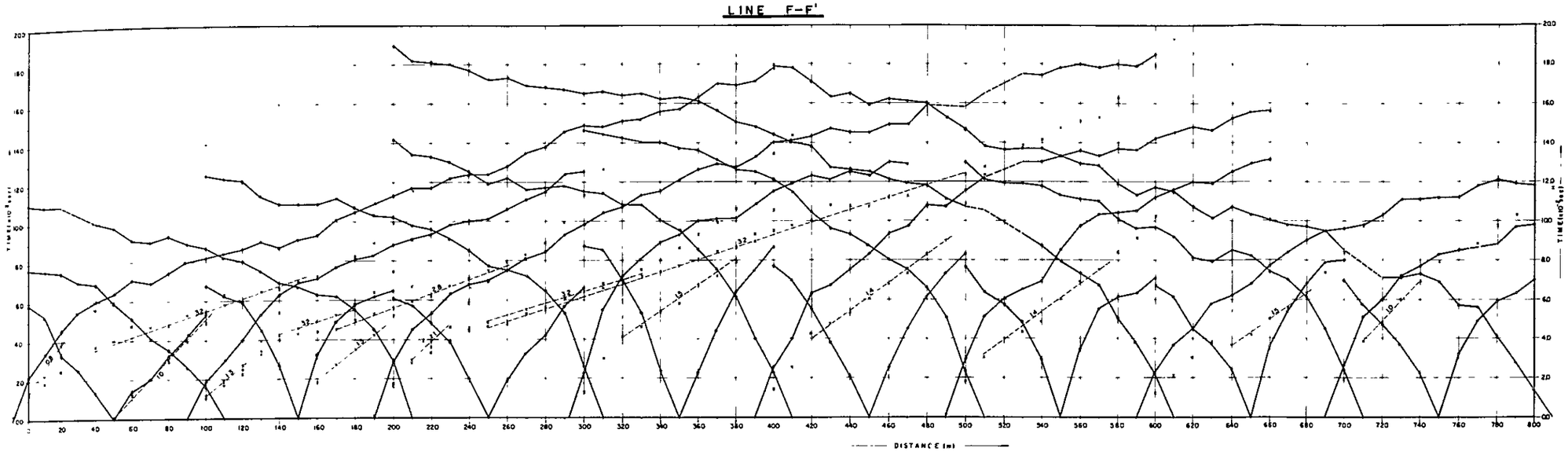
FIGURE 3B-12 TRAVEL TIME CURVE AND VELOCITY PROFILE (PALSIGUAN DAMSITE)

LINE F-F'



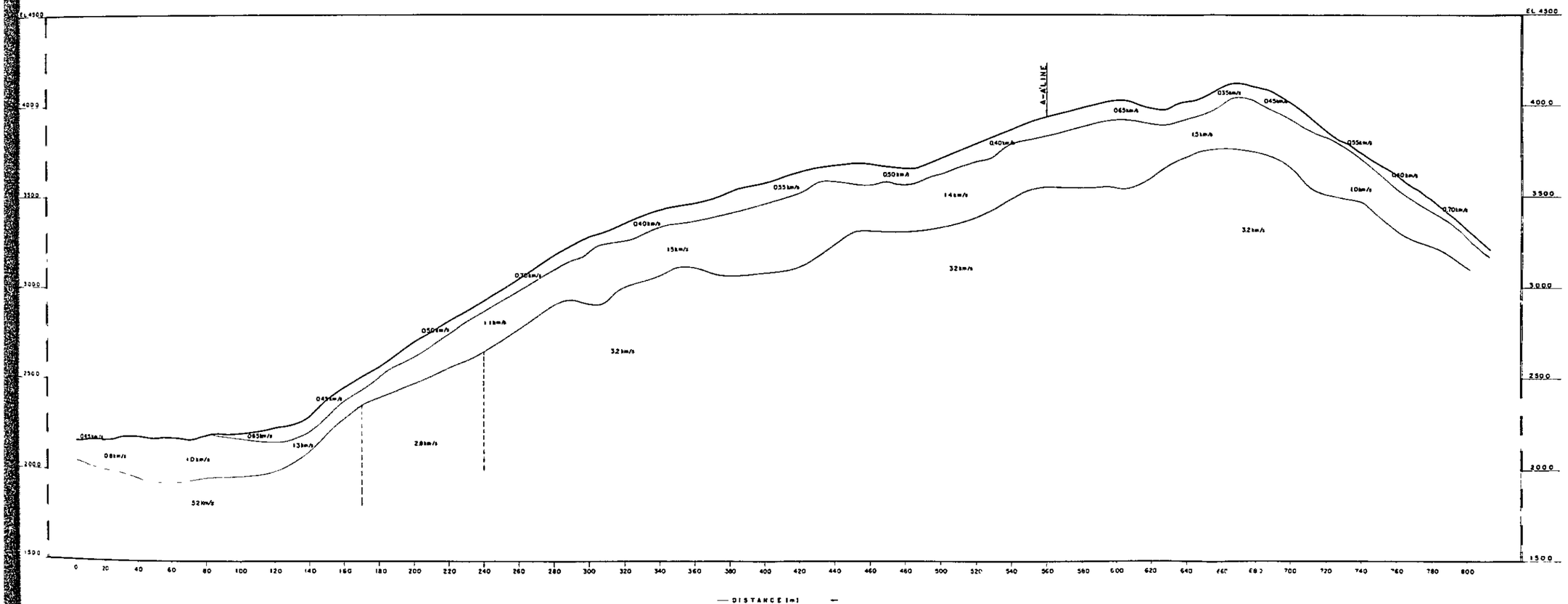


FIGURE 3B-13 TRAVEL TIME CURVE AND VELOCITY PROFILE

(PALSIGUAN DAMSITE)

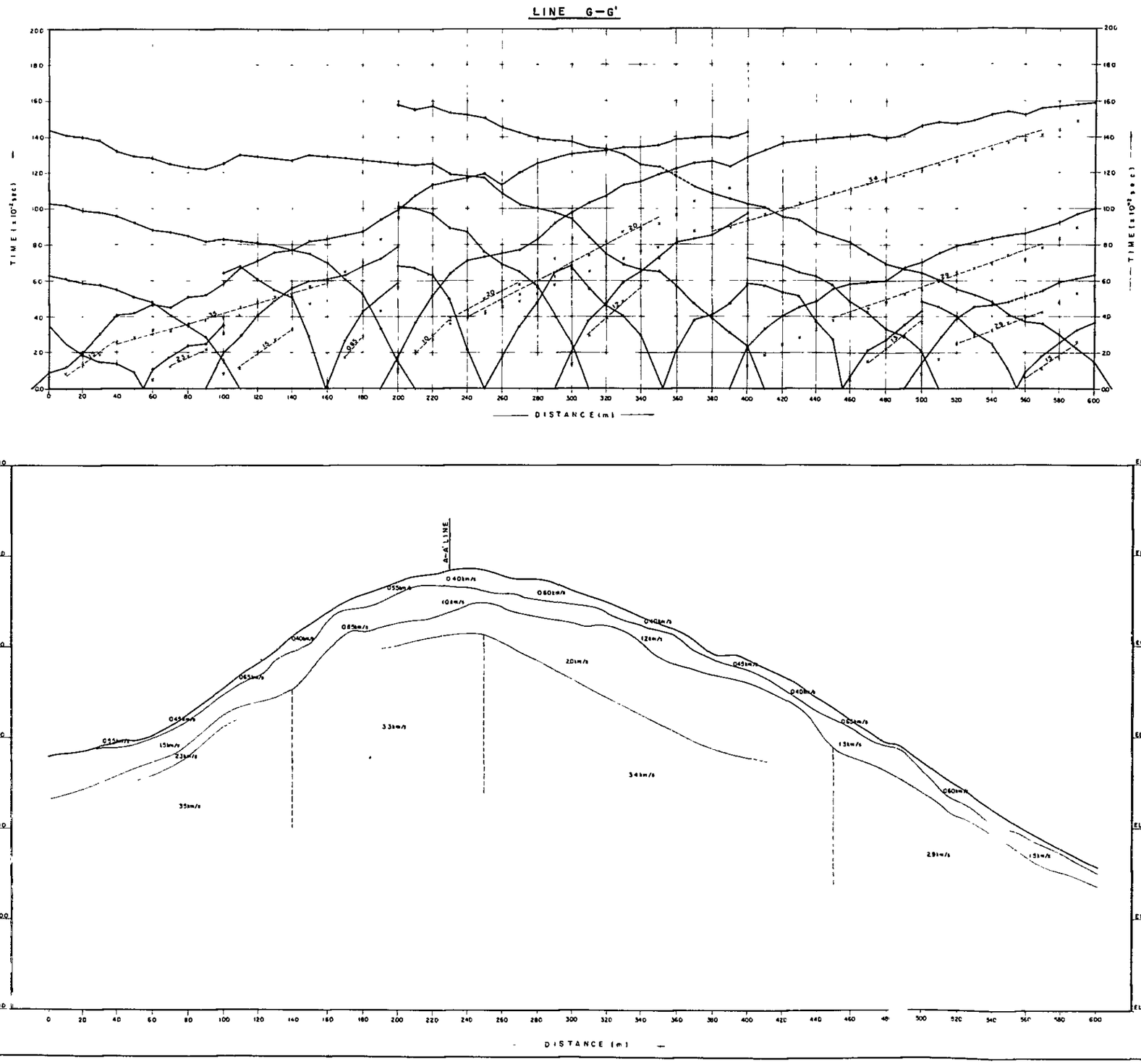


FIGURE 3B-14 TRAVEL TIME CURVE
AND VELOCITY PROFILE

(PALSIGUAN DAMSITE)

LINE H-H'

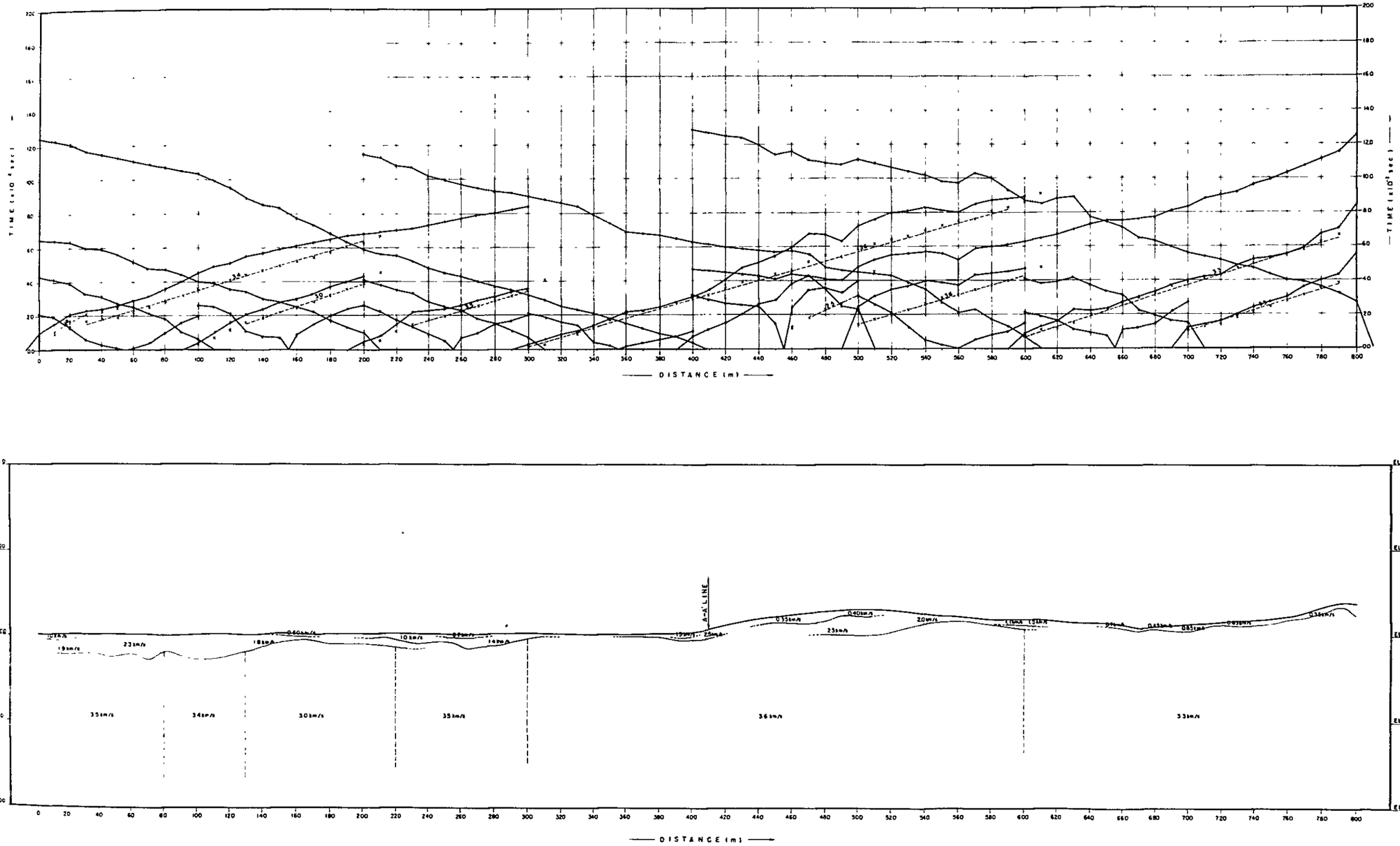
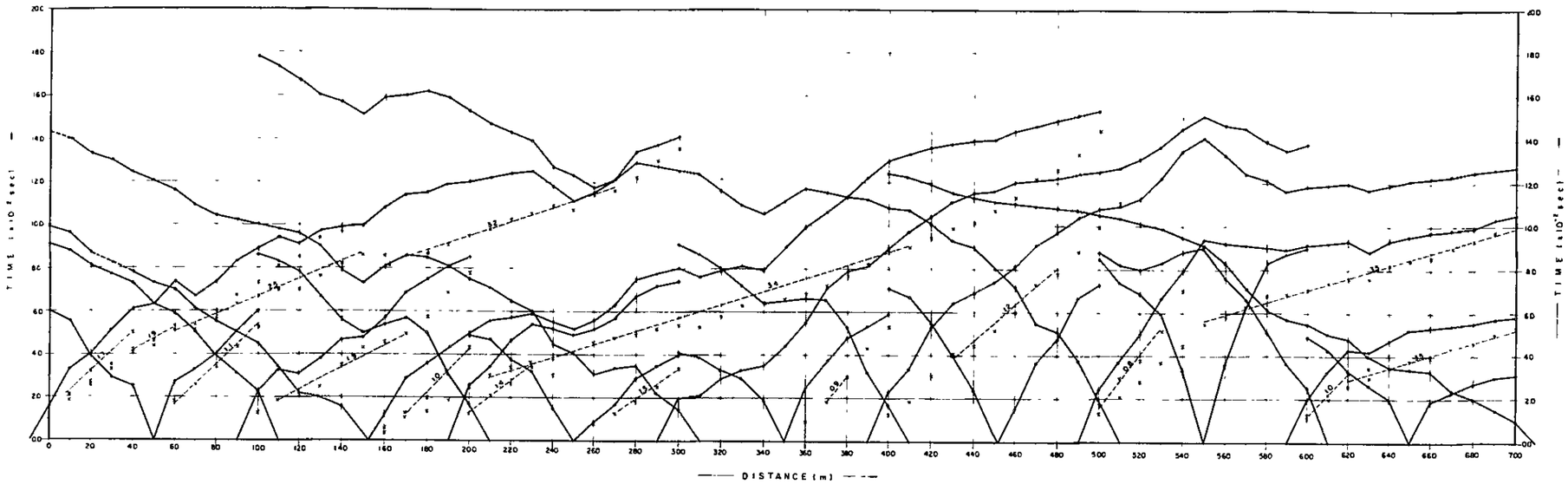


FIGURE 3B-15 TRAVEL TIME CURVE
AND VELOCITY PROFILE

(PALSIGUAN DAMSITE)

LINE I–I'



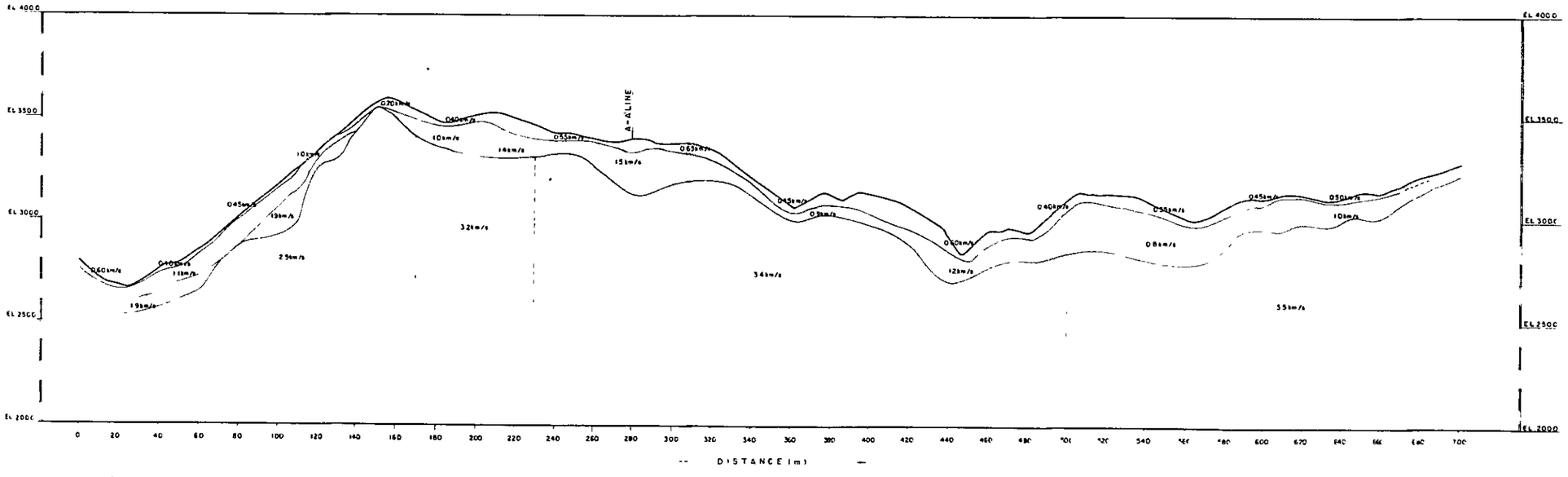


FIGURE 3B-16 LOCATION MAP OF TEST PITS AT POLOT AREA

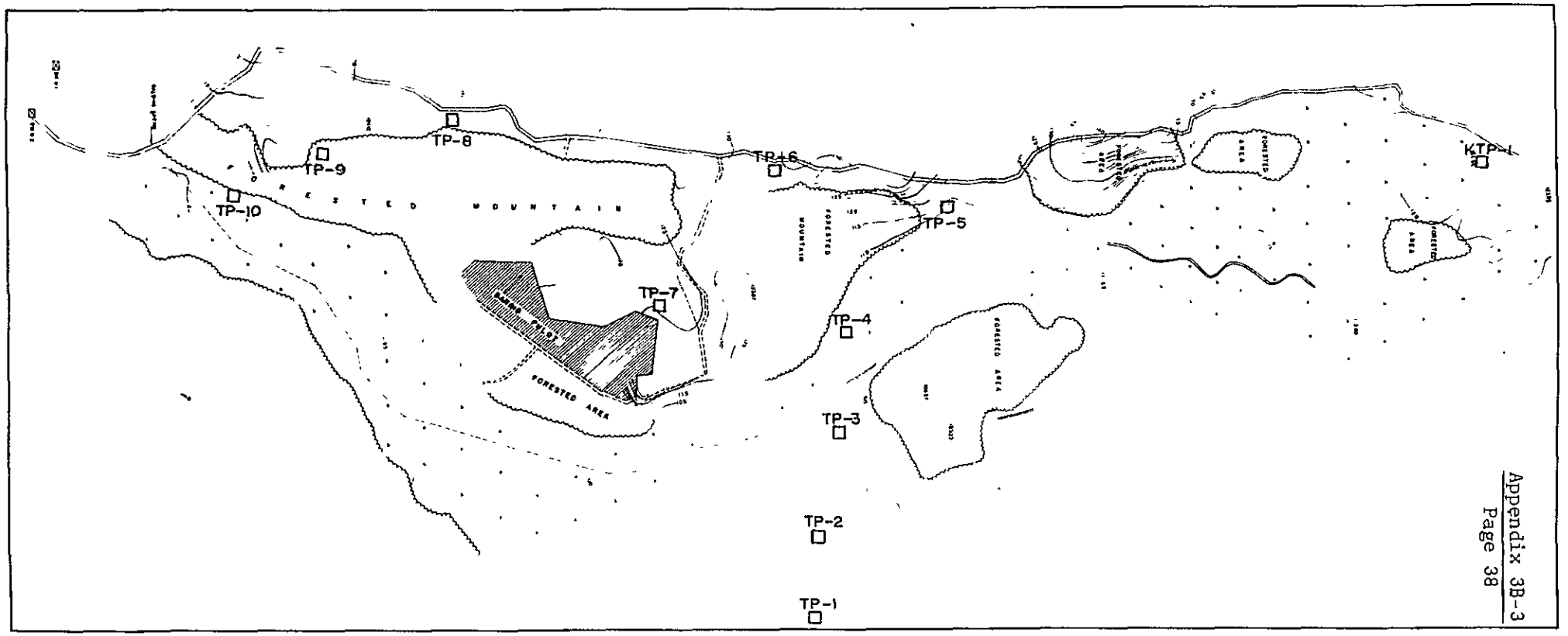


FIGURE 3B-17 LOCATION MAP OF TEST PITS AT MANAOIS AREA

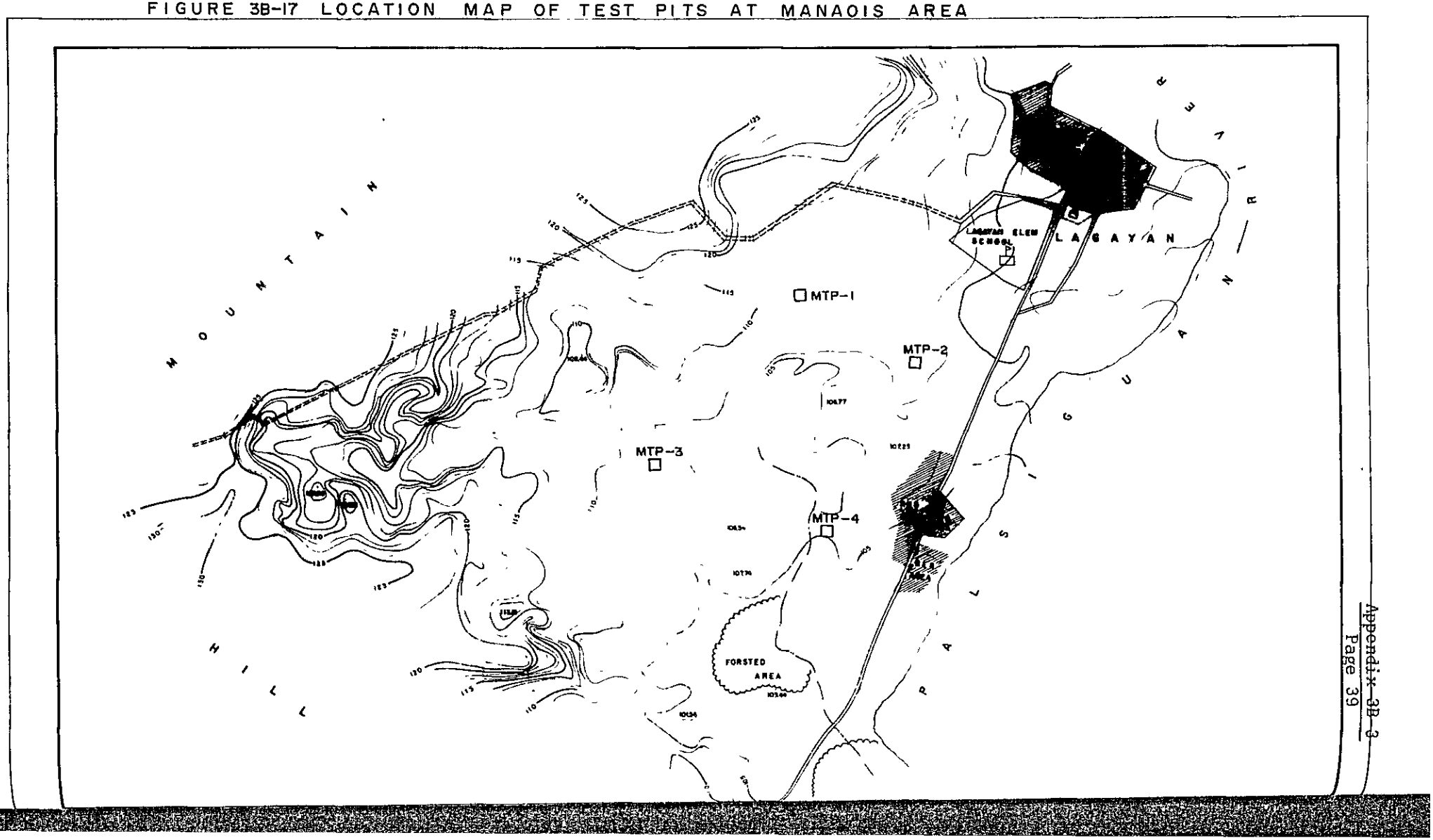


FIGURE 3B - 18 LOG OF TEST PITS

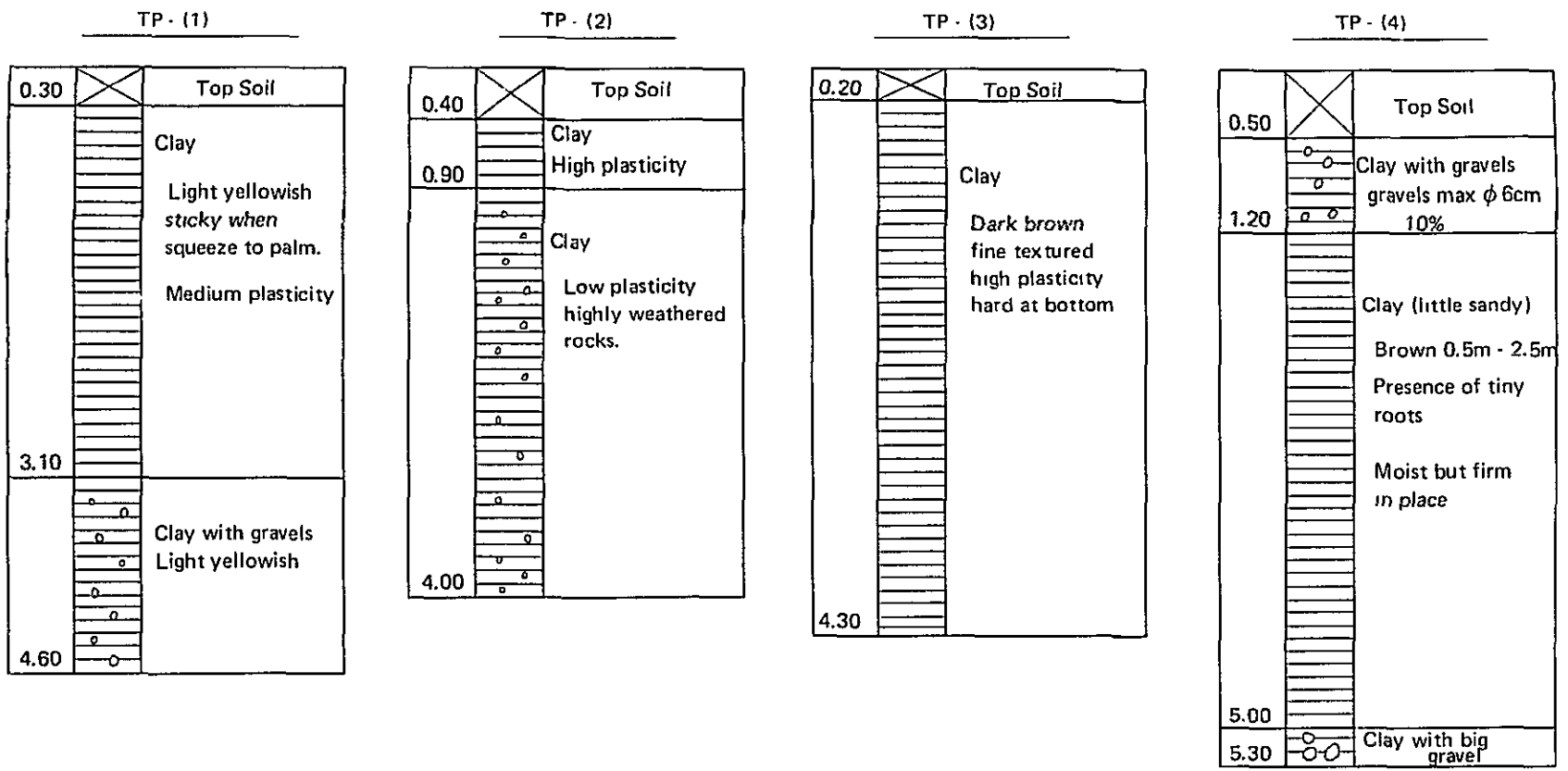


FIGURE 3B - 19 LOG OF TEST PITS

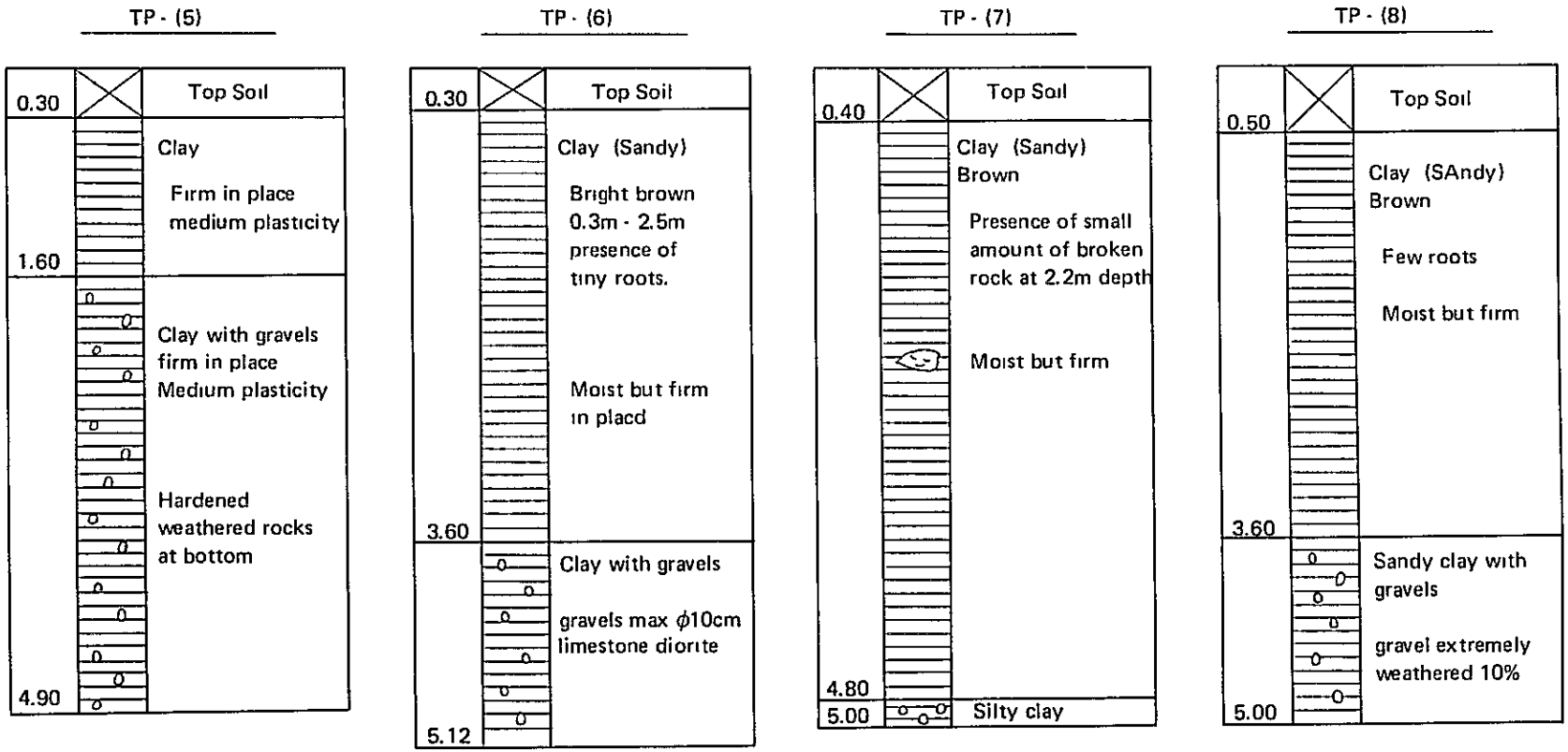


FIGURE 3B - 20 LOG OF TEST PITS

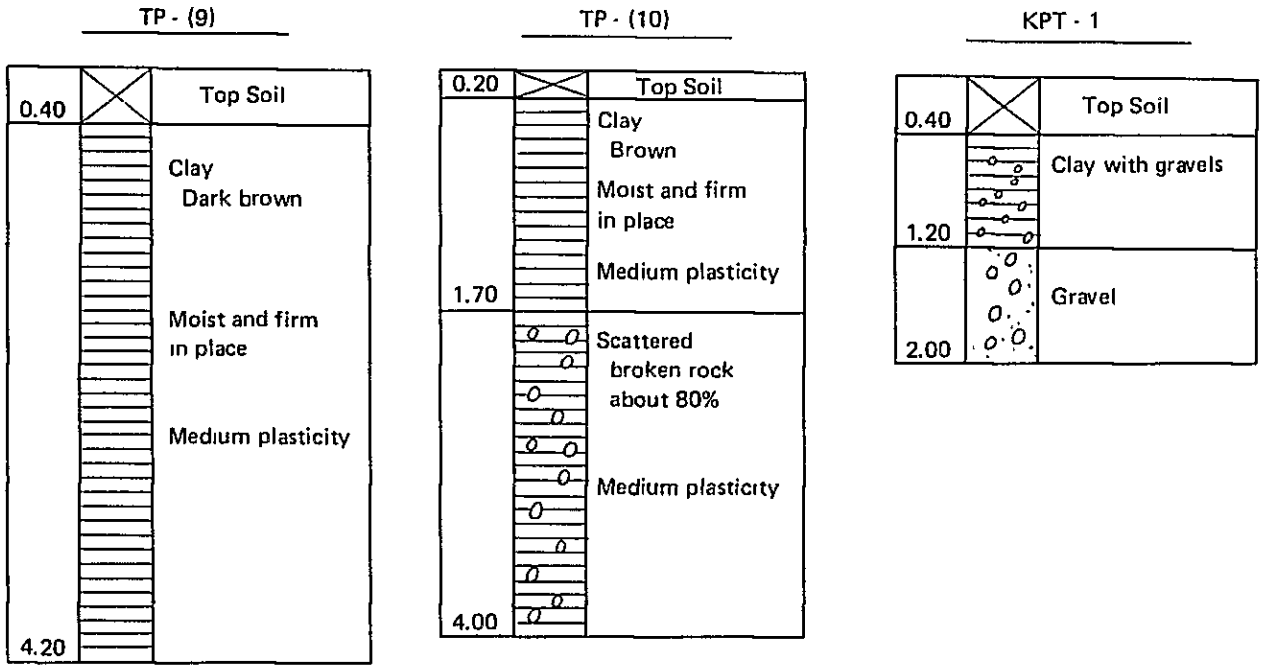


FIGURE 3B - 21 LOG OF TEST PITS

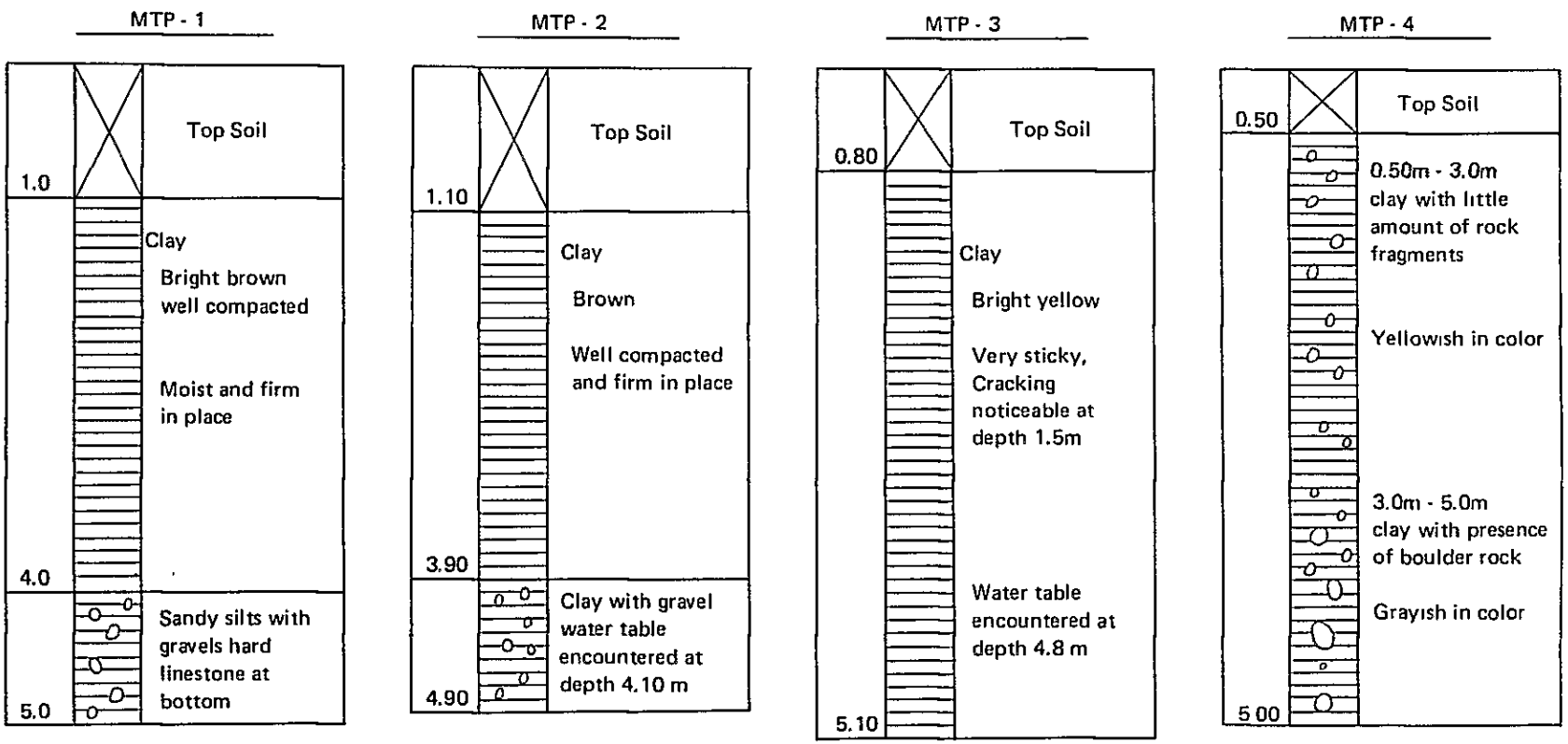


Table 3B-23 Result of Embankment Material Test

Area	Sample	Grandation Analysis (%)				Consistency			Symbol	Specific Gravity	Field Moisture Content(%)	Compaction Test			Permeability Test	Triaxial Test $\frac{U \cdot U}{C \quad \phi}$
		Clay	Silt	Sand	Gravel	L.L.	P.L.	P.I				O.M.C. (%)	γd(Max) (g/cm^3)	E.C. (cm kg/cm^3)	(cm/sec)	(kg/cm^2) (Degree)
Polot	TP-1 (0.3-4.6)	24.0	46.59	18.02	11.39	36.30	26.87	9.43	CL	2.72	29.09	18.75	1.651	18.1		
	TP-2 (0.3-4.0)	15.0	34.21	32.67	18.12	27.50	22.13	5.37	ML	2.76	30.34	17.77	1.693	18.1		
	TP-3 (0.2-4.3)	30.0	44.57	15.99	9.44	37.15	27.97	9.18	CL	2.56	32.87	16.85	1.708	18.1		
	TP-4 (0.4-4.1)	27.0	44.67	14.97	13.36	45.65	32.54	13.11	CL	2.62.	24.07	20.78	1.629	18.1		
	TP-5 (0.3-4.9)	28.5	57.86	10.65	2.99	44.05	31.59	12.46	CL	2.56	28.11	20.20	1.584	18.1		
	TP-6 (1.2-2.0)	27.14	61.84	8.10	2.92	66.00	32.13	33.87	CH	2.73	25.37	25.80	1.526	18.1		
	TP-7 (0.3-4.6)	37.0	45.84	13.77	3.39	51.35	37.15	14.20	CH	2.59	32.78	22.60	1.560	18.1	w = 21.67, 5.22×10^{-7}	w = 25.02, 1.2, 8°.00
	TP-8 (1.3-4.8)	24.41	58.64	10.99	5.96	38.05	23.11	14.94	CL	2.72	30.97	29.6	1.367	5.6	w = 29.67, 3.43×10^{-8}	w = 30.23, 1.2, 0°.00'
	TP-9 (0.4-4.2)	40.5	42.96	13.94	2.60	46.05	33.60	12.45	CL	2.67	27.00	21.25	1.631	18.1	w = 35.85, 1.02×10^{-7}	
	TP-10 (0.2-4.0)	35.0	45.71	10.77	8.52	46.75	34.21	11.54	CL	2.75	-	20.35	1.653	18.1		
Manaois	MTP-2 (4.0-5.0)	24.02	41.26	33.21	1.51	35.10	20.91	14.19	CL	2.72	22.20	22.0	1.591	5.6	w = 15.38, 7.73×10^{-7}	w = 19.31, 0.9, 11°.30'
	MTP-4 (4.0-5.0)	18.86	49.24	23.08	8.82	32.25	26.93	6.32	CL-ML	2.76	22.25		-	-		w = 24.78, 0.6, 0°.00
Kiwas	KTP-1 (0.5-2.0)	1.94		46.60	51.46	NP	NP	NP	GW	2.89	1.57			-		
	C.S-1 (Clay 73%, Gravel 27%)	17.0	36.0	23.0	24.0	-		-	CL	-	22.6	22.6	1.725	25.6	1.27×10^{-7}	
Polot	C.S-2 (Clay 45.3%, Gravel 54.7%)	11.0	23.0	26.0	40.0	-	-		SC		14.0	14.0	1.973	25.6	2.22×10^{-7}	
	C.S-3 (Clay 29.45%, Gravel 70.55%)	7.0	17.0	26.0	50.0	-	-		GC	-	9.1	9.1	2.050	25.6	7.74×10^{-7}	

Note C.S-1, C.S-2 and C.S-3 are mixed samples

Table 3B-24 Rock Test Results (Palsiguan Dam)

Sample No.	Bore-Hole		Compressive	Specific	Absorption	Soundness
	No.	Depth (m)	Strength (kg/cm^2)	Gravity	(%)	(%)
No. 1	DDH-7	57.67-58.20	414.6	2.92	2.27	5.30
No. 2	DDH-7	58.27-59.53	301.8	2.84	2.46	7.22
No. 3	DDH-4	74.00-76.23	358.3	3.00	3.45	4.01
No. 4	DDH-4	59.26-61.86	298.8	2.97	0.23	0.68
No. 5	DDH-5	36.00-36.02	535.0	3.00	0.67	5.24
No. 6	DDH-1	73.08-79.37	599.6	2.98	2.10	2.49
Average			418.0	2.95	1.86	4.15

FIGURE 3B-22 LOCATION MAP OF GEOLOGICAL SURVEY AT NUEVA SERA DAMSITE

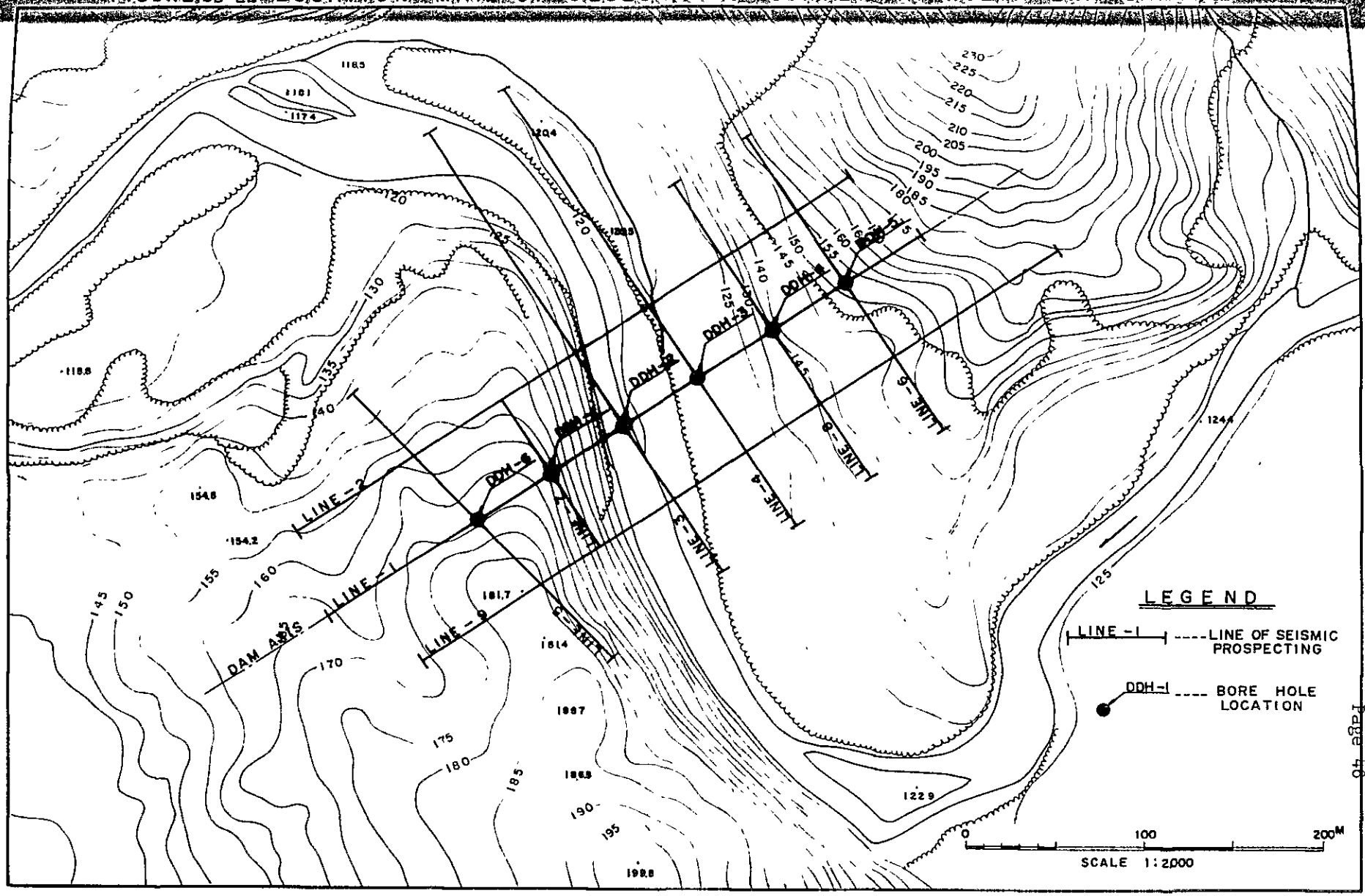
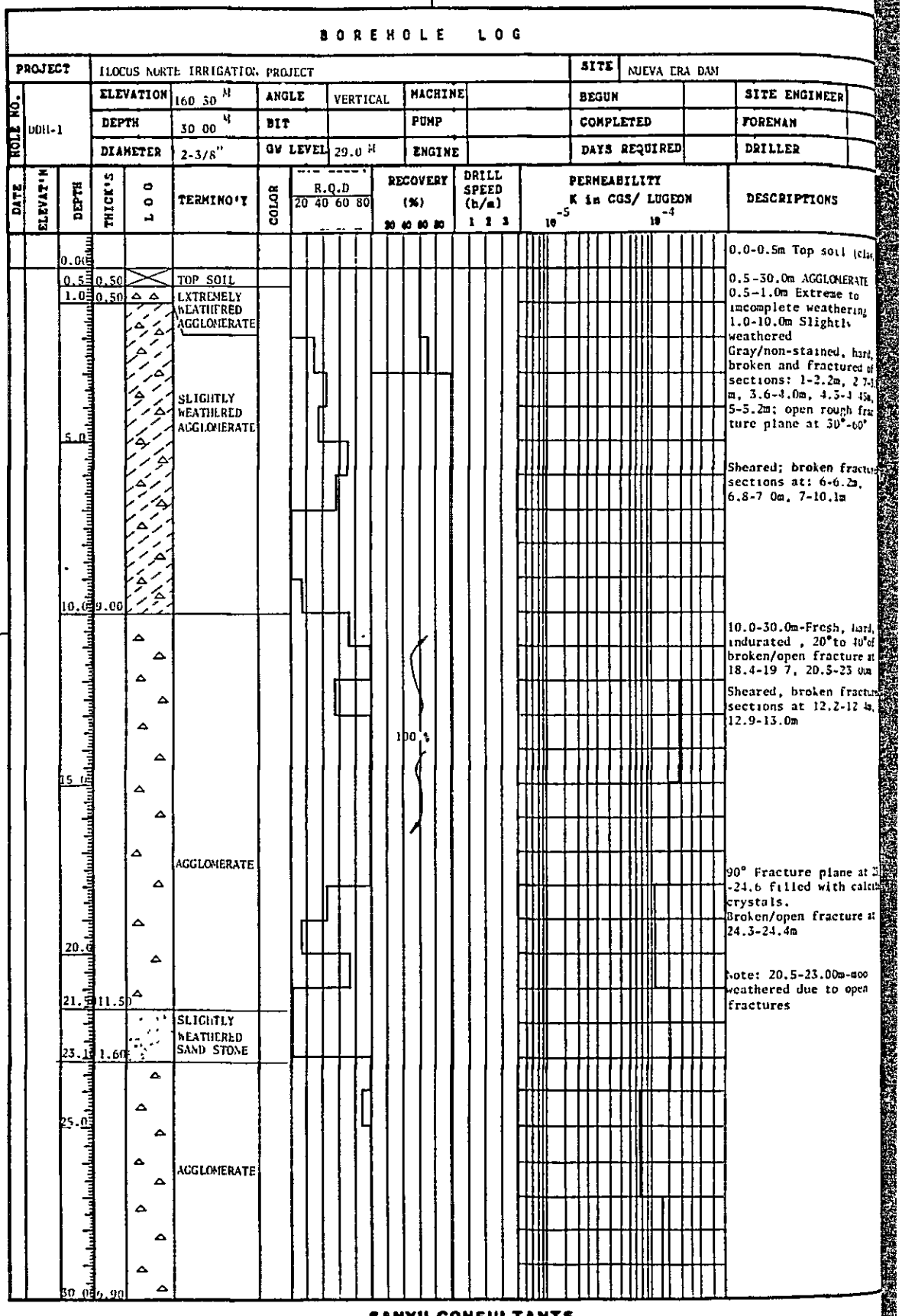


FIGURE 3B - 23 BORE-HOLE LOG AT NUEVA ERA DAM SITE



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BOREHOLE LOG

PROJECT	ILOCOS NORTL IRRIGATION PROJLCT				SITE	NUEVA ERA DAM	
HOLE NO. CDH-2	ELEVATION 120 26	ANGLE VERTICAL	MACHINE		BEGUN		SITE ENGINEER
	DEPTH 30 00 M	BIT	PUMP		COMPLETED		FOREMAN
	DIAMETER 2-3/8 "	GW LEVEL 1.45 M	ENGINE		DAYS REQUIRED		DRILLER

DATE	ELEVAT'N	DEPTH	THICK'S	LOG	TERMINO'Y	COLOR	R.Q.D 20 40 60 80	RECOVERY (%) 20 40 60 80	DRILL SPEED (h/m) 1 2 3	PERMEABILITY K in CGS/ LUGEON 10^{-5} 10^{-4}	DESCRIPTIONS
		0.00									0.00-7.15 M River deposits mixtures of volcanic and diorite broken fragments usually from pebble to cobble in sizes Associated with sandy materials
		5.0			RIVER DEPOSITS						
		7.15	7.15								7.15-30.00 AGGLOMERATE Pebble pyroclasts set in a ground mass of basalt porphyry fractures are healed by calcite/quartz
		10.0									
		15.0			AGGLOMERATE			100%		K=0	
		20									
		25								K=0	
		30.0	22.85								

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BOREHOLE LOG

PROJECT	ILOCOS NORTE IRRIGATION PROJECT					SITE	NULVA ERA DAM		
HOLE NO.	BDH-3	ELEVATION	122.85 M	ANGLE	VERTICAL	MACHINE		BEGUN	SITE ENGINEER
		DEPTH	30.5 M	BIT		PUMP		COMPLETED	FOREMAN
		DIAMETER	2-3/8 "	GW LEVEL	2.5 M	ENGINE		DAYS REQUIRED	DRILLER

DATE	ELEVAT'N	DEPTH	THICK'S	LOG	TERMINO'Y	COLOR	R.Q.D 20 40 60 80	RECOVERY (%) 20 40 60 80	DRILL SPEED (h/m) 1 2 3	PERMEABILITY K in CGS/ LUGEON 10^{-5} 10^{-4}	DESCRIPTIONS
		0.00									
		1.05	1.05								0-14.75m RIVER DEPOSITS 0.0-1.05m 9.3-14.0m Sand
		9.30	8.25		RIVER DEPOSITS						
		14.05	4.70								
		14.75	0.75								14.75-30.5 AGGLOMERATE Fresh, Tight/closed fractures run parallel of 60°-90° of inclination Filled with calcite fillings Broken at sections. 16.5-17, 17.6-17.8, 18-18.2, 19.5-19.8, 22-22.4, 25.6-25.8, 28.45-28.75.
		20.00			AGGLOMERATE			100 %			
		25.00									
		30.00									

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BOREHOLE LOG

PROJECT	ILOCOS NORTE IRRIGATION PROJECT			SITE	NAVA ERA DAM		
HOLE NO. 006-4	ELEVATION 130.16 M	ANGLE VERTICAL	MACHINE	BEGUN		SITE ENGINEER	
	DEPTH 31 60 M	BIT	PUMP	COMPLETED		FOREMAN	
	DIAMETER 3"	GW LEVEL 17.0 M	ENGINE	DAYS REQUIRED		DRILLER	

DATE	ELEVAT'N	DEPTH	THICK'S	LOG	TERMINO'Y	COLOR	R.Q.D 20 40 60 80	RECOVERY (%) 20 40 60 80	DRILL SPEED (h/m) 1 2 3	PERMEABILITY K in CGS/ LUGEON 10^{-5} 10^{-4}	DESCRIPTIONS
		0.00									0,0-2.0m OVER BURDEN Clay
		2.00	2.00		OVER BURDEN						2.0-17.0m TERRACE DEPOSITS Sand and Clay
					TERRACE DEPOSITS						
		17.00	15.00								17.00-31.6 AGGLOMERATE 17.0-21.5 Moderately weathered with iron stains along 30°-50° fracture planes. Generally broken from 17.00-21.5m. Moderately hard but brownish gray.
					MODERATELY WEATHERED AGGLOMERATE	BROWNISH GRAY					
		21.50	6.50								21.5-31.6 Fresh, gray and sound Tight/closed fractures at 60°-90° plane filled with calcites
					AGGLOMERATE	GRAY		100%		K=2-3x10^{-6}	
		30.10									

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BOREHOLE LOG

PROJECT	ILOCOS NORTE IRRIGATION PROJECT				SITE	MULVA IRA DAM	
HOLE NO. DDH-5	ELEVATION 154.65 M	ANGLE VERTICAL	MACHINE		BEGUN		SITE ENGINEER
	DEPTH 32.50	BIT	PUMP		COMPLETED		FOREMAN
	DIAMETER 3"	GW LEVEL 23.5 M	ENGINE		DAYS REQUIRED		DRILLER

DATE	ELEVAT'N	DEPTH	THICK'S	LOG	TERMINO'Y	COLOR	R.Q.D 20 40 60 80	RECOVERY (%) 20 40 60 80	DRILL SPEED (h/m) 1 2 3	PERMEABILITY K in CGS/ LUGEON 10^{-5} 10^{-4}	DESCRIPTIONS
		0.00									
		3.00	3.00		OVER BURDEN						0.0-3.0m OVER BURDEN Clay
		5.00									3.0-14.50m TERRACE DEPOSITS Sand and Clay
		10.00			TERRACE DEPOSITS						
		14.50	11.50								
		15.00			MODERATELY WEATHERED AGGLOMERATE						14.50-32.50m AGGLOMERATE 14.5-21.0m Moderately weathered. Generally broken 60° to 90° fracture plane. Calcite filled
		20.00									
		21.00	5.50		SLIGHTLY WEATHERED AGGLOMERATE						21.0-25.0m Slightly weathered
		25.00	4.00					100 %			25-32.5m Fresh. Tight and calcite filled fractures with 60° to 90° planes. Broken at sections: 22-25, 26.8-27, 27-27.3, 30-30.2, 32.3-32.5.
		30.00			AGGLOMERATE						

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BOREHOLE LOG

PROJECT	ILOCOS NORTE IRRIGATION PROJECT					SITE	NUEVA ERA DAM		
HOLE NO. DDH-6 (1)	ELEVATION	170.30 M	ANGLE	VERTICAL	MACHINE		BEGUN		SITE ENGINEER	
	DEPTH	50.00 M	BIT		PUMP		COMPLETED		FOREMAN	
	DIAMETER		GW LEVEL	19.6 M	ENGINE		DAYS REQUIRED		DRILLER	

DATE	ELEVAT'N	DEPTH	THICK'S	LOG	TERMINO'Y	COLOR	R.Q.D 20 40 60 80	RECOVERY (%) 20 40 60 80	DRILL SPEED (h/m) 1 2 3	PERMEABILITY K in CGS/ LUGEON 10^{-5} 10^{-4}	DESCRIPTIONS
		0.00									
			5.00		OVER BURDEN	REDDISH BROWN					
		5.00									3.0-8.0m PEBBLE AGGLOMERATE Pebble pyroclasts set in a basaltic matrix. Slightly weathered along fracture planes.
		5.00			AGGLOMERATE						8.0-15.0m PEBBLE AGGLOMERATE Fresh Fractures are relatively tight and calcite-healed.
		15.00									15.0-25.0m Parallel jointings encountered at sect. 16.20-19.6m (at sect.) 19.25-17.56m, Sheared zone is present.
		20.00						100 %			
		25.00									25.00-35.00m Pebble Agglomerate Fractures are very few and very tight (calcite-healed) sometimes gravelss of quart calcite are present. Present of minerals veinlets usually intersecting
		30.00								k=0	

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BOREHOLE LOG

PROJECT	ILOCOS NORTE IRRIGATION PROJECT				SITE	NUEVA ERA DAM	
HOLE NO. DDH-6 (2)	ELEVATION		ANGLE		MACHINE	BEGUN	SITE ENGINEER
	DEPTH		BIT		PUMP	COMPLETED	FOREMAN
	DIAMETER		GW LEVEL		ENGINE	DAYS REQUIRED	DRILLER

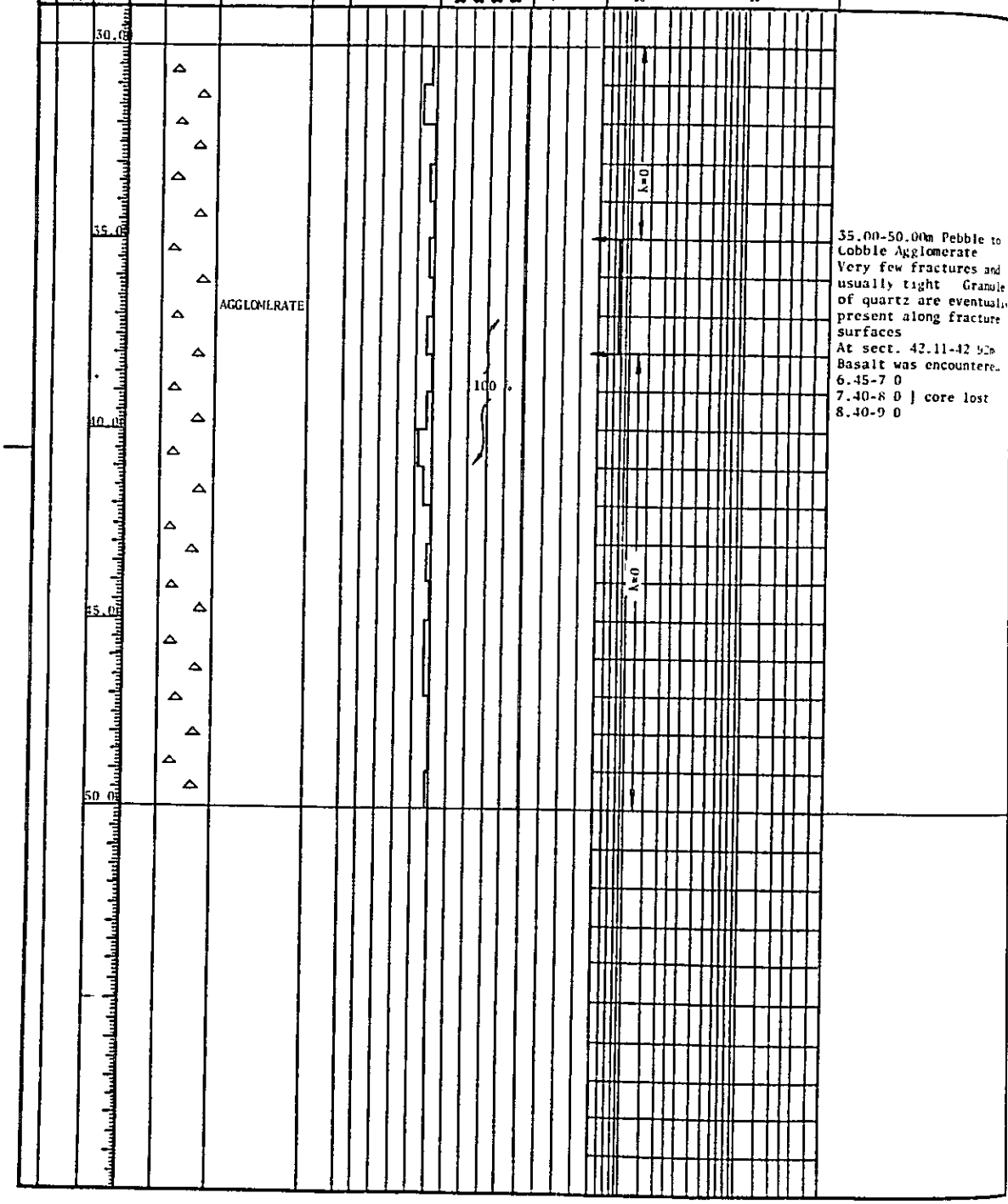

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FIGURE 3B-24 TRAVEL TIME CURVE
AND VELOCITY PROFILE
(NUEVA ERA DAM)

SCALE 1 500

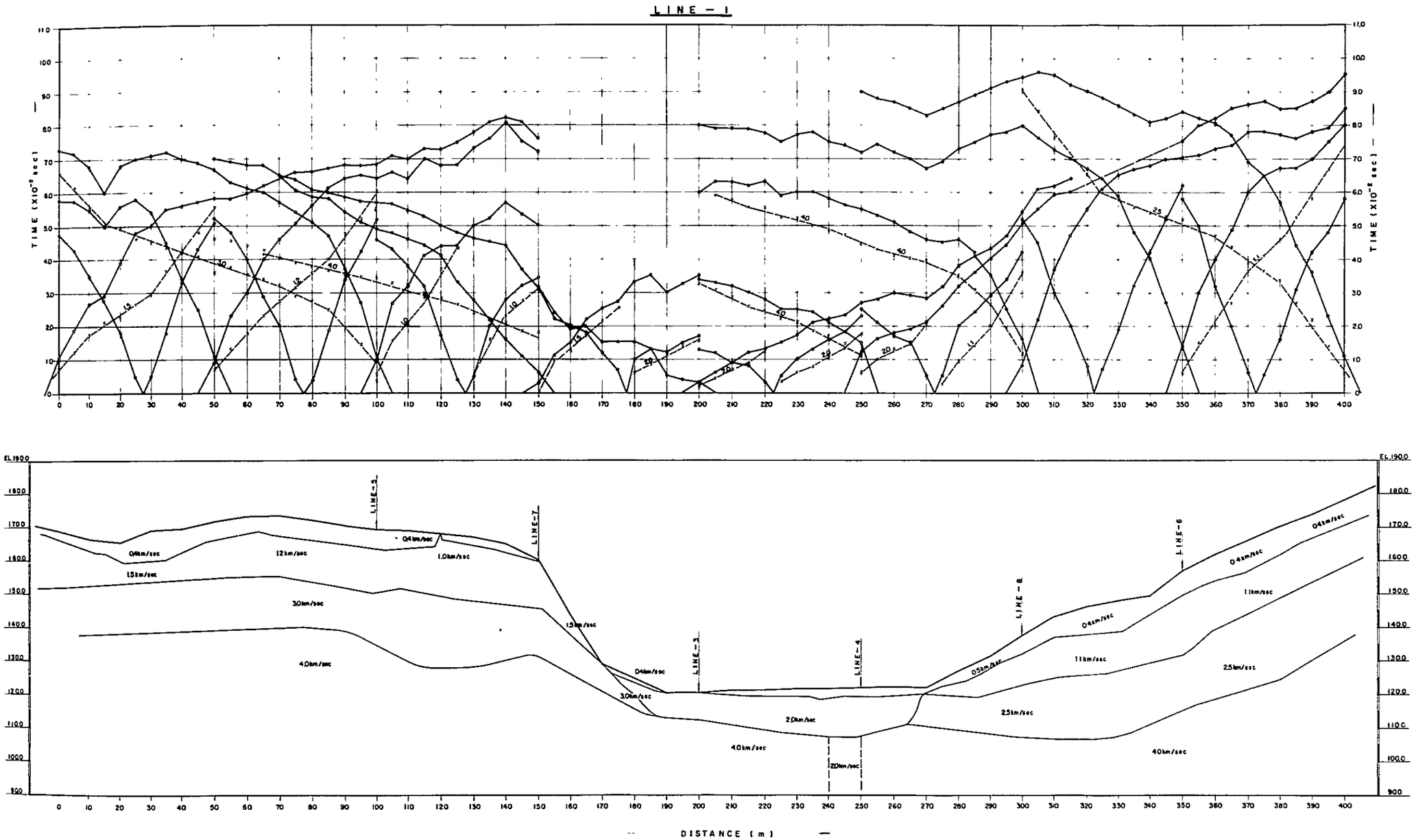


FIGURE 3B-25 TRAVEL TIME CURVE
AND VELOCITY PROFILE
(NUEVA ERA DAM)
SCALE 1 500

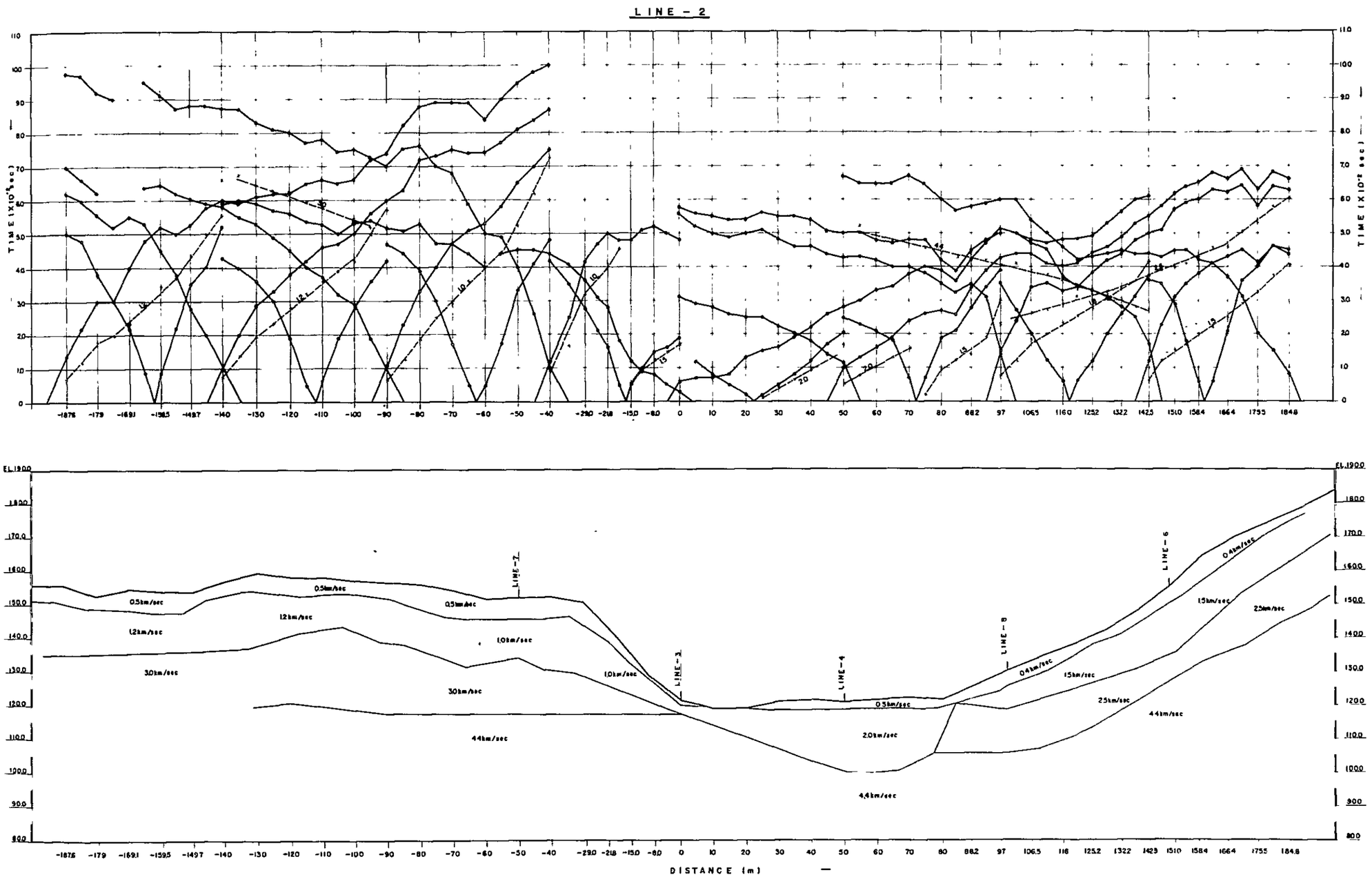


FIGURE 3B-26 TRAVEL TIME CURVE
AND VELOCITY PROFILE
(NUEVA ERA DAM)

SCALE 1:500

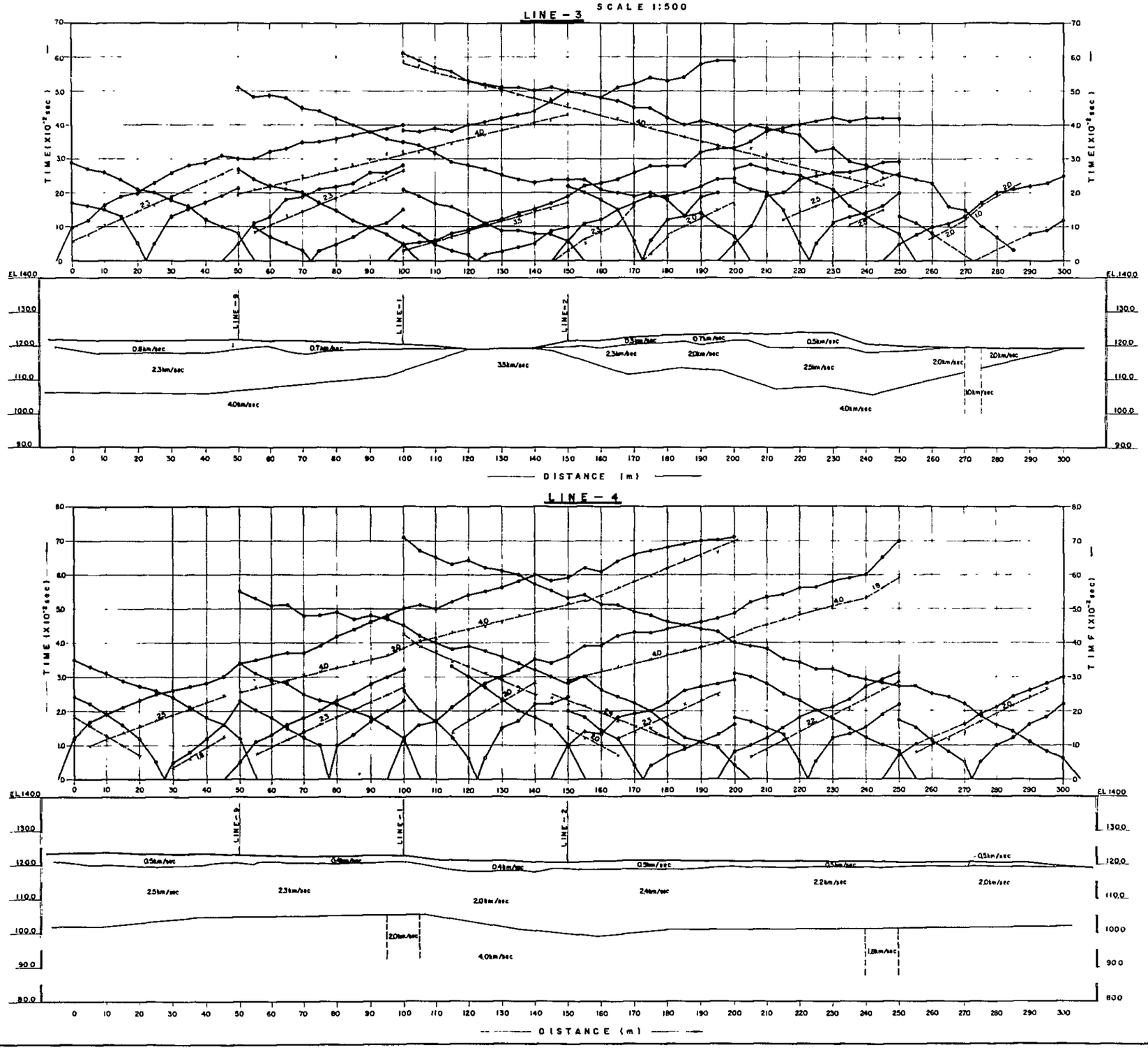


FIGURE 3B-27 TRAVEL TIME CURVE AND VELOCITY PROFILE (NUEVA ERA DAM)

SCALE 1:500

LINE – 5

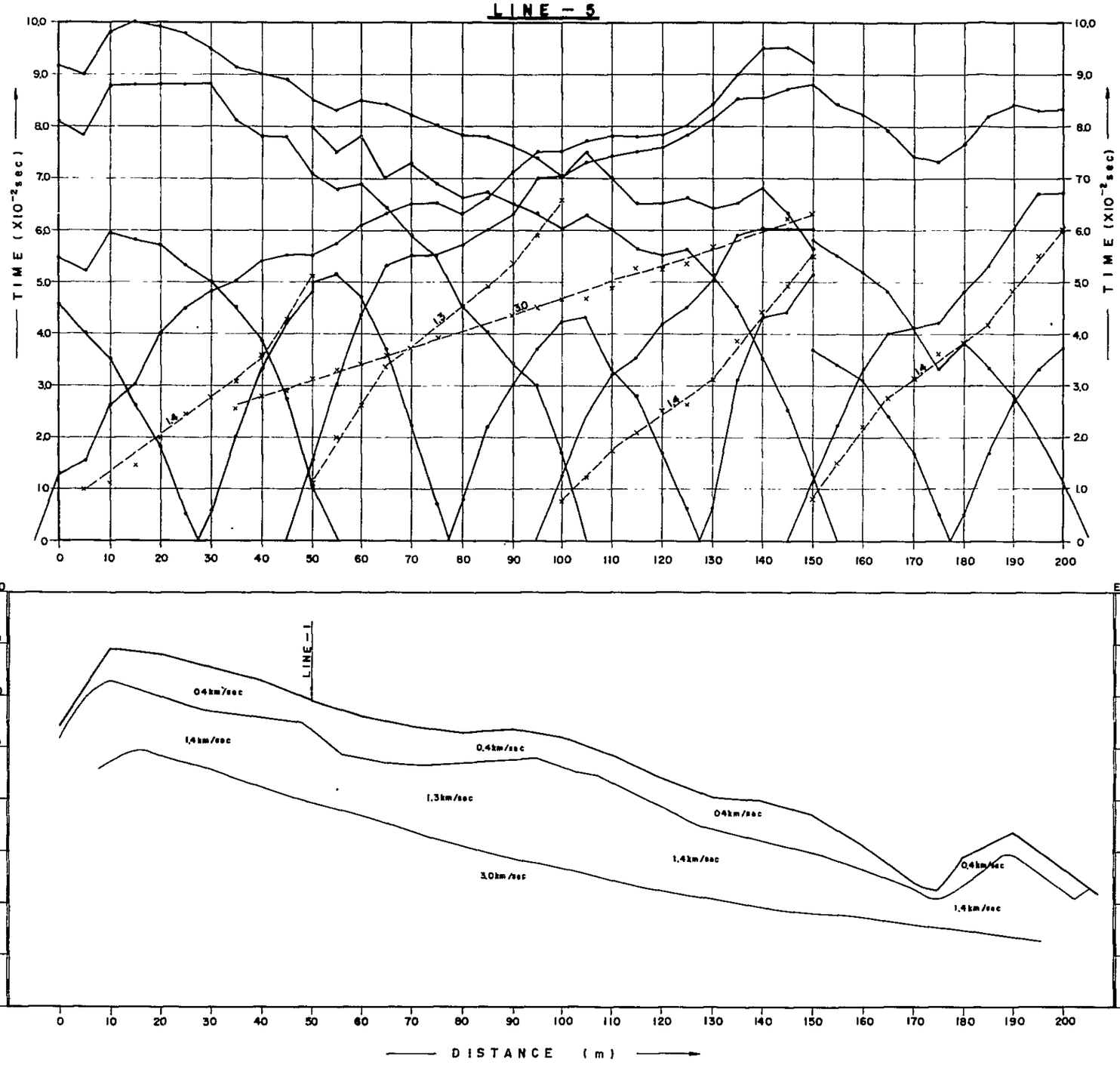


FIGURE 3B-28 TRAVEL TIME CURVE AND VELOCITY PROFILE (NUEVA ERA DAM)

SCALE 1:500

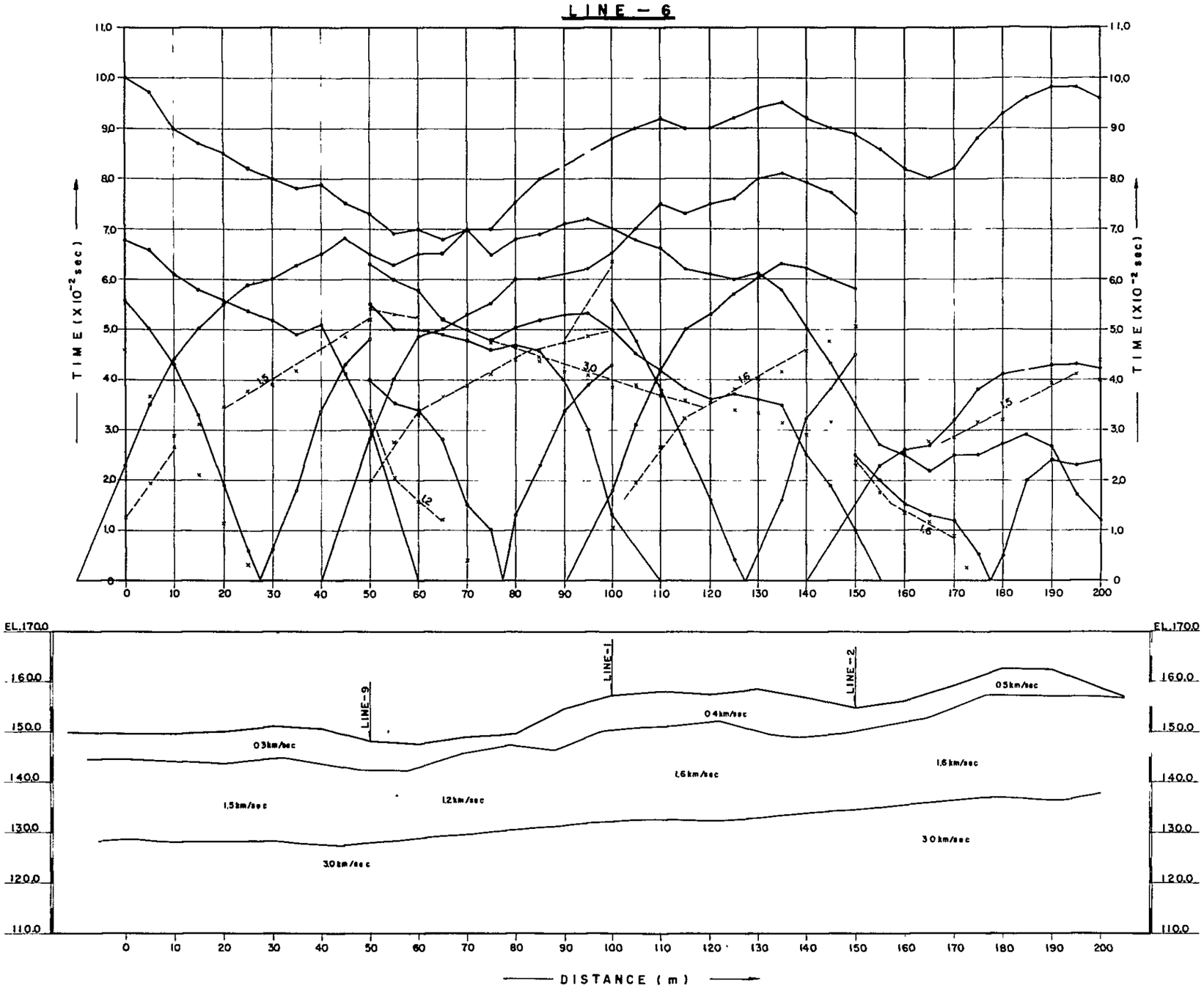


FIGURE 3B-29 TRAVEL TIME CURVE
AND VELOCITY PROFILE
(NUEVA ERA DAM)

SCALE 1:500

LINE - 7

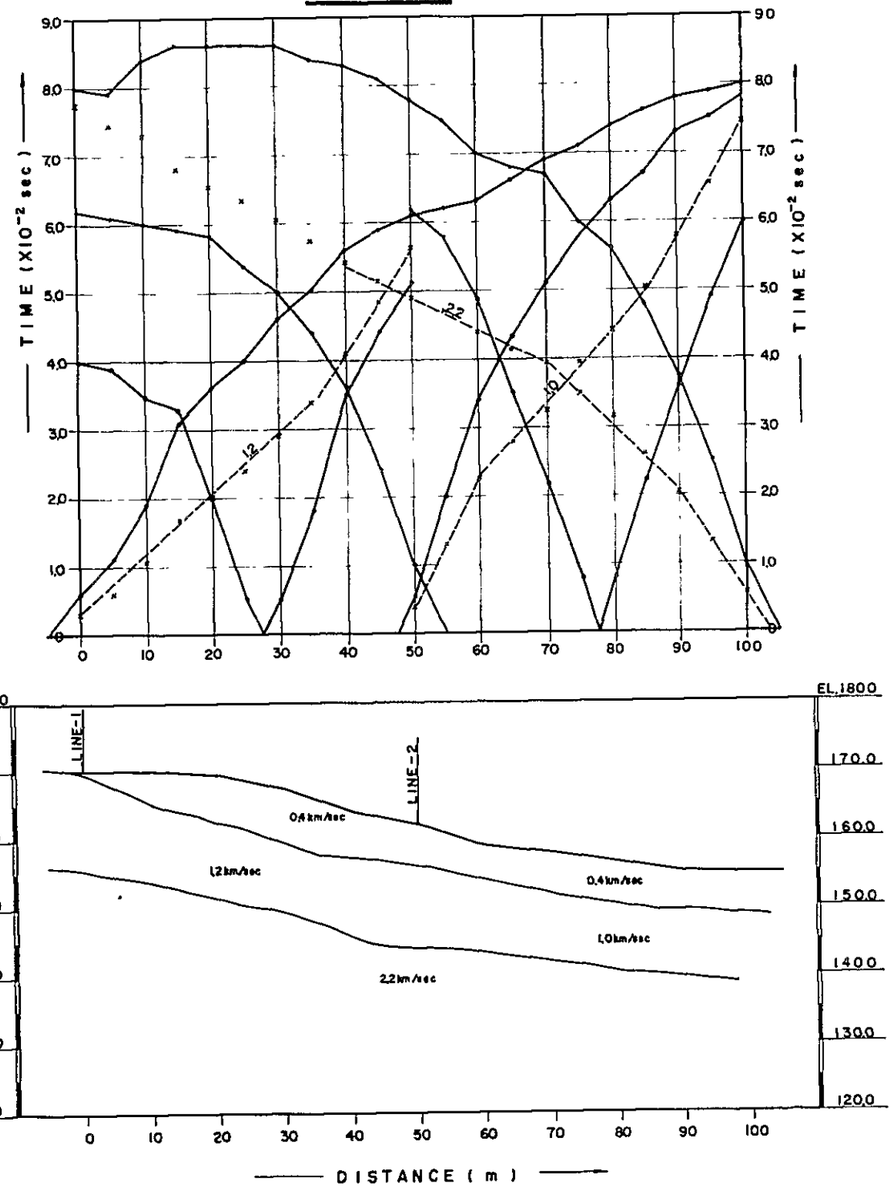


FIGURE 3B-30 TRAVEL TIME CURVE AND VELOCITY PROFILE (NUEVA ERA DAM)

SCALE 1:500

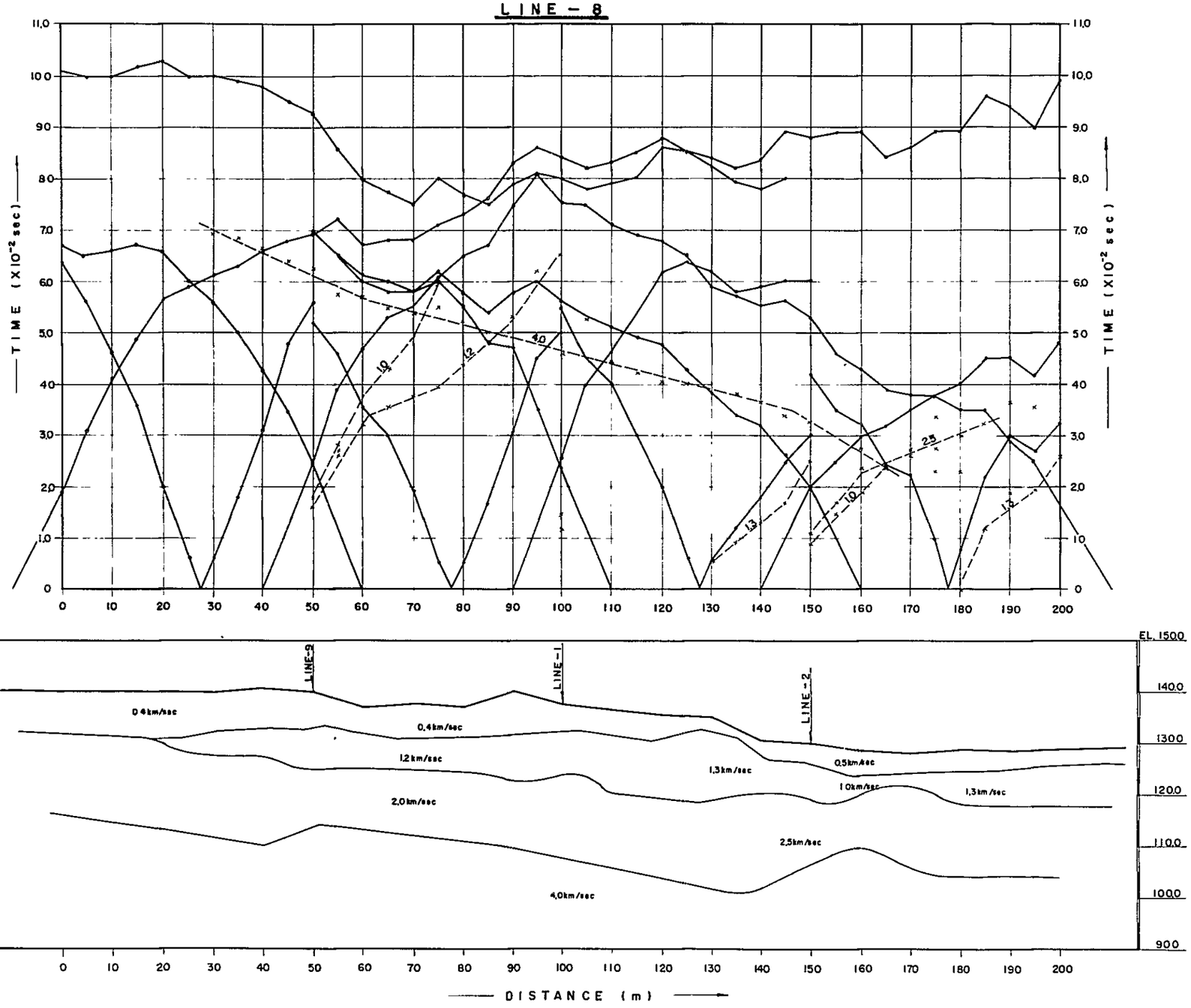


FIGURE 3B-31 TRAVEL TIME CURVE
AND VELOCITY PROFILE
(NUEVA ERA DAM)

SCALE 1:500

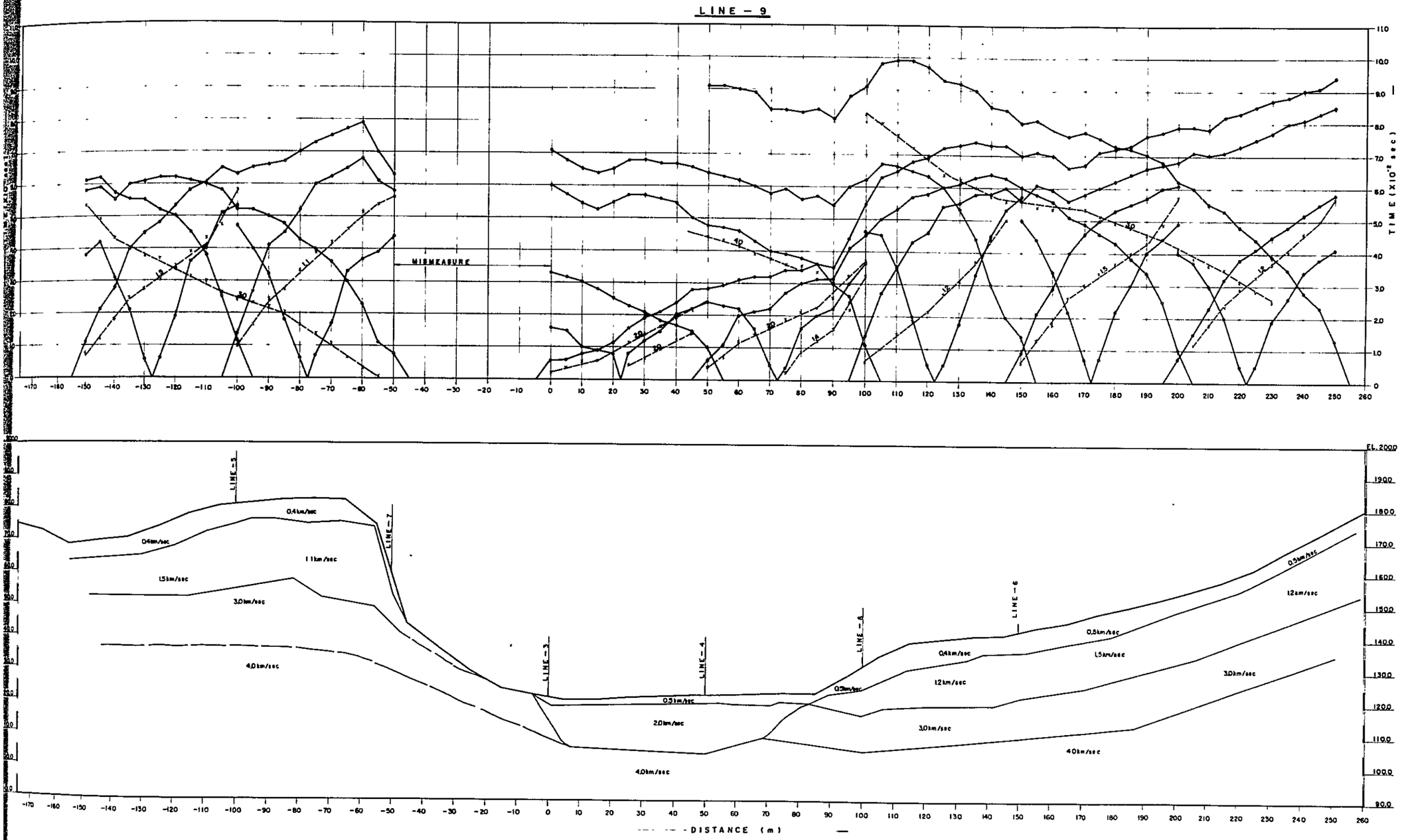


FIGURE 3B-32 LOCATION MAP OF GEOLOGICAL INVESTIGATION FOR DIVERSION DAM SITE

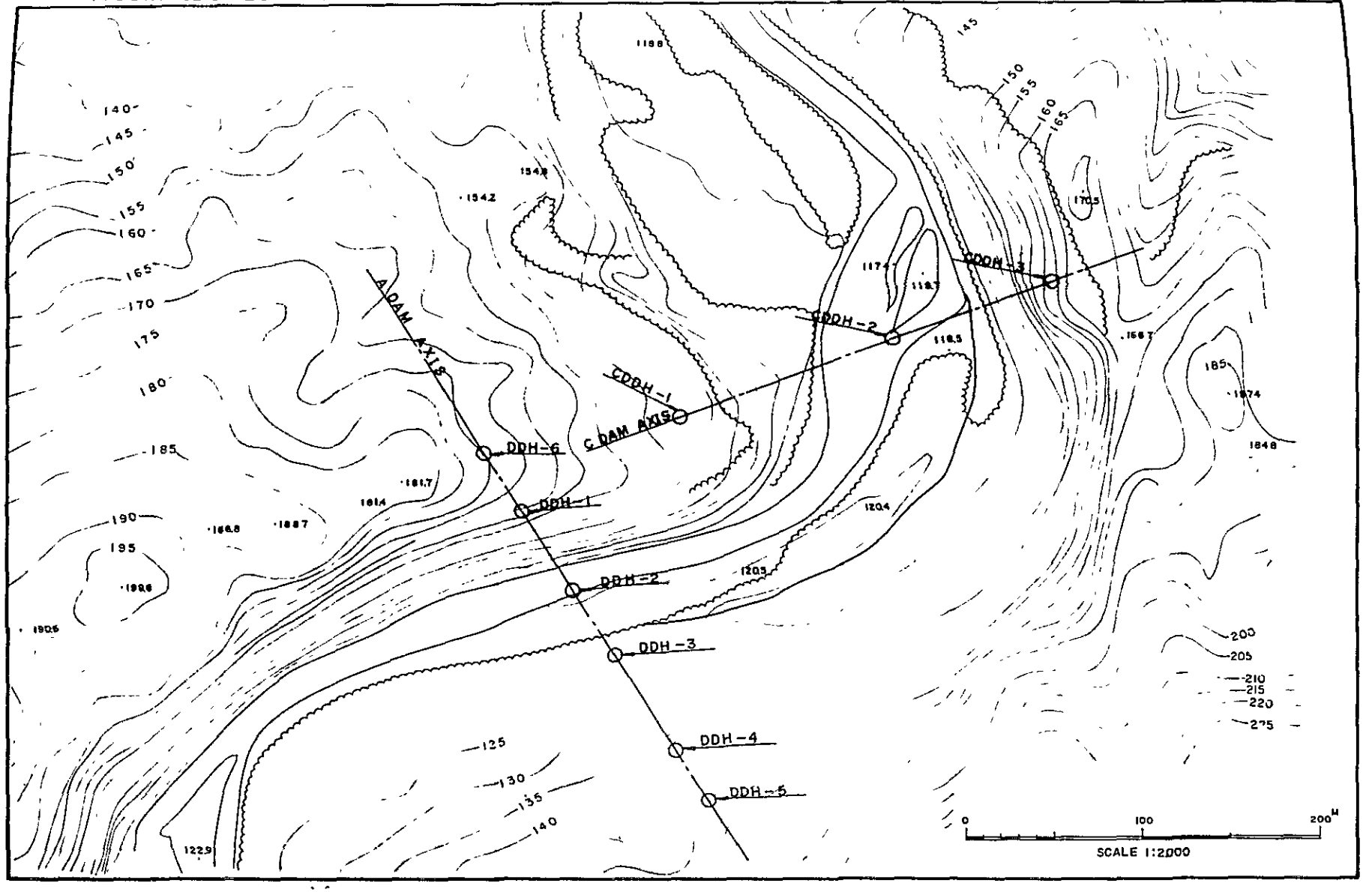
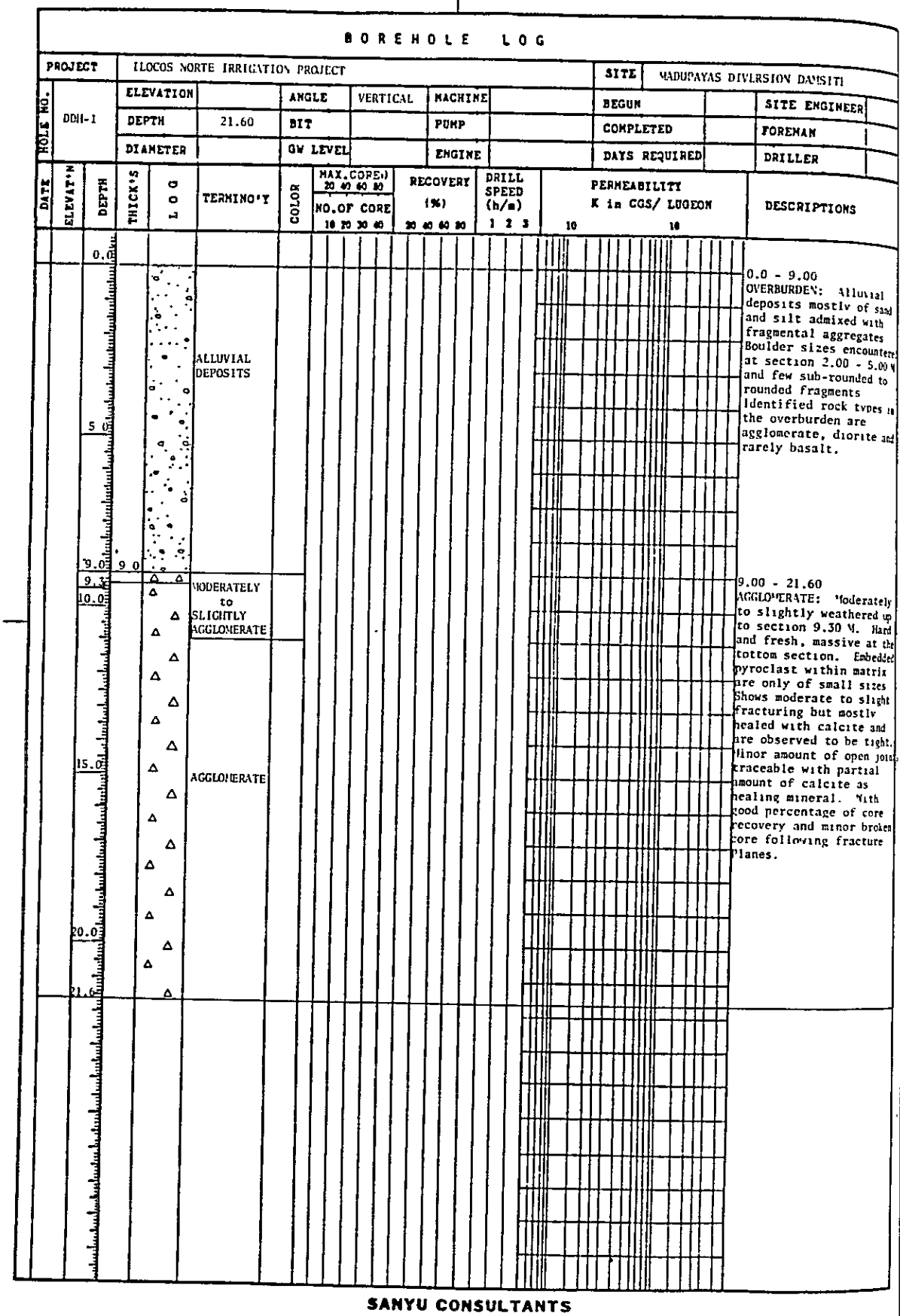


FIGURE 3B - 33 BORE-HOLE LOG AT MADUPAYAS DIVERSION DAM SITE



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BOREHOLE LOG

PROJECT	ILOCOS NORTE IRRIGATION PROJECT					SITE	MADUPAYAS DIVERSION DAM SITE		
HOLE NO.	DDH-2	ELEVATION	E.L. 84.40	ANGLE	VERTICAL	MACHINE		BEGUN	SITE ENGINEER
		DEPTH	25.50 M	BIT		PUMP		COMPLETED	FOREMAN
		DIAMETER		GW LEVEL	2.95 M	ENGINE		DAYS REQUIRED	DRILLER

DATE	ELEVAT'N	DEPTH	THICK'S	LOG	TERMINO'Y	COLOR	MAX.CORE() 20 40 60 80 / NO.OF CORE 10 20 30 40	RECOVERY (%) 20 40 60 80	DRILL SPEED (h/m) 1 2 3	PERMEABILITY K in CGS/ LUGEON 10 ... 10	DESCRIPTIONS
		0.0	0.0								
		5.0			ALLUVIAL DEPOSITS						0.0 - 12.80 OVERBURDEN, length of run intercepted occasional boulders which are fresh to slightly weathered and sandy soil
		10.0									
		12.8	12.8								
		15.0			AGGLOMERATE						12.80 - 25.50 AGGLOMERATES with good percentage core recovery. The bedrock is primarily fractured however eventually healed by quartz/calcite. Along its zones of fractures. Veinlets of quartz/silica predominates in the bedrock. SECTIONS HEAVILY FRACTURED: 14.35 - 14.55 M 16.00 - 16.40 M 17.30 - 17.40 M fractured zone with iron staining and quartz/calcite filling 18.40 - 18.70 M 20.80 - 20.90 M thin healing materials of quartz along fractured zone, oriented 45° from the horizontal. Slightly epidotized. 24.25 - 24.45 M fractured zone with iron staining 25.30 - 25.50 heavily fragmented with iron staining
		20.0									
		25.0									
		25.5									

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BOREHOLE LOG

PROJECT	ILOCOS NORTE IRRIGATION PROJECT				SITE	MADUPAYAS DIVERSION DAMSITE	
HOLE NO. DDH-3	ELEVATION E.L.84.0	ANGLE	VERTICAL	MACHINE	BEGUN		SITE ENGINEER
	DEPTH 21.00 M	BIT		PUMP	COMPLETED		FOREMAN
	DIAMETER	GW LEVEL	3.15 M	ENGINE	DAYS REQUIRED		DRILLER

DATE	ELEVATION	DEPTH	THICKNESS	LOG	TERMINOLOGY	COLOR	MAX. CORED 20 40 60 80 / NO. OF CORE 10 20 30 40	RECOVERY (%) 20 40 60 80	DRILL SPEED (h/m) 1 2 3	PERMEABILITY K in CGS/ LUGEON 10 — 10	DESCRIPTIONS
		0.0	0.0								
		5			ALLUVIAL DEPOSITS						0.00 - 4.00 M OVERBURDEN. Broken core of agglomerate, generally from cobble to pebble fragments, usually sub angular to angular, slightly weathered and iron-stained.
		7.45	7.45								4.00 - 7.45 Fragments of pebble agglomerate. Slightly weathered. Sandy materials have been noted at some sections
		10.0			SLIGHTLY AGGLOMERATE						7.45 - 9.00 Pebble agglomerate Slightly fresh Fractures are usually healed by calcite/quartz, sometimes chlorite films are visible, others are limonitic. 9.00 - 12.00 Slightly fresh, medium-grained agglomerate Fracturings are sparsely distributed but with numerous calcite/quartz veinlets. Fracture surfaces are often coated with calcite and epidote sometimes granules of quartz. 13.00 - 17.00 Agglomerate. Fresh, hard and massive Calcite/quartz veinlets are intersecting/dissecting and fracturings are evenly distributed Fracture surfaces are occasionally rusty-coated and eventually epidotized. 17.00 - 21.00 Agglomerate. Fresh, hard and massive. Sparsely distributed joints/fracturings, usually calcite-healed have been noted, especially at sect. 19.00 - 21.00. Rusty coatings along fracture's surfaces are often visible. Presence of numerous veinlets are also noted
		12.0									
		15.0			AGGLOMERATE						
		20.0									
		21.0									

FIGURE 3B-34 BORE-HOLE LOG AT TIBANGRAN DIVERSION DAM SITE

BOREHOLE LOG

PROJECT	ILOCOS NORTE IRRIGATION PROJECT					SITE	TIBANGRAN DIVERSION DAMSITE		
HOLE NO. DDH-2	ELEVATION	E.L.34.95	ANGLE	VERTICAL	MACHINE		BEGUN		SITE ENGINEER
	DEPTH	17.0 M	BIT		PUMP		COMPLETED		FOREMAN
	DIAMETER		GW LEVEL	10.0 M	ENGINE		DAYS REQUIRED		DRILLER

DATE	ELEVAT'N	DEPTH	THICK'S	LOG	TERMINO'Y	COLOR	MAX. CORE: 20 40 60 80 / NO. OF CORE 10 20 30 40	RECOVERY (%) 20 40 60 80	DRILL SPEED (h/m) 1 2 3	PERMEABILITY K in CGS/ LUGEON 10 ... 10	DESCRIPTIONS
		0.0	0 0								
					ALLUVIAL DEPOSITS						0.00 - 2.00 OVERBURDEN: Gravel, predominant of pebbles, cobbles consist of conglomerates/agglomerates, sandstone and siltstone. 2.00 - 7.00 OVERBURDEN: Occurences of solid pcs. of rock material, probably of boulder origin, frequently interlayered with fine sand particles, reflecting a light-brown to cream color.
		5.0									
											7.00 - 10.00 OVERBURDEN: Broken rock core materials associated with sporadic calcite veinlets.
		10.0	10.0								
		10.5	0.5	V V	BASALT						10.50 - 15.00 Agglomerate: fresh, gray, hard, moderate to slightly weathered at section 11.0 - 11.15, slightly fractured at section 11.8 - 12.6; 30°, 60° rough/rusty fractures. 14.0 - 14.60 - solid, splitted to 4 pieces 14.60 - 15.00 - broken to moderately crushed.
					AGGLOMERATE						
		15.0									15.00 - 16.00 Agglomerate generally fresh, gray, hard, with sub-angular cobble-sized pyroclasts. 15.0 - 15.2 - broken 15.2 - 16.0 - solid with 45°, 10° semi to smooth fracture surfaces.
		7.0									
											16.00 - 17.00 Agglomerate: medium-grained, fresh to slightly weathered, hard, solid and broken to 12 pieces at an average of 7.62 cm/ piece.

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BOREHOLE LOG

PROJECT	ILOCOS NORTE IRRIGATION PROJECT	SITE	TIBANGRAN DIVERSION DAMSITE

HOLE NO.										
DDH-3 (1)	ELEVATION	E.L.35.25	ANGLE	VERTICAL	MACHINE		BEGUN		SITE ENGINEER	
	DEPTH	37.0 M	BIT		PUMP		COMPLETED		FOREMAN	
	DIAMETER		GW LEVEL	4.45	ENGINE		DAYS REQUIRED		DRILLER	

DATE	ELEVAT'N	DEPTH	THICK'S	LOG	TERMINO'Y	COLOR	MAX. CORE(cm) 20 40 60 80 / NO. OF CORE 10 20 30 40	RECOVERY (%) 20 40 60 80	DRILL SPEED (h/m) 1 2 3	PERMEABILITY K in CGS/ LUGEON 10 10	DESCRIPTIONS
		0.0									
		5.0									0.0 - 27.5 m Alluvial deposits consisting of alternating sequence of gravel (pebbles and cobbles and oftentimes boulder) and sand/silt. Gravels are composed of sub-rounded agglomerate(d) diorite, basalt and occasional chert rock fragments
		10.0			ALLUVIAL DEPOSITS						27.5 - 37.0 m BASALT: generally fresh to slightly weathered, hard, massive and mostly solid. broken at section 28 3 - 28.5 characterized by moderate weathering and calcitic fractures. 15°, 20°, 5° fractures at span 29.0 - 30.0 m. slightly broken with predominance of calcite veinlets occupying fracture spaces dipping at 60°, 2 in section 30.0 - 31.0 m.
		15.0									broken at section 31 0 to 31.5 with fractures at 1, 20°. section 32 - 34 m broken with 15°, 5° fracture planes rusty fractures at 70°, 15°, 10°, 5° in span 34 - 35.0 m.
		20.0									section 35.0 - 36.0 - slightly to moderately weathered and slightly fractured. Open and calcitic fracture surface section 36.0 - 37.0 - SW to MW and moderately fractured with 10°, 45°, 30° rough fracture planes
		25.0									
		27.5	27.5								
		30.0			BASALT						

BOREHOLE LOG

PROJECT	ILOCOS NORTE IRRIGATION PROJECT				SITE	TIBANGRAN DIVERSION DAMSITE	
HOLE NO. DDH-3 (2)	ELEVATION	ANGLE	MACHINE	BEGUN		SITE ENGINEER	
	DEPTH	BIT	PUMP	COMPLETED		FOREMAN	
	DIAMETER	GW LEVEL	ENGINE	DAYS REQUIRED		DRILLER	

DATE	ELEVAT'N	DEPTH	THICK'S	LOG	TERMINO'Y	COLOR	MAX.CORE) 20 40 60 80 / NO.OF CORE 10 20 30 40	RECOVERY (%) 20 40 60 80	DRILL SPEED (h/m) 1 2 3	PERMEABILITY K in CGS/ LUGEON 10 — 10	DESCRIPTIONS
		30									
					BASALT						
		35									
		37									

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BOREHOLE LOG

PROJECT	ILOCOS NORTE IRRIGATION PROJECT				SITE	TIBANGRAN DIVERSION DAMSITE	
HOLE NO. DDH-4 (1)	ELEVATION E.L.37.50	ANGLE VERTICAL	MACHINE		BEGUN		SITE ENGINEER
	DEPTH 47.0M	BIT	PUMP		COMPLETED		FOREMAN
	DIAMETER	GW LEVEL 7.55 M	ENGINE		DAYS REQUIRED		DRILLER

DATE	ELEVAT'N	DEPTH	THICK'S	LOG	TERMINO'Y	COLOR	MAX. CORE 20 40 60 80 / NO. OF CORE 10 20 30 40	RECOVERY (%) 20 40 60 80	DRILL SPEED (h/m) 1 2 3	PERMEABILITY K in CGS/ LUGEON 10 ... 10	DESCRIPTIONS
		0.0									0.0 - 42.00 M The length of run comprises the alluvial deposits on the river bed which is made up of cobbles, pebbles, boulders and sandy soil and gravel The deposit is thick and predominantly boulders and sandy soil materials that were penetrated
		5.0									
		10.0			ALLUVIAL DEPOSITS						
		15.0									
		20.0									
		25.0									
		30.0									

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BOREHOLE LOG

PROJECT	ILOCOS NORTE IRRIGATION PROJECT			SITE	TIBANGRAN DIVERSION DAMSITE		
HOLE NO. DDAH-4 (2)	ELEVATION	ANGLE	MACHINE	BEGUN		SITE ENGINEER	
	DEPTH	BIT	PUMP	COMPLETED		FOREMAN	
	DIAMETER	GW LEVEL	ENGINE	DAYS REQUIRED		DRILLER	

DATE	ELEVAT'N	DEPTH	THICK'S	LOG	TERMINO'Y	COLOR	MAX.CORE) 20 40 60 80 NO.OF CORE 10 20 30 40	RECOVERY (%) 20 40 60 80	DRILL SPEED (h/m) 1 2 3	PERMEABILITY K in CGS/ LUGEON 10 10	DESCRIPTIONS
		50.0									
		55.0			ALLUVIAL DEPOSITS						
		40.0									
		42.0			BASALT						42.00 - 46.80 Dark in color, massive and evenly fine-grained. Some sections are heavily fractured.
		45.0									SECTIONS FRACTURED: 41.55 - 42.45 M 43.25 - 43.50 M 45.50 - 45.65 M
		46.8 47.0			AGGLOMERATE						

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B. Technical Support

1) General Geology

The proposed sites for two dams and two diversion dams are under lain by marine effusive rocks and the intrusive rock of diorite, both of which are the major component rocks forming the Cordillera Central Mountains in the Northern Luzon.

The base of the proposed sites for two diversion dams and Nueva Era dam is mainly composed of dacite into which basalt intrudes, and overlain by thick river deposits. At Nueva Era dam site the base is overlain by river and terrace deposits with about 15 m thick. At Palsiguan dam site river deposit is so thin as about 10 m. The both abutments are composed of favorable rock here.

2) Palsiguan Dam Site

a) General Geology

Palsiguan dam site is located in Ginataran area about seven kilometers upstream of barrio Baybaytin in Abra province. This dam site is situated in the mountainous area with steep slopes. The vegetation is extremely poor around the dam site.

The Palsiguan river running through the dam site flows almost straightly to the SSW, and joins the Tineg river near barrio Polot. The distance between the dam site and this barrio is about 11 km. The dam site is located on the medium reaches of the Palsiguan river.

The dam site has the left abutment slope of about 45°, the right abutment slope of about 35° and the riverbed width of about 30 m. The length/height ratio at the elevation of 340 m on the proposed dam axis is 3.5 (210 m/60 m). The valley has a V-slope whose bottom is a slightly widen.

Palsiguan dam site and its vicinity are underlain by volcanic products of dacite, etc., intruded into by diorite. The dacite and

diorite are the major component rocks forming the Cordillera Central Mountains of the Northern Luzon, however, their ages have not yet been determined.

The base of Palsiguan dam site is mainly composed of dacite. Diorite is distributed about three kilometers upstream of the dam site. Limestone is widely distributed about three kilometers downstream of this dam site.

The access road to the dam site from the downstream will be constructed through this limestone zone.

The geological study inclusive of the geological field investigation, core-hole drilling and seismic prospecting has been conducted up to the present. Results of the geological study are shown in Figure 3B-35 and 3B-36, Appendix 3B-4.

The Dacite and basalt forming the base of this dam site have a remarkable number of joints and cracks. The majority of joints and cracks looks toward the north as the general tectonic lines of the Northern Luzon do so.

However, the rock body itself is hard and compact, and it has a sufficient bearing capacity as the base rock of a rock fill dam.

As a result of core-boring, zoning of the base in the dam site is made, based on the degree of weathering, as follows;

° Medium weathered zone

This zone is 20 to 30 m thick, and distributed in high elevation. A part of this zone has been completely weathered, and altered to soils. The rock body itself is slightly soft. Open cracks are observed at its surface.

° Weakly weathered zone

The rock body is hard and compact, however, the surface

of cracks has been oxidized and contaminated, and is brown in color.

° Fresh zone

The fresh rock has many cracks. Masses of boring cores are sampled due to the mechanical shock given in the course of sampling, however, cracks tightly close under the natural conditions.

A crushed zone which might directly affect the dam to be constructed lies through the right bank saddle. The exposures show that this crushed zone intercalates no soft layers such as fault clay, etc., but its rocks have been crushed and fine-grained.

Based on the permeability test conducted at boring holes, the permeability of the base in this dam site has the following regularities;

° The deeper is the base, the smaller is its permeability.

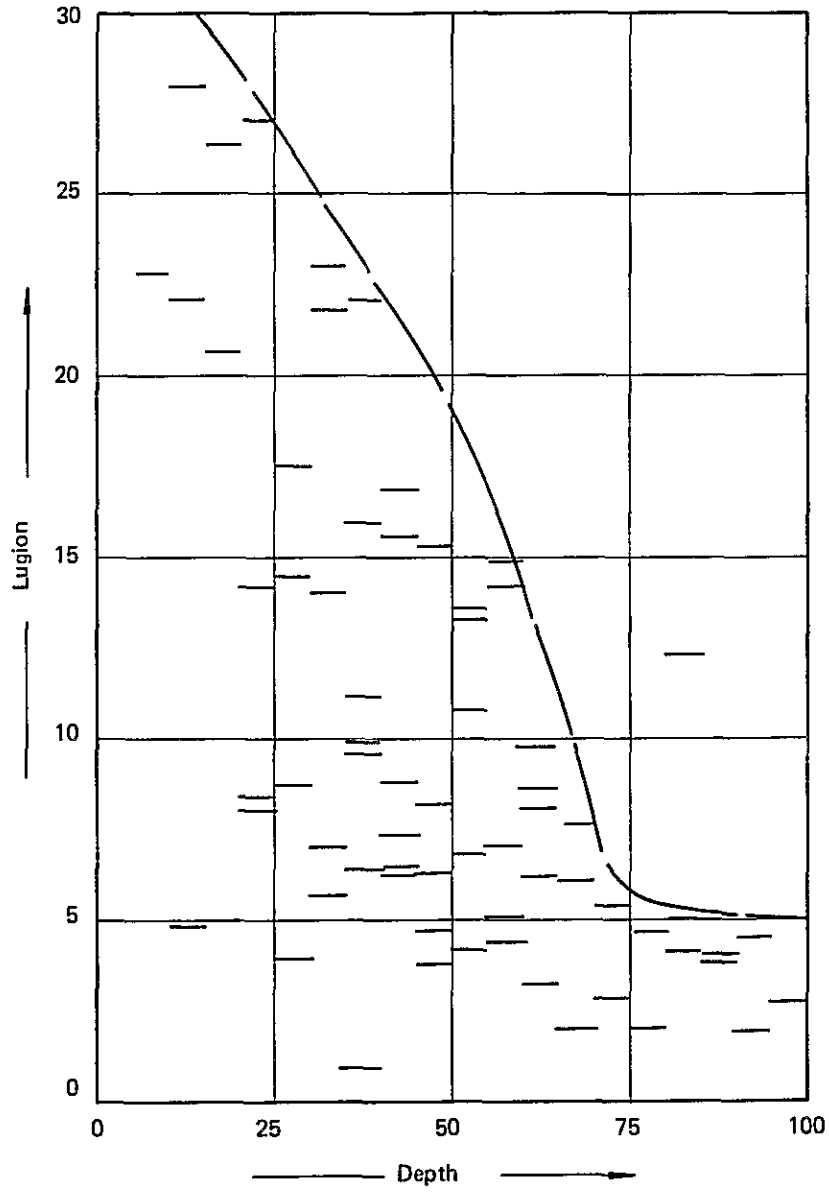
° The coefficient of water permeability of a weathered zone is in the range of 1×10^{-4} to 2×10^{-4} cm/sec.

° The fresh rocks above the depth of about 50 m have a similar coefficient of water permeability to that of a weathered zone.

° The fresh rocks deeper than 70 m from the ground surface have a coefficient of water permeability of 2×10^{-5} to 5×10^{-5} cm/sec.

Under the situations, it can be said that the base falls in the category of semi-permeable rocks.

VALUES OF LUGION WITH DEPTH



Based on the seismic prospecting, the zoning of velocity layers can be made as follows;

Velocity Layer	Velocity (km/sec)	Geologic Condition
No.1 layer	0.35 to 0.5	Surface soils, talus deposit and strongly weathered rocks
No.2 layer	1.0 to 1.5	Medium weathered rocks
No.3 layer	2.0 to 2.4	Weakly weathered rocks and river deposits
No.4 layer	3.0 to 3.4	Fresh rocks

b) Foundation Treatment

In order to construct a rock fill dam with height of about 143 m on the above-mentioned base, the following foundation treatment should be made;

(i) Foundation Excavation of Impervios Zone

The averaged weathered zone has a sufficient bearing capacity to function as a foundation of the dam, however, a part of it has been weathered and decomposed, and the rock itself is relatively soft. Furthermore, it has many open cracks at its surface resulting in difficulty of cutoff. This zone should be removed for safety of the dam so that the impervious zone directly lies on the weakly weathered zone or fresh rock zone.

(ii) Foundation Excavation of the dam body

The prerequisite of the foundation of a dam body is a sufficient bearing capacity. The soft layer consisting of surface soils or talus deposits is thin at the dam site so the whole soft layer should be removed. For safety, it might be better to remove the river deposits. However, since the river deposits is judged to have a similar shearing strength to that of the embankment materials for the dam body, no removal of the river deposits has been planned in this stage of the study though furhter study should be made based on the surveys and tests to be conducted in future.

(iii) Cutoff Treatment

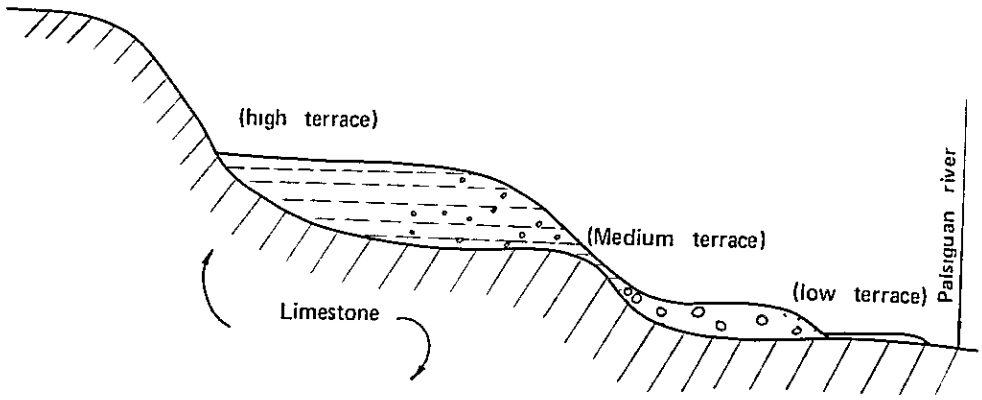
Leakage of stored water through the base, upward pressure against the dam body and leakage throught the crushed zone in the right bank saddle should be taken into consideration. To prevent them, a grouting curtain will be laid from the bottom of the cutoff zone through the foundation of the spillway to the right bank saddle portion. The base of this dam has many cracks, therefore, a thick grout zone should be laid at the joint portion with the cutoff zone in order to control the velocity of seepage water.

c) Surveys and Tests on Embankment Materials

(i) Borrow-pit Survey

As for the borrow-pit survey, a field investigation was conducted in 1979 at the proposed borrow pits shown in Figure 3B-37, Appendix 3B-4. As a result, it has been found out that materials in the A and B areas, which are near from the dam site, consist of terrace and talus deposits can be utilized, in the aspect of quality, as the impermeable materials for the dam construction. However, the layer of such deposits is thin resulting in quantitative shortage. It has been also revealed that the proposed borrow-pits C and D on the downstream reaches are situated in the flat limestone area. Impermeable materials are hardly distributed there.

During the field investigation at the conjuction of the Palsiguan river and the Tineg river (Kiwas, Polot and Manaois areas) it was judged that high terrace deposits on the right bank of the Palsiguan river was worth carrying out the geological studies. Therefore, test pits were dug. The schematic profile is illustrated as follows;



The investigation verified that Kiwas area was not a favorable borrow-pit since the materials available here consist of sand and gravel. Materials in Polot and Manaois areas are sufficient in quantity as shown below, however, being composed of silt and clay, are not completely favorable in quality when utilized to constructed such a high dam as the proposed Palsiguan dam.

Quantity of Embankment Materials Available at Each Borrow-pit

Borrow-pit	Area (sq.m)	Sample Depth (m)	Quantity (cu.m)
Polot	899,000	5.0	3,590,000
Manaois	424,400	5.0	2,500,000

In order to study the physical properties of materials distributed in the both proposed borrow-pits and obtain the basic data prerequisite for future study and design, NIA collected core samples, and conducted the soil mechanical tests. Furthermore, NIA simultaneously conducted the preliminary test on mixed materials in order to utilize the improve materials in the way to mix it with sand and gravel which are available on the river bed.

(ii) Quarry Site

During the field investigations around the dam site, it was found out that continuous explosures of hard rocks ran on the river bed portion of each mountainous mass. The surface layer such as talus deposits, etc., is so thin as one to two meters.

However, the base has many joints and cracks. The higher is an elevation of the base, the thicker is the weathered zone of the base. Under the situations, any mountain mass does not differ from others in the aspect of quantity of materials when selected as quarry site. At present the spillway to be located on the right bank of this dam site and the mountain mass extending from that portion are proposed to be the quarry site in consideration of the following;

- The distance between the dam site and a quarry site should be the shortest possible within the limit that such location of the quarry does not hinder the construction

- The quarry site should make it wasy to construct the access road. Furthermore, the access road should be the shortest possible.

- The access road should not go across the other structures to be constructed.

- A mountain mass on the upstream reaches is more favorable than that on the downstream reaches.

The above-mentioned quarry site is mainly composed of dacite though a small-scalled intrusive rock of basalt is observed. The boring-cores obtained at DDH-4 and DDH-7 show that the base is extremely hard and favorable as rock material, however, has many cracks at its surface. It seems that a big quantity of fine-grained rock will appear in excavating, and that semi-permeable materials will be produced from the weathered layers distributed in a high portion.

Under the circumstances, it should be fully taken into consideration how to treat these materials to be produced in excavation.

As for materials test, rock tests of the boring cores obtained in the geological survey for the dam site were used.

(iii) Impermeable Material Test

Out of soil mechanical tests conducted up to the present, a result of the tests conducted on the sample cores PT-8 and MTP-2, which represents Polot and Manaois areas, is shown in Figure 3B-38 and Figure 3B-39, Appendix 3B-4.

The moisture content of boring-cores obtained in Polot and Manaois area stands at 30% and 22%, respectively. These moisture contents are nearly the optimum moisture content.

The grain size analysis indicates that the materials contain so big volume of clay and silt as 65% to 80%, and consist of extremely small participles size. The plastic index ranges in 10 to 15, and the materials are classified into CL to CH in the soil texture.

Having a coefficient of water permeability ranging from 10^{-7} to 10^{-8} cm/sec, the boring cores are sufficient in impermeability. Regarding the shearing strength, they have a cohension of 5.5 to 1.2 ton/sq.m under the condition of natural moisture content, and the angle of internal friction of about 5°.

Based on the above-mentioned, the following can be mentioned in respect of the boring cores;

- The samples contain more fine participles than the optimum materials in constructing a high dam. It is anticipated that cracks will take place in the materials (represented by the boring cores) if they are utilized for dam construction.

- In case of materials categorized in CL to CH in the soil texture classification, the construction supervision would become difficult to a great extent.

- The boring cores show sufficient permeability, however, a high shearing strength cannot be expected.

- An excess pore pressure easily takes place.

- The shrinkage is large, which results in easily occurrence of cracks.

- With the natural moisture content of 22% to 30% and the liquid limit of 40% to 50%, the compression index is large presumably ranging from 0.2 to 0.4.

- Some samples have the natural moisture content less than the plastic limit. Therefore, it is anticipated that the materials will be unstabilized against leakage water, and that cracks will take place.

Taking into consideration the above-mentioned, careful construction supervision will be required specially in respect of the moisture content and compaction of embankment material, or the improvement of embankment materials would be unavoidably necessary if the materials distributed in Polot and Manaois areas are utilized as impermeable materials in constructing a high dam.

Under the situations, materials obtained in Manaois area were mixed with sand and gravel distributed on the river bed to produce improved embankment materials. Test on the mixed embankment materials was conducted, and its results are shown in Figure 3B-40 and 3B-41, Appendix 3B-4. The mixed material sample numbered CS-2 shows the coefficient of water permeability of 2.2×10^{-7} cm/sec and the density of 1.97 g/cu.m under dry conditions, which suggests that the mixed

materials are considerably favorable when used as impermeable materials.

The mixed materials are judged to be available in construction of such a high dam as the proposed Palsiguan dam. At present it has been planned to utilize the mixed materials as the impermeable materials although further study is necessary on availability of weathered rock distribuged in the upper layers at the quarry site for this purpose.

(iv) Rock Test

Boring-cores obtained in the preliminary geological study at the dam site were used to perform the rock test, and it has been found out that the rock has a specific gravity of 2.95 ton/cu.m, water absorption rate of 1.9% and stability of 4.2%. It can be, therefore, said that the rock is quite favorable when utilized as rock materials. Its unconfined compression strength is relatively small as 418 kg/sq.cm on average. It falls in the category of medium hard rock. Dacite and basalt forming the base of this dam site have a remarkable number of cracks. This is the reason what samples having cracks were unavoidably used in the rock tests.

The compression strength required for the rock materials is computed as follows;

° Dead load of the embankment:

2.0 ton/cu.m x 140 m = 280 ton/sq.m

° Earthquake load:

280 ton/sq.m x 0.2 x 0.2 = 11.2 ton/sq.m

° Safety ratio in compression:

12

° Required compression strength:

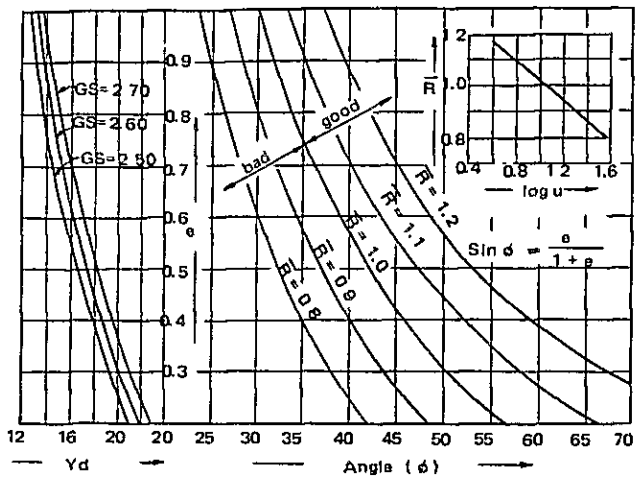
(280 + 11.2) x 12 = 3,494 ton/sq.m

Under the situations, the rock materials are sufficiently high in quality even if the rock is fine-grained to an extent in compaction.

The grain size distribution and the void ratio after the construction of the dam are the major factors in determining the shearing strength in case that the rock materials are utilized for embankment. Such test has not yet been conducted up to the present.

The rock is favorable in quality as mentioned above. The void ratio of about 0.4 could be easily materialized by compaction with a high energy although the volume of fine grained rock and the coefficient of uniform increase to a degree. The shearing strength of the rock materials equivalent to the internal friction angle of 45° could be expected, as shown in the following figure.

RELATION OF VOID RATIO AND INTERNAL PROJECT ANGLE



rd; Dry Density
e; Void Ratio
ϕ; Internal Friction Angle
U; Uniformity Coefficient
Gs; Specific Gravity

Source: T. MOGAMI (1969), Soil Mechanics

3) Nueva Era Dam Site

a) General Geology

Nueva Era dam site is located about 1.5 km south of barrio Nueva Era where the boundary between the mountainous area and the plain runs through.

Terrace deposits are contineously observed from the vicinity of the proposed Nueva Era dam site toward the downstream reaches. Along the downstream reaches of barrio Nueva Era, the terrace deposits have developed in a great scale. The Bonga river running through the dam site comes from the Cordillera Central Mountains, and flows, meandering

to an extent, toward the north, and runs along the western boundary of the Project Area. The downstream of this river is called the Laoag river. The Laoag river empties into the South China Sea.

The reservoir area of the proposed Nueva Era dam is located in a mountainous area with an elevation of 200 to 300 m. The left mountainside slope is about 45° whereas the left slope is about 30°. The river bed width is about 100 m. The cord-height rate of the valley at the elevation of 152 m is 6.1 (190/31) upon the proposed dam axis. Therefore, the valley has an adverse trapezoid shape with a wide base.

The dam site and its surrounding area are mainly underlain by agglomerate interlayered by shale and sandstone. The agglomerate is continuously observed on road-cut explosures, however, it has been weathered to an extent, and has an onion structure. The red weathering crust of matrixes is on the way. On the other hand, fresh rock is continuously observed on the river bed. This fresh rock is massive, and favorable for dam construction.

Two dam axis were set up in performing the geological survey in Nueva Era dam site as shown in Figure 3B-34, Appendix 3B-3. As a result of the survey, it has been found out that thick terrace deposits with 14 to 18 m thick lie on both abutments upon the proposed downstream dam axis whereas fresh rocks exist on the left abutment portion upon the proposed upstream dam axis though thick terrace deposit with 18 m thick covers the right abutment. Under the circumstances, the upstream dam axis has been selected for Nueva Era dam.

The geological study so far performed consists of the seismic prospecting, core-boring and rock material test. Such geological study has revealed that this dam site is underlain by agglomerate, and that river deposit with about 15 m thick and terrace deposit with about 18 m thick are distributed on the river bed portion and

the right abutment, respectively, as shown in Figure 3B-42, Appendix 3B-4. A weathered layer with 5 to 10 m thick is distributed only on the both abutment portions; no weathered layer exists on the river bed portion. The terrace deposit distributed on the right abutment portion is mainly composed of a sand layer, and is relatively weak.

Results of the rock test of agglomerate sampled from the base are shown in Table 3B-25, Appendix 3B-4. The rock test has revealed that this agglomerate falls in the category of hard rock. The seismic prospecting shows that the proposed dam site has the following four velocity layers.

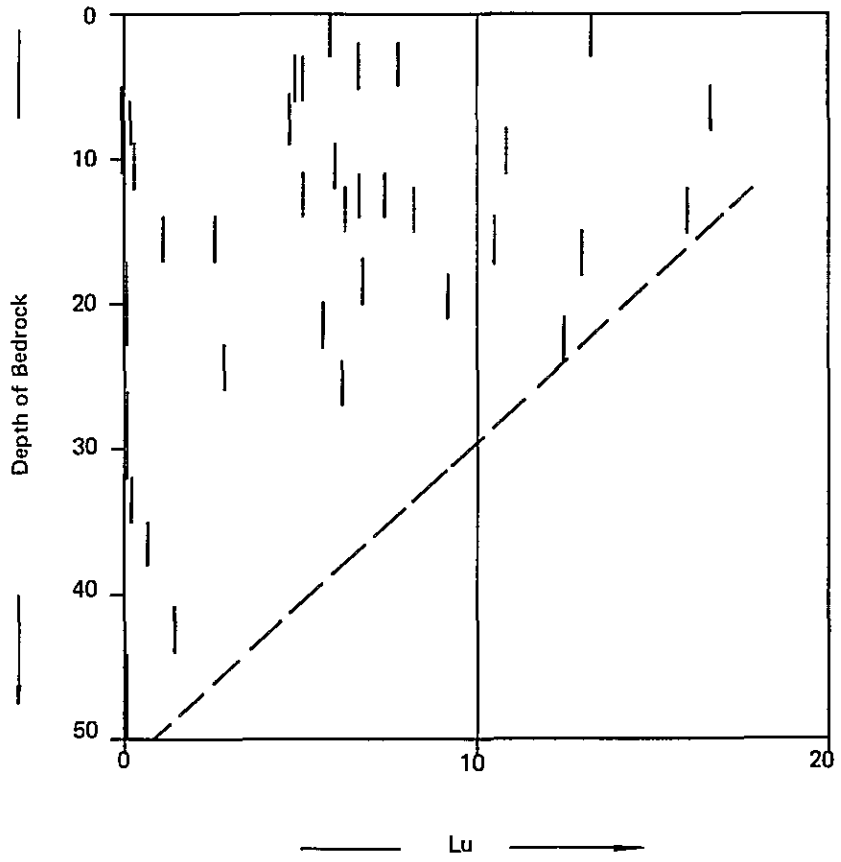
Velocity Layer	Velocity (km/sec)	Geological Condition
No.1 layer	0.4 to 0.5	Surface soils, terrace and river deposits
No.2 layer	1.0 to 1.5	Terrace deposits and weathered zone (strong to medium weathering)
No.3 layer	2.0 to 3.0	River deposits and fresh rocks
No.4 layer	4.0 to 4.4	Fresh rocks
Low velocity layer	2.0	Its presence was not recognized during seismic prospecting

The permeability test results show that the base of this dam site has, as a whole, the following regulality;

- The deeper is the base, the smaller is its permeability.
- The base from its top to the depth of about 30 m has a coefficient of water permeability ranging in 5×10^{-5} to 8×10^{-5} cm/sec.
- The base deeper than about 30 m is almost impermeable.

The relation between a value of Lugion and a depth of the base is shown below;

VALUE OF LUGION WITH DEPTH



b) Foundation Treatment

A gravity-type concrete dam with a height of about 45 m has been planned at this dam site. The presence of crushed zones which might adversely affect in constructing a concrete dam, has not been recognized in the geological study so far conducted. The base has a seismic velocity of 2.5 to 4.0 km/sec and an unconfined compression strength of 250 km/sq.m on an average. Under the circumstances, the base has a sufficient bearing capacity for construction of the above-mentioned dam.

As for foundation treatment, the river deposits and terrace deposits distributed on the right abutment portion should be, as a

matter of course, removed. Out of the weathered rocks, a part of the medium weathered rocks has already been decomposing, and has an insufficient bearing capacity. It should be, therefore, also removed. Weakly weathered rocks have many cracks at their surface. In spite of their sufficient bearing capacity as the bed rock of a dam, those should be removed for the purpose of safety of the proposed dam. Their depth is not so deep.

4) Madupayas Diversion Dam Site

NIA drilled three core-holes with the total depth of 68.1 m, and it has been verified that Madupayas dam site is underlain by agglomerate composed of developed quarts and calcite. Since the river deposit with 7 to 13 m deep is widely distributed, the foundation of this head works will be unavoidably located in the river deposit. The river deposit mainly consists of gravel of agglomerate and diorite, and pebbles of basalt are rarely observed. No soft layers are distributed of which bearing capacity is not sufficient in constructing the proposed head works.

5) Tibangran Diversion Dam Site

NIA drilled three core-holes with the total depth of 101.0 m. As a result, it has been found out that the base of this dam site is composed of agglomerate as same as that of Madupayas dam site, however, many cracks are observed at the surface of this agglomerate. The river deposit is very thick with the maximum depth of 42.0 m. Therefore, the foundation of this dam will be located in the river deposit as same as that of Madupayas head works. The upper portion of the river deposit is mainly composed of the alternation of sand with gravel and silt whereas the lower portion is mostly composed of gravel of agglomerate, diorite and basalt. Chert is rarely observed.

There is no weak layer at Tibangran dam site of which bearing capacity is insufficient in construction of the proposed dam. However, the upper layers contain much silt and sand. Careful attention should be, therefore, paid to the occurrence of piping and erosion.

Figure 3B-44, Appendix 3B-4 shows the geological profile of the two proposed diversion dam sites.

FIGURE 3B-35 GEOLOGICAL MAP AT PALSIGUAN DAMSITE

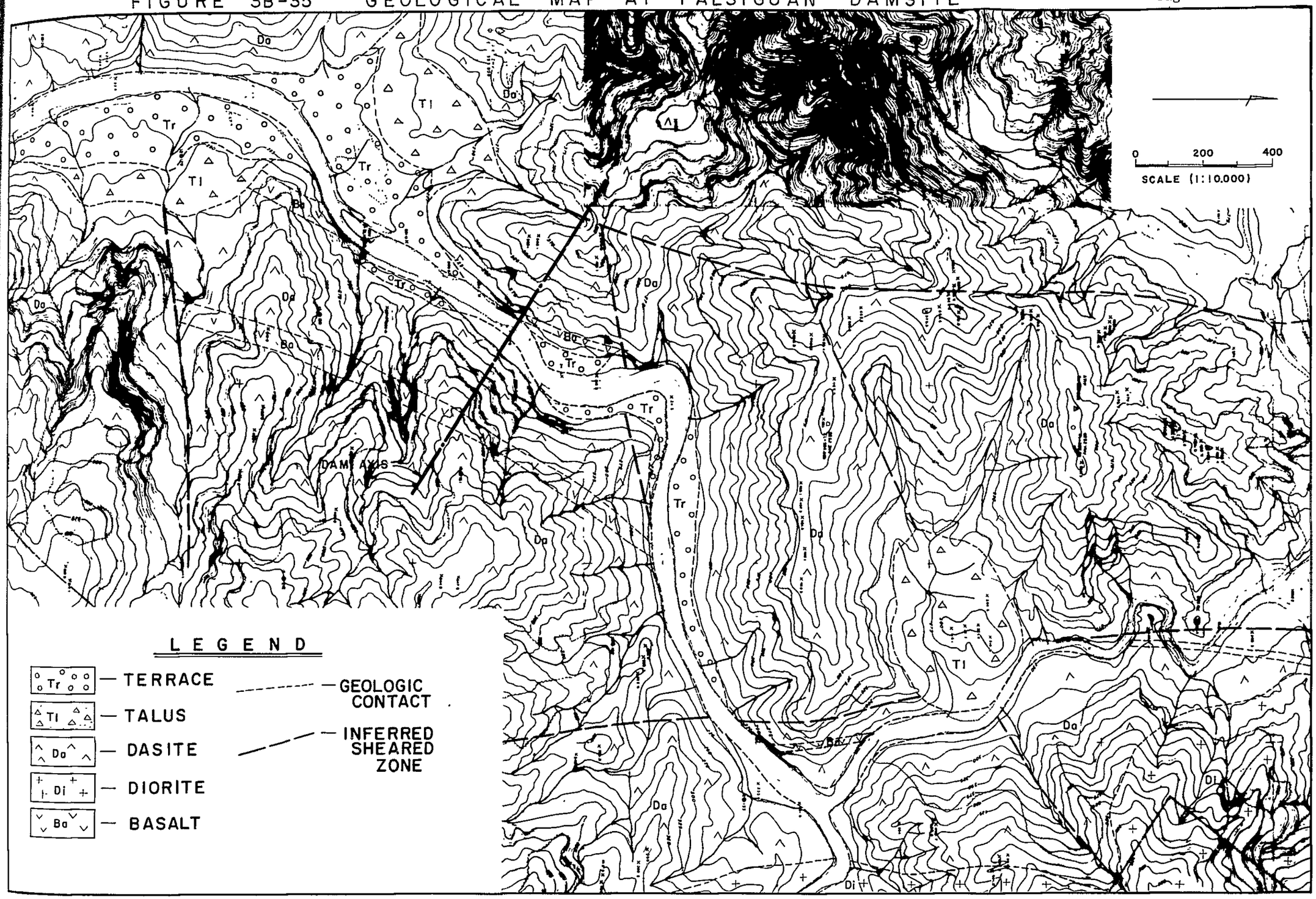
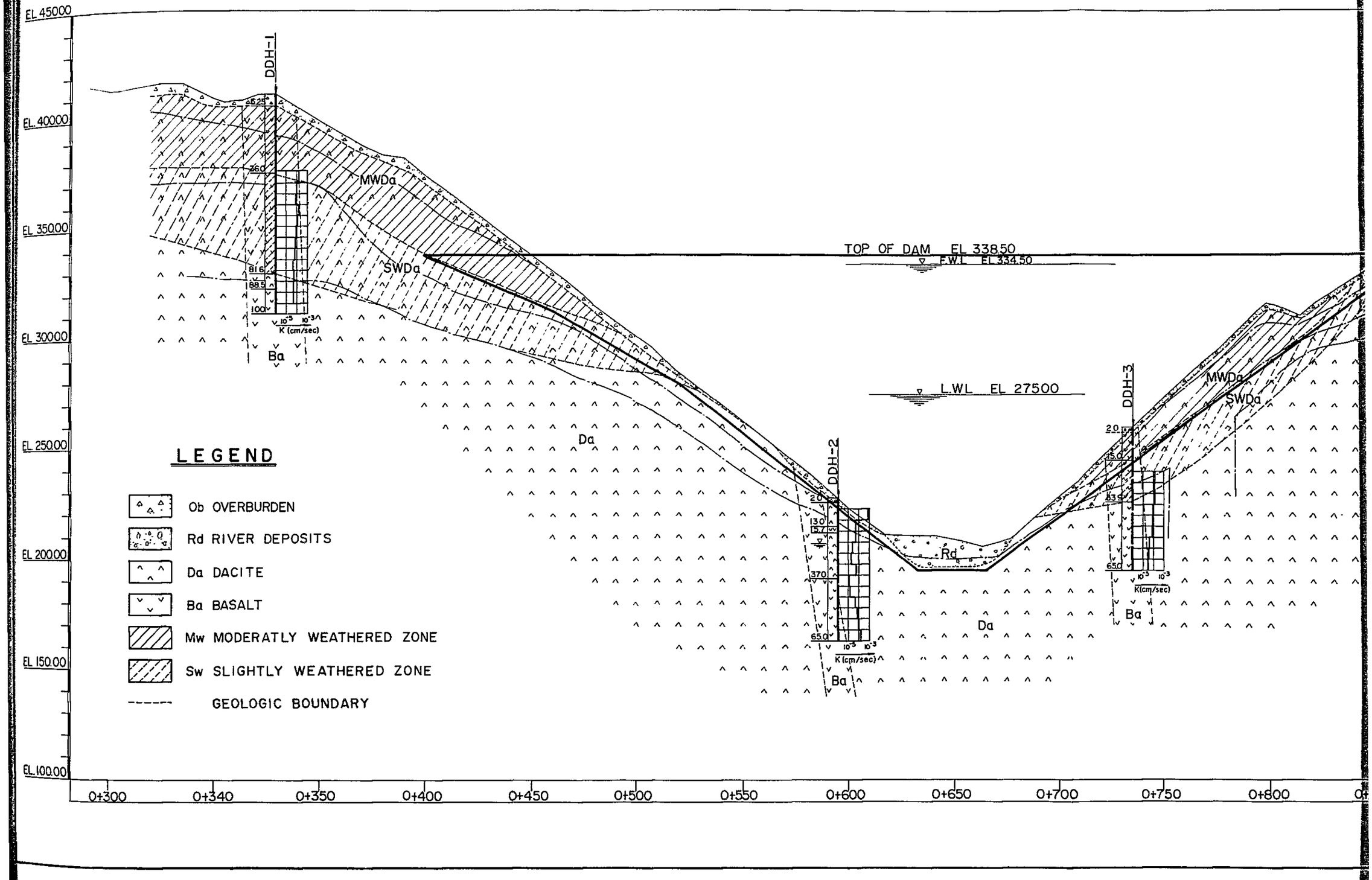
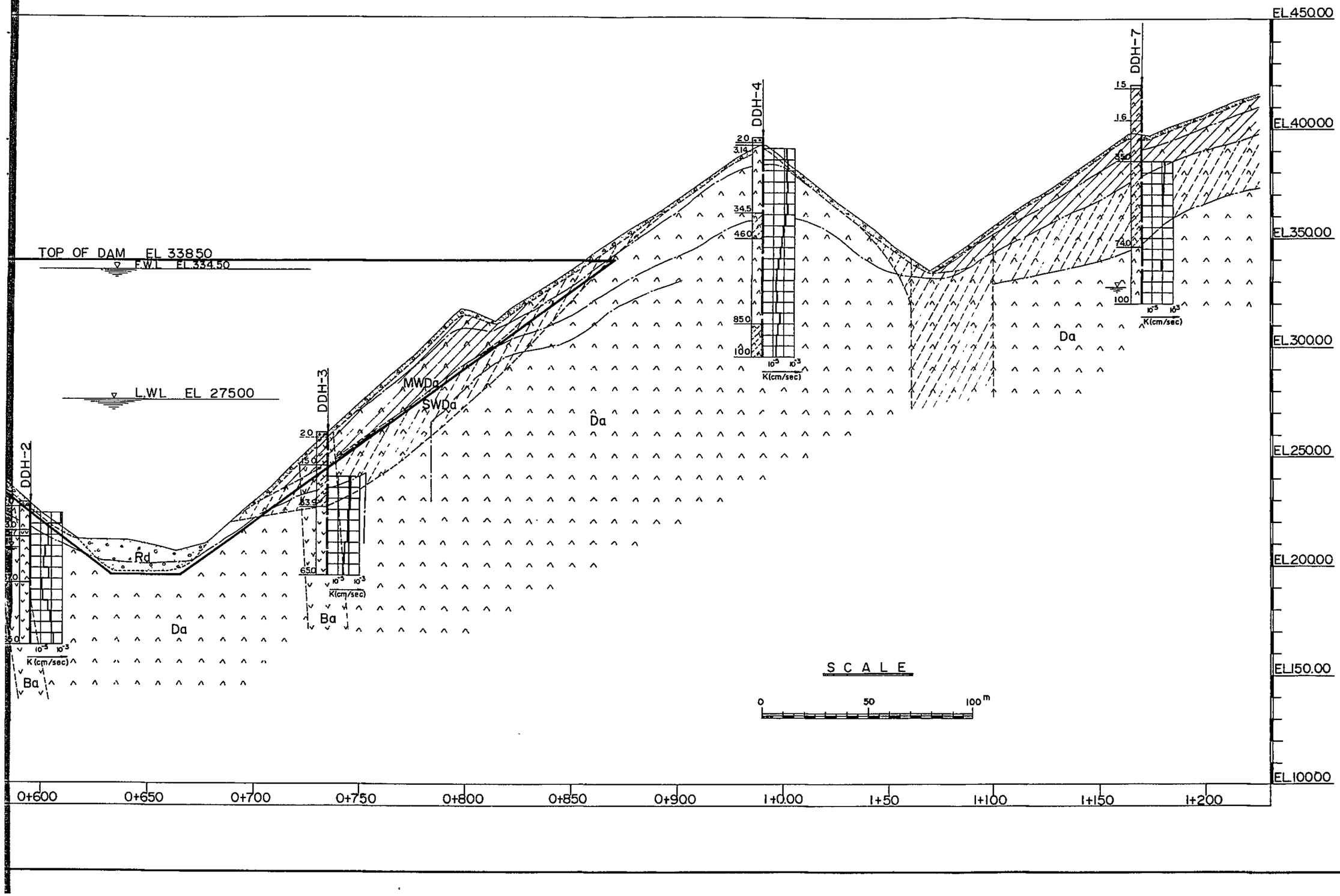


FIGURE 3B-36 GEOLOGICAL PROFILE OF PROPOSED PALSIGUAN DAM



SIGUAN DAM


EL.45000
EL.40000
EL.35000
EL.30000
EL.25000
EL.20000
EL.15000
EL.10000
TOP OF DAM EL 33850
F.W.L EL.334.50
L.W.L EL 27500
DDH-2
DDH-3
DDH-4
DDH-7
MWDa
SWDa
Da
Rd
Ba
K(cm/sec)
SCALE
0
50
100 m
0+600
0+650
0+700
0+750
0+800
0+850
0+900
1+0.00
1+50
1+100
1+150
1+200

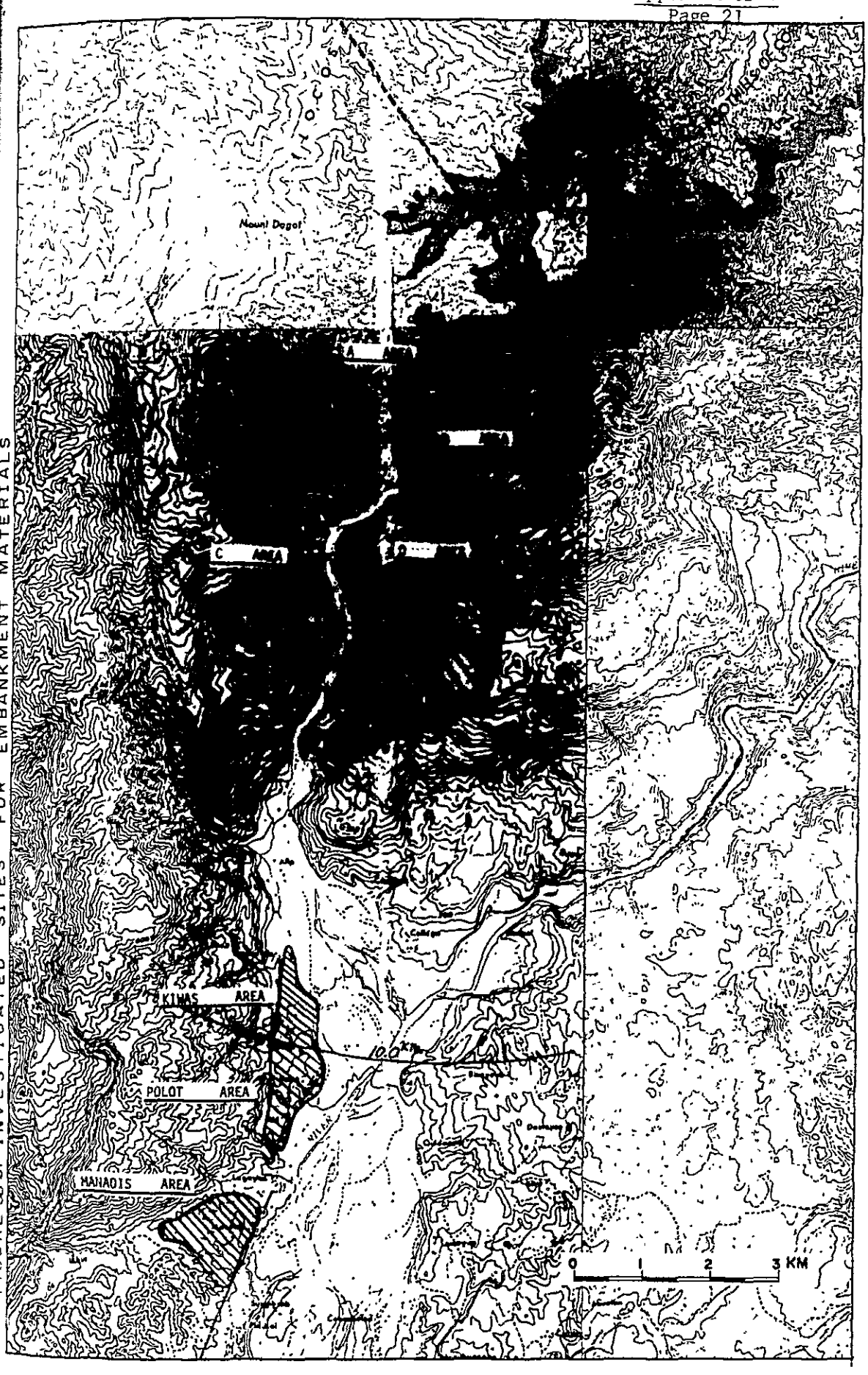


FIGURE 3B-37 INVESTIGATED SITES FOR EMBANKMENT MATERIALS

FIGURE 3B-38 GRADATION ANALYSIS CURVE (Polot)

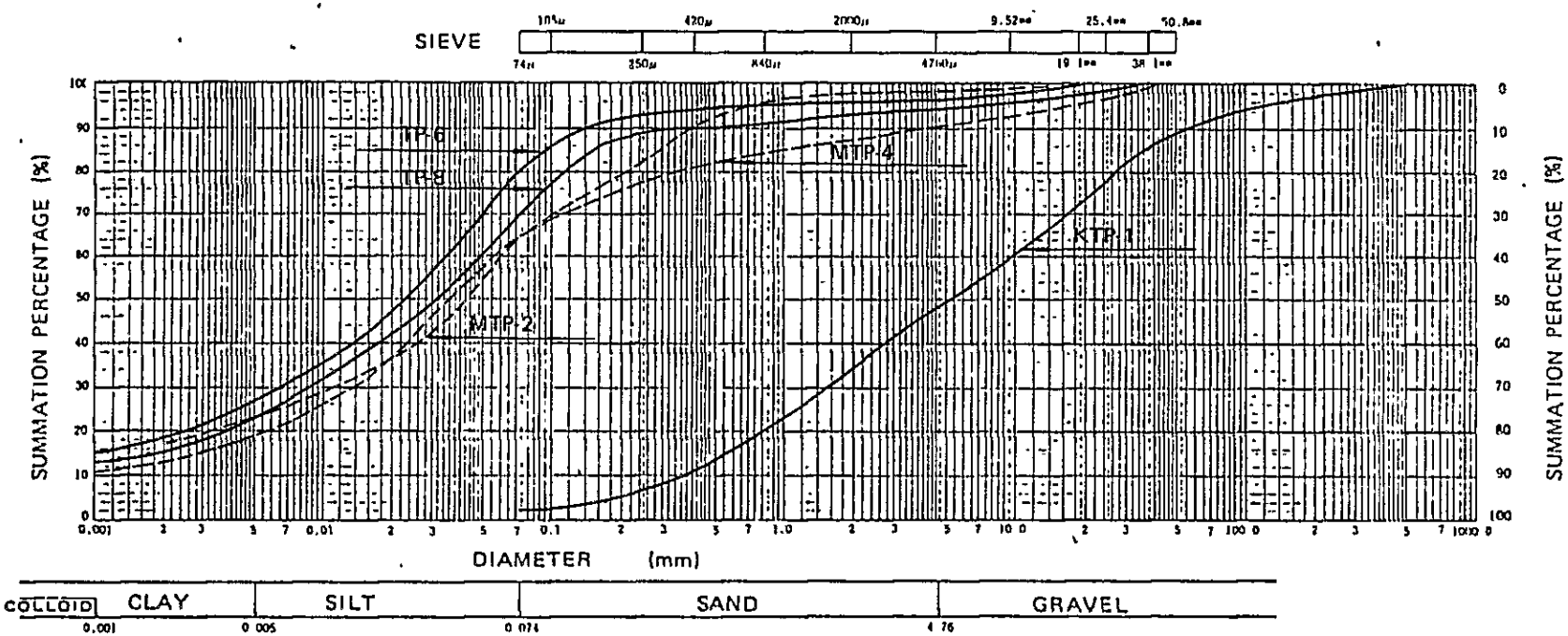


FIGURE 3B-39 RESULTS OF SOIL TESTS (Manaois)

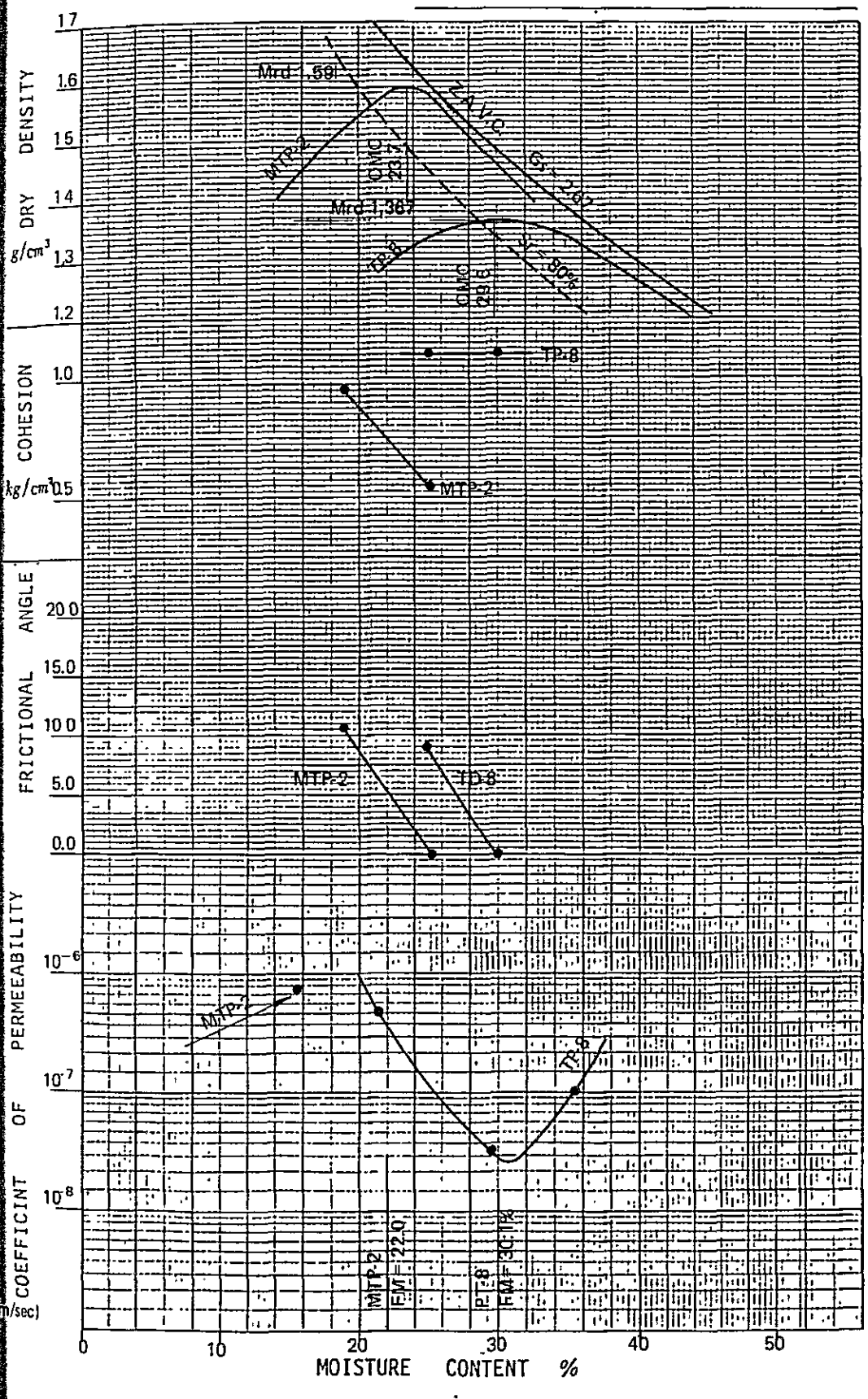


FIGURE 3B - 40 GRADATION ANALYSIS CURVE (Manaois)

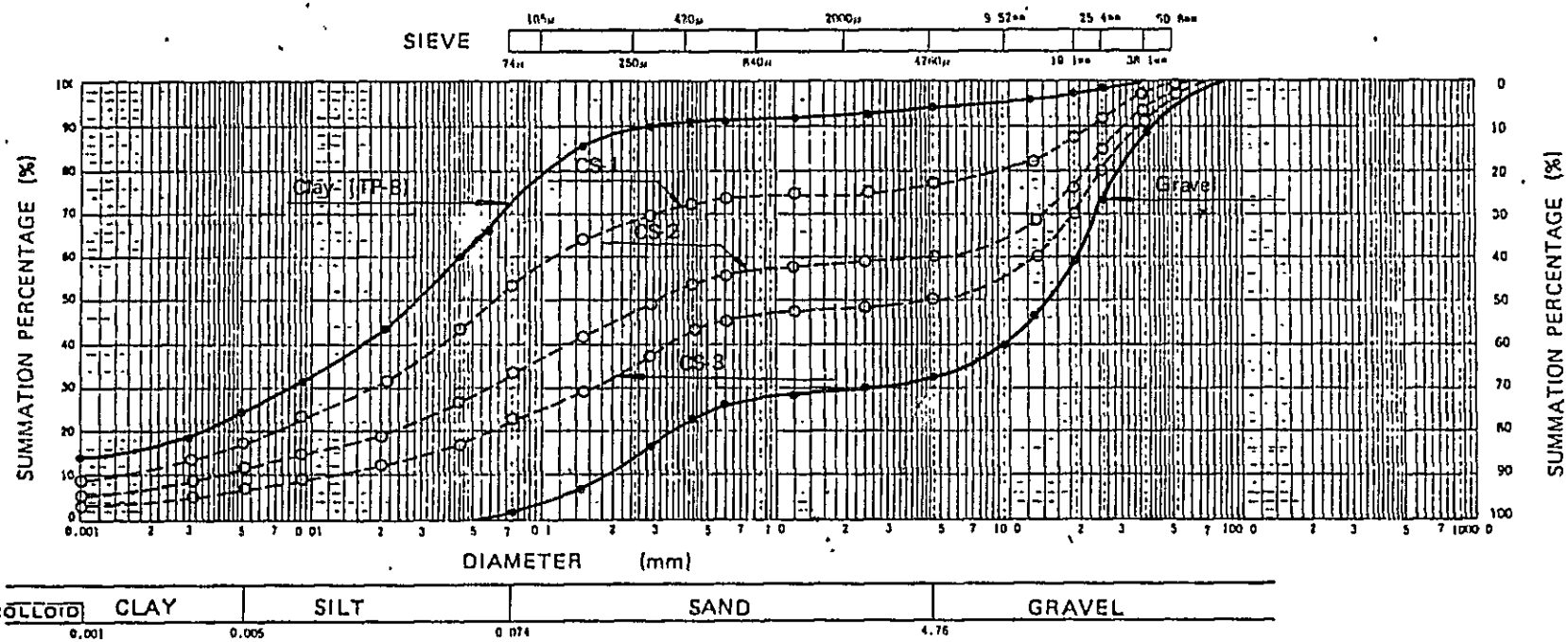


FIGURE 3B-41 RESULTS OF SOIL TESTS (Manaois)

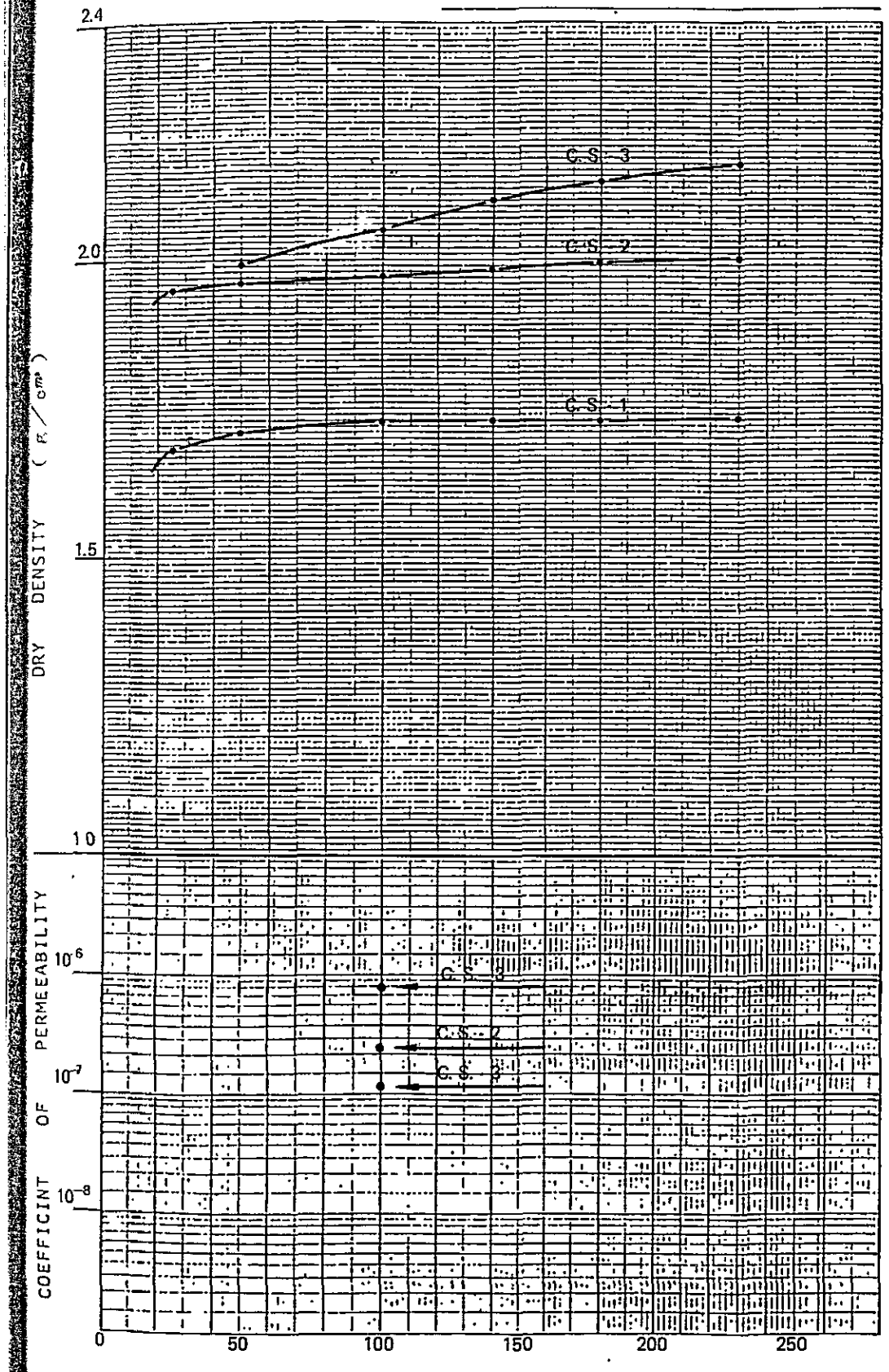
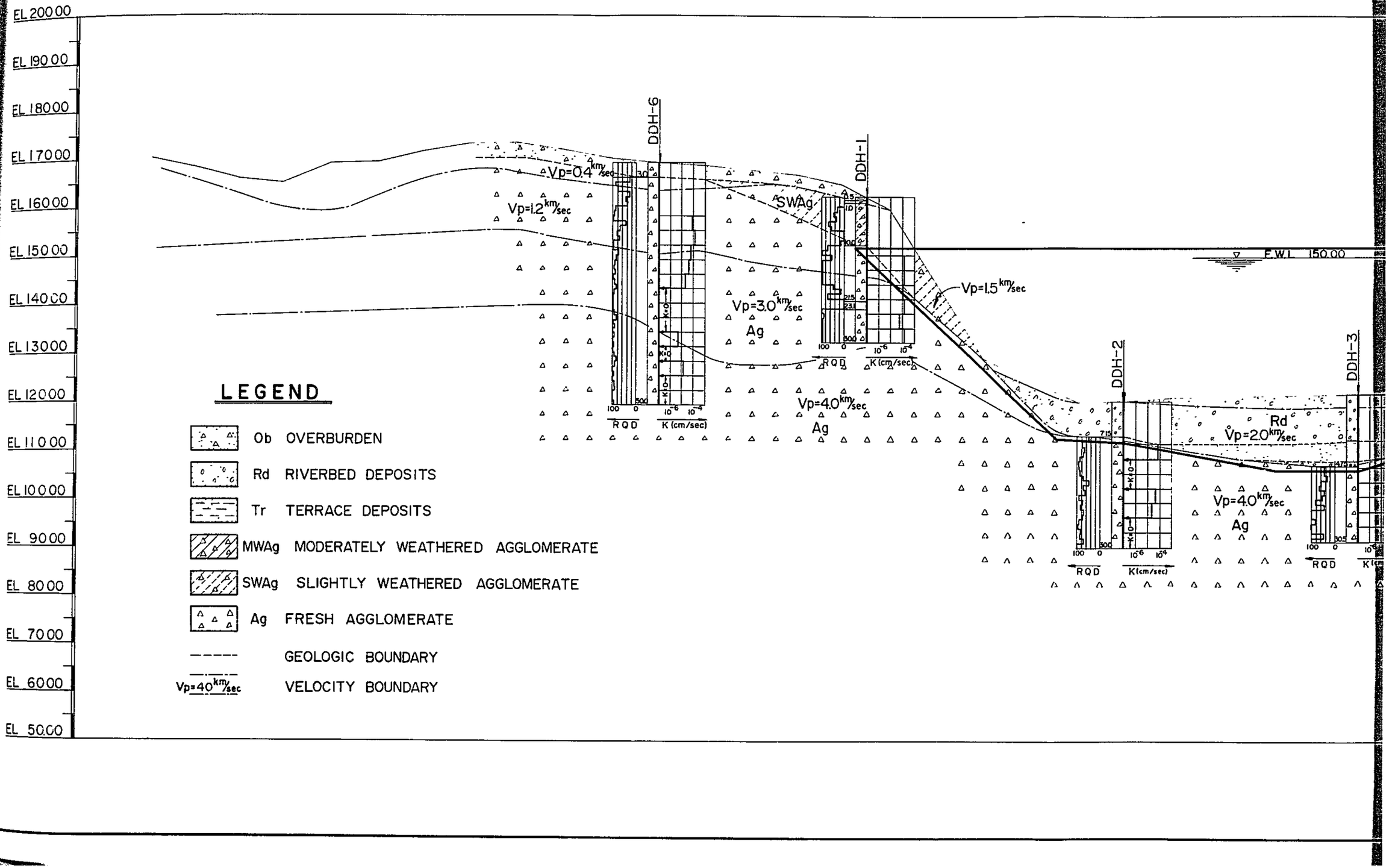


FIGURE 3B-42 GEOLOGICAL PROFILE OF PROPOSED NUEVA ERA DAM



UEVA ERA DAM

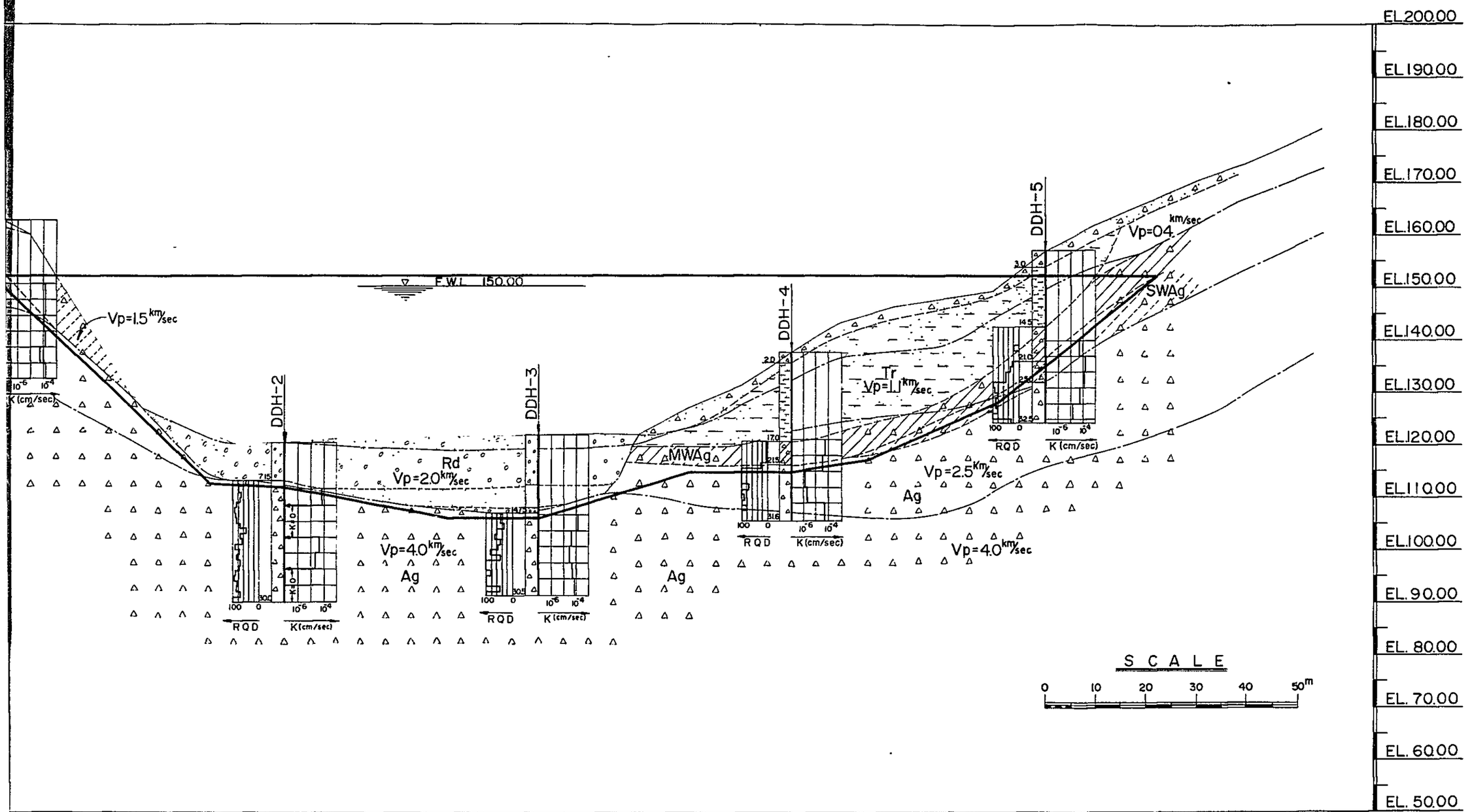
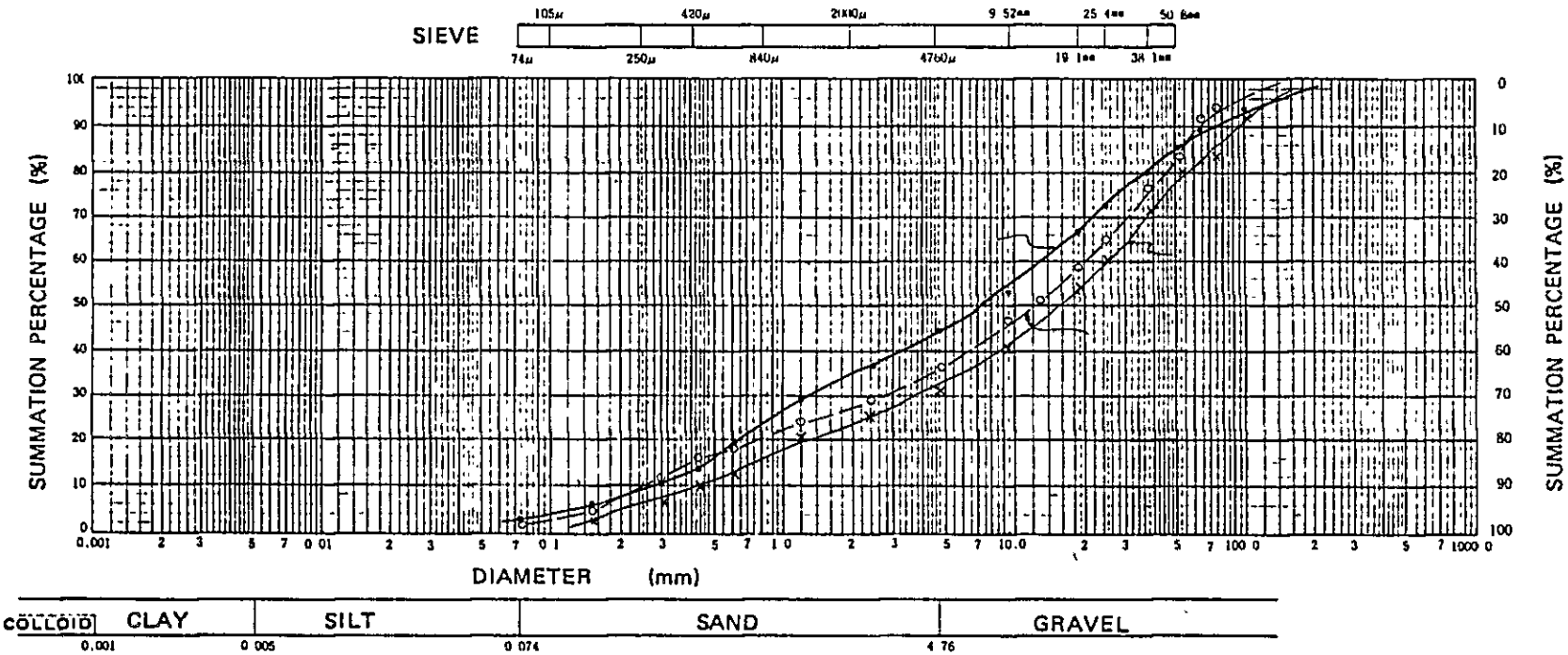

EL.200.00
EL.190.00
EL.180.00
EL.170.00
EL.160.00
EL.150.00
EL.140.00
EL.130.00
EL.120.00
EL.110.00
EL.100.00
EL. 90.00
EL. 80.00
EL. 70.00
EL. 60.00
EL. 50.00
F.W.L 150.00
Vp=1.5 km/sec
K (cm/sec)
DDH-2
DDH-3
DDH-4
DDH-5
Rd
Vp=2.0 km/sec
Vp=4.0 km/sec
Ag
MWAg
SWAg
Tr
Vp=1.1 km/sec
Vp=2.5 km/sec
Vp=04 km/sec
RQD
K (cm/sec)
SCALE
0 10 20 30 40 50 m

Table 3B-25 Rock Test Results (Nueva Era Dam)

Sample No.	Bore - Hole No.	Bore - Hole Depth (m)	Compressive Strength (kg/cm^2)	Specific Gravity	Absorption (%)
No. 1	DDH-1	10.37 - 10.87	251.9	2.94	4.0
No. 2	DDH-2	7.68 - 7.91	292.2	2.74	5.7
No. 3	DDH-3	15.50 - 16.13	272.9	2.72	3.6
No. 4	DDH-4	21.60 - 21.93	206.9	2.79	8.2
No. 5	DDH-5	21.60 - 21.80	227.1	3.03	8.4
No. 6	DDH-6	3.17 - 4.50	256.2	2.79	5.1
Average			251.2	2.84	5.8

FIGURE 3B–42–1 GRADATION ANALYSIS CURVE (Bonga River)



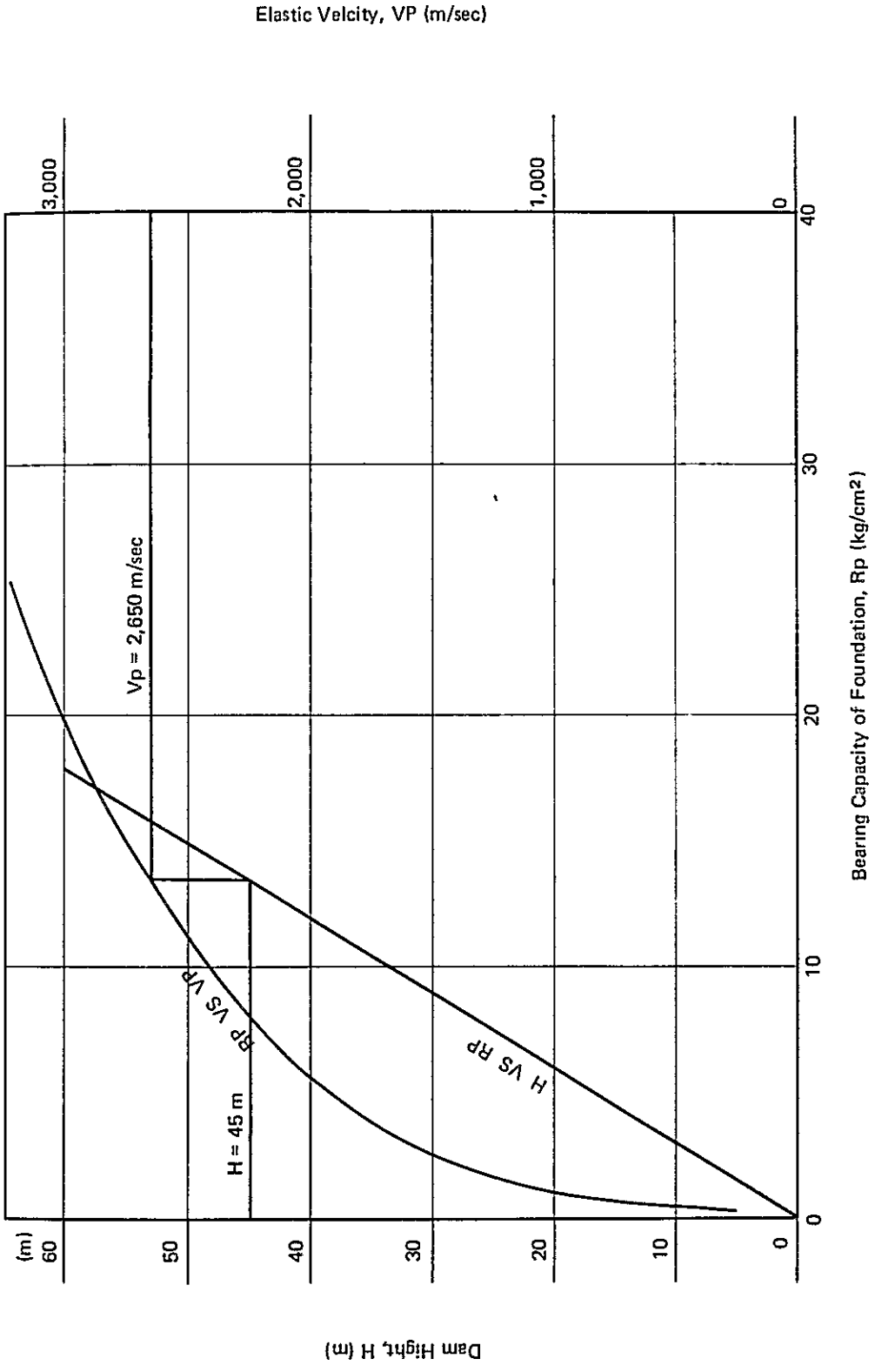
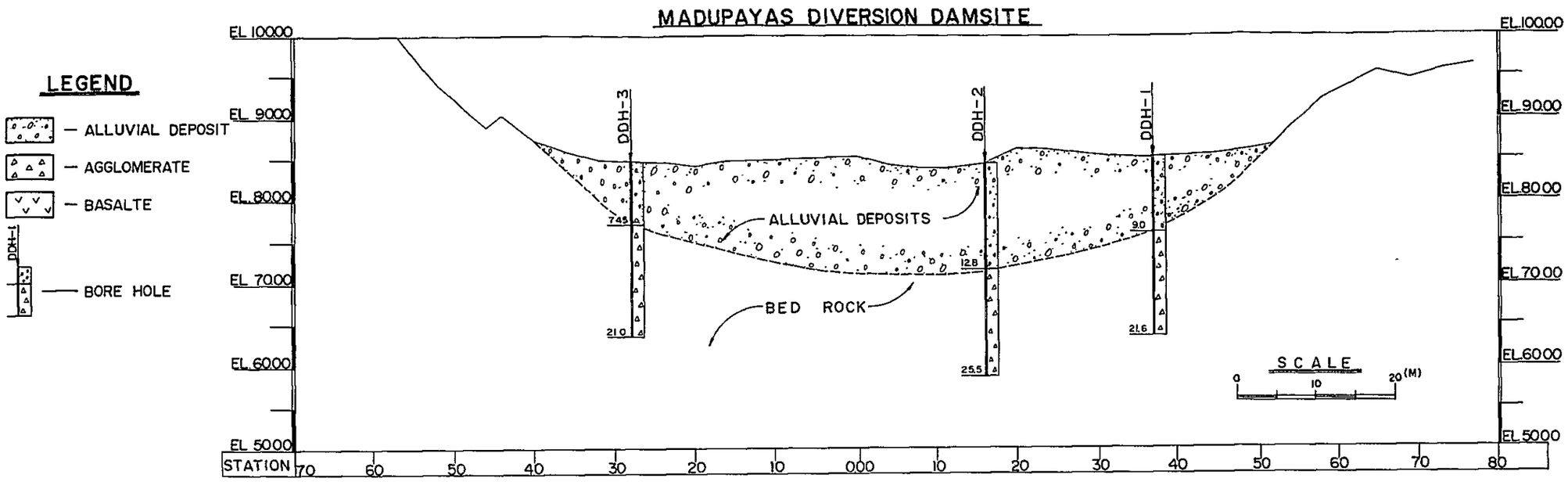
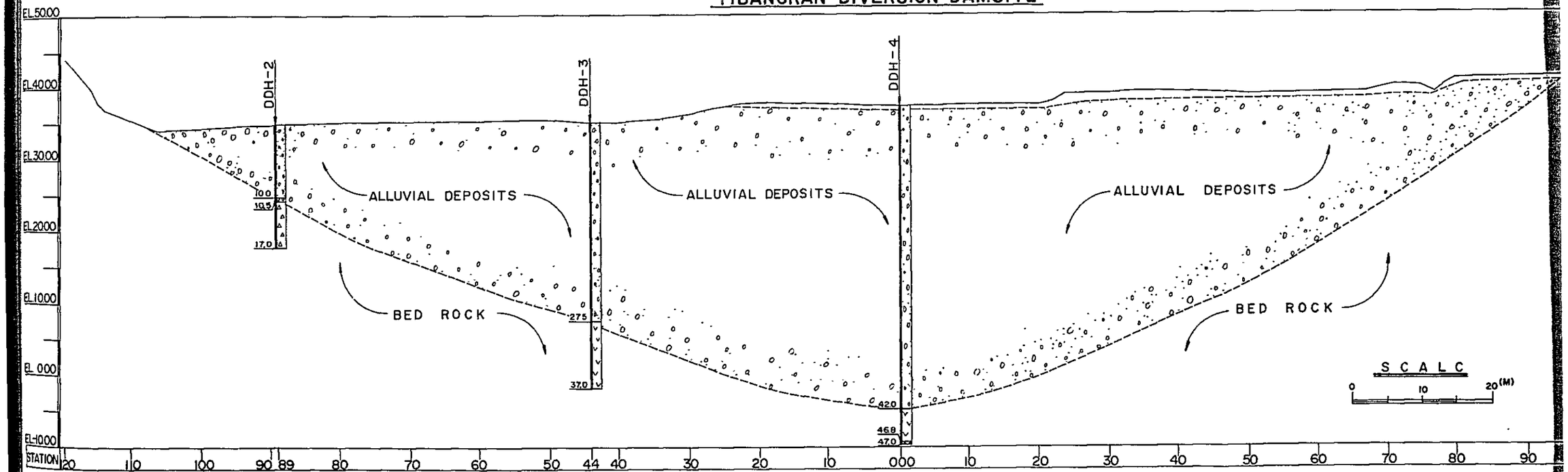


FIGURE 3B - 43 RELATION OF DAM HIGHT, ELASTIC VELOCITY AND BEARING CAPACITY

FIGURE 3B-44 GEOLOGICAL PROFILE OF PROPOSED DIVERSION DAMSITES





RE 3B-44 GEOLOGICAL PROFILE OF PROPOSED DIVERSION DAMSITES

ND

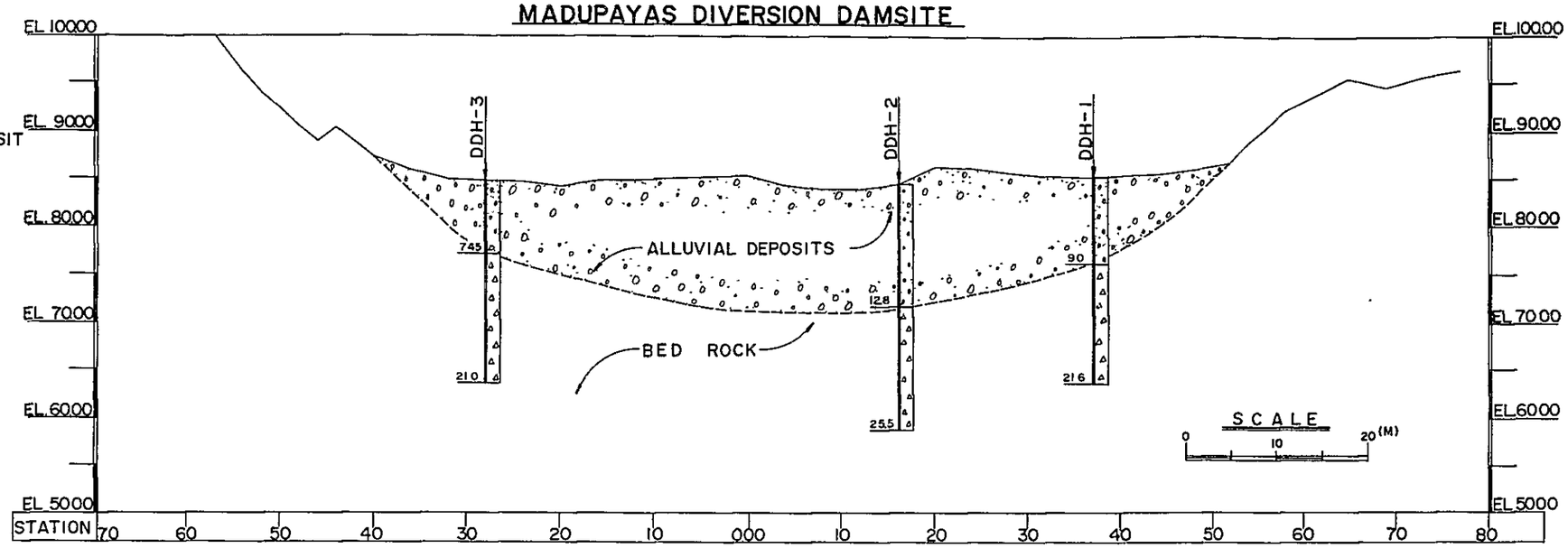
LUVIAL DEPOSIT

GLOMERATE

SALTE

RE HOLE

MADUPAYAS DIVERSION DAMSITE



TIBANGRAN DIVERSION DAMSITE

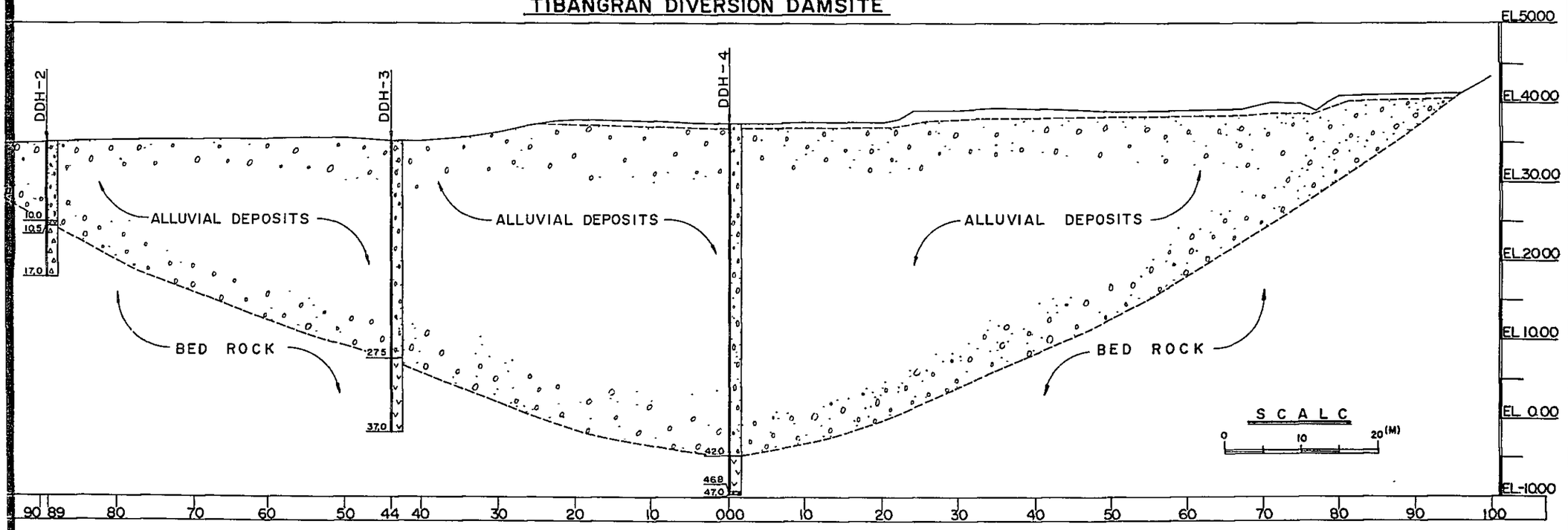
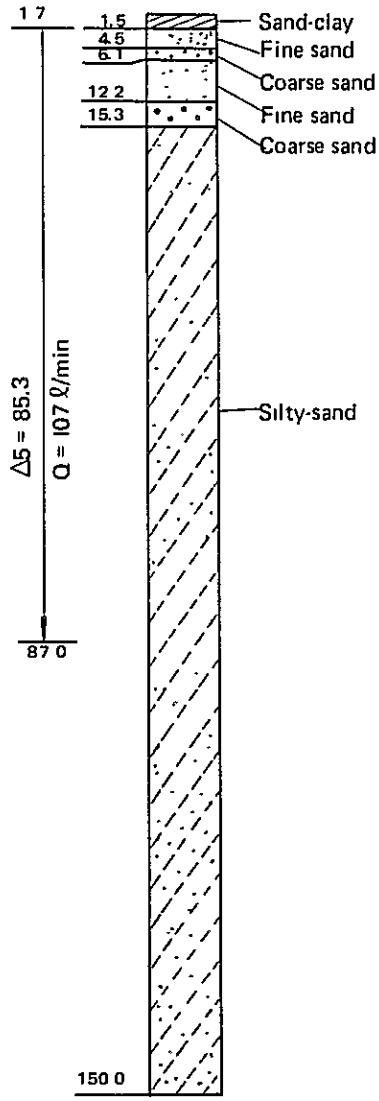


FIGURE 3B - 45 GEOLOGICAL COLUMN OF C-79, PAOAY



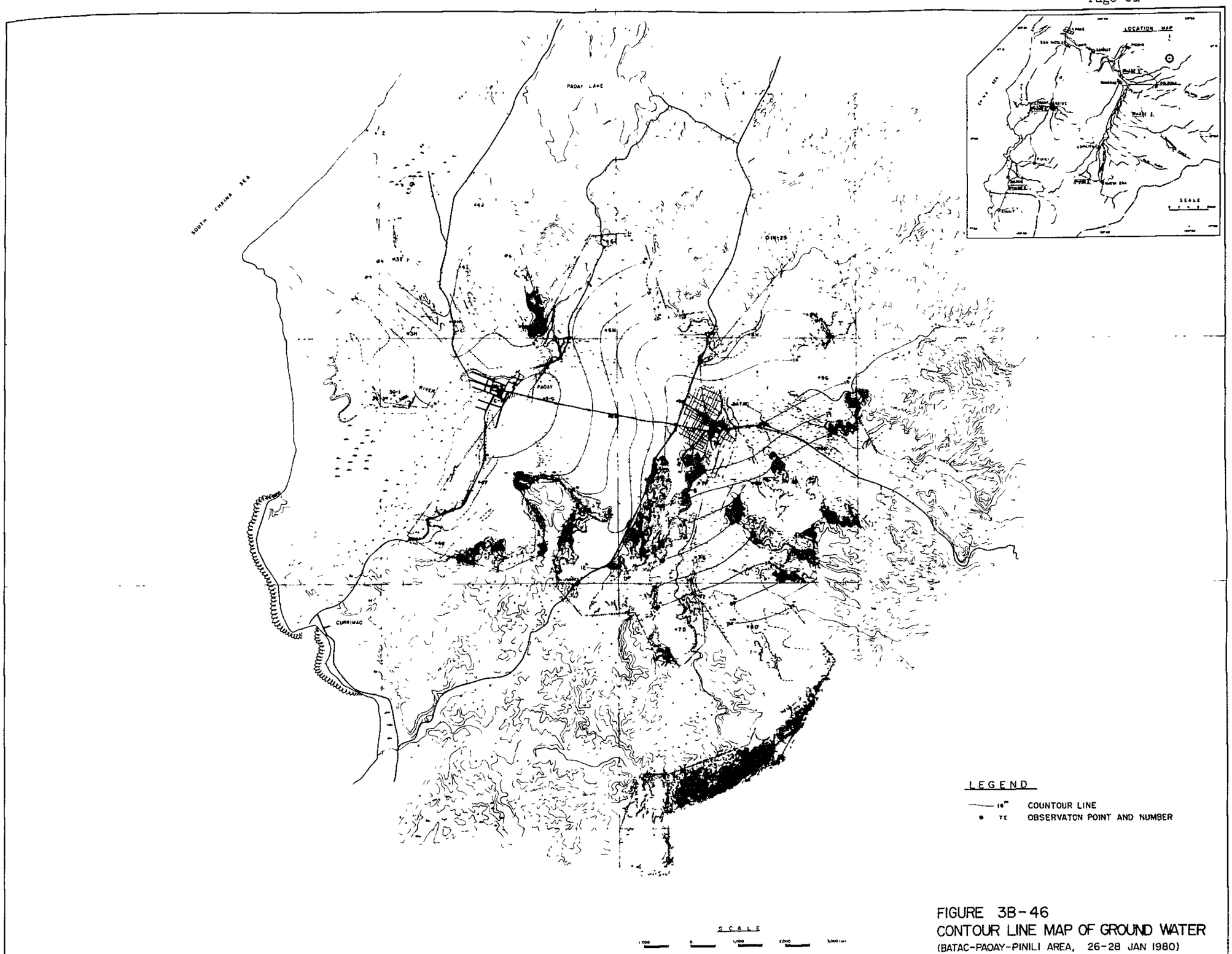


FIGURE 3B-46
CONTOUR LINE MAP OF GROUND WATER
(BATAC-PAOAY-PINILI AREA, 26-28 JAN 1980)

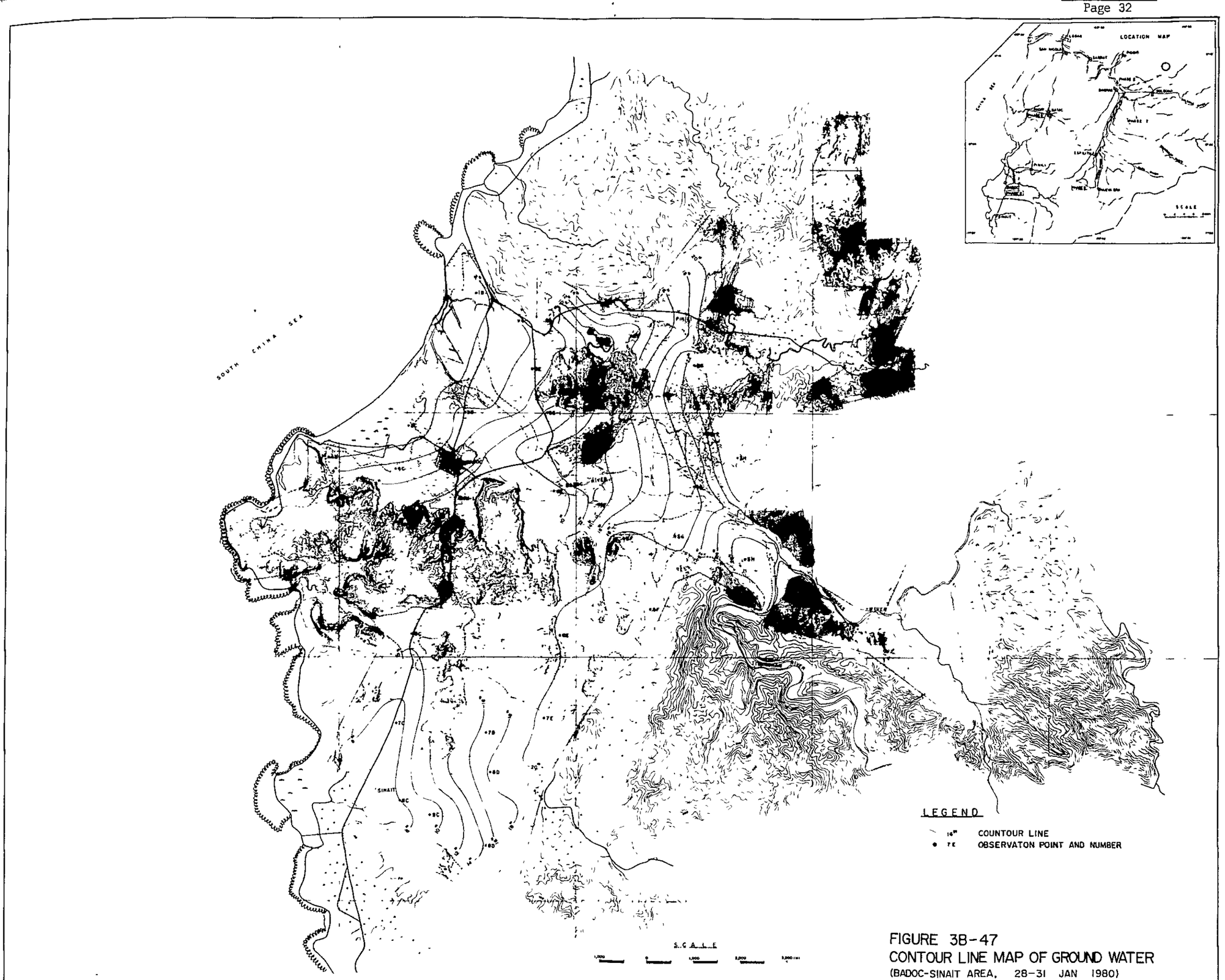
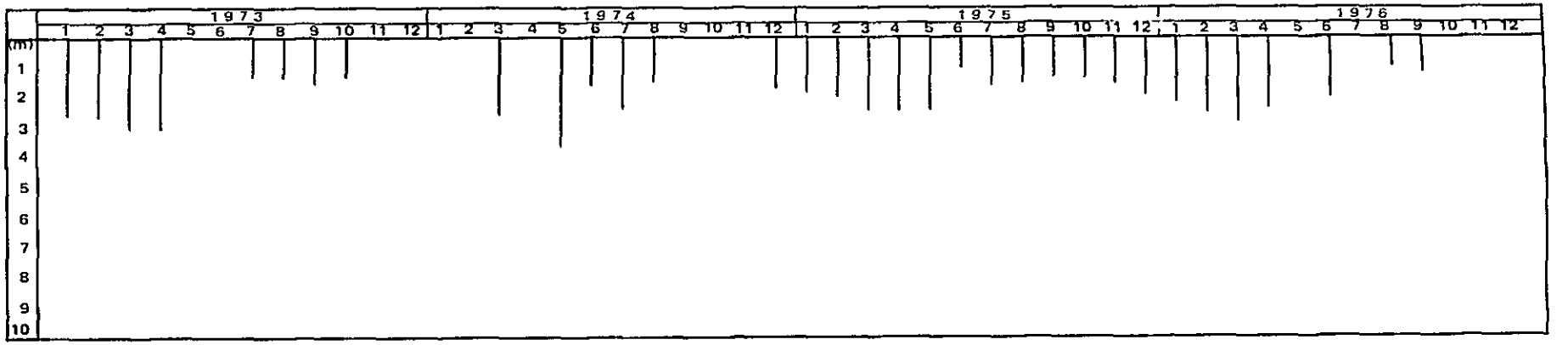


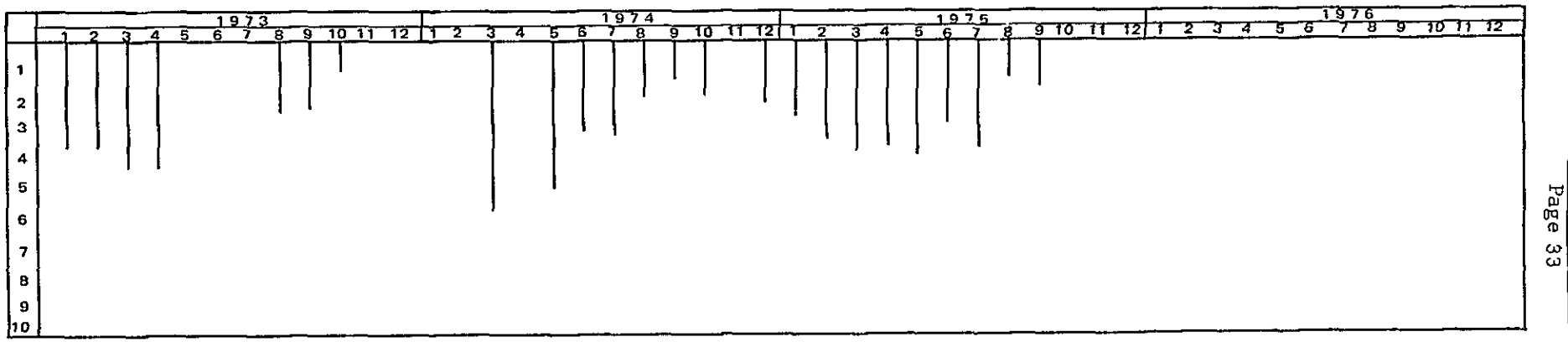
FIGURE 3B-47
CONTOUR LINE MAP OF GROUND WATER
(BADOC-SINAIT AREA, 28-31 JAN 1980)

FIGURE 3B - 4B OBSERVATION OF GROUNDWATER TABLE

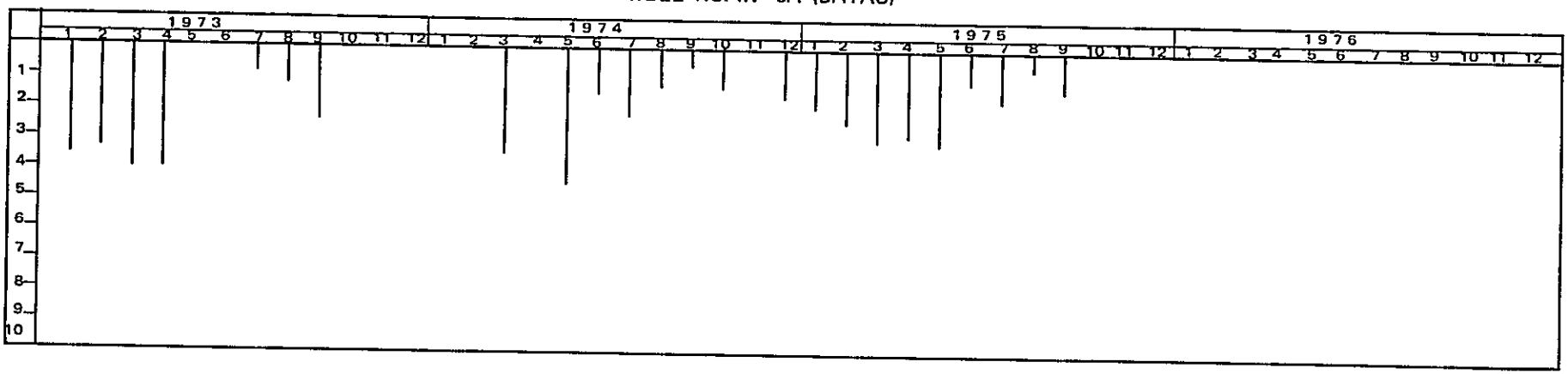
WELL NO. IN - 5 (PAOAY)



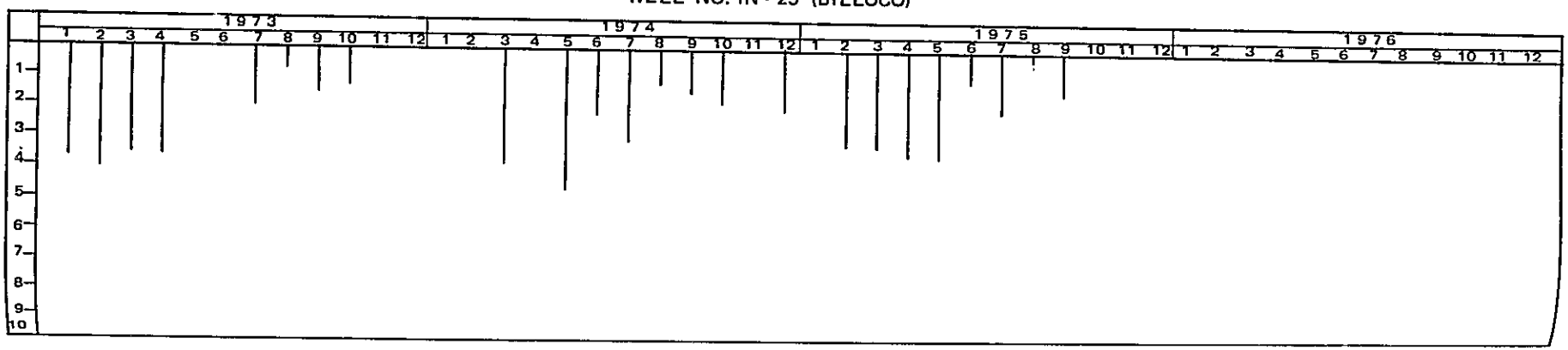
WELL NO. IN - 6 (BATAC)

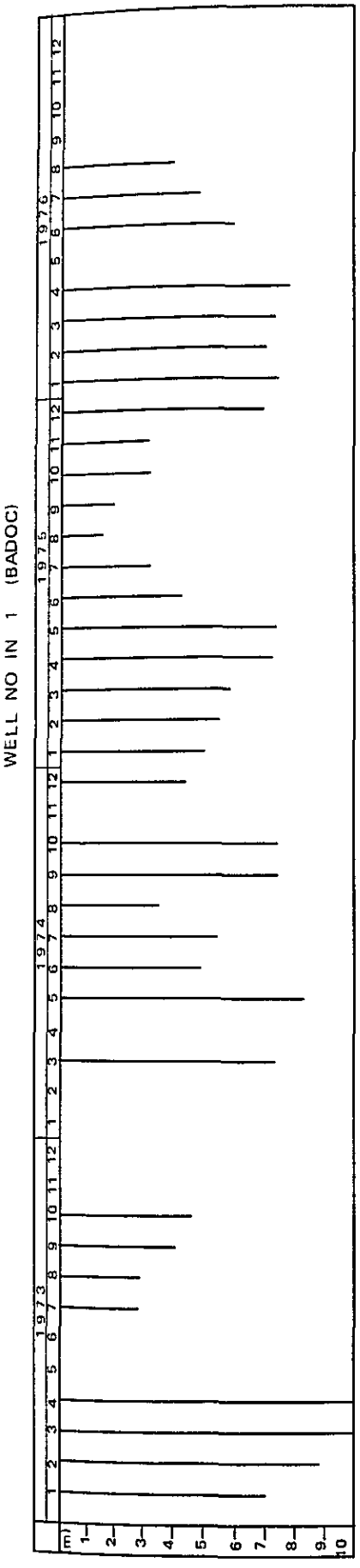


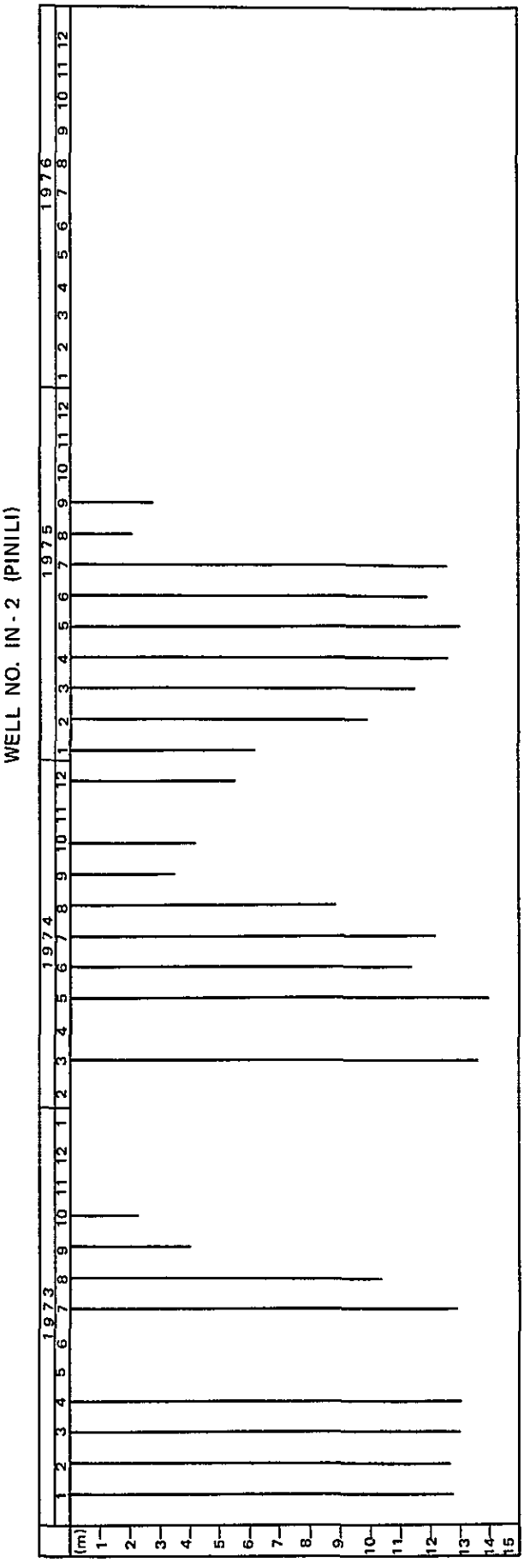
WELL NO. IN - 6A (BATAC)



WELL NO. IN - 25 (BILLOCO)




WELL NO IN 1 (BADOC)
1973
1974
1975
1976
(m)


WELL NO. IN-2 (PINILI)
1973
1974
1975
1976
(m)

Soil and Land Classification

A. Introduction

B. The Project Area

C. Geology and Parent Material

D. Topography

E. Present Land Use

1. Introduction
2. Cultivated Area
   a) Paddy Field
   b) Upland Field
3. Un-cultivated Area

F. Soil Classification and Description

1. Introduction
2. Identified Soil Series
3. Soils of Alluvial Plane
   a) San Manuel Series
   b) Maligaya Series
   c) San Fernando Series
   d) Bantog Series
4. Soils of Upland
   a) Cervantes Series
   b) Bantay Series
5. Soils of the Dune Land
6. Soils of the Riverwash

G. Physical and Chemical Properties

H. Land Classification for Irrigated Paddy Field

1. Objective of the Study
2. Land Class Symbols
3. Description of Land Classes

a) Diversified Crop Land

b) Rice Land

c) Dual Class Land

d) Class 6 Land

e) M Land

f) Rights-of-Way (ROW)

1. Summary of Conclusions and Recommendations

Soil and Land Classification

A. Introduction

The soil and land classification surveys have been carried out to classify the following items:

i) To review the report on the soil survey which is conducted in the Project Area by NIA.

ii) To re-examine the present soil condition

iii) To collect the necessary data for the feasibility study

iv) To identify the land class based on the soil, topography, drainage and other physical factors.

As to the field survey, topographic map with the scale of 1:10,000 and 1:4,000, and soil map with the scale of 1:50,000 prepared by NIA were used as the base map. And also the soil survey and land classification reports on Ilocos Norte Area Development Project (NIA, 1976) and Palsiguan River Multi-purpose Project (NIA, 1978) were collected for the study.

During the field survey, land use survey, topographic survey, stick boring test and test pit survey were conducted, and necessary data and informations were collected.

B. The Project Area

The Project Area is located in Ilocos Norte and Ilocos Sur Provinces north-western part of Luzon Island. The west part of the Project Area faces on the South China Sea and east part is bordered by the Cordillera Central Mountain and Ilocos Mountain Range, respectively.

The Project Area is divided into the following sub-areas, such as Cura, Nueva Era (left bank), Maduphyas, Batac-Paoay, Pinili and Badoc-Sinait Area.

Cura Area is located in the right bank area of the Cura river, the main tributary of the Bonga river which runs in the province of Ilocos Norte. The Cura river makes a remarkable riverwash zone.

Nueva Era (left bank) Area is situated on the high land in the left bank area of the Bonga river. Its relief is undulating and rolling.

Madupayas Area is located in the basin of upstream of the Badoc river. The Madupayas river, the tributary of the Badoc river runs through this sub-project area.

Batac-Paoay Area is an alluvial plain which faces on the South China Sea. The hill and dune land bound the surrounding border of this sub-project area.

Pinili Area is situated in the right bank area of the Badoc river. Its topography consists of an alluvial plain, hill and small dune land.

Badoc-Sinait Area is an alluvial plain and hill which faces on the South China Sea. The riverwash is developed along the Badoc river. Dune land is developed in the coast of downstream of the Badoc river.

Climate is characteized into two extremes; very dry from November to April and very wet during the rest of the year. The annual average rainfall is 2,016 mm in Laoag and 2,474 mm in Bonga, which indicates that more rainfall are in mountain area and less in plain area. According to the observation in Laoag and Bonga, about 95 percent of annual rainfall is observed in the wet season. Typhoon usually occurs during the month of June to September. The annual average temperature is 27.0 °C in Laoag and average humidity is 76 percent in Laoag.

C. Geology and Parent Material

The geology of the mountains and hills surrounded the Project Area is composed of the sedimentary and intrusive rocks. Their geological age is minly Middle Miocene to Pliocene. The kind of rocks is diorite, gabbro, andesite, basalt, agllomerate, limestone, tuffecious shale, mudstone, sandstone and others. The parent materials of alluvial sediments in the Project Area are mainly derived from these formations.

The parent materials of soils in the each sub-divided areas are as follows:

Cura Area	:	fine to coarse alluvial sediments
Nueva Era Area (Left bank)	:	tuff breccia, terrace gravels and fine alluvial sediments
Madupayas Area	:	fine to coarse alluvial sediments
Batac-Paoay Area	:	fine to coarse alluvial sediments and Neogene shale and sandstone
Pinili Area	:	fine to coarse alluvial sediments and Neogene shale and sandstone
Badoc-Sinait Area	:	fine to coarse alluvial sediments and Neogene shale, sandstone and limestone

D. Topography

The Project Area is composed of a various topography. The topographic features of the Project Area are as follows:

Cura Area

The main topographic unit of the Cura Area is an alluvial plain with riverwash along the Cura and Bagbag river. Its relief is very flat and has an incline of 1:200 on an average. The topographic features and soil condition of this sub-project area are very similar to the western area of Solsona in the Phase I Area.

Naeva Era (left bank) Area

This service area consists of a hilly, undulating and rolling upland. Their hights are from 70 to 140 meters above the sea level. The geology is composed of the pyroclastics such as tuff breccia, terrace gravels and clayey alluvial deposits. Paddy fields are situated on the alluvial deposits, terraces and gentle slopes of the hill.

Madupayas Area

This sub-project area is located on the upstream of the Madupayas river. That major topographic features are an alluvial plain with riverwash. Its relief is very flat. The mountains bound the surrounding border of this survice area.

Batac-Paoay Area

This service area consists of the three main topographic units, such as, i) alluvial plain ii) dune land and iii) hill and terrace.

The alluvial plain is well developed in the vicinity of Batac and Paoay town. This alluvial plain was mainly formed by silting of alluvial sediments in the back marsh of dune land. The river and creek meanders on this alluvial plain.

Most remarkable dune land is extended in parallel with the sea shore line. This dune land is characterized by undurating to rolling topography and its highest part is 50 meters above the sea level. The greater portion of this dune land is unstabilized by sand movement. The other small dune lands are developed in the alluvial plain. Paoay town is located on this inner small dune land.

The hill and terrace are developed at the surrounding border of the Project Area. Their hights are 10 to 70 meters above the sea level.

Pinili Area

This sub-project area is situated in the right bank area of the Badoc river. Its topography consists of an alluvial plain, hill and small dune land. The relief of alluvial plain is very flat in the downstream area, but in the upstream area it is gentl undurating.

Badoc-Sinait Area

This service area is composed of the two topographic units. One of them is a hilly, undulating and rolling upland. Another one is an alluvial plain. Dune land is developed in the coast of downstream of the Badoc river. Riverwash is located along the Badoc river and its tributaries.

E. Present Land Use

1. Introduction

Out of about 21,900 hectares, gross area of the project, 12,900 hectares is used as the cultivated area and remaining 9,000 hectares comprises the un-cultivated area such as class 6 lands (rivers, riverwash, rolling and steep slopes, hilly area, dune land etc.), resedential areas and Rights-of-way (public roads and irrigation canals).

The cultivated areas are cropped with paddy rice as first crop and secondly with garlic, tobacco, corn, mungo beans, sugarcane, peanut, cotton and vegetables.

2. Cultivated Area

a) Paddy Field

The Paddy fields are mostly situated on the alluvial plain, while very limited extent of the upland paddy fields is located on the hilly area.

Out of the paddy fields of about 12,900 hectares, 4,250 hectares is irrigated with connunal irrigation system while remaining 8,580 hectares are under the rainfed condition during the wet season. Duble cropping of rice is practiced within very limited area of about 710 hectares serviced by the existing connunal irrigation systems. The remaining paddy fields are cultivated with diversified crops, or left as fallow land after harvesting the wet season rice. In Batac-Paoay, Pinili and Badoc-Sinait area, the two major diversified crops of tobacco and garlic occupy the area of about 6,220 hectares where water of wells is available through private small pumps for these crops. The other diversified crops such as corn, mungo bean, vegetables etc. are planted in relatively small area of the Project Area. The fallow land during the dry season is estimated at about 44 percent of the total paddy field in the Project Area.

The features of present land use in the paddy field of the sub-project area are as follows.

Cura Area

The paddy rice production in the wet season is a major crops of this survice area. In the dry season the paddy field of this area is mostly idle due to lack of irrigation water supply. Connunal irrigation system is irrigating about 130 hectares land in the dry season. The diversified crops such as corn, mungo bean and vegetables are planted in very limited scale.

Nueva Era (left bank) Area

This sub-project area is a hilly, undulating and rolling upland. Paddy fields are located on the broad valley bottoms and gentle slopes of the hill. Paddy rice in the wet season is a main crops of this area. The diversified crops such as tobacco, corn, mungo bean and vegetables are cultivated in very limited scale. Most paddy fields lie fallow during the dry season due to lack of irrigation water supply.

Madupayas Area

The alluvial plain of this area is mainly used for paddy rice production during the wet season. The diversified crops such as corn, vegetables and tobacco are planted in very limited scale.

Batac-Paoay Area

The alluvial plain of this area is hihgly used for both paddy rice and diversified crops during the wet and dry seasons. The soils of alluvial plain in this area are best suitable for paddy rice production in both seasons if enough irrigation water is available. But at present the clayey soils in this area are widely used for the production of diversified crops after rice was harvested in spite of difficulty to plow when dry. Especially garlic and onion are cultivated under multing by rice straw and ground water supply. The main area planted to garlic is the alluvial plain between Paoay and Batac town. On the other hand tobacco is mainly cultivated in the eastern part of Batac town. Other diversified crops usch as corn, sugarcane, legumes, cotton and vegetables are planted in very limited scale. The paddy rice production in the dry season is also practiced within very small area of about 280 hectares because of lack of surface water supply.

Pinili Area

The alluvial plain in this service area is highly used for both paddy rice and diversified crop production during the wet and dry season. Tobacco and garlic is the major diversified crops in the dry season. Bouble cropping of rice is practiced within limited area of about 80 heactares serviced by the existing communal irrigation system connected with the Badoc river

Badoc-Sinait Area

The alluvial plains developed along the river and creek are also highly used for paddy rice and diverisfied crop production during the wet and dry season. Tobacco and garlic is the main

diversified crops in the paddy field during the dry season. It is estimated at about 66 percent of the total paddy field in the service area. The paddy rice production in the dry season is practiced within very limited area of about 185 hectares. Its irrigation water is mainly supplied from the Badoc river by the existing communal irrigation canal system.

b) Upland Field

The higher portions on slightly undulating alluvial plain, dune land, hill and terrace are used for upland crops such as upland rice, corn, vegetables and root crops.

Paddy field in the dune land is situated on a relatively low-lying area. In that area the groundwater table is very near to the surface during the wet season and under such a water-logged condition rice is planted. It
structure of the surface soil can be improved by the addition of compost and animal dung. After rice, other crops such as corn, sweet potato and legumes are grown.

In the hill and mountian the paddy field is located on a gentle slope and valley bottom under rainfed condition.

Non-irrigated farms are distributed on an alluvial plain, dune land and hill in small patches.

3. Un-cultivated Area

Un-cultivated area are located on the riverwash, steep slope, rolling land and dune land. The riverwash areas are developed along the Cura and Bagbag river in the Cura Area, the Badoc river and its main tributaries in the Badoc-Sinait, Pinili and Madupayas areas. The riverwash consists of barren strip, brush or grass growth and secondary forest. The steep slope of hill and mountain consists of brush, grass land or secondary forest. Dune lands developing in the western border

of the Batac-Paoay area and Badoc-Sinait area are at present under barren strip, brush or grass growth.

Aggregated areas of the present land use are summarized in Table 3B-26, Appendix 3B-5.

F. Soil Classification and Description

1. Introduction

The soils in the Project Area are predominantly composed of fine to coarse alluvial deposits derived from adjacent hills and mountains. The residual soils are developed on the hills, mountains and higher terraces.

Generally the soils in the Project Area were classified into four main groups based on landscape and physiographic position, namely: i) Soils of the alluvial plane, ii) Soils of the upland which comprise the rolling and hilly areas, iii) Soils of the dune land and iv) Soils of the riverwash.

2. Identified Soil Series

The soils of the alluvial plains were classified into the four soil serieses such as the San Mannuel, Maligaya, San Fernando and Bantog series.

The residual soils on the uplands are derived through the weathering of phroclastic rocks, shale, sandstone and limestone. The two soil serieses were classified in the Project Area, namely, the Cervantes and Bantay series.

The soils of the dune land and riverwash are not favorable for agriculture. That lands are covered with clean sand and gravels where are no soil profile development.