head loss
 ** Lugeon value (Lu) to be calculated by following equation
 Lugeon value (l/min/m/10kg/cm²) : $Lu = 10 Q/P \cdot L$

Time		Gauge pressure Po (kg/cm ²)	Effective pressure P (kg/cm ²)	Water pumped-in			Lugeon value (Lu)	Remarks
hr	min			Integrated (l)	Sectional flow (l/min)	Const. rate of flow (l/min)		
15	11	1	1.0x	0				
	12	"	"	0				
	13	"	"	1				
	14	"	"	"				
	15	"	"	2				
	16	"	"	3				
	17	"	"	"				
	18	"	"	4				
	19	"	"	5				
	20	"	"	"				
	21	"	"	6		0.6		
16	22	2	2.0x					
	23	"	"	9				
	24	"	"	13				
	25	"	"	18				
	26	"	"	22				
	27	"	"	27				
	28	"	"	32				
	29	"	"	37				

Stage NO.		Z	Depth of packer & hole bottom	5.0 m - 10.0 m		Test length	5.0 m		Reporter
Time		Elapsed min	Gauge pressure Po (kg/cm ²)	Effective pressure P (kg/cm ²)	Water pumped-in			Lugeon value (Lu)	Remarks
hr	min				Integrated (l)	Sectional flow (l/min)	Const. rate of flow Q (l/min)		
15	30	8	3	3.04	41				
	31	9	"	"	46				
	32	10	"	"	51		4.5		
15	33	0	5	5.04					
	34	1	"	"	61				
	35	2	"	"	71				
	36	3	"	"	82				
	37	4	"	"	92				
	38	5	"	"	102				
	39	6	"	"	114				
	40	7	"	"	126				
	41	8	"	"	137				
	42	9	"	"	148				
	43	10	"	"	160		10.9		
15	46	0	3	3.04					
	47	1	"	"	167				
	48	2	"	"	174				
	49	3	"	"	181				
	50	4	"	"	189				
	51	5	"	"	195				
	52	6	"	"	202				
	53	7	"	"	209				
	54	8	"	"	216				
	55	9	"	"	223				
	56	10	"	"	230		7.0		
15	57	0	1	1.04					
	58	1	"	"	235				
	59	2	"	"	239				
16	00	3	"	"	242				
	1	4	"	"	246				
	2	5	"	"	249				

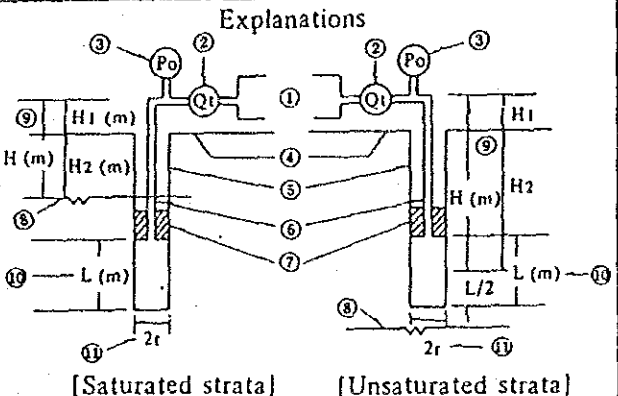
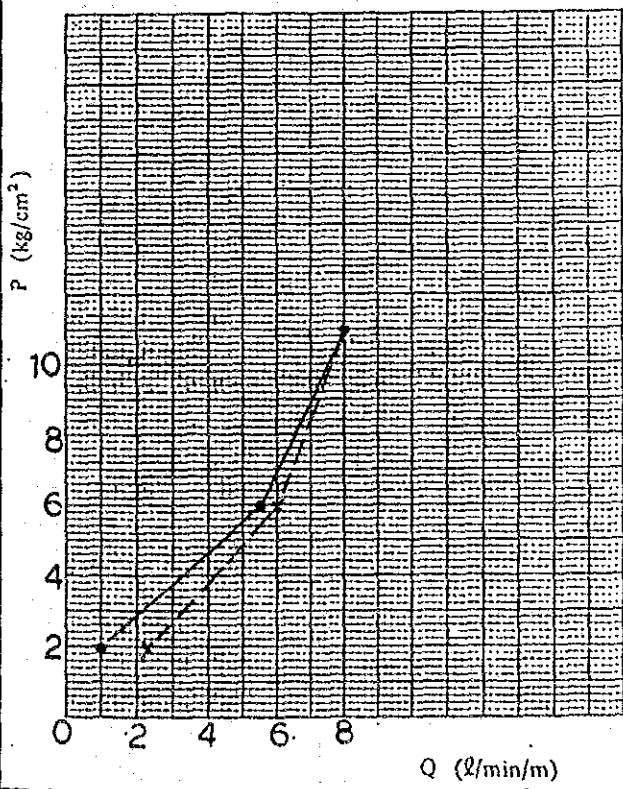
Stage NO.		2		Depth of packer & hole bottom		5.0 m - 10.0 m		Test length		5 m		Reporter	
Time			Gauge pressure Po (kg/cm ²)	Effective pressure P (kg/cm ²)	Water pumped-in			Lugeon value (lu)	Remarks				
hr	min	Elapsed min			Integrated (l)	Sectional flow (l/min)	Const. rate of flow (l/min)						
16	3	6	1	1.04	253								
	4	7	"	"	257								
	5	8	"	"	260								
	6	9	"	"	263								
	7	10	"	"	266		3.6						

PERMEABILITY TEST IN DRILL HOLE (SHEET / OF /)

XE KATAM PROJECT HOLE No. KI-1

LOCATION INTAKB DAM DEPTH OF HOLE 15.0 m TEST DATE Mar. 13, '91
 ELEVATION 468.0 m DIAMETER OF HOLE 6.6 cm TESTED BY H. WATANABE
 COORDINATE _____ DRILLED DEPTH 15.0 m DRILLED BY THONGSAY
 ANGLE FROM HORIZONTAL 90° LEVEL OF WATER TABLE CHECKED BY I. SHIMIZU
 BEARING OF ANGLE HOLE _____ BEFORE T. 8.0 m AFTER T. _____ m
 TEST SECTION FROM 10.0 m TO 15.0 m

L (m)	H ₁ (m)	H ₂ (m)	P ₀ (kg/cm ²)	P (kg/cm ²)	t (min)	Q _t (ℓ)	Q ₀ (ℓ/min)	Q (ℓ/min/m)	Lu (Lugeon)	K (cm/sec)
5	1.1	8.5	1.0	1.96	10	50	5.0	1.0	5.10	2.95 × 10 ⁻⁵
5	"	"	5.0	5.96	10	277	27.7	5.54	9.30	5.38 × 10 ⁻⁵
5	"	"	10.0	10.96	10	401	40.1	8.02	7.54	4.20 × 10 ⁻⁵
5	"	"	5.0	5.96	10	305	30.5	6.10	10.23	5.92 × 10 ⁻⁵
5	"	"	1.0	1.96	10	117	11.7	2.34	11.94	6.91 × 10 ⁻⁵

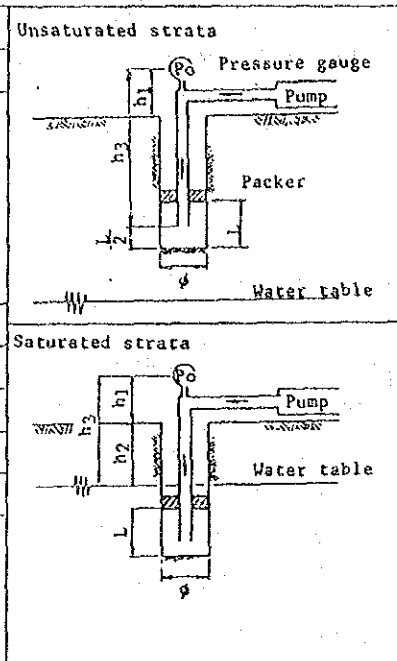


- Explanations**
- ①: Pump
 - ②: Flow meter
 - ③: Pressure gauge
 - ④: Ground surface
 - ⑤: Drill hole
 - ⑥: Injection pipe
 - ⑦: Packer
 - ⑧: Water table
 - ⑨: Hydrostatic head
 - ⑩: Length of test section
 - ⑪: Diameter of hole
- P₀: Gauge pressure
 - H₁: Height of Pressure gauge
 - H₂: Depth of Ground water (Saturated Strata)
 - P: Effective pressure
P = P₀ + H(m)/10, H = H₁ + H₂
 - t: Injected time
 - Q_t: Water volume during time in "t"
 - Q₀: Water volume per one min.
 - Lu: Lugeon value in ℓ/min/m/10kg/cm²
 - K: Coefficient of permeability
 $K = \frac{Q_0 \cdot \log(L/r)}{1200 \pi L(H_1 + H_2 + 10P_0)}$

Feature project **Xe Katam**
 Location **Intake Dam** Coordinates
 Date of test **3-13-1991**

Country **Lao P.D.R.**
 Reporter **THONGSAY**
 Firm name (**HEC**)

Bore hole	Elevation of top	468.0 m	Diameter (φ)	mm; Size
	Dip	90°	Bearing	
Test section	Stage NO.	3	Geology	
	Depth of packer & hole bottom	10.5 m	Basalt lava	
	Elev. of packer & hole bottom	m		
	Length (L)	m		
Height of gauge (h ₁)	1.1 m			
Water table (h ₂)	2.5 m	Temperature of infected water °C		
Pump	Mfr. model	MIG-5A	Pressure Gauge	Type
	Max. discharge	70 l/min	Graduation	1 l
	Max. pressure	60 kg/cm ²	Min.	0.1 kg/cm ²
	Type of packer	kg/cm ²	Max.	15 kg/cm ²



* Effective pressure (kg/cm²) : $P = P_0 + 1/(10(h_3 - h_4))$ h₄ = head loss
 ** Lugeon value (Lu) to be calculated by following equation
 Lugeon value (l/min/m/10kg/cm²) : $Lu = 10 Q/(P \cdot L)$

Time		Gauge pressure Po (kg/cm ²)	Effective pressure P (kg/cm ²)	Water pumped-in			Lugeon value (Lu)	Remarks
hr	min			Integrated (l)	Sectional flow (l/min)	Const. rate of flow (l/min)		
1	50	1	1.96	0				
	51			5				
	52			10				
	53			15				
	54			20				
	55			25				
	56			30				
	57			35				
	58			40				
	59			45				
10	00			50		5.0		
10	05	5	5.96					
	06			78				
	07			105				
	08			133				
	09			161				
	10			188				
	11			216				
	12			244				

WATER PRESSURE TEST IN DRILL HOLE

HOLE NO. K1-1

Sheet NO. 2 of 3

Stage NO.		3		Depth of packer & hole bottom	10.0 m - 15.0 m	Test length	5.0 m	Reporter	
Time			Gauge pressure P ₀ (kg/cm ²)	Effective pressure P (kg/cm ²)	Water pumped-in			Lugeon value (Lu)	Remarks
hr	min	Elapsed min			Integrated (l)	Sectional flow (l/min)	Const. rate of flow Q (l/min)		
12	11	8	5	5.96	272				
	12	9	"	"	300				
	13	10	"	"	327		27.7		
12	21	0	10	10.76					
	22	1	"	"	368				
	23	2	"	"	408				
	24	3	"	"	448				
	25	4	"	"	488				
	26	5	"	"	528				
	27	6	"	"	568				
	28	7	"	"	608				
	29	8	"	"	648				
	30	9	"	"	688				
	31	10	"	"	728		40.1		
12	32	0	5	5.96					
	33	1	"	"	758				
	34	2	"	"	790				
	35	3	"	"	821				
	36	4	"	"	853				
	37	5	"	"	883				
	38	6	"	"	913				
	39	7	"	"	943				
	40	8	"	"	973				
	41	9	"	"	1003				
	42	10	"	"	1033		30.5		
12	43	0	1	1.96					
	44	1	"	"	1.045				
	45	2	"	"	1.057				
	46	3	"	"	1.069				
	47	4	"	"	1.081				
	48	5	"	"	1.092				

Form B

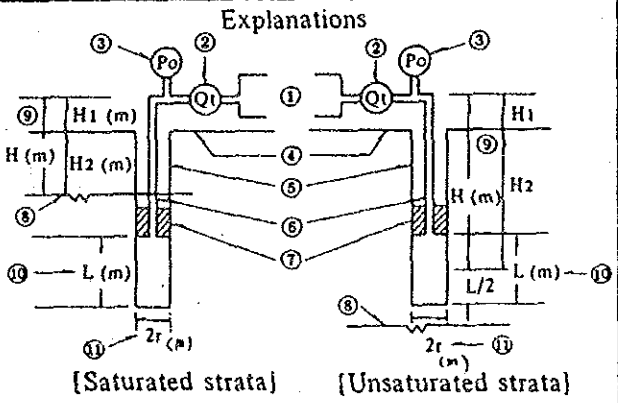
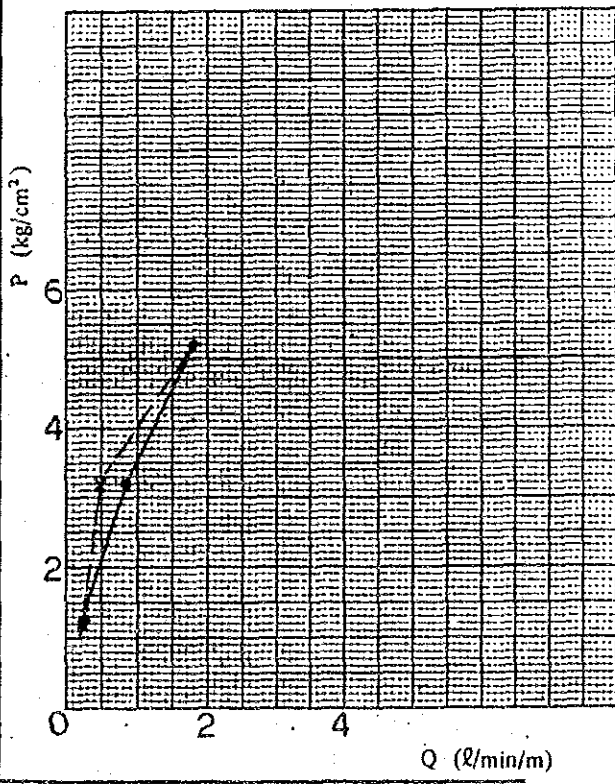
Stage NO.		Depth of packer & hole bottom		Test length		Reporter			
3		100 m - 15.0 m		5 m					
Time			Gauge pressure P ₀ (kg/cm ²)	Effective pressure P (kg/cm ²)	Water pumped-in			Lugeon value (Lu)	Remarks
hr	min	Elapsed min			Integrated (ℓ)	Sectional flow (ℓ/min)	Const. rate of flow Q (ℓ/min)		
12	49	6	1	1.96	1.104				
	50	7	1		1.115				
	51	8	"		1.127				
	52	9	"		1.139				
	53	10	"		1.150		11.7		

PERMEABILITY TEST IN DRILL HOLE (SHEET / OF /)

XE KATAM PROJECT HOLE No. KI - 2

LOCATION INTAKR DAM DEPTH OF HOLE 15.0 m TEST DATE Mar. 15, '91
 ELEVATION 463.9 m DIAMETER OF HOLE 6.6 cm TESTED BY H. WATANABE
 COORDINATE _____ DRILLED DEPTH 6.0 m DRILLED BY THONGSAY
 ANGLE FROM HORIZONTAL 90° LEVEL OF WATER TABLE CHECKED BY I. SHIMIZU
 BEARING OF ANGLE HOLE _____ BEFORE T. 1.0 m AFTER T. _____ m
 TEST SECTION FROM 1.0 m TO 6.0 m

L (m)	H ₁ (m)	H ₂ (m)	P ₀ (kg/cm ²)	P (kg/cm ²)	t (min)	Q _t (ℓ)	Q ₀ (ℓ/min)	Q (ℓ/min/m)	Lu (Lugeon)	K (cm/sec)
5	1.1	1.0	1.0	1.21	10	11	1.1	0.22	1.82	1.01 × 10 ⁻⁵
5	1	1	2.0	3.21	10	43	4.3	0.86	2.68	1.55 × 10 ⁻⁵
5	1	1	5.0	5.21	12	91	7.6	1.82	3.49	2.02 × 10 ⁻⁵
5	1	1	2.0	3.21	10	25	2.5	0.50	1.56	0.90 × 10 ⁻⁵
5	1	1	1.0	1.21	10	12	1.2	0.24	1.98	1.15 × 10 ⁻⁵



- Explanations**
- ①: Pump
 - ②: Flow meter
 - ③: Pressure gauge
 - ④: Ground surface
 - ⑤: Drill hole
 - ⑥: Injection pipe
 - ⑦: Packer
 - ⑧: Water table
 - ⑨: Hydrostatic head
 - ⑩: Length of test section
 - ⑪: Diameter of hole
- P₀: Gauge pressure
 - H₁: Height of Pressure gauge
 - H₂: Depth of Ground water (Saturated Strata)
 - P: Effective pressure
P = P₀ + H(m)/10, H = H₁ + H₂
 - t: Injected time
 - Q_t: Water volume during time in "t"
 - Q₀: Water volume per one min.
 - Lu: Lugeon value in
ℓ/min/m/10 kg/cm²
 - K: Coefficient of permeability
$$K = \frac{Q_0 \cdot \text{Log}(L/r)}{1200 \pi L (H_1 + H_2 + 10P_0)}$$

Feature *Small-Scale Hydroelectric Power Plan* project *Xe Katam*

Country *Lao PDR.*

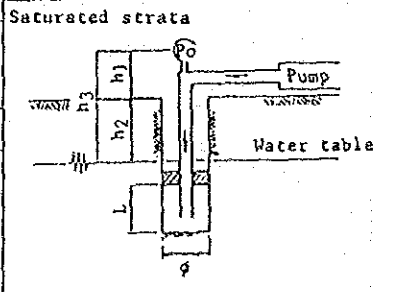
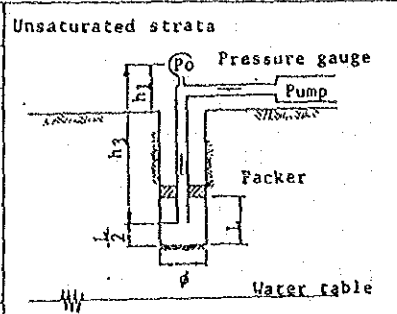
Location *Intake Dam* Coordinates

Reporter *THONGSAI*

Date of test *3-15-1991*

Firm name (*HEC*)

Bore hole	Elevation of top	<i>463.7 m</i>	Diameter(φ) <i>66</i> mm; Size	
	Dip	<i>90°</i>	Bearing	
Test section	Stage NO.	<i>1</i>	Geology	
	Depth of packer & hole bottom	<i>1.0 m - 6.0 m</i>	<i>Basalt lava</i>	
	Elev. of packer & hole bottom	<i>m - m</i>		
	Length (L)	<i>5 m</i>		
Height of gauge (h ₁)	<i>1.14</i>			
Water table (h ₂)	<i>1.0 m</i>	Temperature of infected water °C		
Pump	MF. model	<i>MG-5A</i>	Type	
	Max. discharge	<i>70 l/min</i>	Min. graduation	<i>1 l</i>
	Max. pressure	<i>60 kg/cm²</i>	Min.	<i>0.1 kg/cm²</i>
	Type of packer	<i>kg/cm²</i>	Max.	<i>15 kg/cm²</i>



* Effective pressure (kg/cm²) : $P = P_0 + 1/(10(h_3 - h_4))$, h₄ = head loss
 ** Lugeon value (Lu) to be calculated by following equation
 Lugeon value (l/min/m/10kg/cm²) : $Lu = 10 Q/P \cdot L$

Time	Elapsed	Gauge pressure	Effective pressure	Water pumped-in			Lugeon value	Remarks
				Integrated (l)	Sectional flow (l/min)	Const. rate of flow (l/min)		
hr	min	P ₀ (kg/cm ²)	P (kg/cm ²)					
<i>9</i>	<i>34</i>	<i>0</i>	<i>1.2</i>	<i>0</i>				
	<i>35</i>	<i>1</i>	<i>"</i>	<i>1</i>				
	<i>36</i>	<i>2</i>	<i>"</i>	<i>3</i>				
	<i>37</i>	<i>3</i>	<i>"</i>	<i>4</i>				
	<i>38</i>	<i>4</i>	<i>"</i>	<i>5</i>				
	<i>39</i>	<i>5</i>	<i>"</i>	<i>6</i>				
	<i>40</i>	<i>6</i>	<i>"</i>	<i>7</i>				
	<i>41</i>	<i>7</i>	<i>"</i>	<i>8</i>				
	<i>42</i>	<i>8</i>	<i>"</i>	<i>9</i>				
	<i>43</i>	<i>9</i>	<i>"</i>	<i>10</i>				
	<i>44</i>	<i>10</i>	<i>"</i>	<i>11</i>		<i>1.1</i>		
<i>10</i>	<i>6</i>	<i>3</i>	<i>3.2</i>					
	<i>7</i>	<i>"</i>	<i>"</i>	<i>16</i>				
	<i>8</i>	<i>"</i>	<i>"</i>	<i>19</i>				
	<i>9</i>	<i>"</i>	<i>"</i>	<i>25</i>				
	<i>10</i>	<i>"</i>	<i>"</i>	<i>30</i>				
	<i>11</i>	<i>"</i>	<i>"</i>	<i>34</i>				
	<i>12</i>	<i>"</i>	<i>"</i>	<i>38</i>				
	<i>13</i>	<i>"</i>	<i>"</i>	<i>42</i>				

It should be better not to extend time interval.

Stage NO.		1		Depth of packer to hole bottom	1.0 m	6.0 m	Test length	5.4 m	Reporter
Time			Gauge pressure	Effective pressure	Water pumped-in			Lugeon value	Remarks
hr	min	Elapsed min	P ₀ (kg/cm ²)	P(kg/cm ²)	Integrated (l)	Sectional flow (l/min)	Const. rate of flow (l/min)	(Lu)	
10	14	8	3	3.21	46				
	15	9	"	"	50				
	16	10	"	"	54		4.3		
10	23	0	5	5.21					
	24	1	"	"	61				
	25	2	"	"	70				
	26	3	"	"	79				
	27	4	"	"	88				
	28	5	"	"	96				
	29	6	"	"	105				
	30	7	"	"	115				
	31	8	"	"	125				
	32	9	"	"	135				
	33	10	"	"	145		9.1		
10	40	0	3	3.21					
	41	1	"	"	148				
	42	2	"	"	151				
	43	3	"	"	154				
	44	4	"	"	156				
	45	5	"	"	158				
	46	6	"	"	160				
	47	7	"	"	162				
	48	8	"	"	165				
	49	9	"	"	168				
	50	10	"	"	170		2.5		
10	52	0	1	1.21					
	53	1	"	"	171				
	54	2	"	"	173				
	55	3	"	"	175				
	56	4	"	"	177				
	57	5	"	"	179				

Don't extend the interval

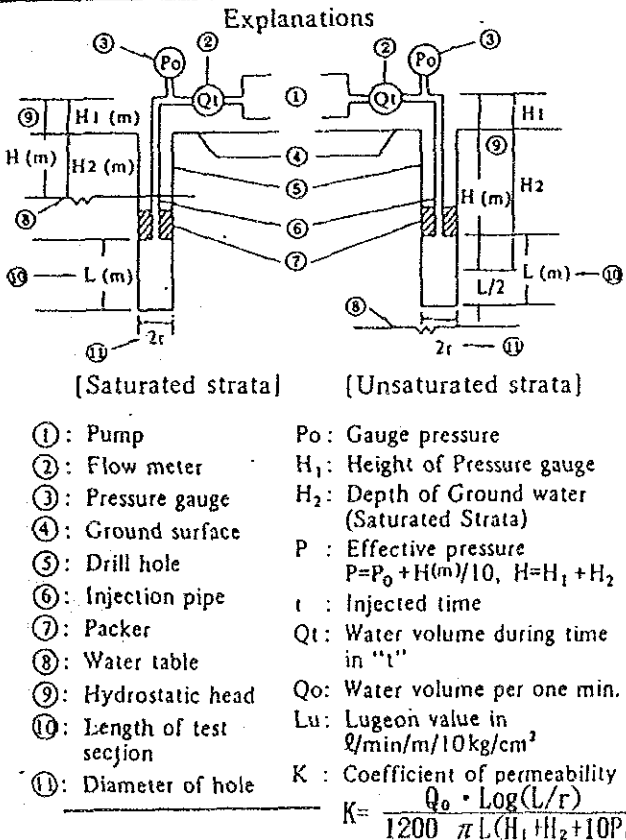
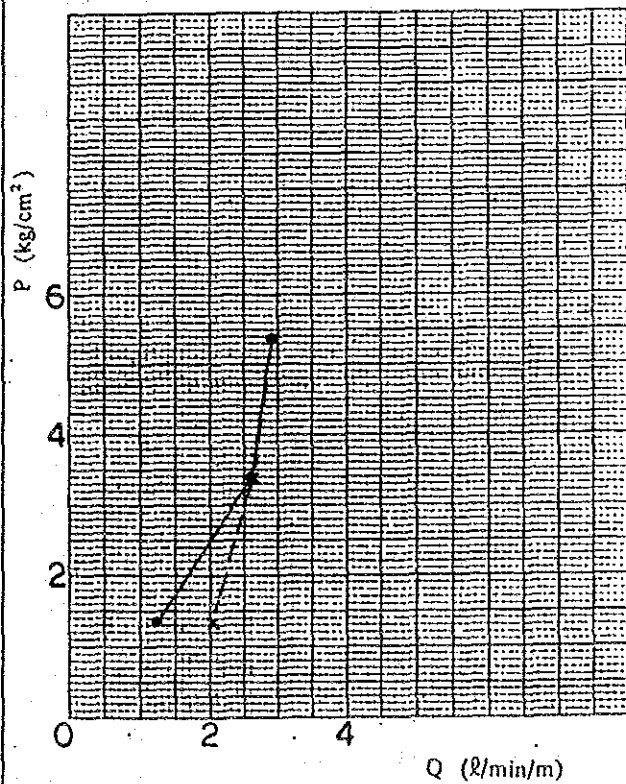
Stage NO.		1		Depth of packer & hole bottom	1.0 m - 6.0 m		Test length	5.0 m		Reporter
Time			Gauge pressure Po (kg/cm ²)	Effective pressure P (kg/cm ²)	Water pumped-in			Lugeon value (Lu)	Remarks	
hr	min	Elapsed min			Integrated (L)	Sectional Flow (l/min)	Const. rate of flow Q (l/min)			
10	58	6	1	1.21	180					
	59	7	"	"	180					
11	00	8	"	"	181					
	1	9	"	"	182					
	2	10	"	"	182		1.2			

PERMEABILITY TEST IN DRILL HOLE (SHEET / OF /)

XE KATAM PROJECT HOLE No. KI-2

LOCATION INTAKE DAM DEPTH OF HOLE 15.0 m TEST DATE Mar. 16, '91
 ELEVATION 463.9 m DIAMETER OF HOLE 6.6 cm TESTED BY H. WATANABE
 COORDINATE _____ DRILLED DEPTH 10.0 m DRILLED BY THONGSAY
 ANGLE FROM HORIZONTAL 90° LEVEL OF WATER TABLE _____ CHECKED BY I. SHIMIZU
 BEARING OF ANGLE HOLE _____ BEFORE T. 3.5 m AFTER T. _____ m
 TEST SECTION FROM 5.0 m TO 10.0 m

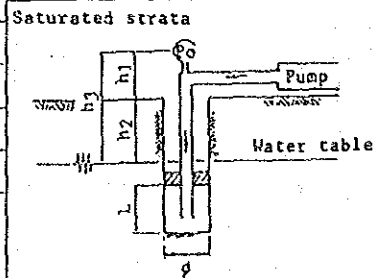
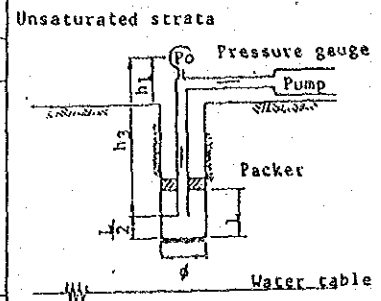
L (m)	H ₁ (m)	H ₂ (m)	P ₀ (kg/cm ²)	P (kg/cm ²)	t (min)	Q _t (ℓ)	Q ₀ (ℓ/min)	Q (ℓ/min/m)	Lu (Lugeon)	K (cm/sec)
5	0.1	3.4	1.0	1.35	10	60	6.0	1.26	9.33	5.40 × 10 ⁻⁵
5	"	"	2.0	2.35	10	102	10.2	2.04	7.88	4.51 × 10 ⁻⁵
5	"	"	5.0	5.35	10	148	14.8	2.96	5.50	3.20 × 10 ⁻⁵
5	"	"	2.0	2.35	10	123	12.3	2.66	7.96	4.59 × 10 ⁻⁵
5	"	"	1.0	1.35	10	102	10.2	2.04	15.11	8.74 × 10 ⁻⁵



Feature project Xe Katam
 Location Intake Dam Coordinates
 Date of test 3-16-1991

Country Lao PDR.
 Reporter THONGSAY
 Firm name (HEC)

Bore hole	Elevation of top	463.9 m	Diameter(φ)	66 mm; Size
	Dip	90°	Bearing	-
Test section	Stage NO.	2	Geology	
	Depth of packer & hole bottom	5.0 m - 10.0 m	Basalt lava	
	Elev. of packer & hole bottom	m - m		
	Length (L)	5 m		
Height of gauge (h ₁)	0.1 m			
Water table (h ₂)	3.4 m	Temperature of infected water °C		
Pump	Mfr. model	M/G-5A	Type	
	Max. discharge	70 l/min	Min. graduation	1 l
	Max. pressure	60 kg/cm ²	Min.	0.1 kg/cm ²
	Type of packer	kg/cm ²	Max.	15 kg/cm ²



* Effective pressure(kg/cm²) : $P = P_0 + 1/(10(h_3 - h_4))$, h₄ = head loss
 ** Lugeon value (Lu) to be calculated by following equation
 Lugeon value (l/min/m/10kg/cm²) : $Lu = 10 Q/P \cdot L$

Time	Elapsed	Gauge pressure	Effective pressure	Water pumped-in			Lugeon value	Remarks
				Integrated	Sectional	Const. rate		
hr	min	Po(kg/cm ²)	P(kg/cm ²)	(l)	flow (l/min)	Q (l/min)	(Lu)	
15	50	0	1.35	0				
	51	1	"	7				
	52	2	"	13				
	53	3	"	19				
	54	4	"	26				
	55	5	"	32				
	56	6	"	39				
	57	7	"	45				
	58	8	"	51				
	59	9	"	57				
16	00	10	"	63		6.3		
16	2	0	3.35					
	3	1	"	76				
	4	2	"	89				
	5	3	"	102				
	6	4	"	116				
	7	5	"	130				
	8	6	"	140				
	9	7	"	156				

Stage NO.		2		Depth of packer & hole bottom	5.0 m - 10.0 m	Test length	5.0 m	Reporter	
Time			Gauge pressure Po (kg/cm ²)	Effective pressure P (kg/cm ²)	Water pumped-in			Lugeon value (Lu)	Remarks
hr	min	Elapsed min			Integrated (L)	Sectional flow (l/min)	Const. rate of flow (l/min)		
16	10	8	3	3.35	169				
	11	9	"	"	182				
	12	10	"	4	195		13.2		
16	15	0	5	5.35					
	16	1	"	"	209				
	17	2	"	"	223				
	18	3	"	"	239				
	19	4	"	"	253				
	20	5	"	"	268				
	21	6	"	"	283				
	22	7	"	"	298				
	23	8	"	"	313				
	24	9	"	"	328				
	25	10	"	"	343		14.8		
16	27	0	3	3.35					
	28	1	"	"	356				
	29	2	"	"	369				
	30	3	"	"	383				
	31	4	"	"	396				
	32	5	"	"	409				
	33	6	"	"	422				
	34	7	"	"	435				
	35	8	"	"	448				
	36	9	"	"	462				
	37	10	"	"	476		13.3		
16	39	0	1	1.35					
	40	1	"	"	484				
	41	2	"	"	494				
	42	3	"	"	504				
	43	4	"	"	514				
	44	5	"	"	525				

WATER PRESSURE TEST IN DRILL HOLE

HOLE NO. K1-2

Sheet NO. 3 of 3

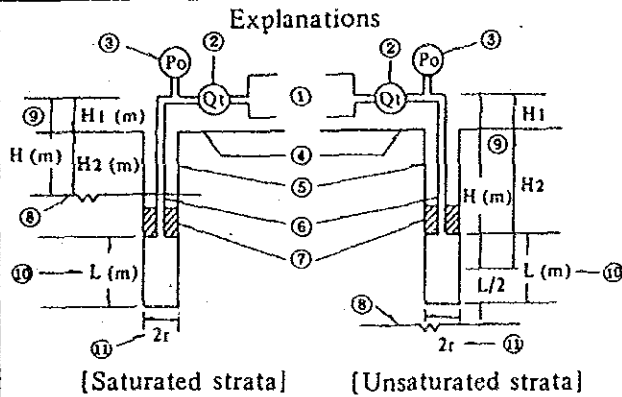
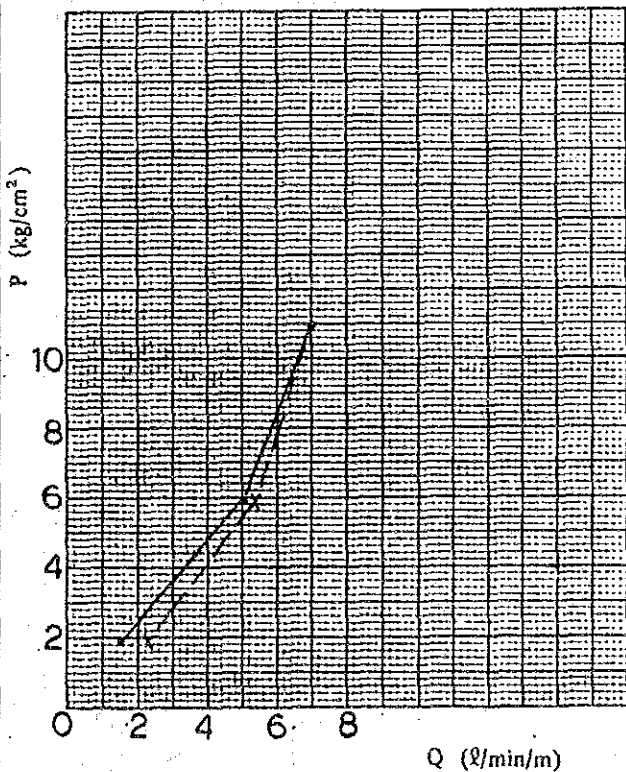
Stage NO.		Z	Depth of packer & hole bottom	5.0 m- 10.0 m	Test length	5.0 m		Reporter	
Time		Elapsed min	Gauge pressure Po(kg/cm²)	Effective pressure P(kg/cm²)	Water pumped-in			Lugeon value (Lu)	Remarks
hr	min				Integrated (l)	Sectional flow (l/min)	Const. rate of flow (l/min)		
16	45	6	1	1.35	536				
	46	7	.	.	547				
	47	8	.	.	558				
	48	9	.	.	569				
	49	10	"	"	579		10.2		

PERMEABILITY TEST IN DRILL HOLE (SHEET / OF /)

XE KATAM PROJECT HOLE No. KI - 2

LOCATION INTAKE DAM DEPTH OF HOLE 15.0 m TEST DATE Mar. 17, '91
 ELEVATION 463.9m DIAMETER OF HOLE 6.6 cm TESTED BY H. WATANABE
 COORDINATE _____ DRILLED DEPTH 15.0 m DRILLED BY THONGSAY
 ANGLE FROM HORIZONTAL 90° LEVEL OF WATER TABLE _____ CHECKED BY I. SHIMIZU
 BEARING OF ANGLE HOLE _____ BEFORE T. 8.4 m AFTER T. _____ m
 TEST SECTION FROM 10.0 m TO 25.0 m

L (m)	H ₁ (m)	H ₂ (m)	P ₀ (kg/cm ²)	P (kg/cm ²)	t (min)	Q _t (ℓ)	Q ₀ (ℓ/min)	Q (ℓ/min/m)	Lu (Lugeon)	K (cm/sec)
5	1.1	8.4	1.0	1.95	10	79	7.9	1.58	8.10	4.67 × 10 ⁻⁵
5	"	"	5.0	5.95	10	254	25.4	5.08	8.54	4.94 × 10 ⁻⁵
5	"	"	10.0	10.95	10	252	25.2	7.04	6.67	3.72 × 10 ⁻⁵
5	"	"	5.0	5.95	10	270	27.0	5.50	9.08	5.25 × 10 ⁻⁵
5	"	"	6.0	1.95	10	116	11.6	2.32	11.90	6.88 × 10 ⁻⁵

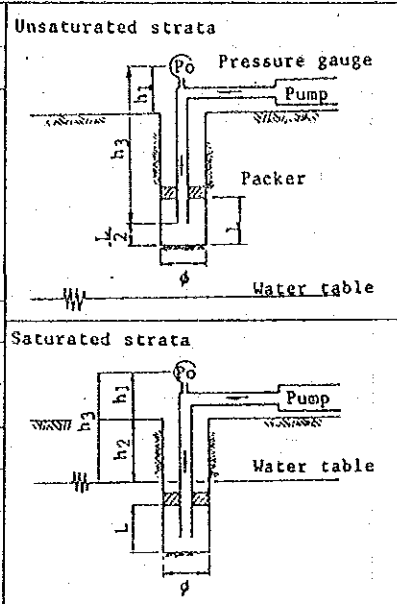


- Explanations**
- ①: Pump
 - ②: Flow meter
 - ③: Pressure gauge
 - ④: Ground surface
 - ⑤: Drill hole
 - ⑥: Injection pipe
 - ⑦: Packer
 - ⑧: Water table
 - ⑨: Hydrostatic head
 - ⑩: Length of test section
 - ⑪: Diameter of hole
- P₀: Gauge pressure
 - H₁: Height of Pressure gauge
 - H₂: Depth of Ground water (Saturated Strata)
 - P: Effective pressure
 $P = P_0 + H(m)/10$, $H = H_1 + H_2$
 - t: Injected time
 - Q_t: Water volume during time in "t"
 - Q₀: Water volume per one min.
 - Lu: Lugeon value in ℓ/min/m/10kg/cm²
 - K: Coefficient of permeability
 $K = \frac{Q_0 \cdot \text{Log}(L/r)}{1200 \pi L (H_1 + H_2 + 10P_0)}$

Feature project **Xe Katam**
 Location **Intake Dam** Coordinates
 Date of test **3 - 17 - 1991**

Country **Lao PDR**
 Reporter **THONGISAT**
 Firm name (**HEC**)

Bore hole	Elevation of top	463.9 m	Diameter(φ) 66 mm; Size
	Dip	90°	Bearing
Test section	Stage NO.	3	Geology Basalt lava
	Depth of packer & hole bottom	10.0 m - 15.0 m	
	Elev. of packer & hole bottom	m - m	
	Length (L)	5 m	
Height of gauge(h ₁)	1.1 m		
Water table(h ₂)	8.4 m		Temperature of infected water °C
Pump	Mfr. model	MG-32	Type
	Max. discharge	75 l/min	Min. graduation
	Max. pressure	60 kg/cm ²	Min.
Type of packer		kg/cm ²	Max.



* Effective pressure(kg/cm²) : $P = P_0 + 1/10(h_3 - h_4)$, h₄= head loss
 ** Lugeon value (Lu) to be calculated by following equation
 Lugeon value (l/mip/m/10kg/cm²) : $Lu = 10 Q/P \cdot L$

Time	Gauge pressure		Effective pressure P (kg/cm ²)	Water pumped-in			Lugeon value (Lu)	Remarks
	Elapsed min	Po(kg/cm ²)		Integrated (l)	Sectional flow (l/min)	Const. rate of flow Q (l/min)		
9:14	0	1	1.95					
15	1	"	"	9				
16	2	"	"	16				
17	3	"	"	25				
18	4	"	"	32				
19	5	"	"	39				
20	6	"	"	47				
21	7	"	"	55				
22	8	"	"	63				
23	9	"	"	71				
24	10	"	"	79		2.9		
9:30	0	5	5.95					
31	1	"	"	104				
32	2	"	"	129				
33	3	"	"	153				
34	4	"	"	178				
35	5	"	"	203				
36	6	"	"	230				
37	7	"	"	255				

Stage NO.		3		Depth of packer to hole bottom		10 m 15 m		Test length		5 m		Reporter	
Time			Gauge pressure P ₀ (kg/cm ²)	Effective pressure P (kg/cm ²)	Water pumped-in			Lugeon value (Lu)	Remarks				
hr	min	Elapsed min			Integrated (l)	Sectional flow (l/min)	Const. rate of flow Q (l/min)						
9	38	8	5	5.95	281								
	39	9	"	"	307								
	40	10	"	"	333			25.4					
9	43	0	10	10.95									
	44	1	"	"	369								
	45	2	"	"	405								
	46	3	"	"	440								
	47	4	"	"	475								
	48	5	"	"	510								
	49	6	"	"	545								
	50	7	"	"	580								
	51	8	"	"	615								
	52	9	"	"	650								
	53	10	"	"	685			35.2					
9	54	0	5	5.95									
	55	1	"	"	710								
	56	2	"	"	738								
	57	3	"	"	766								
	58	4	"	"	793								
	59	5	"	"	820								
10	00	6	"	"	847								
	1	7	"	"	874								
	2	8	"	"	901								
	3	9	"	"	928								
	4	10	"	"	955			27.0					
10	5	0	1	1.95									
	6	1	"	"	963								
	7	2	"	"	973								
	8	3	"	"	985								
	9	4	"	"	997								
	10	5	"	"	1.009								

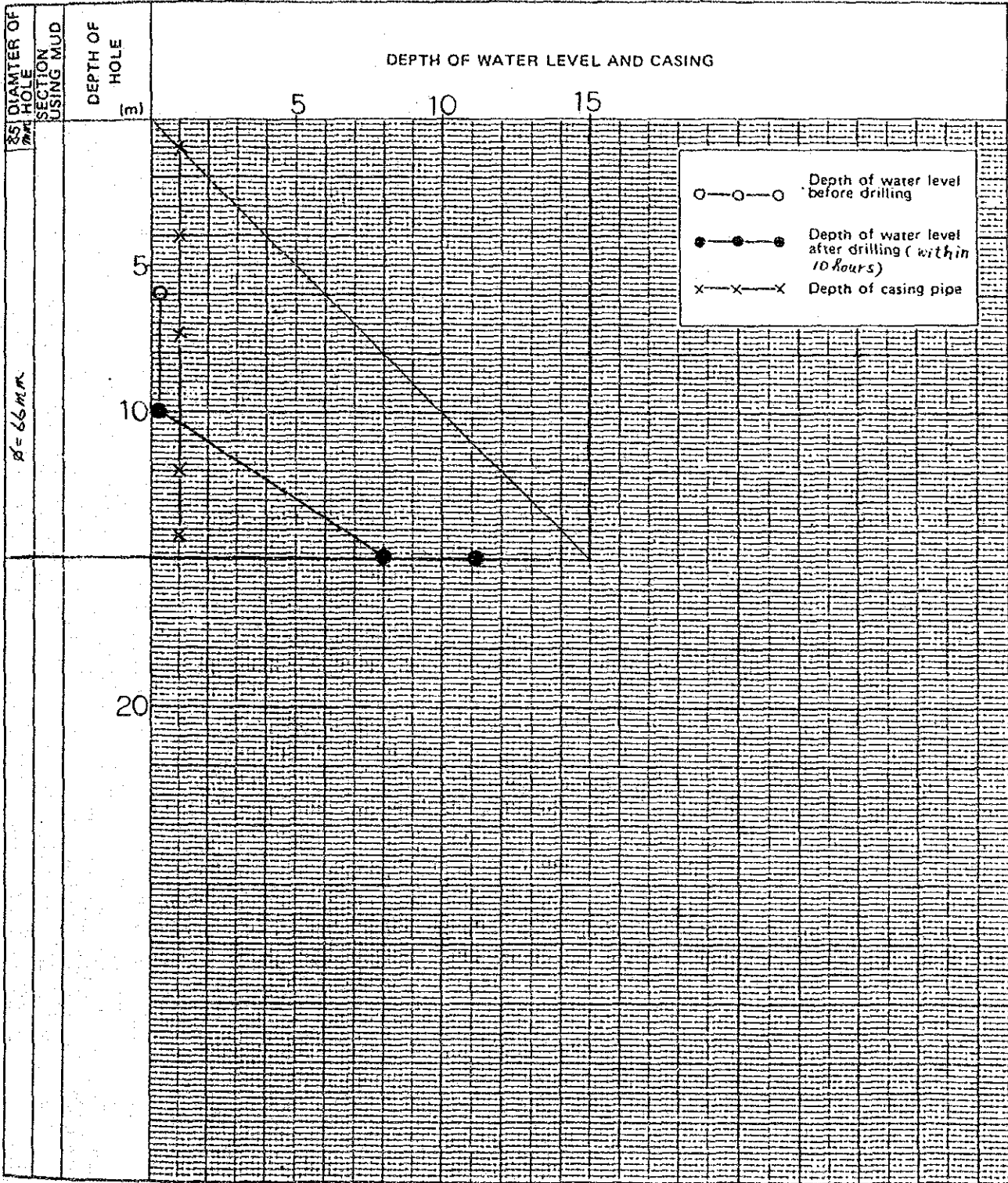
Stage NO.		3		Depth of packer & hole bottom		10.0 m - 15.0 m		Test length		5 m		Reporter	
Time		Elapsed hr min	Gauge pressure P_0 (kg/cm ²)	Effective pressure P (kg/cm ²)	Water pumped-in			Lugeon value (Lu)	Remarks				
hr	min				Integrated (l)	Sectional flow (l/min)	Const. rate of flow Q (l/min)						
10	11	6	1	1.95	1.021								
	12	7	"	"	1.033								
	13	8	"	"	1.045								
	14	9	"	"	1.058								
	15	10	"	"	1.071			11.6					

Form B

Record of Water Level in Borehole During Drilling

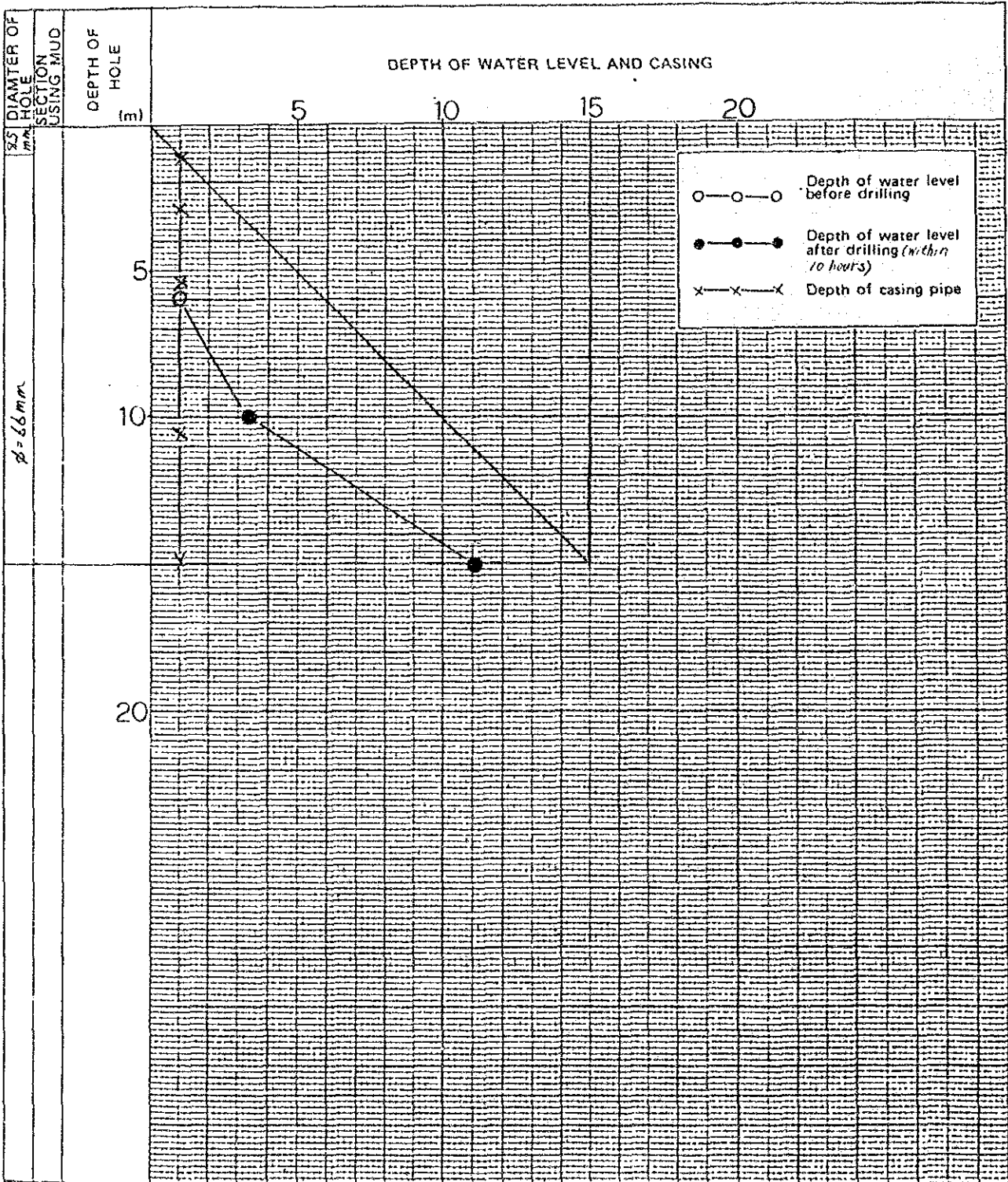
RECORD OF WATER LEVEL IN BOREHOLE DURING DRILLING
(DIAGRAM)

PROJECT	XE KATAM	HOLE No.	KI-1	(SHEET / OF 7)	
LOCATION	INTAKE DAM	DEPTH OF HOLE	15 m	COMMENCED	Mar. 10 '91
ELEVATION	488.0m	DIAMETER OF HOLE	66 mm	COMPLETED	Apr. 9 '91
COORDINATE					
ANGLE FROM HORIZONTAL	90°			MEASURED BY	THONGSAY



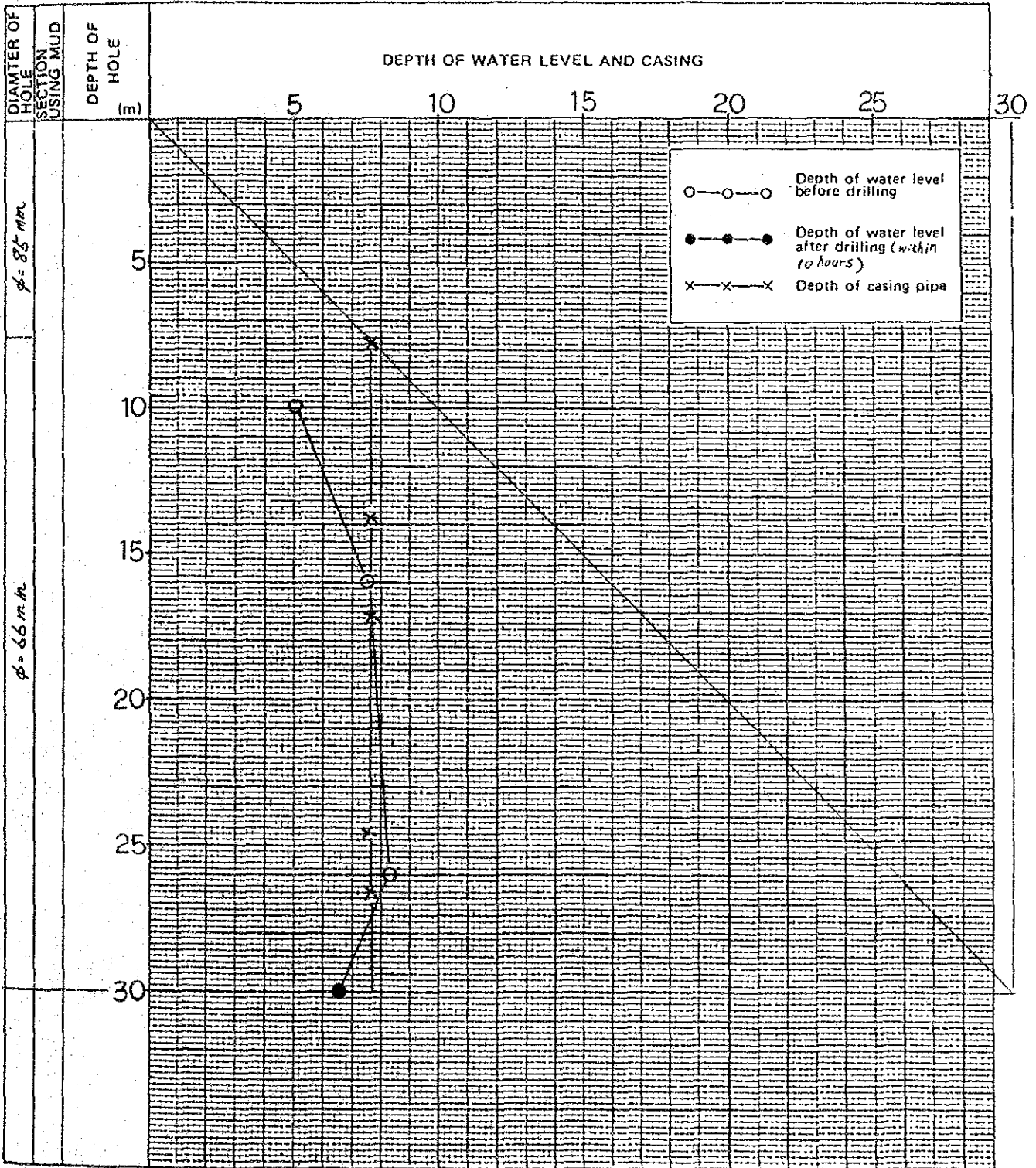
RECORD OF WATER LEVEL IN BOREHOLE DURING DRILLING (DIAGRAM)

PROJECT XE KAJAM HOLE No. K1-2 (SHEET 2 OF 7)
 LOCATION INTAKE DAM DEPTH OF HOLE 15 m COMMENCED Mar. 15 '91
 ELEVATION 463.9m DIAMETER OF HOLE 66 mm COMPLETED Apr. 16 '91
 COORDINATE _____ MEASURED BY THONG SAY
 ANGLE FROM HORIZONTAL 90°



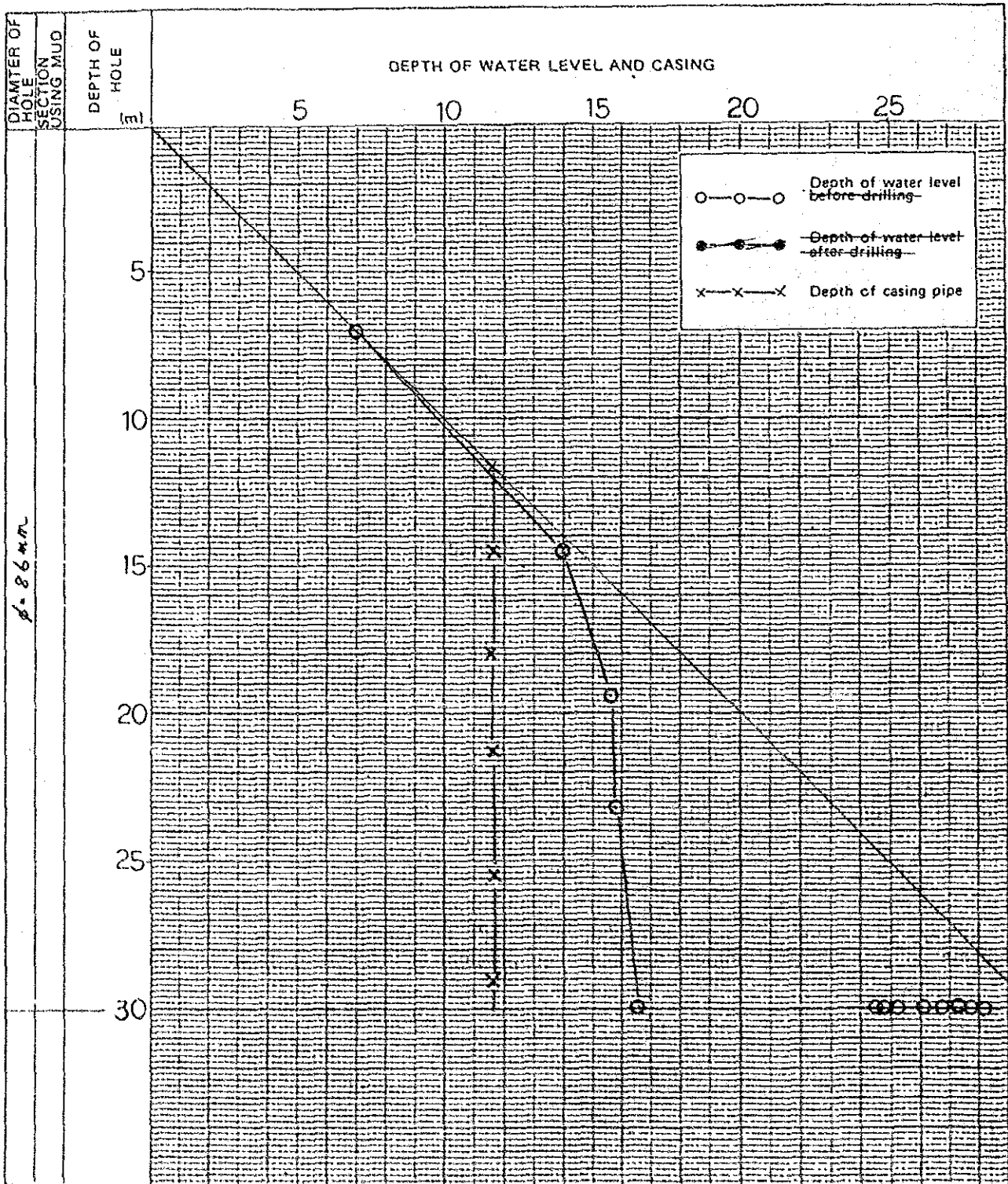
RECORD OF WATER LEVEL IN BOREHOLE DURING DRILLING (DIAGRAM)

XE KATAM PROJECT		HOLE No. KT-1	ISHEET 3 OF 7
LOCATION <u>TUNNEL</u>	DEPTH OF HOLE <u>30</u> m	COMMENCED <u> </u> '91	
ELEVATION <u>473.3m</u>	DIAMETER OF HOLE <u>66</u> mm	COMPLETED <u> </u> '91	
COORDINATE <u> </u>		MEASURED BY <u>THONG SAY</u>	
ANGLE FROM HORIZONTAL <u>90°</u>			



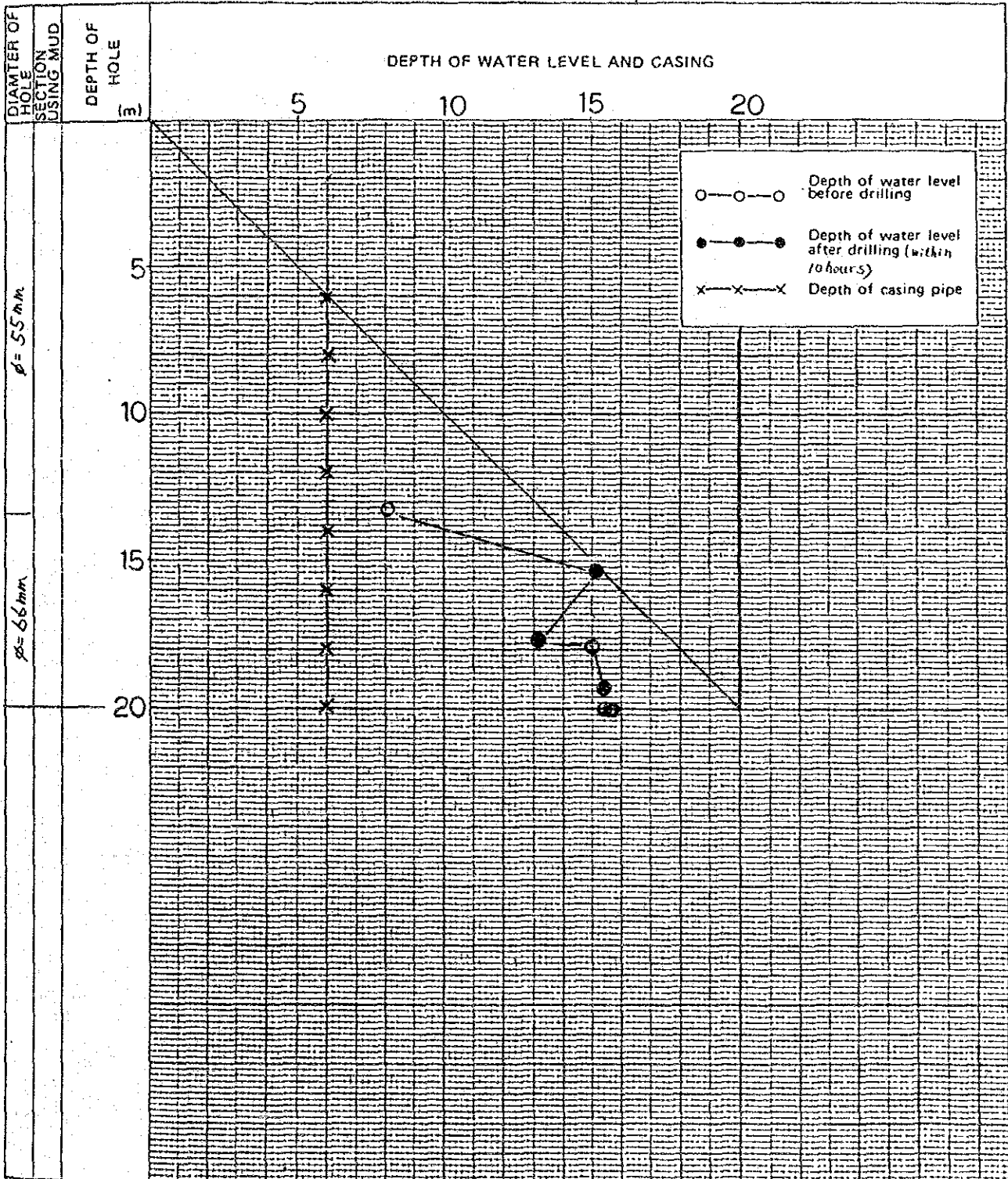
RECORD OF WATER LEVEL IN BOREHOLE DURING DRILLING
(DIAGRAM)

XE KATAM PROJECT HOLE No. KT--2 (SHEET 4 OF 7)
 LOCATION TUNNEL DEPTH OF HOLE 30 m COMMENCED .. '91
 ELEVATION 479.8 m DIAMETER OF HOLE 86 mm COMPLETED .. '91
 COORDINATE _____ MEASURED BY THONGSAY
 ANGLE FROM HORIZONTAL 90°



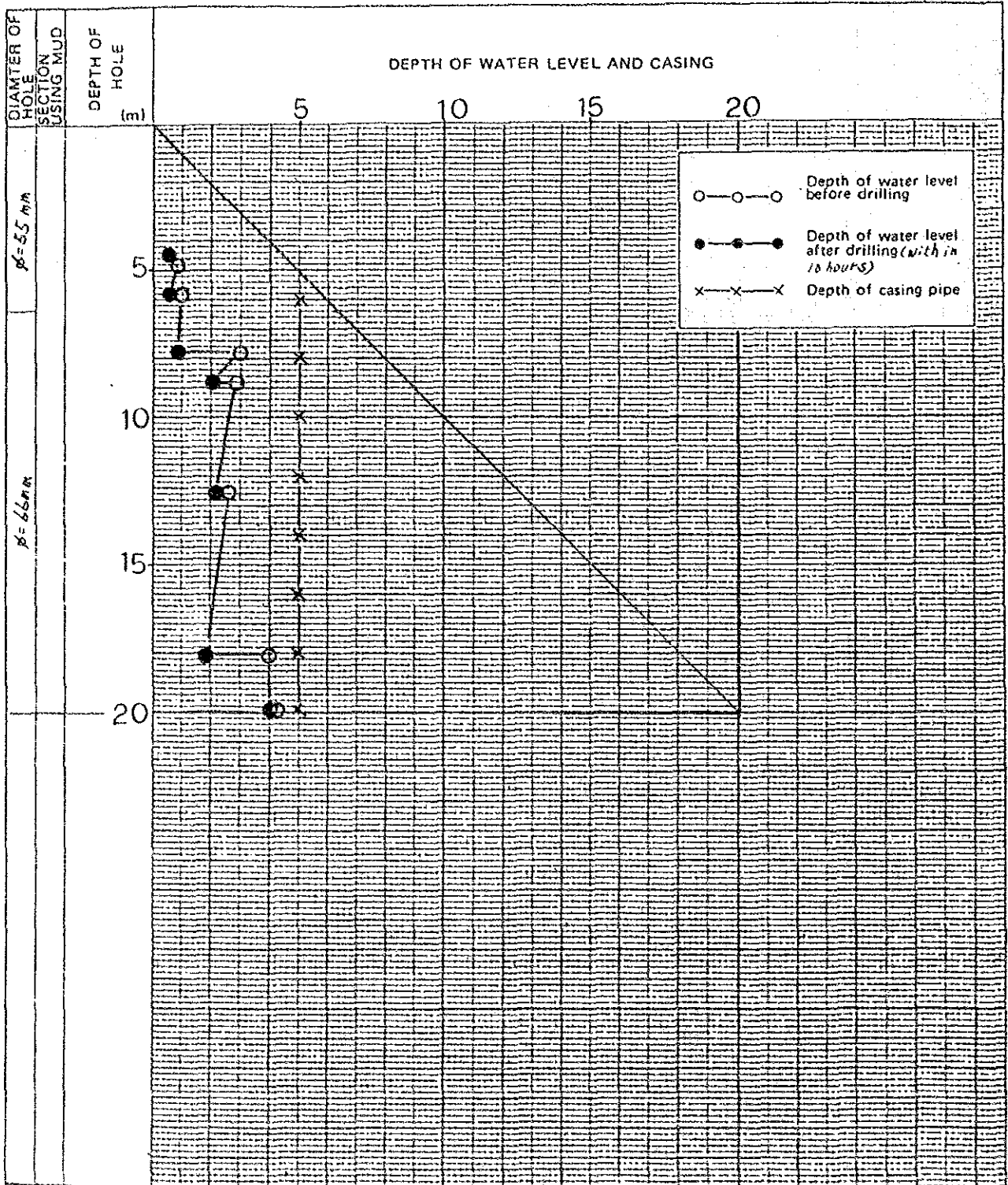
RECORD OF WATER LEVEL IN BOREHOLE DURING DRILLING
(DIAGRAM)

XE KATAM PROJECT HOLE No. KP-1 (SHEET 5 OF 7)
 LOCATION PENSTOCK DEPTH OF HOLE 20 m COMMENCED .91
 ELEVATION 361.5m DIAMETER OF HOLE 66 mm COMPLETED .91
 COORDINATE _____
 ANGLE FROM HORIZONTAL 90° MEASURED BY JHONGSAY



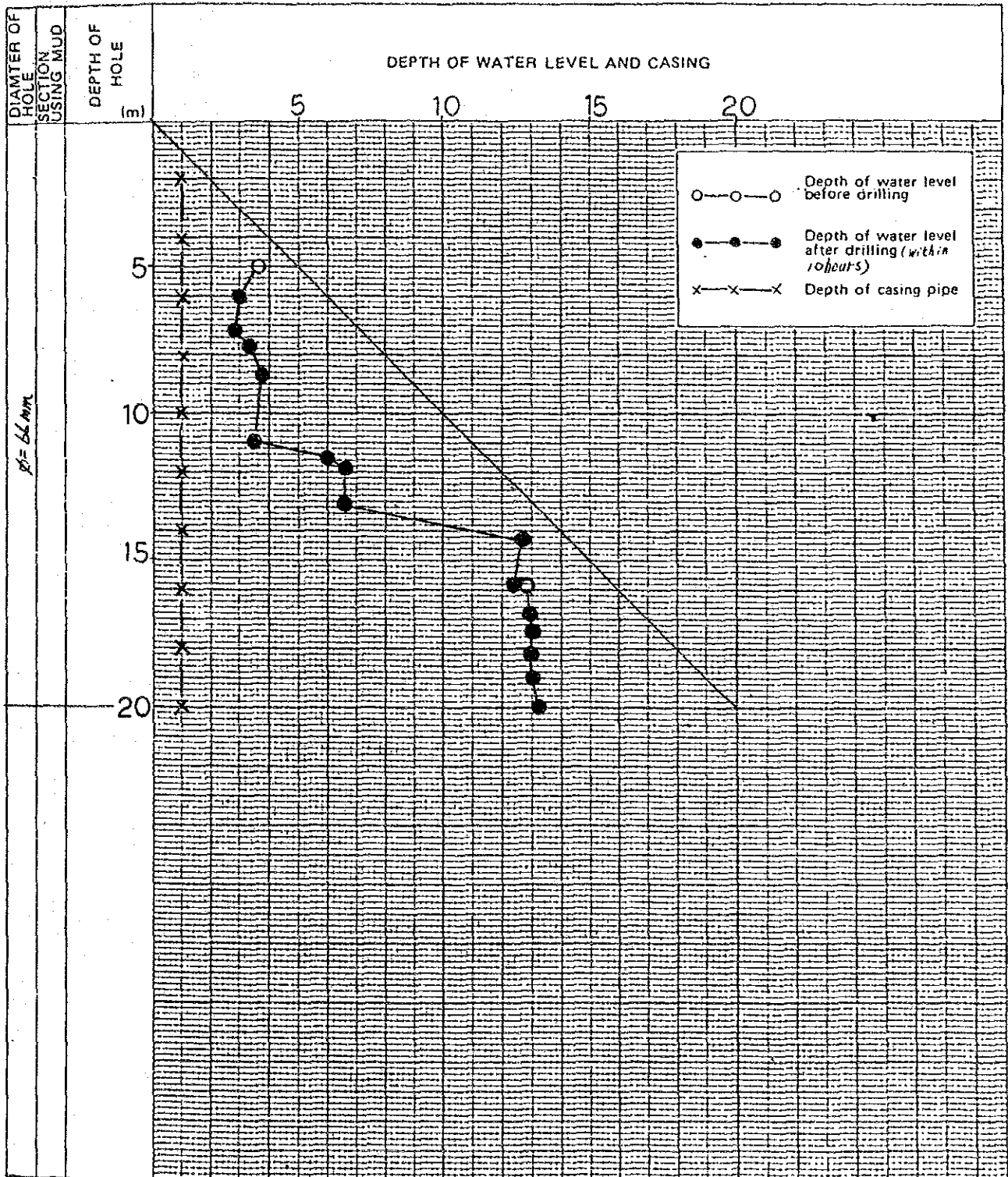
RECORD OF WATER LEVEL IN BOREHOLE DURING DRILLING (DIAGRAM)

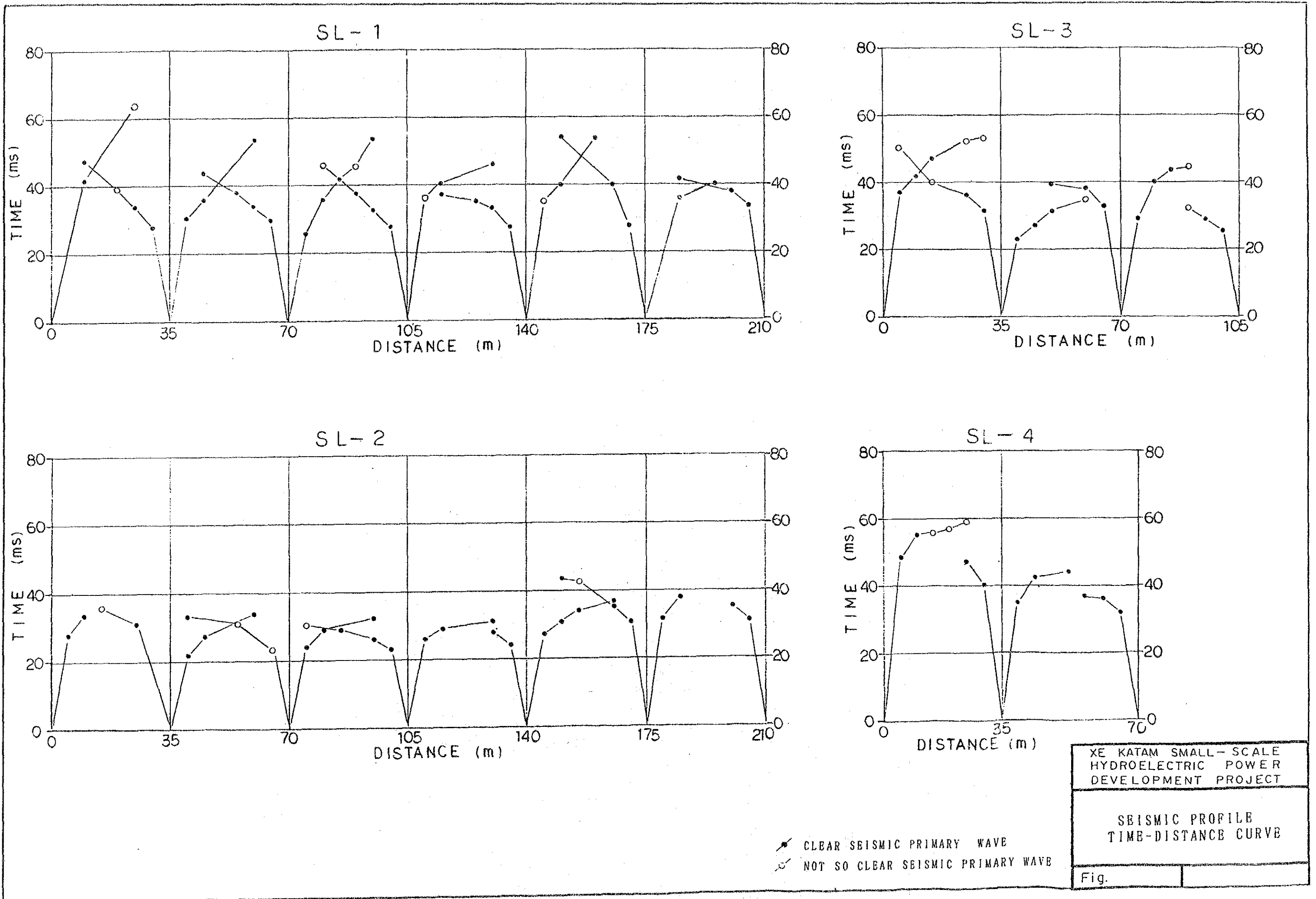
XE KATAM PROJECT HOLE No. KP-2 (SHEET 6 OF 7)
 LOCATION POWERHOUSE DEPTH OF HOLE 20 m COMMENCED 1991
 ELEVATION 307.3 m DIAMETER OF HOLE 66 mm COMPLETED 91
 COORDINATE _____
 ANGLE FROM HORIZONTAL 90° MEASURED BY JHONGSAY

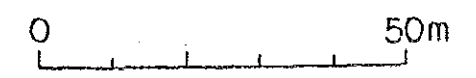
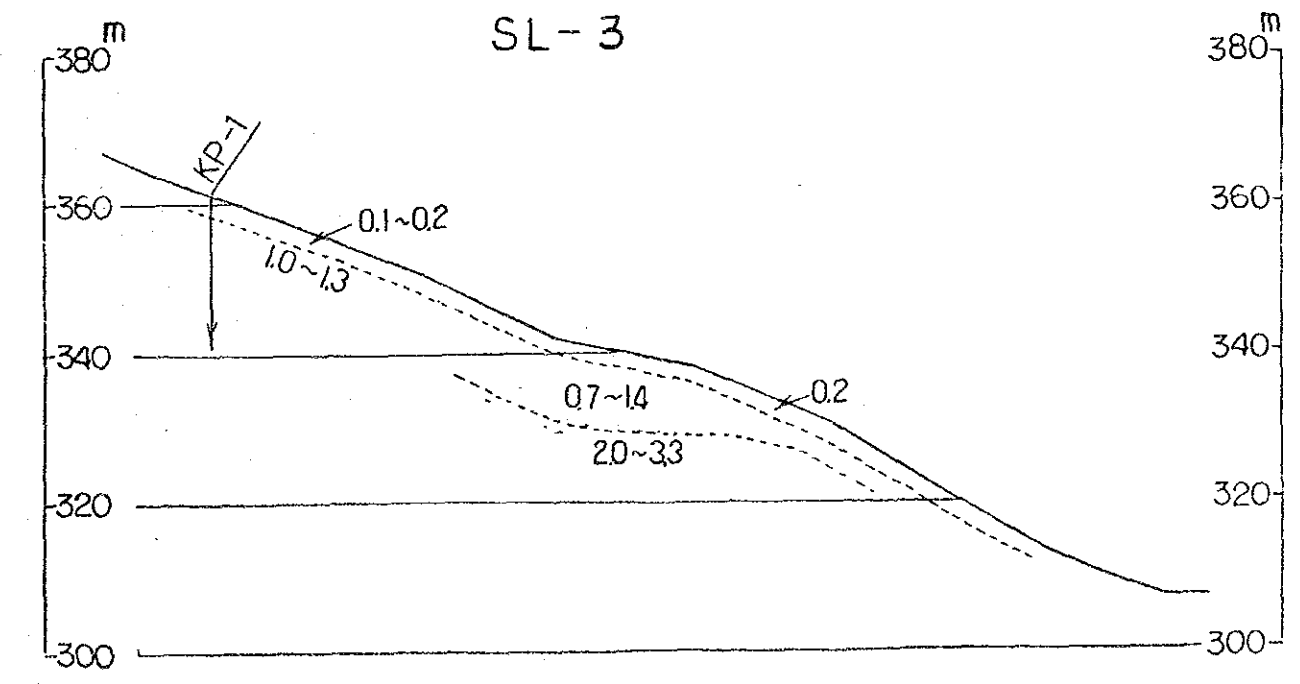
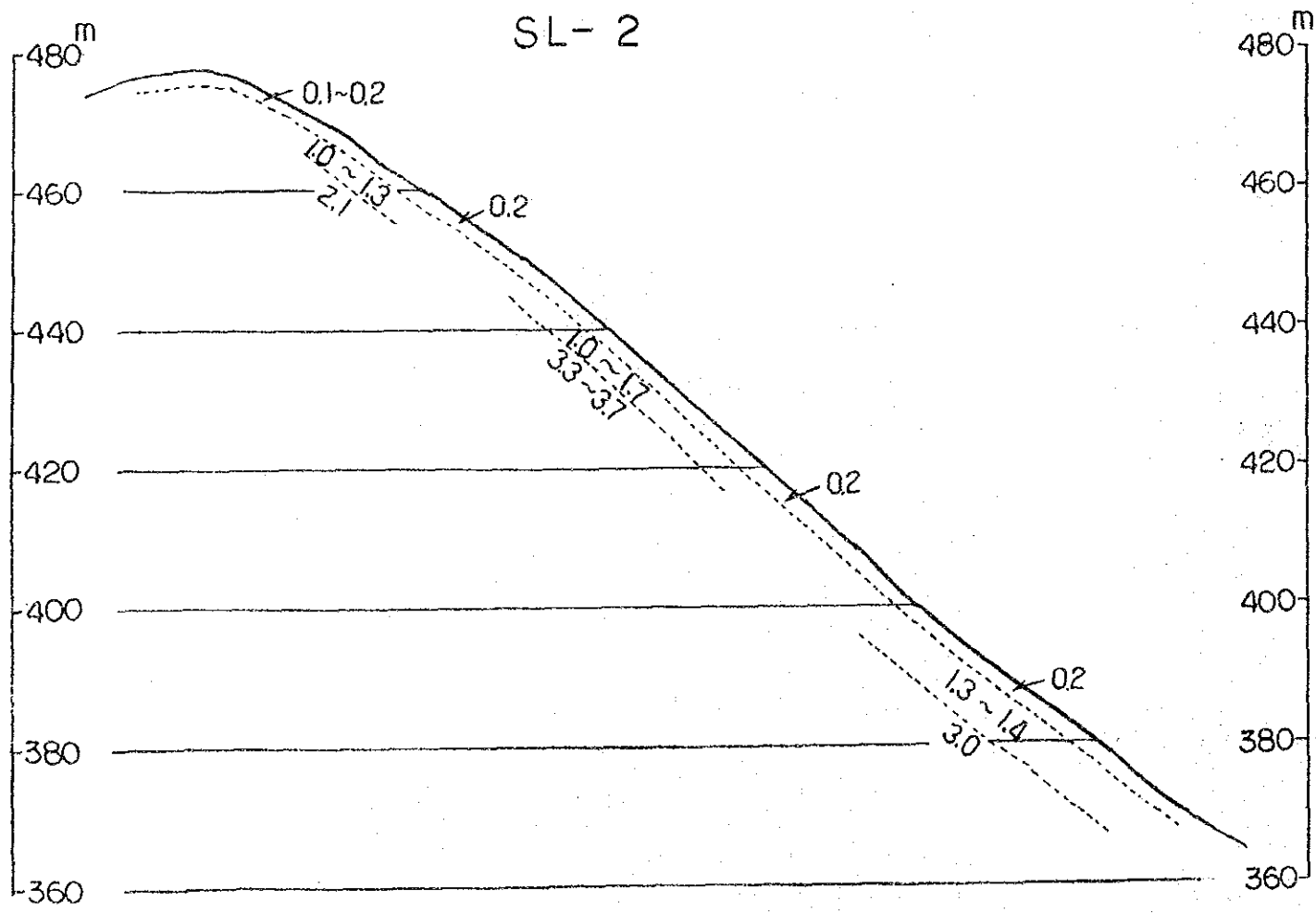
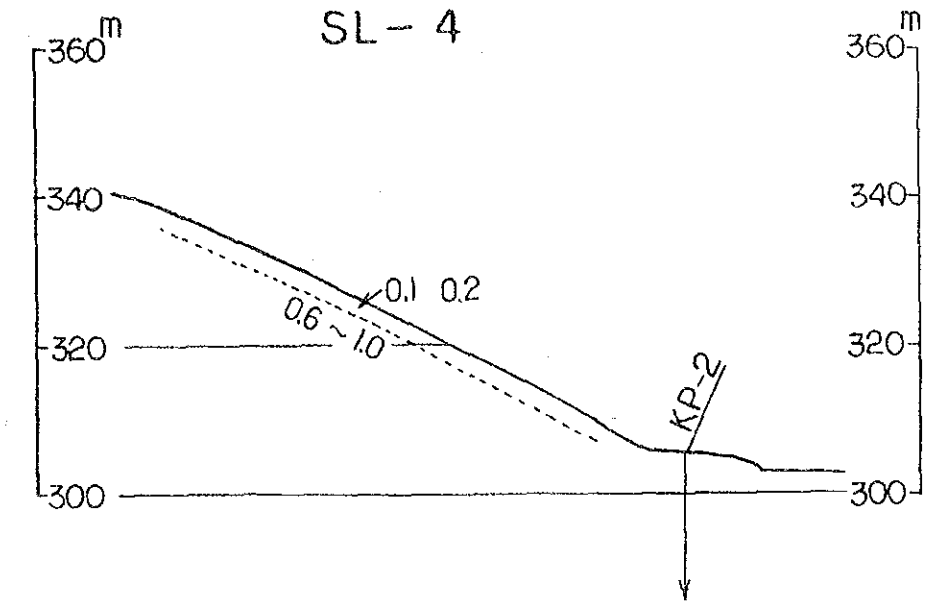
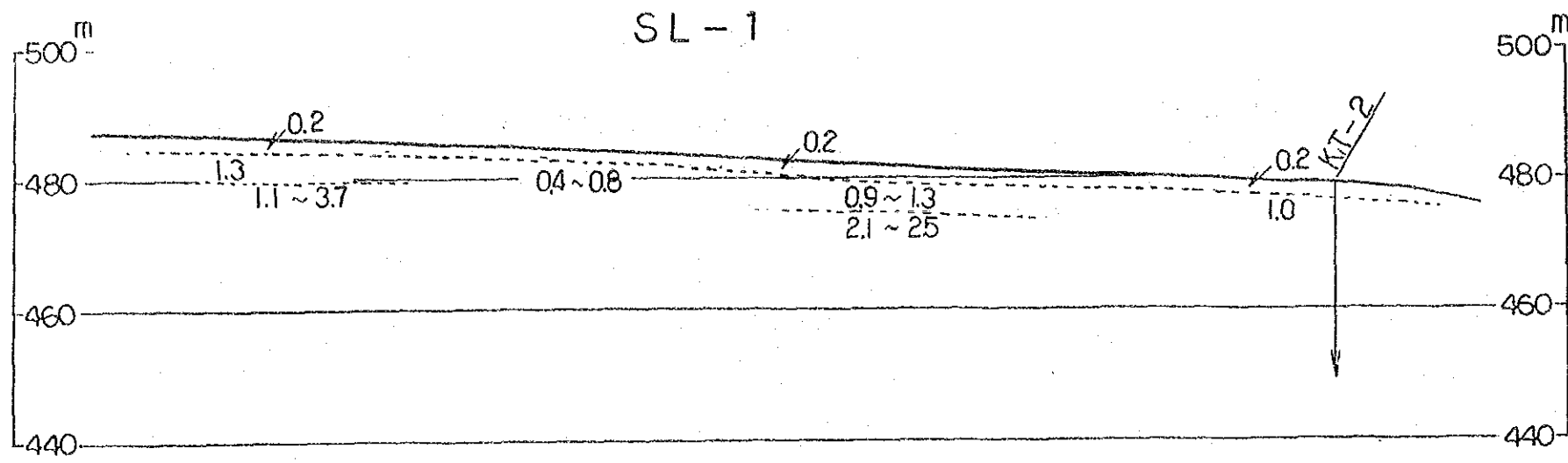


RECORD OF WATER LEVEL IN BOREHOLE DURING DRILLING (DIAGRAM)

<u>XE KATAM</u> PROJECT	HOLE No. <u>KP-3</u>	(SHEET <u>7</u> OF <u>7</u>)
LOCATION <u>POWERHOUSE</u>	DEPTH OF HOLE <u>20</u> m	COMMENCED <u>'91</u>
ELEVATION <u>308.5m</u>	DIAMETER OF HOLE <u>66</u> mm	COMPLETED <u>'91</u>
COORDINATE _____		
ANGLE FROM HORIZONTAL <u>90°</u>	MEASURED BY <u>THONGSAY</u>	







XE KATAM SMALL-SCALE
HYDROELECTRIC POWER
DEVELOPMENT PROJECT

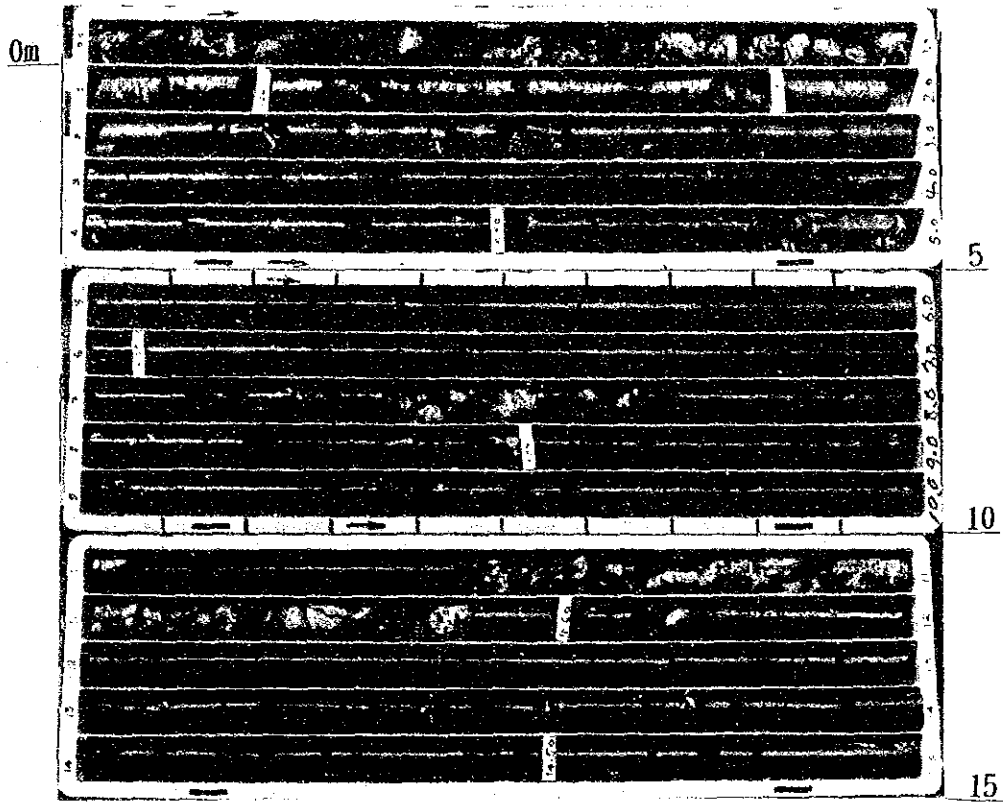
SEISMIC PROFILE

0.2 / BOUNDARY AND VELOCITY OF
1.4 SEISMIC PRIMARY WAVES (in km/s)

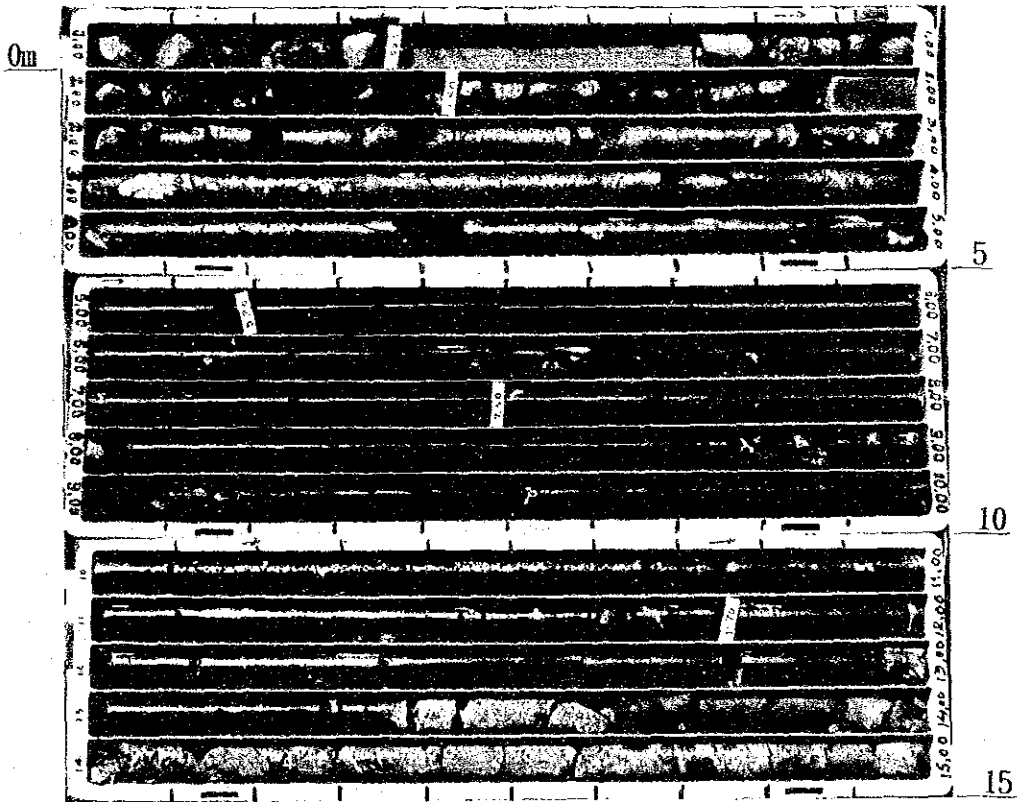
Fig. _____

Core-Photograph

K I - 1 : Length=15m

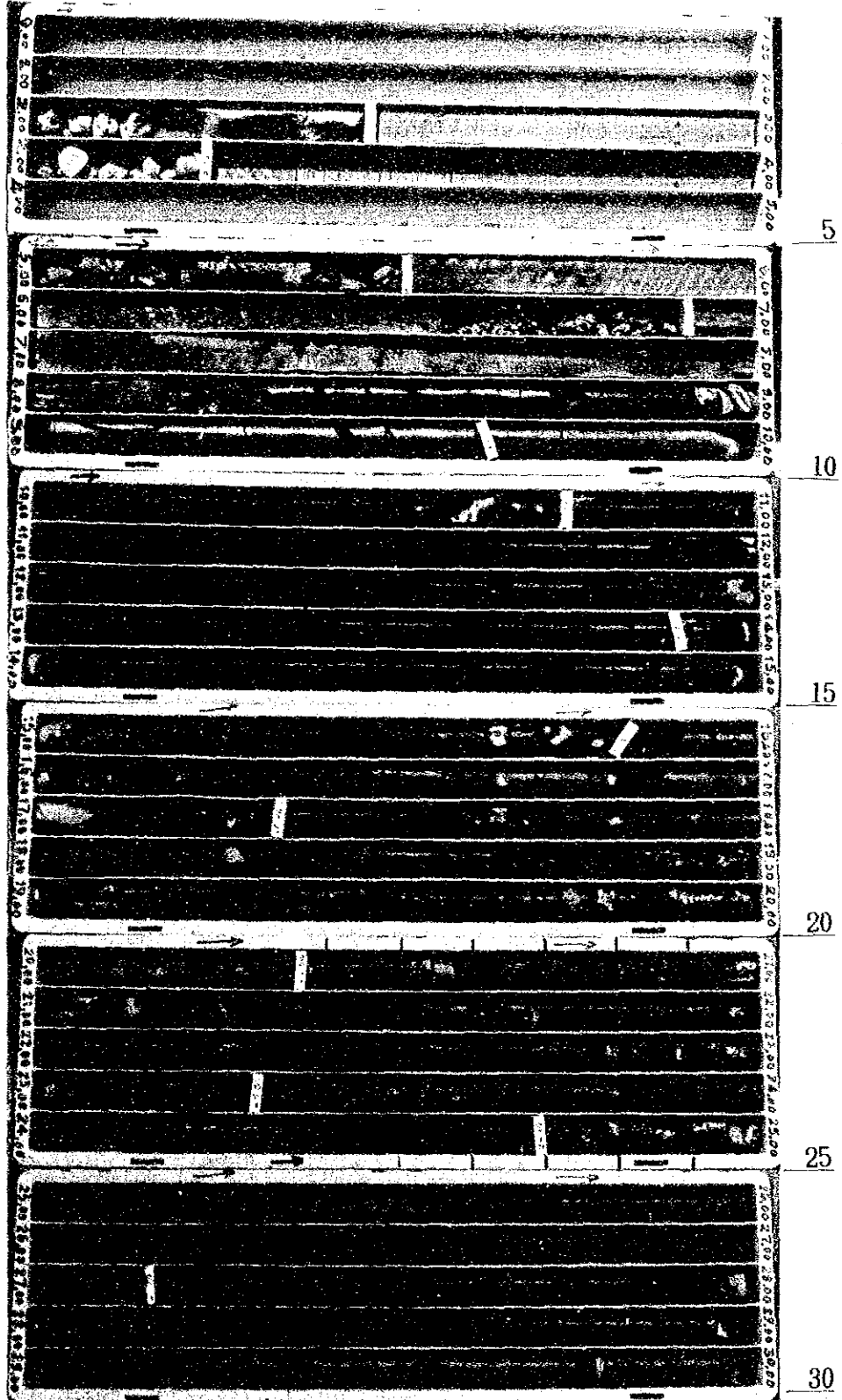


K I - 2 : Length=15m



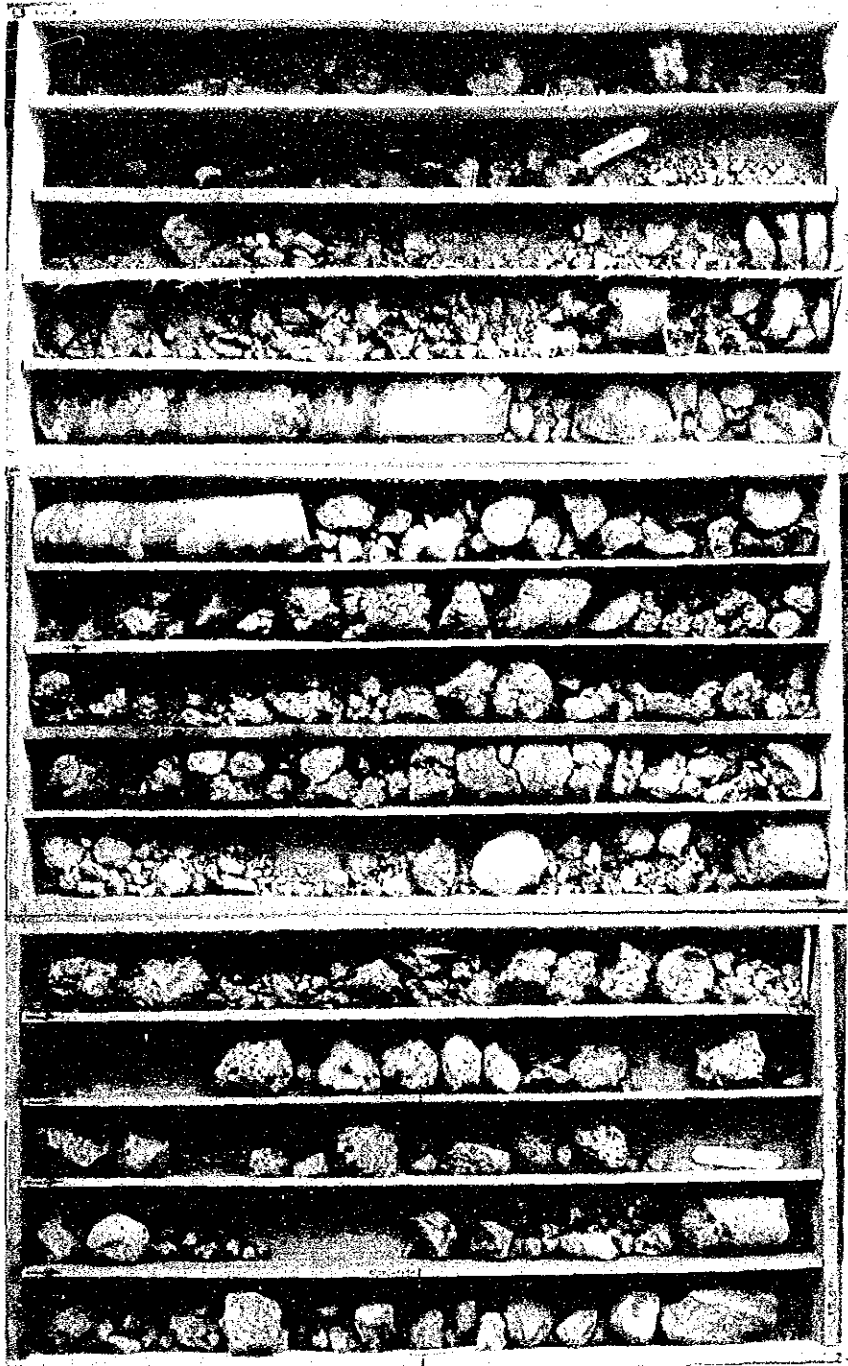
KT-1:Length=30m

0m



KT - 2 : Length = 30m

0m

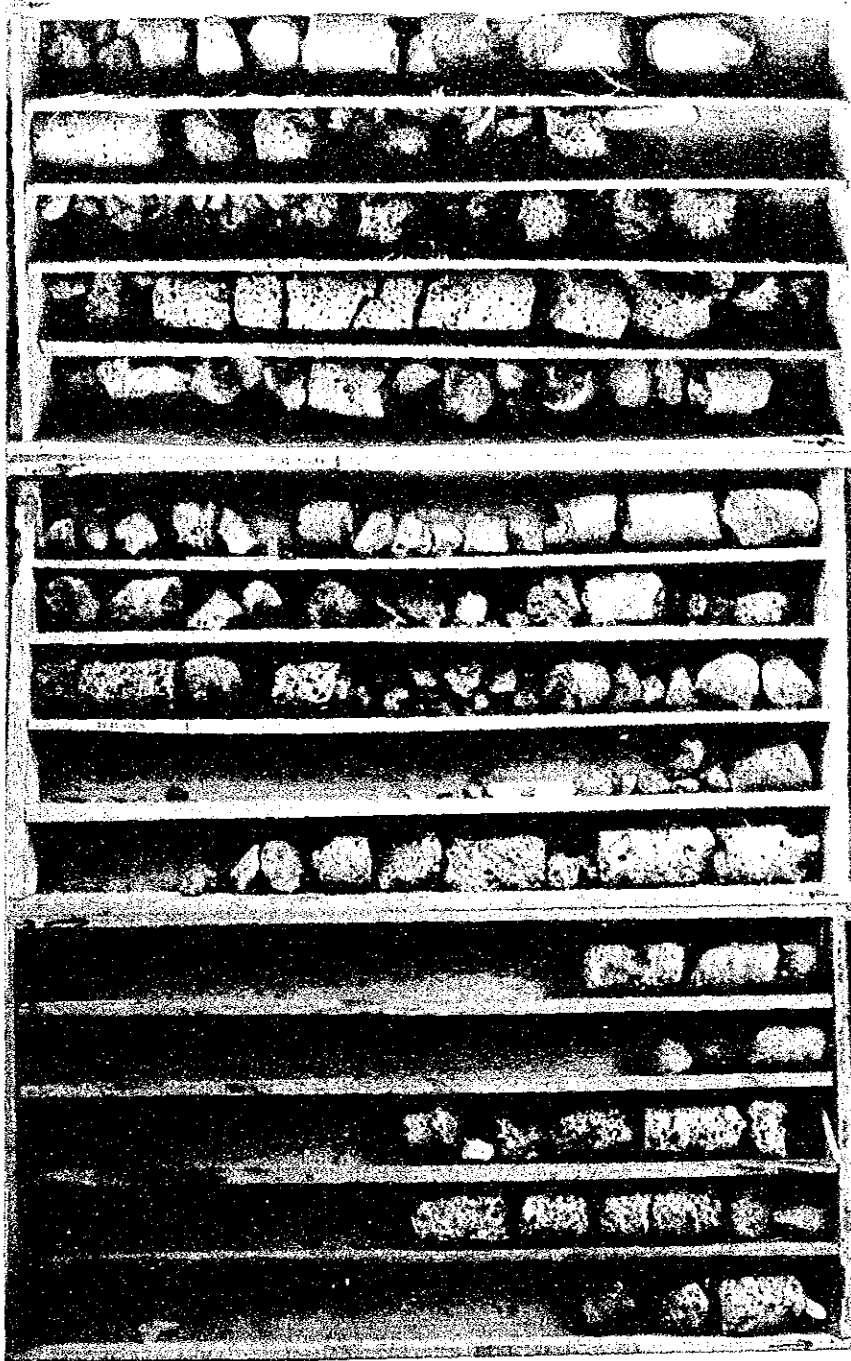


5

10

15

KT - 2 : Length = 30m

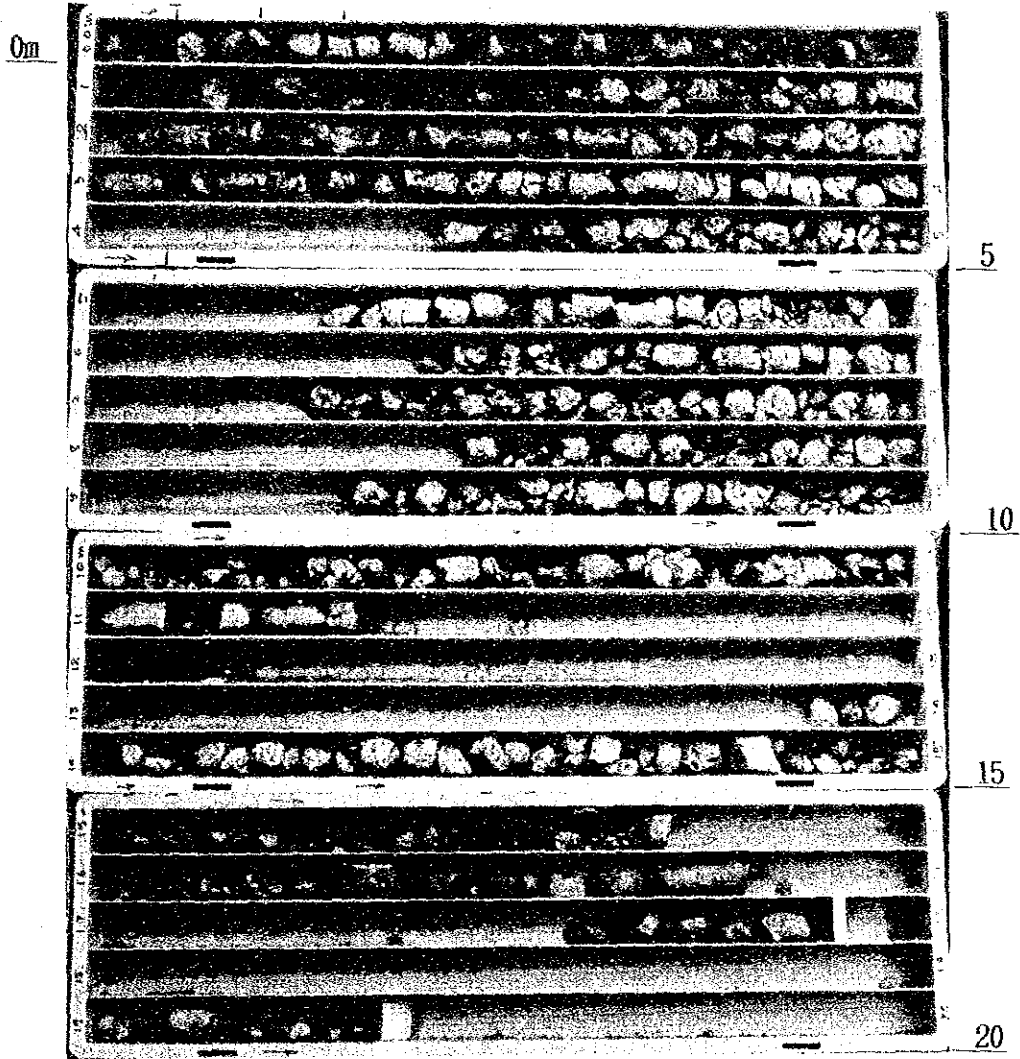


20

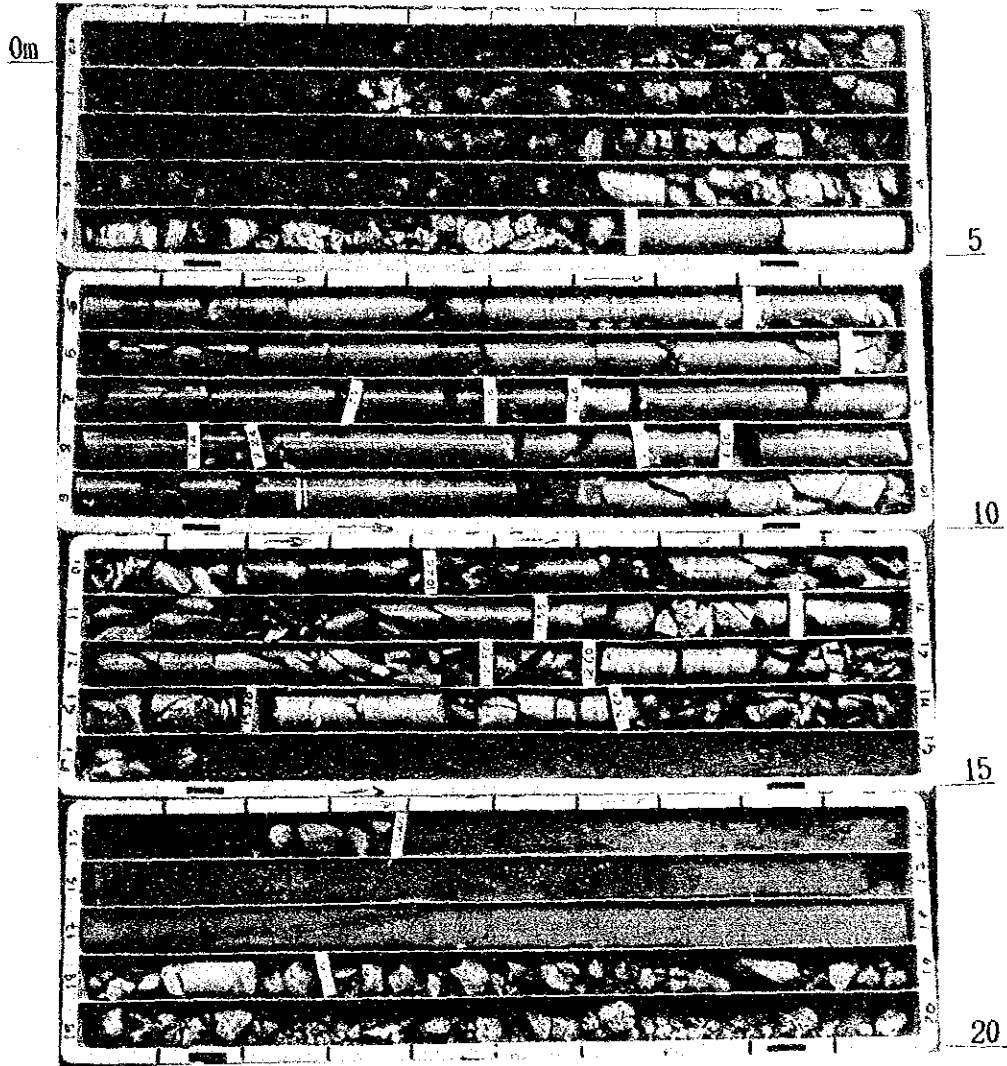
25

30

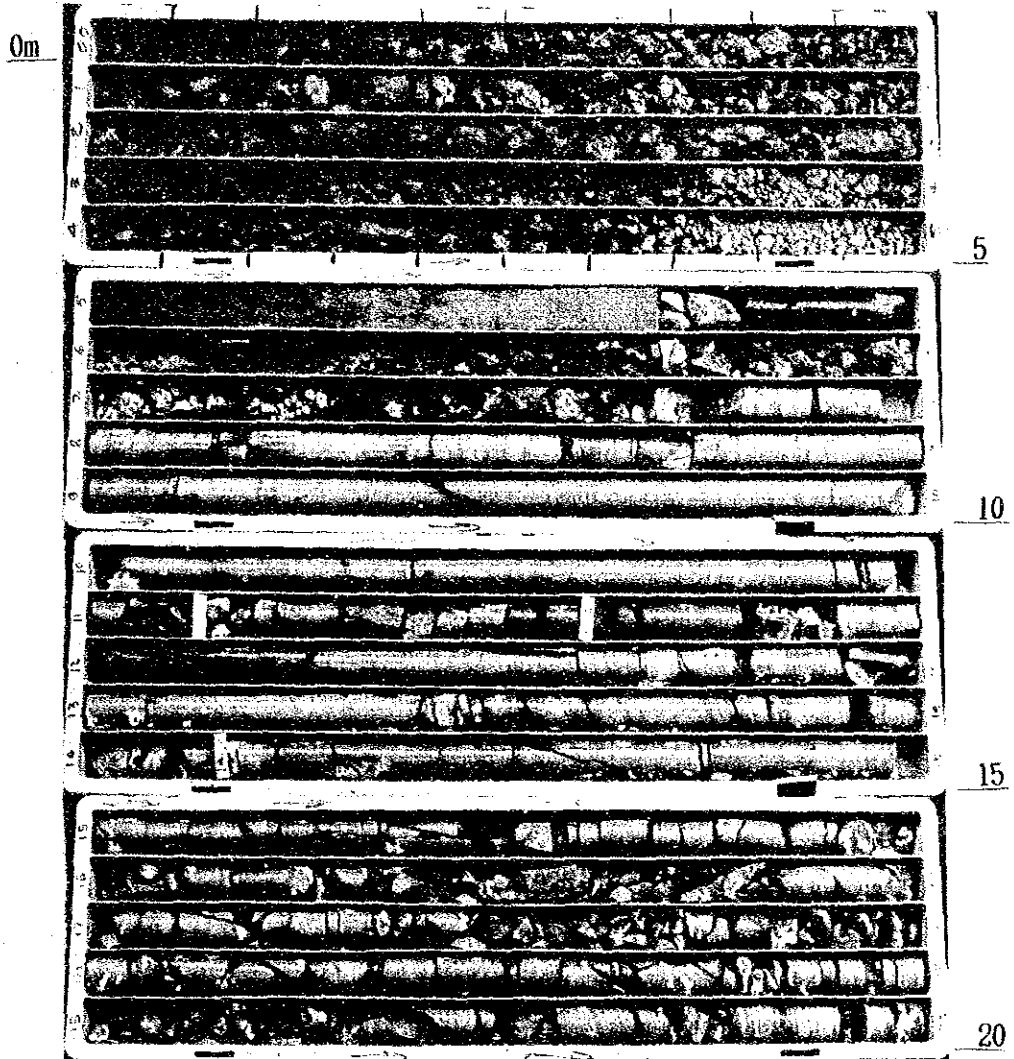
KP-1:Length=20m



KP - 2 : Length=20m



KP-3 : Length=20m



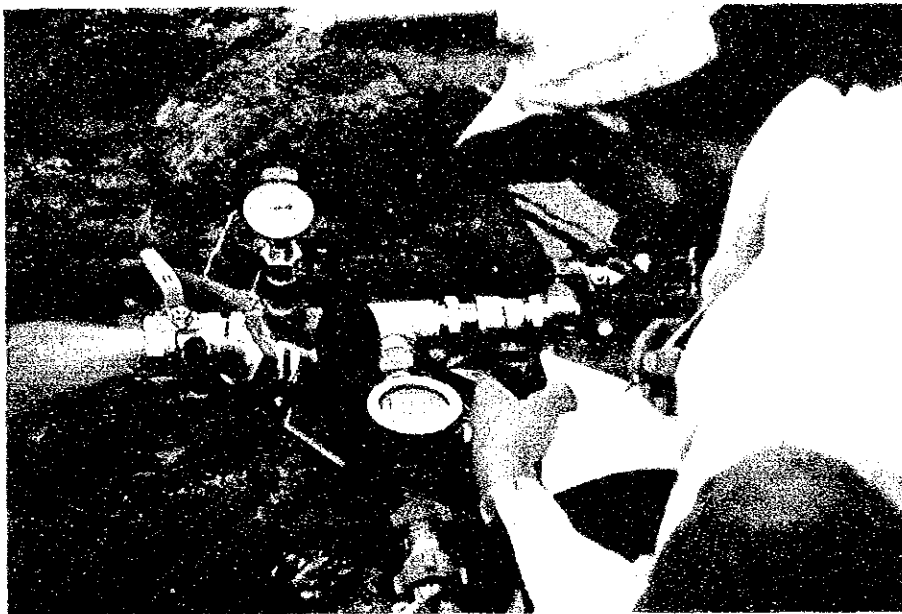
Drilling Work Photograph



Drilling KI-2



Drilling KT-1



Performing permeability test at KI-2



Removing the core drilling equipments along penstock route

Micrograph and Petrographic Description of Rock

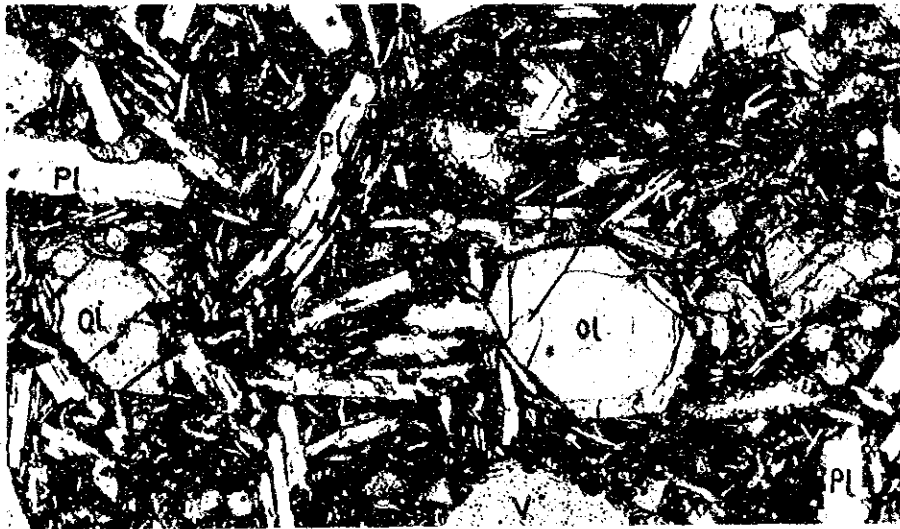
Sample No: R-1

Locality : Intake Dam

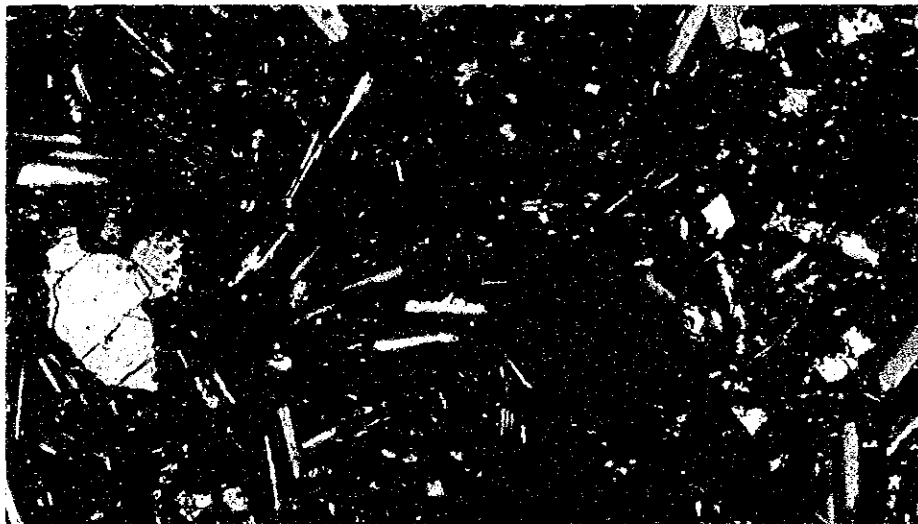
Rock Name: Olivine Basalt

Petrographic Description

Crystals are olivine, plagioclase. Olivines are idiomorphic crystals (0.1 ~ 1.0mm), plagioclases are idiomorphic laths (0.1 ~ 0.8mm). The constituents of the groundmass are plagioclase, pyroxene, olivine, and minor amounts of glass. Rock is very flesh.



0 0.2mm
 (Open nicols)



0 0.2mm
 (Crossed nicols)

Ol:olivine, Pl:Plagioclase, V:vacant

Appendix 3. 気象および水文

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A 3 気象および水文

A 3.1 調査団が実施したXe Namnoy川流域での気象および水文調査

A 3.1.1 自記雨量計設置位置の選定

本調査の第一回現地調査において、Xe Katam流域内の2地点及びXe Namnoy本流流域内の3地点に雨量計設置位置を選定し、設置工事の後、1991年2月より観測を開始した。それぞれの設置位置は次の通りである。

番号	流域	設置位置	設置標高*	経度*	緯度*
No.1	Xe Katam	Ban Xekatom	1060m	106° 26' 15"	15° 14' 00"
No.2	Xe Katam	Ban Tongvay	950m	106° 31' 15"	15° 12' 30"
No.3	Xe Namnoy	Ban Houayong	890m	106° 31' 30"	15° 07' 45"
No.4	Xe Namnoy	Ban Latsasin	750m	106° 36' 15"	15° 03' 15"
No.5	Xe Namnoy	Ban Namkong	700m	106° 34' 30"	14° 59' 00"

*. 標高、経度、緯度は 1/100,000の地形図による概略値。

自記雨量計の設置位置選定に当たっては、流域内に均等に配置することを基本とした。しかし、設置台数が限られていることから、以下の点を配慮して最終的な設置位置を決定した。

- ・観測計器の保守、記録を現地住民に依頼する必要性から、集落内またはその隣接地に設置することとした。また、観測計器の設置、観測記録の入手の都合上、車両が進入可能な場所を選定することとした。
- ・一般的に平地に比べ山間部の方が降雨量が多く、河川の流量はこのような多降雨地域の降雨量により強く影響される。Xe Katam川の流域の左岸側（北側）には標高約1,500mの山稜が控えているため、Xe Katam川左岸流域内への設置を検討したが、アクセスが困難なため諦めざるを得ず、極力山稜部に近い地点としてBan Xe Katam地点とBan Tongvay地点を選定した。

- ・平坦部の降雨量を把握するための地点としてはXe Katam川中流域内のBan Nonghin地点への設置も考えられた。しかし、この地点はBan Tongvay地点に比較的近い位置にあるため、Xe Katam川の流域外ではあるが地形的には連続しているBan Houaykong地点に設置することとした。

- ・Xe Namnoy川本流域では本流中流部左岸側のBan Latsasin地点及びBan Namkong地点を選定し、車両のアクセスが不可能なXe Katam川の北側（左岸側）流域とXe Namnoy川の上流域、及び右岸側流域に設置することは、諦めざるを得なかった。

A 3.1.2 自記水位計設置位置の選定

本調査の第一回現地調査において、Xe Katam川及びXe Namnoy川本流の各1地点に水位計の設置位置を選定し、設置工事の後、1991年2月より観測を開始した。それぞれの設置位置は次のとおりである。

番号	河川	設置位置	設置標高	流域面積
No.1	Xe Katam	Ban Nonghin	840 m	171 km ²
No.2	Xe Namnoy	Ban Latsasin	720 m	537 km ²

設置位置の選定にあたっては、以下の点を配慮して決定した。

- ・水位計の管理、量水標による定時観測、水位流量曲線作成のための流量観測等について、現地の住民に業務を委託することを前提として、集落の隣接地に位置を選定した。
- ・Xe Katam川については、最下流部に位置するXe Katam計画地点（流域面積290km²）の近傍に適当な集落がないため、Xe Katam中流部のBan Nonghin地点（流域面積171km²）に設置することとした。

- ・ Xe Namnoy川については、車両によるアクセスが可能で、本流中流部沿いにある Ban Latsasin地点（流域面積537km²）に設置することとした。

A 3.1.3 流量測定

本調査で検討されるXe Katam川及び Xe Namnoy川の各計画地点の流量資料を得ることを目的として、水位計設置地点を含むいくつかの地点において流速計による流量測定を実施した。調査団による流量測定の結果を Table A3-1 に示す。

Table A3-1 Discharge Measurement by JICA Team

<u>River</u>	<u>Location</u>	<u>Catchment Area</u>	<u>Date</u>	<u>Discharge</u>
Xe Katam	Ban Nonghin	171 km ²	Dec.28,1990	1.8 m ³ /s
			Mar.28,1991	0.64 m ³ /s
			Mar.30,1991	0.58 m ³ /s
	Upstream of Planned Damsite	288 km ²	Dec.28,1990	3.3 m ³ /s
			Mar.28,1991	0.80 m ³ /s
			Mar.28,1991	0.78 m ³ /s
			Jul. 5,1991	13.3 m ³ /s
Planned Damsite	290 km ²	Mar.28,1991	0.78 m ³ /s	
Downstream of Planned Damsite	295 km ²	Mar.30,1991	0.75 m ³ /s	
Xe Katam	Ban Xekatam	49 km ²	Mar.27,1991	0.33 m ³ /s
Xe Namnoy	Ban Latsasin	537 km ²	Dec.29,1990	5.2 m ³ /s
			Mar.26,1991	0.55 m ³ /s
			Mar.31,1991	0.48 m ³ /s
	Powerhouse site of Xe Katam Project	784 km ²	Mar.30,1991	2.2 m ³ /s
H. Makchan	H.Makchan Nikhon34	39 km ²	Mar.27,1991	0.28 m ³ /s
			Jun.23,1991	1.9 m ³ /s
			Jul. 8,1991	2.3 m ³ /s
H. Champi	H. Champi Ban Itou	53 km ²	Apr. 1,1991	0.46 m ³ /s

A3.2 Hydrological Records observed in the Xe Namnoy River Basin

A3.2.1 River Flow Survey on Xe Katam River in 1991

Discharge Measurement Records at Ban Nonghin

XEKATAM SMALL HYDRO-ELECTRIC POWER PROJECT

LIST OF DISCHARGE MEASUREMENT

RIVER : XEKATAM

HYDROLOGIC YEAR 1991

STATION : BAN NONGHIN

SHEET ... 4

Made by : Mr.Sengchanh

Approved by : Mr.Somsack PHRASONTHI

No.	DATE	GAUGE HEIGHT m	AREA sq.m	MEAN VELOCITY m/s	DISCHARGE cu.m/s	G.H CHANGE	REMARKS
1	3-5-91	0,34	7,030	0,185	1,304		
2	8-5-91	0,34	6,830	0,212	1,450		
3	13-5-91	0,33	6,575	0,183	1,208		
4	16-5-91	0,45	9,315	0,255	2,383		
5	18-5-91	0,49	10,460	0,271	2,837		
6	22-5-91	0,49	9,985	0,265	2,654		
7	27-5-91	0,43	7,450	0,240	1,792		
8	30-5-91	0,42	8,100	0,222	1,805		
9	5-6-91	0,41	7,588	0,197	1,497		
10	13-6-91	0,55	11,490	0,333	3,826		
11	18-6-91	0,48	11,135	0,222	2,469		
12	26-6-91	0,68	11,950	0,440	6,134		
13	4-7-91	0,77	16,225	0,622	10,087		
14	7-7-91	0,69	14,023	0,630	6,30		
15	17-7-91	0,81	16,822	0,584	9,832		
16	24-7-91	1,14	28,05	1,178	33,029		
17	31-7-91	0,96	22,35	0,865	19,322		
18	7-8-91	0,94	21,575	0,843	18,186		
19	16-8-91	1,05	21,755	0,985	23,677		
20	17-8-91	1,24	31,45	1,275	40,080		
21	20-8-91	1,28	32,70	1,465	47,894		
22	27-8-91	1,15	27,875	1,189	33,158		
23	29-8-91	1,16	27,85	1,270	35,361		
24	3-9-91	0,96	20,15	0,934	18,817		
25	15-9-91	0,93	19,85	0,869	17,259		
26	18-9-91	0,84	17,666	0,796	14,069		
27	25-9-91	0,94	21,194	0,923	19,555		
28	4-10-91	1,13	27,413	1,294	35,487		