

TABLES

Table-E.3.3: SEISMIC REFRACTION PROSPECTING; LENGTH AND LOCATION OF PROFILE LINE

Line No.	Length (m)			Site
	On Land	In the River	Total	
SL - 1	605	195	800	Damsite A
2	310	190	500	Damsite A
3	300	-	300	Damsite A
4	200	-	200	Damsite A
5	200	-	200	Gravel Deposit A
6	500	-	500	Damsite A
7	200	-	200	Damsite A
8	400	-	400	Damsite A
9	250	-	250	Damsite A
10	935	170	1,105	Damsite B
11	860	140	1,000	Damsite C
12	600	-	600	Damsite B, C
13	1,000	-	1,000	Damsite B, C
14	300	-	300	Damsite A
15	760	140	900	Damsite B
16	630	170	800	Damsite C
17	705	-	705	Damsite B, C
SLG - 1	1,100	-	1,100	Gravel Deposit B
2	1,000	-	1,000	Gravel Deposit B
3	305	-	305	Gravel Deposit B
4	310	-	310	Gravel Deposit B
Total 21 Lines	11,470	1,005	12,475	

Note: See Fig.-E.3 for each site

Table-E.3.4: MAIN INSTRUMENTS AND MATERIALS USED

Item	Name	Description	Quantity
Amplifier	OYO: TR-4-24	24-channel	1 No.
Field Graph	OYO; Model-1230	25-trace	1 No.
Detector	HALL-SEARS; HS-J	14 Hz	30 Nos.
Blaster	KOKUTO RIKEN; GB-105		4 Nos.
Takeout Cable	GT-12	12-channel	4 rolls
Relay Cable	GR-24	24-channel	3 rolls
Linagraph	KODAK; Type 1895	SPEC 2	23 rolls
Dynamite			218.4 kg
Detonator			801 pcs

Table-E.3.5: LAYERED VELOCITIES AND CORRELATIVE GEOLOGY

I. Damsite

Zoning	Velocity (km/sec)	Correlative Geology
1st layer*	0.3 to 0.5	Top soil, talus deposits and surfacial loose layer of terrace deposits
2nd layer	0.5 to 0.8	} Unconsolidated clay, silt, sand and gravel; terrace deposits, residual soil and decomposed rocks
3rd layer	0.7 to 1.3	
4th layer	1.6 to 2.2	Saturated and deep terrace deposits, saturated sand and gravel deposits in the riverbed and weathered rocks
5th layer**	2.6 to 3.0	Bedrock; soft rocks
	3.1 to 3.8	Bedrock; moderately hard and solid rocks

II. Gravel Deposit B Site

Zoning	Velocity (km/sec)	Correlative Geology
1st layer*	0.3 to 0.4	Top soil, silty soil
2nd layer	0.4 to 0.6	Loose sand and gravel
3rd layer	1.1 to 1.4	} Saturated sand and gravel ↑ Dense
4th layer	1.6 to 1.9	
5th layer	2.2 to 2.5	
6th layer**	2.5 to 3.5	Cemented conglomerates and/or bedrock (Inferred)

* Uppermost low-speed layer

** Deepest layer

Table-E.3.6: CORE DRILLING LENGTH

Hole No.	Length Drilled (in Linear Meter)	Location	Time Drilled
DG-1*	37.2	A; Left	Before F/S
DG-2*	50	A; Left	- do -
DG-3*	31.3	A; River	- do -
B80-1	40	A; River	F/S Stage I
B80-2	40	A; River	- do -
B80-3	45	A; Left	- do -
B81-1	30	A; Left	F/S Stage II
B81-2	50	B; Left	- do -
B81-3	50	B; Right	- do -
B81-4	40	A; Right	- do -
B81-5	50	B; Left	- do -
B81-6	36	B; River	- do -
B81-7	50	C; Left	- do -
B81-8	40	A; Right	- do -
B81-9	40	A; Left	- do -
B81-10	40	A; Left	- do -
B81-11	30.5	B; River	- do -
B81-12	60	B; Left	- do -
B81-13	50	B; River	- do -
B81-14	50	C; Left	- do -
B81-15	50	B; River	- do -
B81-16	50	C; Right	- do -
B81-17	50	B; Right	- do -
B81-18	50	C; Left	- do -
Total length	1,060 m	A site 11 Holes	Before F/S 3 Holes
(F/S stage total	941.5 m)	B site 9 Holes	F/S Stage I 3 Holes
		C site 4 Holes	F/S Stage II 18 Holes

Note: A; : Dam site A Left, : Left bank
 B; : Dam site B Right : Right bank
 C; : Dam site C River : Riverbed
 F/S : Feasibility Study

* : Holes drilled before F/S stage

Table-E.3.7: LIST OF ROCK SAMPLES FOR LABORATORY TEST

Hole No.	Location	Depth (m)	Rock Name	Strata
B81-5	Damsite B Left bank	10.4 - 10.75	Medium Sandstone	MS-6 Member
		16.0 - 16.6	Medium Sandstone	
		21.55 - 22.0	Dark-gray Siltstone	
		25.1 - 26.0	Yellowish Sandstone	
		31.4 - 31.95	Breccia (Calcareous)	
B81-14	Damsite C Left bank	6.2 - 7.0	Medium Sandstone	MS-4 Member
		13.0 - 13.55	Fine Sandstone (Calcareous)	
		21.0 - 21.45	Medium Sandstone	
		29.0 - 29.5	Sandy Mudstone	
TG-4	Damsite B Left bank	7.6 - 8.0	Dark-gray Siltstone	At-5 Member
		9.0 - 10.0	Sandy Mudstone	

Table-E.3.8: APPLIED PRESSURE IN
THE WATER PRESSURE TEST

Depth (m)	Overburden Pressure ^{/1} (kg/cm ²)	Stage ^{/2} No.	Applied Pumping Pressure ^{/3} (kg/cm ²)
0	0	1	1 → 2 → 1
5	1.25	2	1 → 2 → 3 → 2 → 1
10	2.5	3	1 → 2.5 → 4 → 2.5 → 1
15	3.75	4	1 → 3 → 5 → 3 → 1
20	5.0	5	1 → 3 → 5 → 7 → 4 → 2
25	6.75	6	2 → 4 → 6 → 8 → 5 → 3
30	7.5	7	2 → 4 → 7 → 9 → 6 → 3
35	8.75	8	
40	10.0	9	2 → 5 → 8 → 10 → 7 → 3
45	11.25	10	(The same pattern was applied in the stages from 8th to 12th)
50	12.5	11	
55	13.75	12	
60	15.0		

Remarks: /1; The density of overburden is assumed as 2.5 g/cm³.

/2; The section length of a stage was fixed in five meter in general.

/3; Pressure was varied from left one to right one in the same stage.

Table-E.3.9: LUGEON TEST RESULTS

(Unit in Lugeon)

Depth (m)	Bore - holes on Left Bank					in River Channel					on Right Bank					Stage Average	
	B81-9	B81-12	B81-2	B81-5	B81-14	B81-7	B81-18	B80-1	B80-2	B80-15	B80-13	B81-4	B81-8	B81-3	B81-17		B81-16
0																	0.6
5					0.6												
10					0.1								1.0	0.71			40.3
15	7.4			0.4	2.8		3.2						1.1	2.33	2.4		4.03
20	1.75	4.7	3.4	9.0	1.04	3.6	3.68		17.7				2.8	2.45	1.2	4.91	4.58
25	1.59	5.9	2.2	13.08	0.64	22.2	13.48	2.54	3.13				7.2	1.28	0.8	10.2	14.6
30	1.49	5.8	9.9	0.69	1.69	6.5	0.63	6.64	5.6				7.6	1.83	1.14	6.88	4.19
35	8.2	11.0	0.53	10.78	0.2	6.8	3.6	3.15	3.49	0.34	0.05	2.3	20.4	2.3	1.08	12.5	9.98
40	8.1	12.2	0.31	0.89	0.6	1.78	0.98	6.57	4.97	0.39	0	10.4	2.22	2.07	0.62	2.46	3.41
45		2.1	1.1	1.14	0.02	0.9			0.32	0.05				4.66	1.88	6.44	1.86
50		1.1	1.18	1.18	0	7.28	1.88		0.55	0.15				1.62	2.04	16.75	3.07
55		1.3															1.3
60		1.3															1.3
Average	21.9	6.68	4.94	3.70	2.22	3.66	5.14	2.65	4.30	3.86	2.39	2.73	6.12	2.14	1.39	8.59	7.35

Table-E.3.10: PERMEABILITY OF TERRACE DEPOSIT AND RIVERBED DEPOSIT

No.	Borehole No.	Depth (m)	Geology	Method	L (cm)	r (cm)	H (cm)	$\frac{Q}{cm^3/sec}$	k (cm/sec)
1	B81-1	0 - 19.0	T1	P	1,900	4.3	950	263.3	1.41×10^{-4}
2	B81-10	36.2 - 37.6	T2	P	140	3.3	620	683.3	4.69×10^{-3}
3	B81-13	5.0	R	O	-	5.08	200	8.3	1.5×10^{-3}
4	B81-13	10.0	R	O	-	5.08	1,060	196.7	6.65×10^{-3}
							2,060	296.7	5.16×10^{-3}
							3,060	503.3	5.89×10^{-3}
							Average	5.9	5.9×10^{-3}

Note: Geology: T1 = Terrace deposit of sandy site with scattered pebbles, cobbles and boulders.

T2 = Terrace deposit of sand and gravel.

R = Riverbed deposit.

Method : P = The pumping-in test; O = The open-end pipe test (see report discussion in the Section 5.4.1)

L = The length of test section.

r = The radius of hole tested or the internal radius of casing.

H = The differential head of water; $H = H$ (gravity) + H (pressure).

Q = The constant head of flow into the hole.

k = The permeability.

Formulas for the tests: (1) Method P: $k = \frac{Q}{2\pi L \cdot H} \log_e \frac{L}{r}$ (2) Method O: $k = \frac{Q}{5.5 r \cdot H}$

Table-E.3.11: WATER TABLE OBSERVED IN BOREHOLES

Hole No.	Completion of Drilling	Water Table Elevation on the Date of					
		Completion	Feb. 26	Mar. 8	Mar. 18	Mar. 27	Apr. 7
B81-1	Nov. 6, '81	(Dry in deep at the bottom EL.202.46 m)					
B81-2	Feb. 10, '82	244.0	243.2	243.1	242.85	239.75	239.3
B81-3	Mar. 17, '82	198.95	-	-	198.6	195.5	195.25
B81-4	Dec. 4, '81	221.2	204.9	204.7	204.2	203.95	203.95
B81-5	Feb. 21, '82	221.7	225.85	224.7	224.5	224.25	223.9
B81-6	Mar. 26, '82	(Drilled in the river)					
B81-7	Mar. 3, '82	229.2	-	-	217.5	222.6	222.5
B81-8	Nov. 23, '81	201.5	197.0	196.9	196.6	196.5	195.9
B81-9	Nov. 3, '81	195.8	-	-	-	-	-
B81-10	Dec. 27, '81	194.6	-	-	-	-	-
B81-11	Feb. 21, '82	(Drilled in the river)					
B81-12	Jan. 28, '82	221.2	221.1	220.65	220.2	219.8	219.4
B81-13	Apr. 9, '82	(Drilled in the river)					
B81-14	Jan. 4, '82	197.2	195.35	195.45	195.2	195.1	194.85
B81-15	Apr. 9, '82	(Drilled in the river)					
B81-16	Mar. 31, '82	217.6	-	-	-	-	217.0
B81-17	Mar. 24, '82	185.7	-	-	-	185.4	185.4
B81-18	Apr. 10, '82	198.9	-	-	-	-	-
TG-6	Mar. 5, '82	190.9	-	190.5	190.5	190.4	190.4

Note: 1) Unit in meter
 2) -; Not measured
 3) The borehole B81-8 encountered confined ground water at the depth of 32 m (Head = 36.5 m).

Table-E.3.12: TABLE OF TEST GROUTING RESULTS

Sequcence of Grouting	Primary Holes			Secondary Hole	Tertiary Holes			Check Holes		Whole Average		
	TC-1	TC-2	Aver- age		TC-3	TC-4	TC-5	Aver- age	TC-6		TC-7	Aver- age
Lugeon Test (Ingeon)	Hole No.											
	(Stage No.)	137.9	720	429.0	5.0	4.2	3.8	4.0	1.2	-	1.2	145.4
	1st Stage; 5 to 10 m, 1.25 kg/cm ²											
	2nd Stage; 10 to 15 m, 2.5 kg/cm ²	3.2	3.7	3.5	2.6	2.6	3.0	2.8	0.07	0.2	0.14	2.2
	3rd Stage; 15 to 20 m, 3.75 kg/cm ²	26.9	1.5	14.2	1.1	1.7	2.2	2.0	0.2	0.1	0.15	4.8.
	4th Stage; 20 to 25 m, 5 kg/cm ²	2.5	1.8	2.2	1.2							1.8
Grout Take (lit/m)	Hole No.											
	5th Stage; 25 to 30 m, 6.5 kg/cm ²	1.4	1.6	1.5	0.9							1.3
	Hole Average	34.4	145.7	90.1	2.2	2.8	3.0	2.9	0.5	0.15	0.5	(31.1)
	1st Stage; 5 to 10 m, 1.25 kg/cm ²	309.6	164.3	237.0	3.6	30.6	2.3	16.5				102.1
	2nd Stage; 10 to 15 m, 2.5 kg/cm ²	5.9	3.7	4.8	2.3	1.4	1.8	1.6				3.0
	3rd Stage; 15 to 20 m, 3.75 kg/cm ²	1,212.4	11.4	612.1	7.2	1.8	4.5	3.2				247.5
Take (Cement kg/m)	Hole No.											
	4th Stage; 20 to 25 m, 5 kg/cm ²	18.9	4.5	11.7	4.5							9.3
	5th Stage; 25 to 30 m, 6.5 kg/cm ²	2.7	64.3	33.5	2.3							23.1
	Hole Average	309.9	49.7	179.8	4.0	11.3	2.9	7.1				(88.6)
	1st Stage; 5 to 10 m, 1.25 kg/cm ²	107.7	49.5	78.6	0.4	9.2	0.7	5.0				33.5
	2nd Stage; 10 to 15 m, 2.5 kg/cm ²	0.7	0.6	0.7	0.7	0.4	0.5	0.5				0.6
Take (Cement kg/m)	Hole No.											
	3rd Stage; 15 to 20 m, 3.75 kg/cm ²	345.3	1.4	173.4	0.9	0.6	1.4	1.0				69.9
	4th Stage; 20 to 25 m, 5 kg/cm ²	2.3	0.5	1.4	1.4							1.4
	5th Stage; 25 to 30 m, 6.5 kg/cm ²	0.3	7.7	4.0	0.7							2.9
	Hole Average	91.3	11.9	51.6	0.8	3.4	0.9	2.2				(25.4)

Table-E.3.13: EXCAVATED ADIT LENGTH

Adit No.	Portal		Tunnel						
	N Nos.	L m	UL m	Substituted		Fore poling		TL m	TV m ³
				N Nos.	L m.	N Nos.	L m.		
TA-1	1	1.5	40.5	9	9.5	0	0	50.0	150
TA-2	2	2.0	38.5	4	4.5	8	7	50.0	150

Note: N : Number of supports L : Tunnel linear length
 UL : Unsupported section linear length
 TL : Total linear length TV : Total excavated volume

Table-E.3.14: LABORERS, EQUIPMENTS AND MATERIALS FOR TEST ADIT EXCAVATION

<u>Item</u>	<u>Description</u>	<u>Quantity</u>
<u>A. Laborers engaged</u>	Drillers	314 Man-days
	<u>Common Labors</u>	<u>500 Man-days</u>
	Total	814 Man-days
<u>B. Equipments used</u>		
1. Air-compressor	HOKUETSU; PDR-370, 10.5 m ³ /min;	1 No.: 150 Hours
2. Leg Drill	FURUKAWA; 322D-LB56	2 Nos: 133 Hours
3. Pick Hammer	FURUKAWA; CA-7	2 Nos
4. Generator	YMG-35; 110 V, 3 kVA	1 No.: 377 Hours
5. Water Tank	0.3 m ³	1 No.
6. Pump	KOKEN; MG-5	1 No.
7. Bench Grinder		1 No.
<u>C. Material consumed</u>		
1. Dynamite	Made in India	1,025 kg
2. Detonators	Made in India	2,422 pcs
3. Timber	Logs; 150 mm dia. x 1,800 mmL	60 pcs
- do -	Logs; 100 mm dia. x 1,800 mmL	40 pcs
- do -	Plate; 200 x 1,500 x 40 mm	5,127 m ³
- do -	Square; 100 x 100 x 3,000 mm	1.83 m ³
4. Fuel	For Diesel Engines	2,240 Lit.

Table-E.3.15: TEST ITEMS AND NUMBER OF SAMPLES TESTED

Test Item	Rock Group				
	I	II	III	IV	V
1. Apparent specific gravity, water absorption and porosity	1	1	1	1	1
2. P-wave and S-wave velocities (air-dried state)	3	3	2	2	2
3. P-wave and S-wave velocities (saturated state)	3	3	-	-	-
4. Unconfined compression test	-	-	2	2	2
5. Poisson's ratio (air-dried state)	3	3	-	-	-
6. Poisson's ratio (saturated state)	3	3	-	-	-
7. Brazilian test (tensile strength)	2	3	-	-	-
8. Triaxial compression test ($\sigma_3 = 10 \text{ kg/cm}^2$)	3	-	-	-	-
9. Triaxial compression test ($\sigma_3 = 20 \text{ kg/cm}^2$)	3	-	-	-	-
10. Weathering test	1	1	-	-	-

Table-E.3.16(2): SUMMARY OF ROCK TEST (2)

SAMPLE NO.	1-5	1-6	2-2(1)	2-2(2)	2-2(3)	2-2(4)	2-2(5)	2-2(6)	2-2(7)	2-2(8)	2-2(9)	3-1(1)	3-1(2)	3-2
LOCATION NO. & DEPTH	B81-5 16.0 to 16.6 m	B81-5 25.2 to 25.6 m										B81-5 21.5 to 22.0 m		IG-4 7.6 to 8.0 m Sandy silt- stone
ROCK NAME IN LITHOLOGY	Medium sandstone	Medium sandstone	Sandy mudstone											
OBSERVATION	White Gray Massive	Yellowish gray Some weathered	Greenish gray Being cracks due to slaking											
CONDITION OF SPEC. MEN IN ROCK TEST	NAT NOT	NAT NOT	NAT NOT	NAT NOT	NAT NOT	NAT NOT	NAT NOT	NAT NOT	NAT NOT	NAT NOT	NAT NOT	NAT NOT	NAT NOT	NAT NOT
APPARENT SPECIFIC GRAVITY G_s	2.337	2.324	2.561									2.616		2.700
DENSITY γ (kg/cm^3)	2.276	2.270	2.574	2.558	2.574	2.576	2.570	2.588	2.551	2.560	2.544	2.621	2.617	2.681
NATURAL WATER CONTENT W_n (%)	0.56	0.60	3.04									2.12		0.44
WATER ABSORPTION W_{at} (%)	6.73	5.72	4.00									2.75		0.63
APPARENT POROSITY n (%)	14.89	12.67	9.92									7.03		1.69
P WAVE V_p (km/sec)			2.97	3.11	3.00	2.93	3.01	3.00				3.34	3.20	
S WAVE V_s (km/sec)			1.67	1.67	1.62	1.56	1.65	1.54				1.94	1.67	
DYNAMIC MODULUS OF ELASTICITY E_D (kg/cm^2)			6.92x10 ⁵	1.88x10 ⁵	1.89x10 ⁵	1.67x10 ⁵	1.88x10 ⁵	1.65x10 ⁵				2.50x10 ⁵	1.96x10 ⁵	
DYNAMIC POISSON'S RATIO μ_D			0.269	0.298	0.294	0.302	0.285	0.321				0.245	0.313	
UNCONFINED COMPRESSIVE STRENGTH σ_c (kg/cm^2)			163.9	261.3	207.8	53.0	93.5	77.0				206.5	131.7	
STATIC MODULUS OF ELASTICITY E_S (kg/cm^2)			1.21x10 ⁴	2.97x10 ⁴	2.00x10 ⁴	3.4x10 ³	5.6x10 ³	4.5x10 ³				2.68x10 ⁴	3.66x10 ⁴	
STATIC POISSON'S RATIO μ_s			0.338	0.354	0.312	0.300	0.397	0.367						
GRAZIAN TENSILE STRENGTH σ_t (kg/cm^2)									12.38	6.80	4.63			
CONFINING PRESSURE σ_3 (kg/cm^2)														
STRESS DIFFERENCE $\sigma_1 - \sigma_3$ (kg/cm^2)														
COHESION c (kg/cm^2)														
ANGLE OF INTERNAL FRICTION ϕ														
DRY & SAT. PASSING PERCENT LOSS (%)			2											
WEATHERING TEST			100											

REMARKS

Table-E. 3.17: DETERMINATION OF PROPERTY OF ROCK SAMPLES

SAMPLE NO.	1-1 to 1-5		2-2		3-1 and 3-2		4-1		5-1	
	BSI-14 (6.2 to 7, 10 to 11, 21 to 21.4 m) BSI-5 (10.4 to 10.7, 16 to 16.6, 25 to 25.6 m) Medium sandstone		TG-4 (9.0 to 10.0 m) Sandy mudstone		BSI-5 (21.5 to 22.0 m) TG-4 (7.6 to 8.0 m) Siltstone		BSI-5 (31.4 to 31.9 m) Breccia		BSI-14 (13.0 to 13.5 m) Fine sandstone	
LOCATION NO. & DEPTH										
ROCK NAME IN LITHOLOGY										
OBSERVATION										
CONDITION OF SPEC. MEN IN ROCK TEST	MOISTURE	NAT	SAT	NAT	SAT	NAT	NAT	NAT	NAT	NAT
APPARENT SPECIFIC GRAVITY G_a	2.407			2.561		2.653		2.690		2.666
DENSITY ρ (kg/cm^3)										
NATURAL WATER CONTENT, Wt (%)				4.00				0.70		0.85
WATER ABSORPTION, Wt (%)	5.24			9.92				1.88		2.25
APPARENT POROSITY, n (%)	12.07									
P WAVE V_p (km/sec)	1.63	2.07		3.03	2.98			5.02		4.38
S WAVE V_s (km/sec)	0.91	0.97		1.65	1.58			2.99		2.50
DYNAMIC MODULUS OF ELASTICITY E_d (kg/cm^2)	5.11×10^4	6.34×10^4		1.90×10^5	1.72×10^5			6.02×10^5		4.39×10^5
DYNAMIC POISSON'S RATIO μ_D	0.271	0.359		0.287	0.303			0.226		0.262
UNCONFINED COMPRESSIVE STRENGTH σ_c (kg/cm^2)	126.1	100.0		211.0	75.2			688.8		686.1
STATIC MODULUS OF ELASTICITY E_s (kg/cm^2)	2.05×10^4	1.13×10^4		2.06×10^4	4.5×10^3			3.52×10^5		3.14×10^5
STATIC POISSON'S RATIO μ_s	0.329	0.308		0.335	0.355					
BRAZILIAN TENSILE STRENGTH σ_t (kg/cm^2)	6.02			7.94						
CONFINING PRESSURE σ_3 (kg/cm^2)	20	10								
STRESS DIFFERENCE $\sigma_1 - \sigma_3$ (kg/cm^2)	340.3	285.7								
COHESION c (kg/cm^2)	20			26						
ANGLE OF INTERNAL FRICTION ϕ (°)	54			53						
DRY & SAT. PASSING PERCENT LOSS (%)	5			2						
PERCENT LOSS (%)	0			100						
REMARKS	/1 NAT : Tested under the natural moistured condition. /2 SAT : Tested under the saturated condition.									

Table-E.3.18: LIST OF TRENCHES

Trench No.	Location		Length / ⁴ (m)	Geology Revealed	
	Site	Line No. / ²		Stake No. / ³	Overburden / ⁵
TR-1	Damsite B : L / ¹	SL-10	75 to 83	Tr	Sst and Ms-8
TR-2	Damsite B : R	SL-10	212 to 220	(Thin)	At-3
TR-3	Damsite C : L	SL-11	69 to 75	Tr	Ms-5
TR-4	Damsite C : R	SL-11	193 to 199	(Thin)	At-1
Total			156.1		

Note: /¹; Site: L = Left bank; R = Right bank.

/²; Seismic refraction profile line No.

/³; Survey stake No. of a seismic refraction profile.

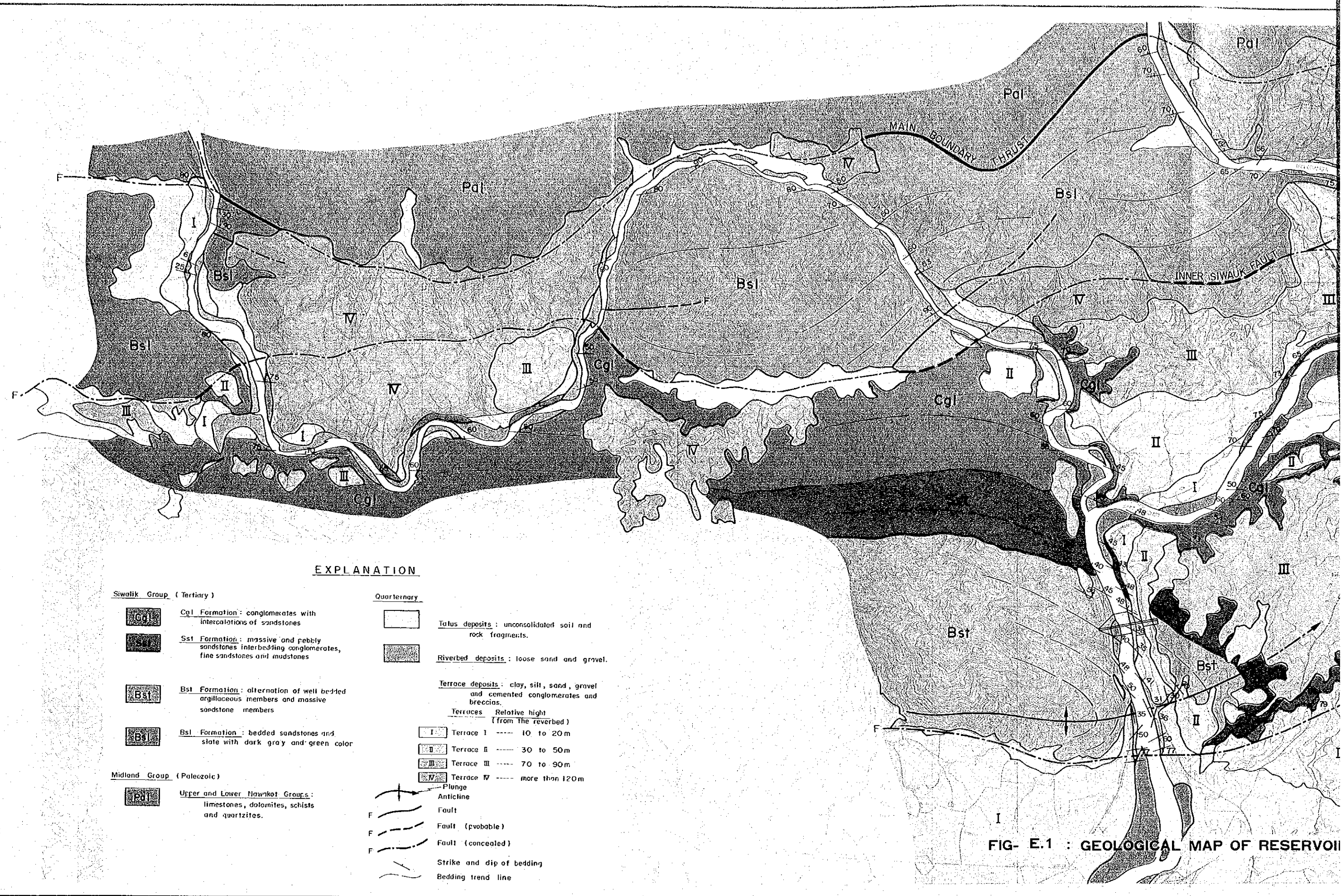
/⁴; Linear length of trench excavated along the slope.

/⁵; Overburden: Tr = Terrace deposits.

/⁶; Sst = Sst Formation.

Ms-8, Mt-3, Ms-5 and At-1 are members of Bst Formation.

FIGURES



EXPLANATION

Siwalik Group (Tertiary)

- Cgl** Cgl Formation: conglomerates with intercalations of sandstones
- Sst** Sst Formation: massive and pebbly sandstones interbedding conglomerates, fine sandstones and mudstones
- Bst** Bst Formation: alternation of well bedded argillaceous members and massive sandstone members
- Bs** Bs Formation: bedded sandstones and slate with dark gray and green color

Midland Group (Paleozoic)

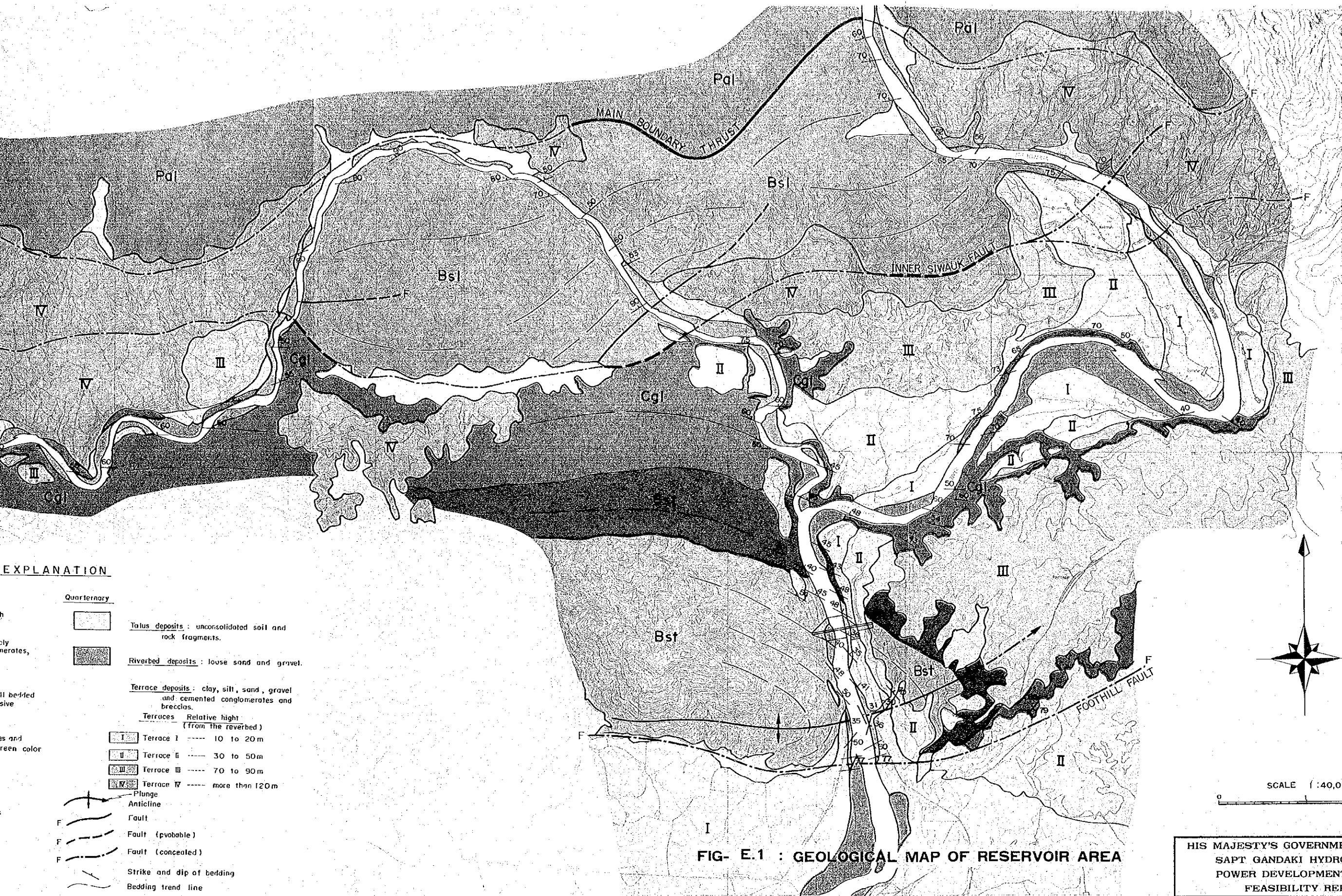
- PaI** Upper and Lower Nawkot Groups: limestones, dolomites, schists and quartzites.

Quaternary

- Talus deposits: unconsolidated soil and rock fragments.
 - Riverbed deposits: loose sand and gravel.
 - Terrace deposits: clay, silt, sand, gravel and cemented conglomerates and breccias.
- | Terraces | Relative height (from the riverbed) |
|----------|-------------------------------------|
| I | 10 to 20m |
| II | 30 to 50m |
| III | 70 to 90m |
| IV | more than 120m |

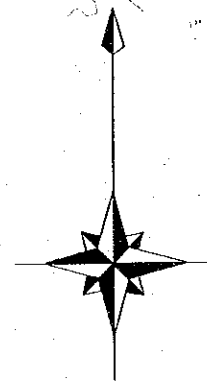
- Plunge
- Anticline
- Fault
- Fault (probable)
- Fault (concealed)
- Strike and dip of bedding
- Bedding trend line

FIG- E.1 : GEOLOGICAL MAP OF RESERVOIR



EXPLANATION

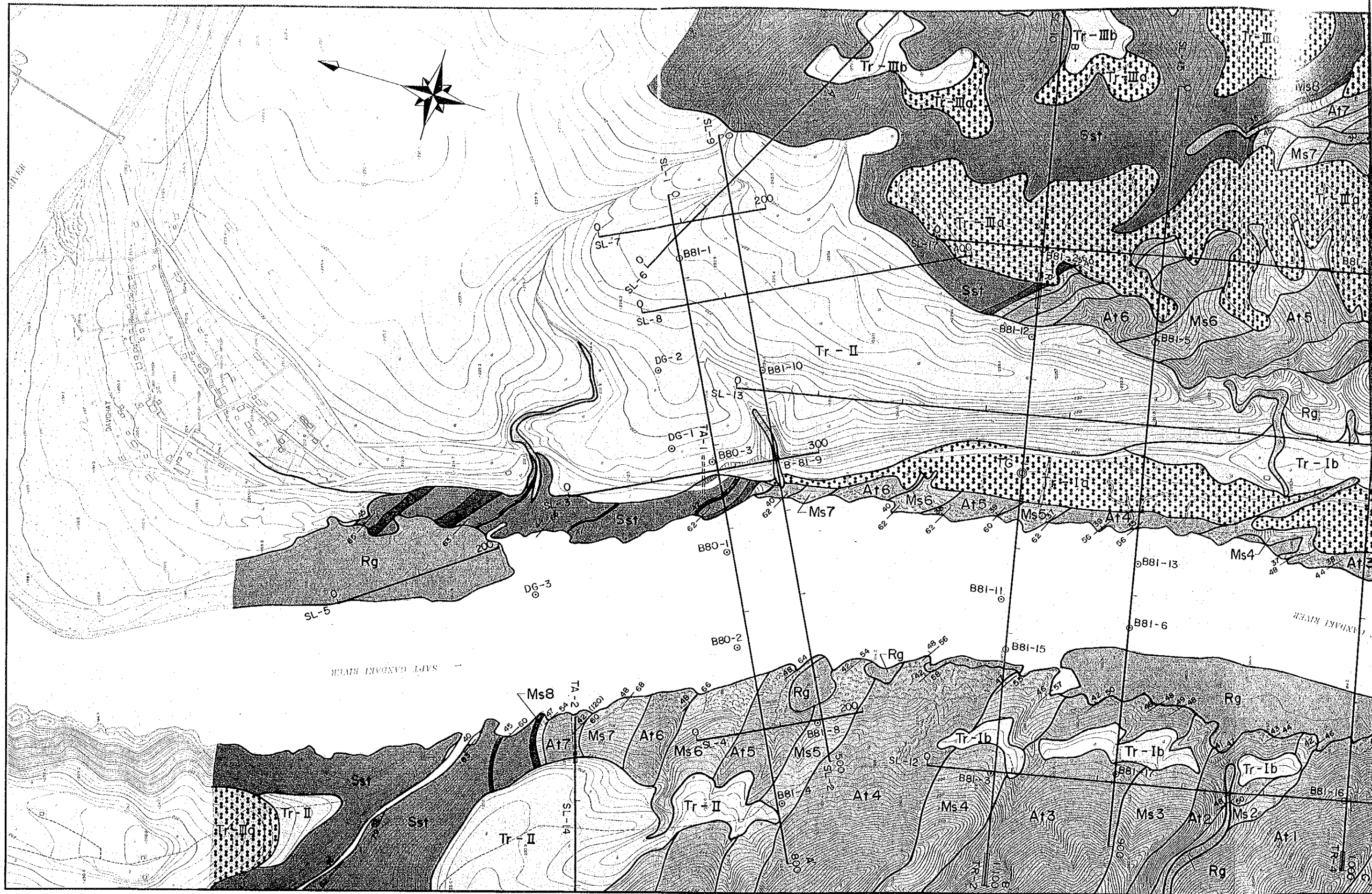
- Quaternary**
- Talus deposits : unconsolidated soil and rock fragments.
 - Riverbed deposits : loose sand and gravel.
 - Terrace deposits : clay, silt, sand, gravel and cemented conglomerates and breccias.
- Terraces** Relative height (from the riverbed)
- Terrace I ----- 10 to 20m
 - Terrace II ----- 30 to 50m
 - Terrace III ----- 70 to 90m
 - Terrace IV ----- more than 120m
- Plunge
- Anticline
- Fault
- Fault (probable)
- Fault (concealed)
- Strike and dip of bedding
- Bedding trend line



SCALE 1:40,000
0 2km

FIG- E.1 : GEOLOGICAL MAP OF RESERVOIR AREA

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
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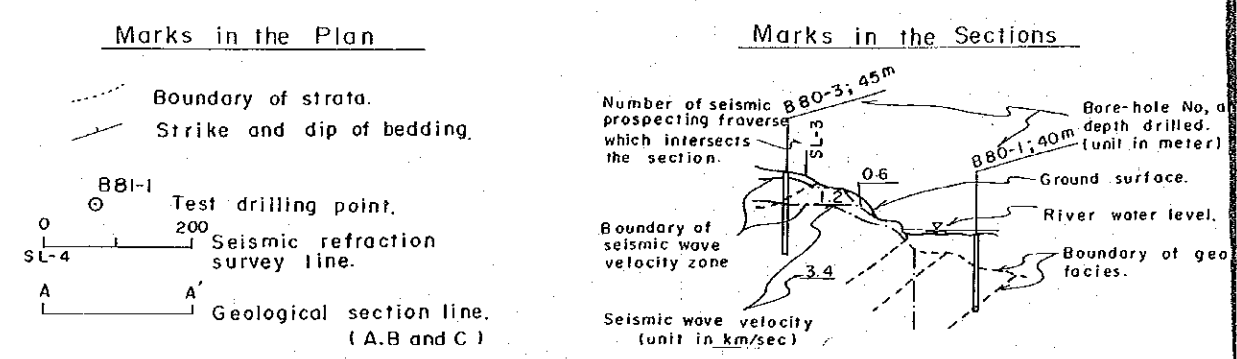
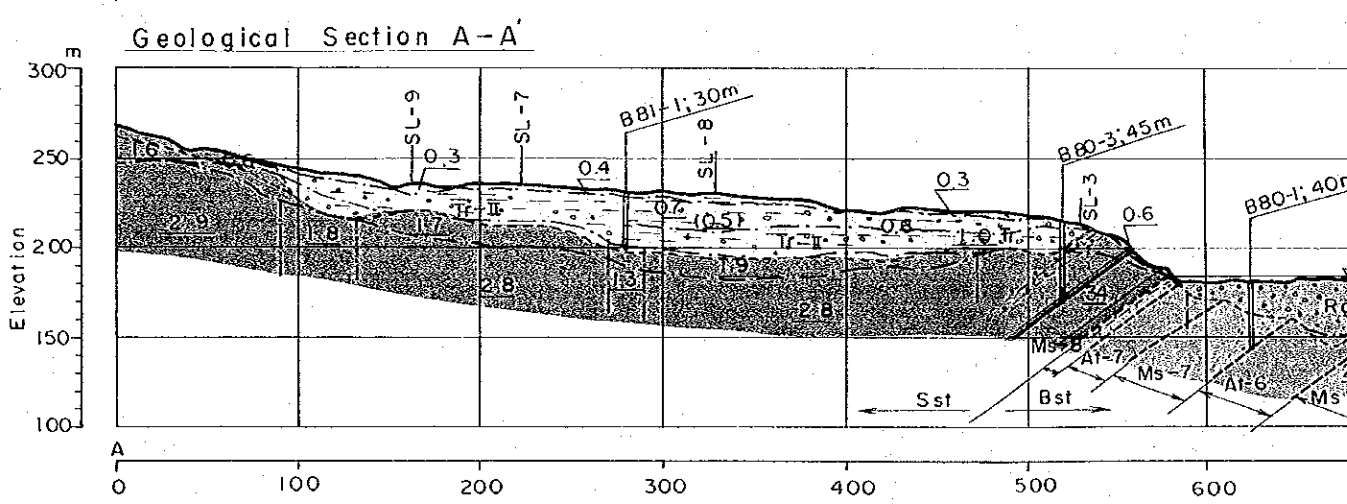
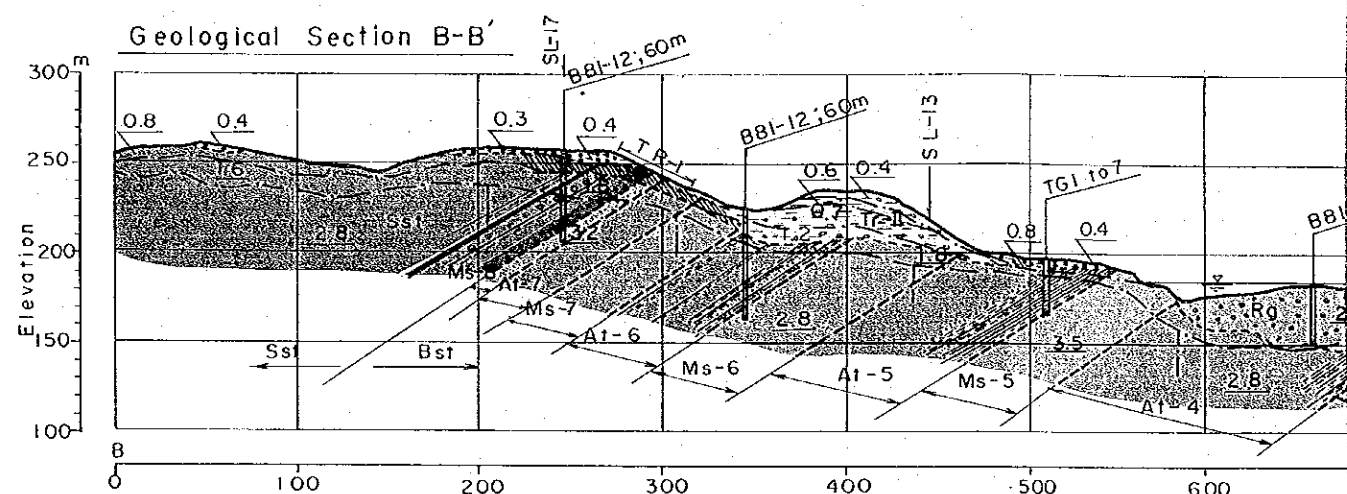
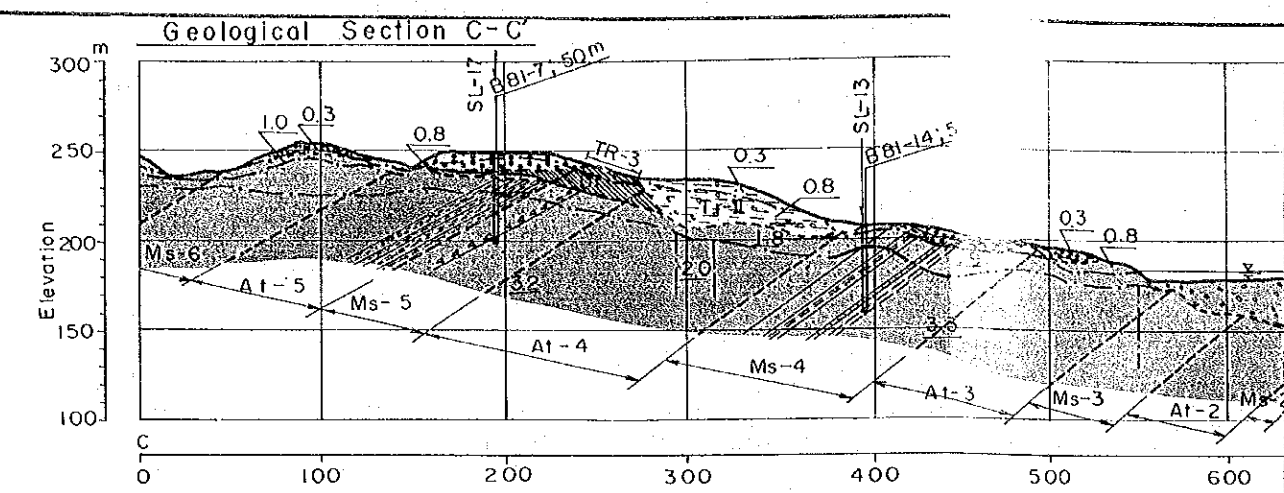
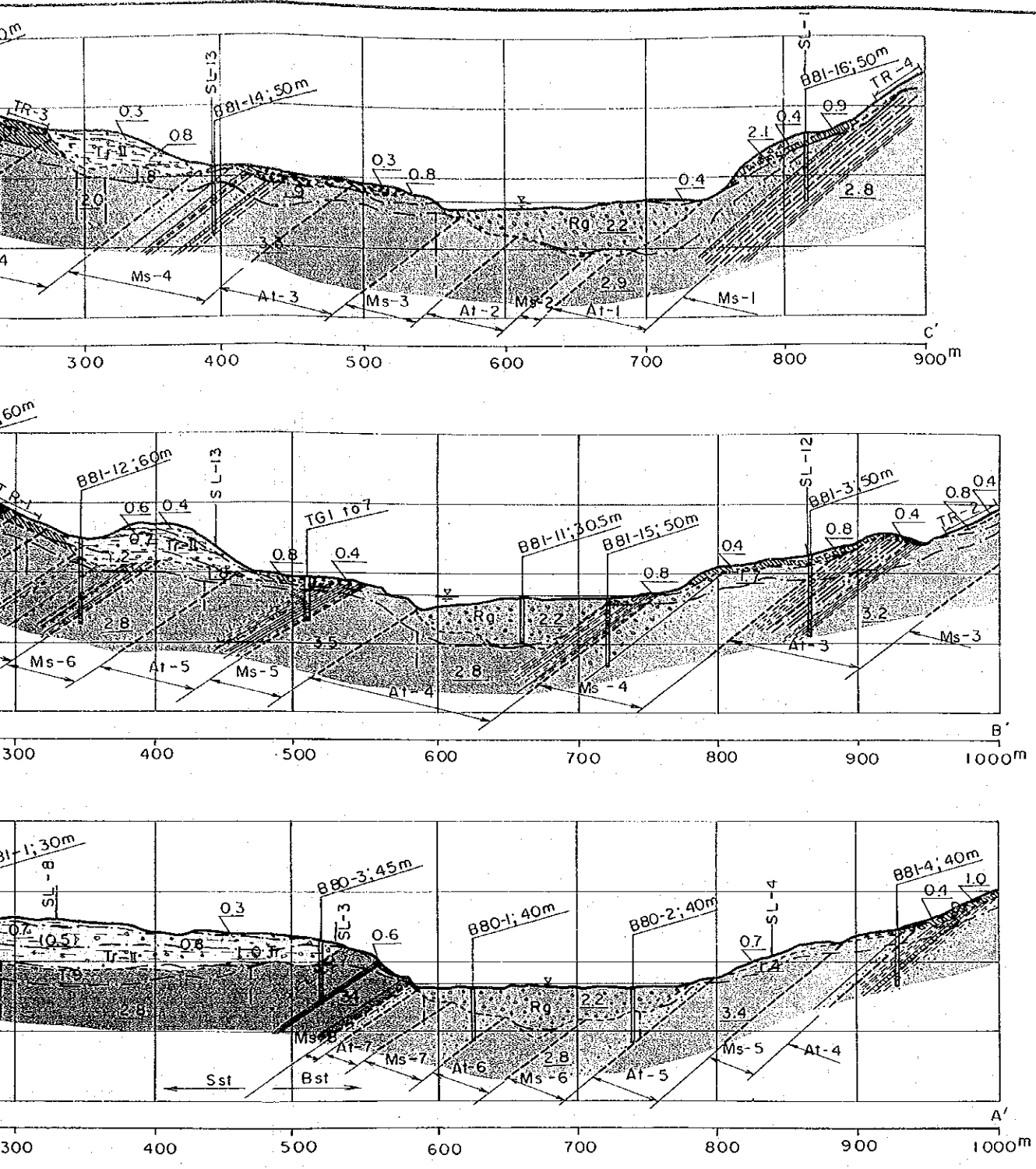


FIG- E.2



Explanation

		Descriptions		Thickness	
Alluvium	Riverbed Deposits	Rg	Silt, sand and gravel.	15 to 40 m in the main channel	
	Terrace Deposits	Lower Terrace	Tr-Ia	Silt, sand, gravel and cemented conglomerates.	0 to 8 m
			Tr-Ib	Silt, sand and gravel.	3 to 10 m
		Middle Terrace	Tr-II	Thick deposits of clay, silt, sand and gravel and cemented conglomerates; including large boulders.	20 to 40 m
		Higher Terrace	Tr-IIIa	Brownish color clay, silt and sand with basal gravel.	3 to 10 m
Tr-IIIb	Brownish color clay, silt and sand with soft pebbles and underlying residual soil.		2 to 8 m		
Siwalik Group	Sst Formation (200 m+)	Mudstone Bed	Massive and pebbly, medium to coarse sandstones; with interbeds of 3 to 7 m-thick pebble conglomerate beds and argillaceous rock beds.	200 m+	
		Conglomerate Bed			
	Bst Formation (600 m+)	Ms-8 Member	Ms-8	Massive and pebbly sandstones.	7 m
		At-7 Member	At-7	Bedded calcareous shales, muddy sandstones and fine sandstones; interbedding an intraformational breccia.	15 to 20 m
		Ms-7 Member	Ms-7	Massive medium to coarse sandstones; including laminations and concretions.	25 m
		At-6 Member	At-6	Bedded calcareous shales, greenish mudstones and sandstones; the lower half is thickly bedded fine sandstones.	30 m
		Ms-6 Member	Ms-6	Massive medium to coarse sandstones; including pebbles and concretions; fine sandstones are interbedded in the lower.	30 m
		At-5 Member	At-5	Bedded shales, mudstones, fine sandstones and breccias; argillaceous rocks and fine sandstones are alternated.	35 m
		Ms-5 Member	Ms-5	Massive medium to very coarse sandstones separated in three units by two layers of greenish thin mudstones; pebble layers are in the lower.	25 to 30 m
		At-4 Member	At-4	Bedded shales, mudstones, fine to very fine sandstones and breccias; shales are calcareous and hard with thick bedding.	65 m
		Ms-4 Member	Ms-4	Massive medium to very coarse sandstones with a few intercalations of calcareous shales, mudstones and fine sandstones.	45 to 60 m
		At-3 Member	At-3	Bedded shales, mudstones, fine to very fine sandstones and breccias; a few meter thick calcareous shales are striking in the middle part.	50 to 65 m
		Ms-3 Member	Ms-3	Massive sandstones with scattered pebbles; laminations and concretion layers are included.	30 m
		At-2 Member	At-2	Bedded shales, mudstones and fine to very fine sandstones with intraformational fragments; fine sandstones are predominant.	35 m
		Ms-2 Member	Ms-2	A thick bed of medium to coarse sandstone.	10 m
		At-1 Member	At-1	Bedded shales, mudstones, very fine to medium sandstones and breccias; generally calcareous except greenish color sandy mudstone.	45 m
		Ms-1 Member	Ms-1	Massive medium to coarse sandstones with pebbles; a few meter thick intraformational breccia interbedded in the middle.	105 m
		At-0 Member	At-0	Bedded shales, mudstones and fine sandstones.	15 m+

Marks in the Sections

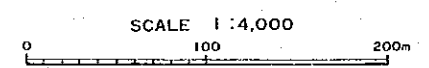
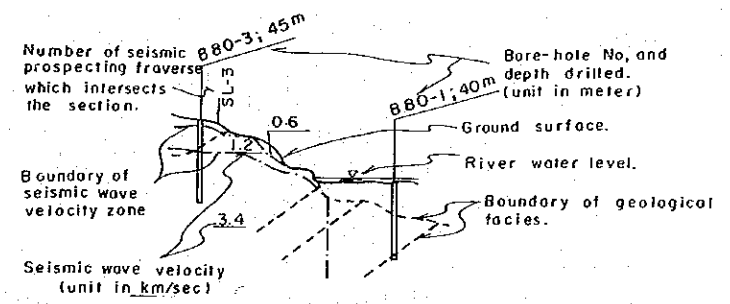


FIG- E.2 : GEOLOGICAL MAP AND SECTION OF DAMSITE

HIS MAJESTY'S GOVERNMENT OF NEPAL
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- LEGEND**
- DG- Core drilling hole
B80-
B81-
 - TG Location of Test Grouting
 - TP Test pit for earth material
 - CTP Test pit for coarse aggregate of concrete
 - FTP Test pit for fine aggregate of concrete
 - R Location of quarry rock sampling
 - Test adit
 - SL- Traverse of seismic exploration
 - 1/500 Topographic survey area

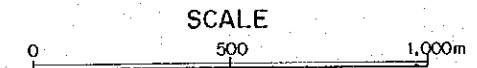
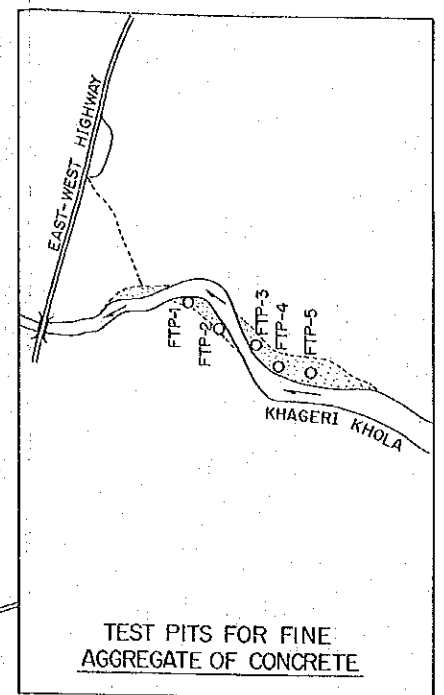
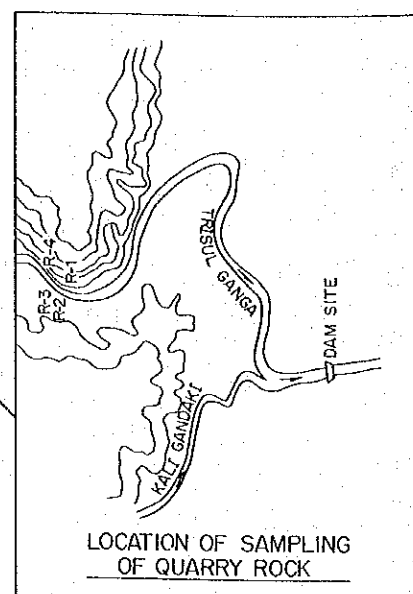
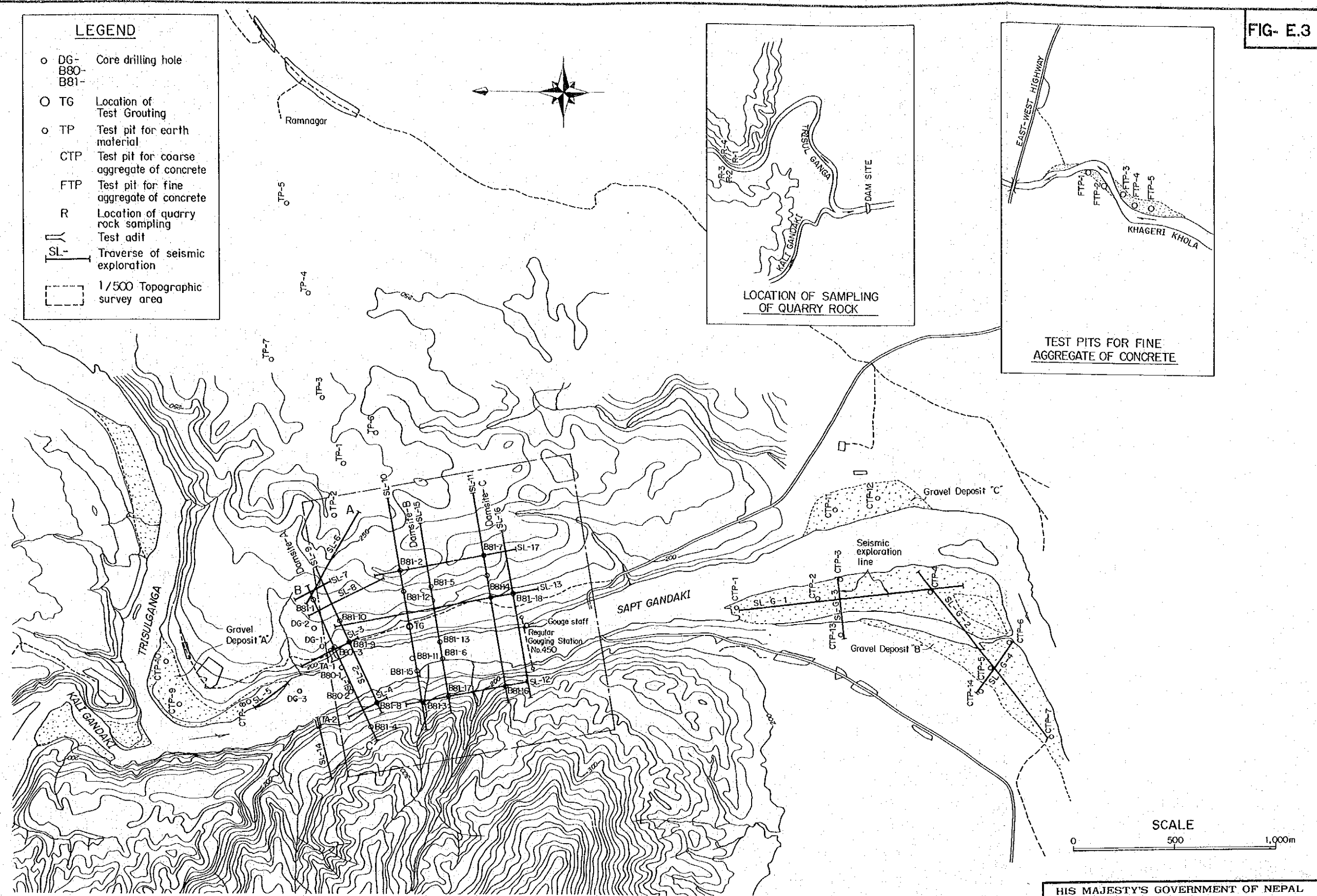


FIG- E.3 : LOCATION MAP OF INVESTIGATION

HIS MAJESTY'S GOVERNMENT OF NEPAL
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 POWER DEVELOPMENT PROJECT
 FEASIBILITY REPORT
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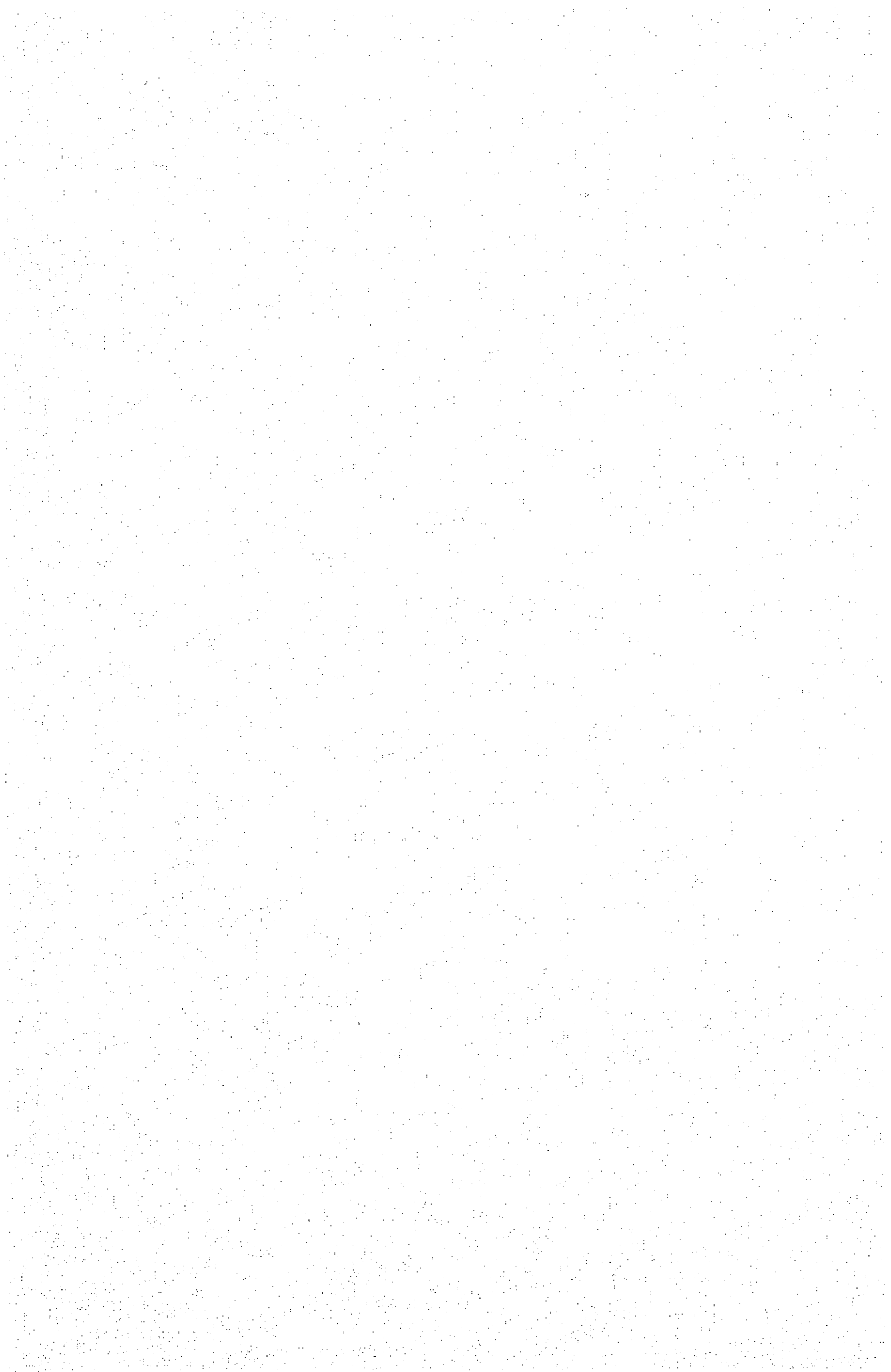


FIG- E.4

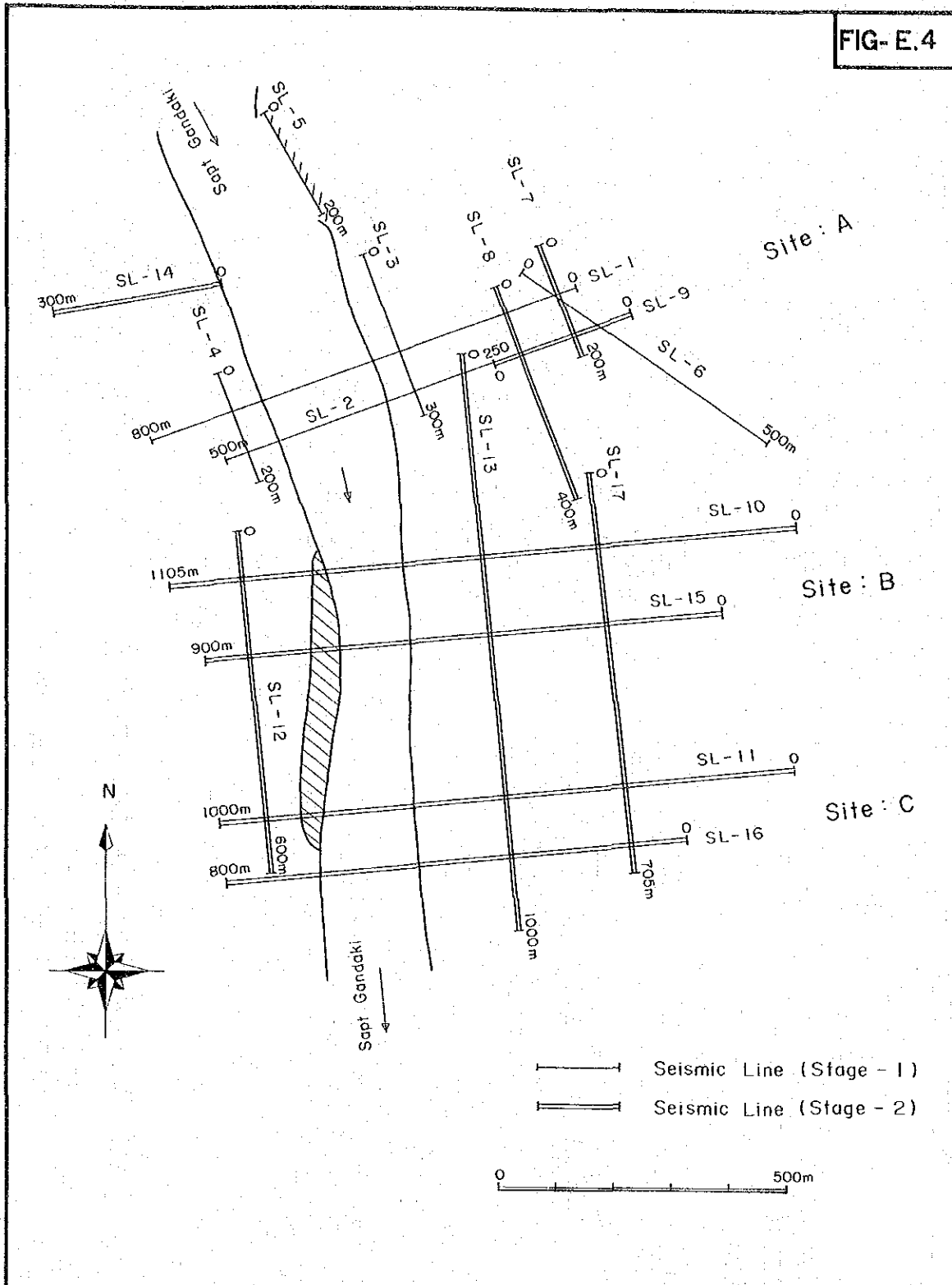


FIG- E.4 : ARRANGEMENT OF SEISMIC REFRACTION PROFILE LINES IN THE DAMSITE

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
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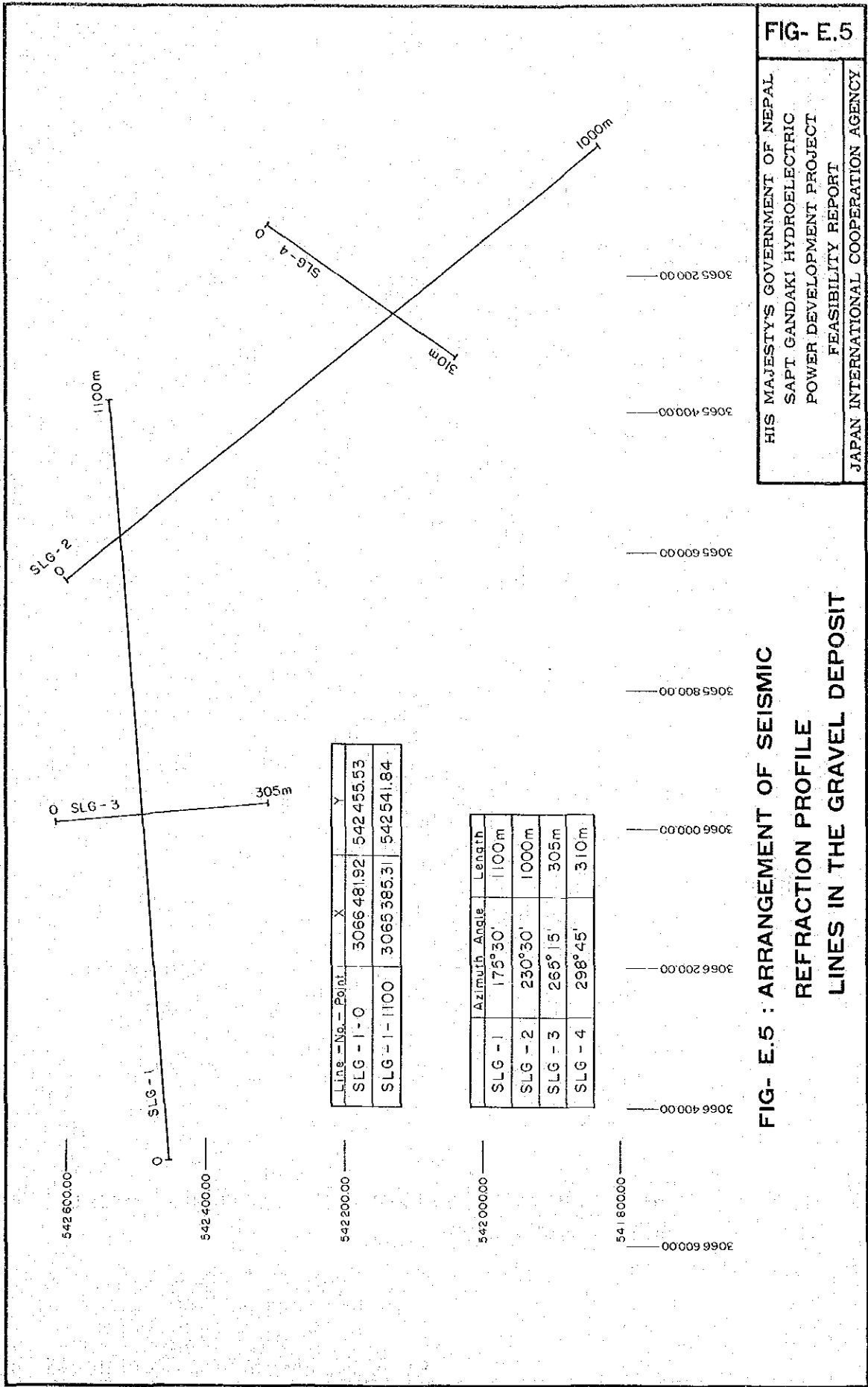
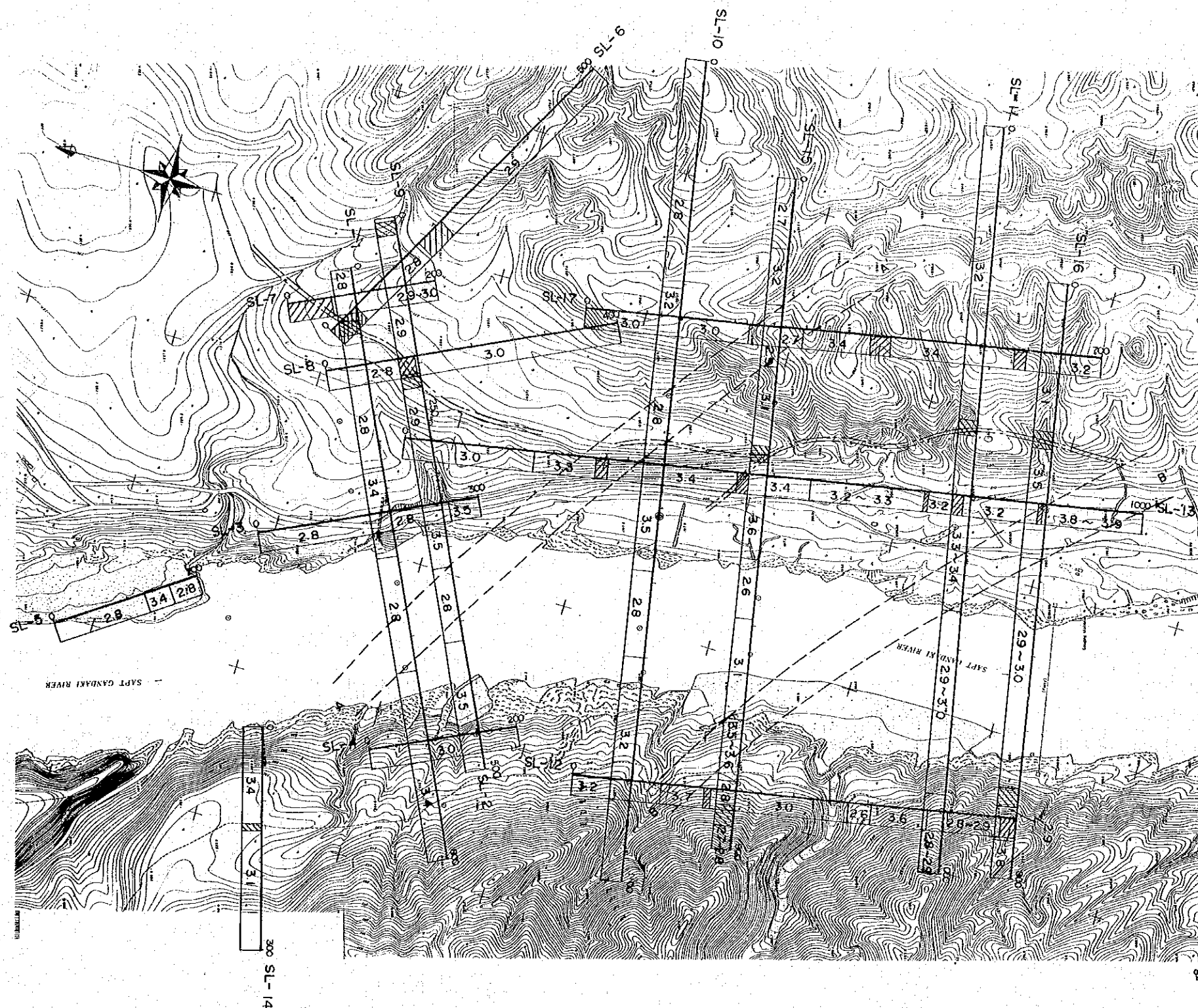


FIG- E.5 : ARRANGEMENT OF SEISMIC REFRACTION PROFILE LINES IN THE GRAVEL DEPOSIT

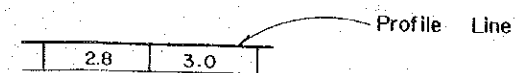
FIG. E.5

HIS MAJESTY'S GOVERNMENT OF NEPAL
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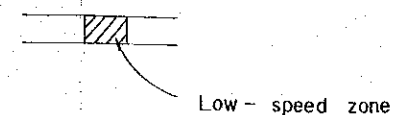


EXPLANATION

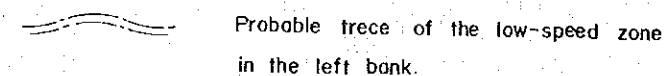
SL- 1 to 17 : Refraction Profile NO.



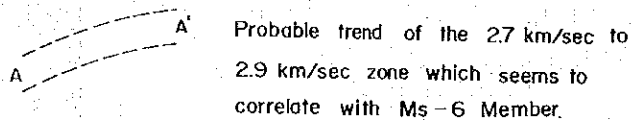
Speed of the deepest layer
(unit in km/sec)



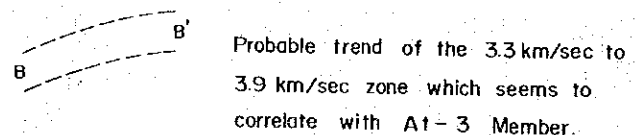
Low - speed zone



Probable trace of the low-speed zone
in the left bank.

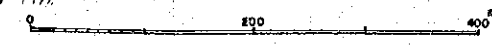


Probable trend of the 2.7 km/sec to
2.9 km/sec zone which seems to
correlate with Ms - 6 Member.



Probable trend of the 3.3 km/sec to
3.9 km/sec zone which seems to
correlate with A1 - 3 Member.

- Note:
- 1 The deepest layer generally represents the basement (fresh bedrock) in refraction profile.
 - 2 The trace of the low - speed zone in the left bank probably correlates to the steep edge line of old river channels.



**FIG- E.6 : DISTRIBUTION OF SPEED OF DEEPEST LAYER
IN SEISMIC REFRACTION PROFILE**

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FIG- E.7

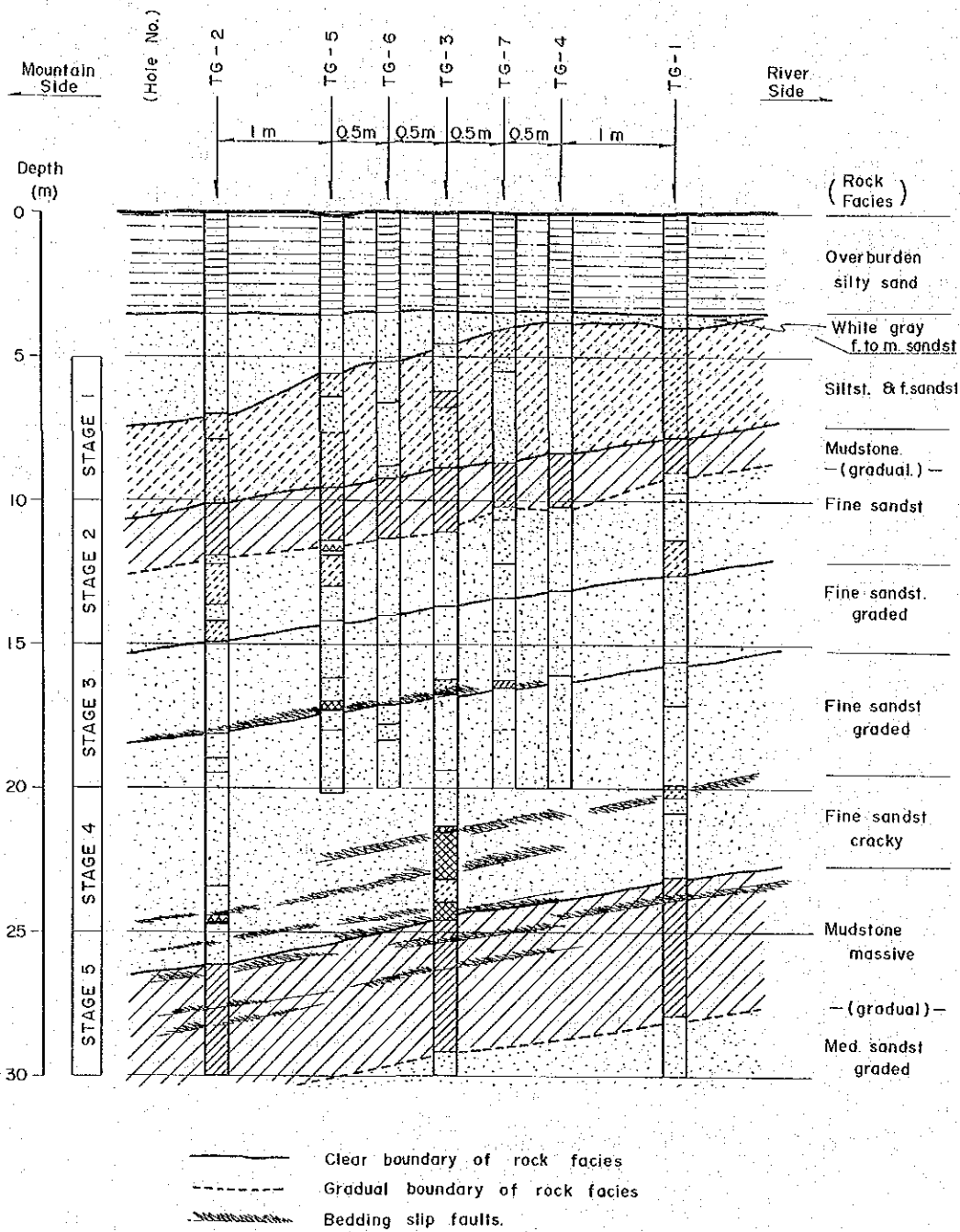


FIG- E.7 : GEOLOGIC SECTION OF THE TEST GROUT SITE

HIS MAJESTY'S GOVERNMENT OF NEPAL
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FIG- E.8

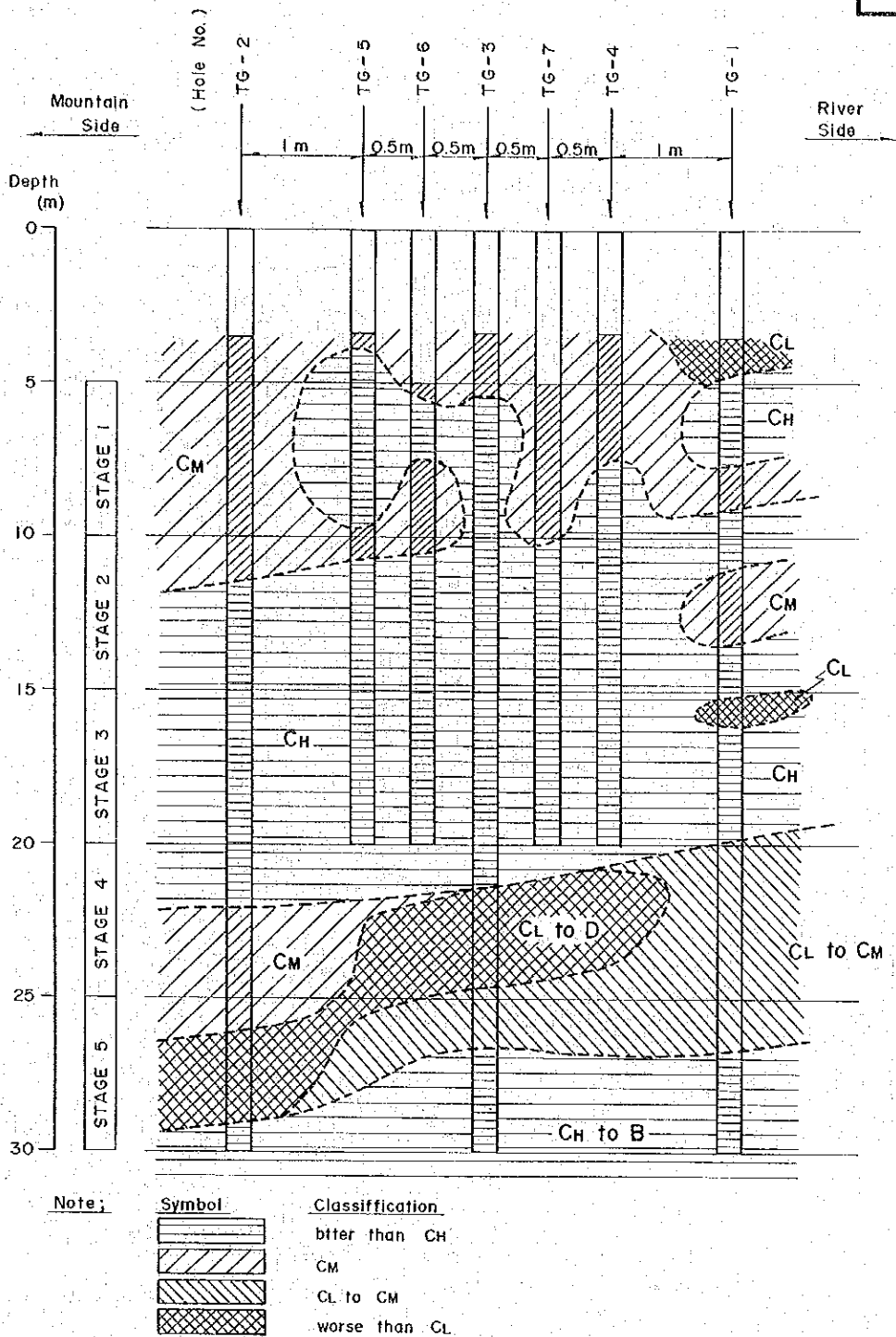


FIG- E.8 : CROSS SECTION OF ROCK CLASSIFICATION IN THE TEST GROUT SITE

Depth (m)	Grouting Stage No.	TG-2 (Primary Hole)		TG-5 (Tertiary H.)		TG-6 (Check Hole)		TG-3 (Secondary H.)		TG-7 (Check Hole)		TG-4 (Tertiary Hole)		TG-1 (Primary Hole)	
		1m apart	0.5m	0.5m	0.5m	0.5m	0.5m	0.5m	0.5m	0.5m	0.5m	1m	(Ground surface)		
0	(No grouting)														
5	1	720.00 49.52	3.84 0.68	1.2	5.12 0.43	not tested	4.15 9.16							137.92 107.68	Dec 9
10	2	3.68 0.58	3.04 0.54	0.07	2.56 0.68	0.2	2.64 0.41							3.20 0.71	Dec 10
15	3	1.49 1.41	2.24 1.35	0.2	1.07 0.87	0.1	1.71 0.55							26.88 345.31	Dec 12
20	4	1.76 0.54			1.20 1.36									2.48 2.27	Dec 15
25	5	1.60 7.73			0.92 0.68									1.42 0.32	Dec 17
30															

Date of grouting

Upper: Result of Lugeon Test (Lugeon unit)
Lower: Grout take cement weight in kg. per bore-hole, linear meter

* Check holes were not grouted. Then dates show the Lugeon tested date. The 1st stage of TG-7 was not tested due to leakage of water from TG-6.

FIG-E.9 : RECORD OF TEST GROUTING