THE SOCIALIST REPUBLIC OF THE UNION OF BURMA

FEASIBILITY REPORT

ON

SOUTH NAWIN IRRIGATION PROJECT

VOLUME III

(APPENDIX－II)

MARCH 1980

JAPAN INTERNATIONAL COOPERATION AGENCY

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Table 4C-1 Total Distribution of Labour Requirement, with Project

Unit: man-day

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
I. Man-day/ac													
a. Paddy (HYV) Mechanized						4.0	12.0	7.0	3.0	2.0	12.0	5.0	45.0
b. " " Non-Mech.						4.0	12.0	7.0	3.0	3.0	12.0	5.0	46.0
c. " (LIV) Mechanized					1.6	9.0	10.4	2.0	2.0	2.0	10.0	4.0	41.0
d. " (") Non-mecha.					1.6	9.0	10.4	2.0	2.0	2.0	10.0	4.0	41.0
e. G'nuts (Monsoon) Mechanized					9.0	6.0	4.0	66.0					85.0
f. Sunflower	9.0	66.0									10.0	9.0	94.0
g. Gram	4.0	6.0	4.0							1.0	2.0	4.0	21.0
h. Sesame (Dry) Mechanized		6.0	6.0	6.0	32.0								52.0
i. " (") Non-Mecha.		8.0	6.0	6.0	32.0								52.0
j. G'nuts (Dry) Mechanized	5.0	5.0	66.0								6.0	5.0	87.0
k. " (") Non-Mech.	5.0	5.0	66.0								6.0	5.0	87.0
l. Cotton (L.S.) Mechanized	8.0	8.0	4.0	4.0						5.0	8.0	8.0	45.0
m. G'nuts (Monsoon) Non-Mech.					9.0	6.0	4.0	66.0					85.0
II. Total Labour													
a. 15,000 ac						60,000	180,000	105,000	45,000	30,000	180,000	75,000	675,000
b. 20,000						80,000	240,000	140,000	60,000	60,000	240,000	100,000	920,000
c. 5,000					8,000	45,000	52,000	10,000	10,000	10,000	50,000	20,000	205,000
d. 13,000					20,800	117,000	135,200	26,000	26,000	26,000	130,000	52,000	533,000
e. 5,000					45,000	30,000	20,000	330,000					425,000
f. 3,000	27,000	198,000									30,000	27,000	282,000
g. 13,000	52,000	78,000	52,000							13,000	26,000	52,000	273,000
h. 10,000		80,000	60,000	60,000	320,000								520,000
i. 14,000		112,000	84,000	84,000	448,000								728,000
j. 5,000	25,000	25,000	330,000								30,000	25,000	435,000
k. 5,000	25,000	25,000	330,000								30,000	25,000	435,000
l. 6,000	48,000	48,000	24,000	24,000						30,000	48,000	48,000	270,000
m. 1,000					45,000	30,000	20,000	330,000					425,000
Total (Man-day)	177,000	566,000	880,000	168,000	886,800	362,000	647,200	941,000	141,000	169,000	764,000	424,000	6,126,000
III. Cattle Operator*	66,000	257,000	115,000	3,000	99,000	211,500	181,200	37,800		30,000	260,500	101,500	1,202,500
IV. Machinery Operator**	7,500	15,500	4,500	4,000	6,500	16,000	15,500	5,000	4,000	10,000	12,500	10,500	111,500
V. Grand Total (II+III+IV)	250,500	838,500	999,500 (58%)	175,000	992,300	589,500	843,900	983,800	145,000	209,000	1,037,000	536,000	7,440,000 (34.3%)
VI. Labour Resource (63,800) 27 working days/month	1,722,600	1,722,600	1,722,600 (100)	1,722,600	1,722,600	1,722,600	1,722,600	1,722,600	1,722,600	1,722,600	1,722,600	1,722,600	20,671,200 (100)
VII. Balance													

* See Table 4C-2 ** See Table 4C-3

Table 4C-2 Total Distribution of Cattle Requirement, with Project

Unit: Cattle-day

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
I. Cattle-day/ac													
a. Paddy (HYV) Mechanized	3.0					3.0	3.0				5.0	4.0	18.0
b. " Non-Mech.	3.0					11.0	11.0				5.0	4.0	18.0
c. Paddy (LIV) Mechanzied	1.0				1.2	3.0	1.8				4.0	3.0	14.0
d. " Non-Mech.	1.0				4.2	11.0	6.8				4.0	3.0	30.0
e. G'nuts (Monsoon) Mech.					8.0			12.0					20.0
f. " Non-Mech.					38.0			12.0					50.0
g. Sunflower	3.0	2.0									28.0	3.0	36.0
h. Gram		8.0	8.0										16.0
i. Sesam (Dry) Mechanized		4.0			2.0								6.0
j. " Non-Mech.		26.0			2.0								28.0
k. G'nuts (Dry) Mechanized			12.0								8.0		20.0
l. " Non-Mech.			12.0								30.0		42.0
m. Cotton (L.S.) Mech.			1.0	1.0						10.0			12.0
II. Total Cattle													
a. 15,000 ac	45,000					45,000	45,000				75,000	60,000	270,000
b. 20,000	60,000					220,000	220,000				100,000	80,000	360,000
c. 5,000	5,000				6,000	15,000	9,000				20,000	15,000	70,000
d. 13,000	13,000				54,600	143,000	88,400				52,000	39,000	390,000
e. 5,000					40,000			60,000					100,000
f. 1,300					49,400			15,600					65,000
g. 3,000	9,000	6,000									84,000	9,000	108,000
h. 13,000		104,000	104,000										208,000
i. 10,000		40,000			20,000								60,000
j. 14,000		364,000			28,000								392,000
k. 5,000			60,000								40,000		100,000
l. 5,000			60,000								150,000		210,000
m. 6,000			6,000	6,000						60,000			72,000
Total (Cattle-day)	132,000	514,000 (97.5%)	230,000	6,000	198,000	423,000	362,400	75,600		60,000	521,000 (98.8%)	203,000	2,405,000 (38.0%)
III. Cattle Operator (man-day)	66,000	257,000	115,000	3,000	99,000	211,500	181,200	37,800		30,000	260,500	101,500	1,202,500
IV. Cattle Resource (19,523) 27 working days/month	527,121	527,121 (100.0)	527,121	527,121	527,121	527,121	527,121	527,121	527,121	527,121	527,121 (100.0)	527,121	6,325,452 (100.0)
V. Balance	395,121	13,121	297,121	521,121	329,121	104,121	164,721	451,521	527,121	467,121	6,121	324,121	3,920,452

Table 4C-3 Total Machinery Operator Requirement, with Project

Unit: man-day

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
I. Man-day/ac													
a. Paddy (HYV) Mech						0.7	0.7	0.2	0.2	0.2	0.3	0.2	2.5
b. Paddy (LIV) "					0.1	0.7	0.6	0.2	0.2	0.2			2.0
c. G'nuts (Monsoon) "					1.0	0.4	0.4	0.2					2.0
d. Sesame (Dry) "		1.1	0.4	0.4	0.1								2.0
e. G'nuts (Dry) "	0.3	0.3	0.1								1.0	0.3	2.0
f. Cotton (L.S.) "	1.0	0.5								1.0	0.5	1.0	4.0
II. Total Operator													
a. 15,000 ac						10,500	10,500	3,000	3,000	3,000	4,500	3,000	37,500
b. 5,000					500	3,500	3,000	1,000	1,000	1,000			10,000
c. 5,000					5,000	2,000	2,000	1,000					10,000
d. 10,000		11,000	4,000	4,000	1,000								20,000
e. 5,000	1,500	1,500	500								5,000	1,500	10,000
f. 6,000	6,000	3,000								6,000	3,000	6,000	24,000
Total (man-day)	7,500	15,500	4,500	4,000	6,500	16,000	15,500	5,000	4,000	10,000	12,500	10,500	111,500

Table 4C-4 Requirement of Seeds

	Required Quantity (ton)	Annual Requirement (ton)		Unit Cost (Kats)	Total Cost (Kats)
Paddy	1,659	553	(26,500 bkts)	9.0	238,500
G'nuts	1,109	370	(32,630 ")	60	1,957,800
Sesame	71	24	(980 ")	100	98,000
Gram	407	136	(4,345 ")	30	130,350
Sunflower	7	2.3	(241 ")	40	9,640
L.S. Cotton	147	49	(30,000 viss)	0.6	18,000

Table 4C-5 Requirement of Fertilizers

Crops	Acreage (ac)	Urea (lb/ac)	Urea (ton)	T.S.P. (lb/ac)	T.S.P. (ton)	Potash (lb/ac)	Potash (ton)	Organic (ton/ac)	Organic (ton)
Paddy (LIV)	18,000	56	457	28	229	0	0	2	36,000
Paddy (HYV)	35,000	112	1,778	84	1,334	28	445	6	210,000
G'nuts	16,300	28	207	28	207	0	0	4	65,200
Sesame	24,000	28	305	28	305	0	0	4	96,000
Gram	13,000	28	165	28	165	0	0	0	0
Sunflower	3,000	84	115	56	76	28	38	4	12,000
L.S. Cotton	6,000	84	229	56	152	28	76	4	24,000
Total			3,256		2,468		559		443,200
Unit Cost @		25kg/bag = K.9		50kg/bag = K.62.2		50kg/bag = K.30		K.10/ton	
Total Cost (K)		1,172,160		3,070,192		335,400		4,432,000	

Table 4C-6 Requirement of Agro-chemicals

Crops	Acreage (ac)	Unit (kg/ac)	Total (ton)	Unit Price* K/kg	Total Cost (K)	Remarks
Paddy	53,000	24	1,272	2.75	3,498,000	Lindane P065, P130, etc.
G'nuts	16,300	25	408	3.08	1,256,640	Lindane P065. P130, Aldrin 2.5%
Sesame	24,000	2	48	38.0	912,000	Linden L 20
Gram	13,000	25	325	2.72	884,000	Aldrin 2.5%, Lindane P065, etc.
Sunflower	3,000	2	6	38.0	228,000	Linden L 20
L.S. Cotton	6,000	20	120	4.75	570,000	Sevin, Thimet etc.
	115,300		2,179			

* Average price of insecticides and pesticides.

4C-2. Agricultural Mechanization

A. Selection of Farm Machinery

The selection of farm machinery to be used in the Area has been made in due consideration of the local climate and soil conditions in the irrigation Project Area, proposed works and those practices, furthermore, the experiences of prevailing farm mechanization in Burma and other countries.

1. Tractors and Power tillers

Four wheel tractors of 50 HP class and two wheel power tillers of 8 HP are selected as the main power in this programme. This type of tractors and power tillers are most popularly introducing in the country at present in spite of high population density of farm labours. This tendency is as same as world trend due to the requirement of high efficiency of higher horsepower machinery and suplemental work of insufficient cattle power. From the repair and maintenance point of view, present assembling of this type of tractors and power tillers would be helpful in convinience.

The paddy cultivation practices such as ploughing, puddling, levelling, etc. are usually implemented in the muddy wet field. However, mechanical operation under said conditions in the Project Area will be low efficiency and/or difficult due to the soil characteristics, comparatively uneffective drainage and small plot of field under non-land-consolidations except very limitted area. The other hand, land preparations for upland crops such as harrowing, drawing of sowing lines etc. should be carried out more carefully in the project compared to traditional method.

In those areas, two wheel power tillers will be required to the supplementary operations of four wheel tractors.

2. Attachments

As for the elementary attachments to the tractors and power tillers, the following type and size are selected on the basis of

the experiences in Burma.

For ploughing:	Disc plough having 3 discs of 26".
For harrowing:	Offset disc harrow which consist of two gangs. Each gang will be equiped with 8 discs of 24".

In addition to the above, rotarrator is proposed for final soil preparations by power tillers. The rotary harrowing is not popularly practiced in Burma at present, but it will be much applicable for preparation of good seed bed for paddy and upland crops.

3. Plant Protection Equipment

Very high efficiency plant protection equipment such as tractor driven power sprayers, boom sprayers, air blast sprayers, etc. would not use in the project area, because there are no farm road with non-land-consolidation except very limitted area. Therefore, plant protection machinery are selected by those limitted factors.

Knapsack type machinery will be usefull in the project area for spraying liquid chemicals, powder dust and/or granules.

B. Required Numbers of Farm Machinery

The number of farm machinery are studied on the basis of the operation programme, cropping patterns, workability specified in each machinery, and workable days to be estimated hereinunder.

(1) Estimation of Workable Days and Working Hours a Day

The weather conditions were checked in connection with the workable days on the field operations. However, land preparation for paddy field and paddy transplanting works are able to carried out in the rain. Other farming practices are mostly arranged in the dry season. Therefore, the influence of rainfall are not so important in the consideration of workable days. The real net holidays including national holidays, sundays, heavy rainfall days, religious

holidays will be estimated at 3 or 5 day per month. Therefore, the workable days in each month are estimated at 27 days in average after the project.

It is assumed that the daily working hours of farm machinery are estimated at eight hours in the normal conditions.

However, the draft cattles in the field operations will be 4 hours only per day as usual.

(2) Working Capacity and Efficiency in Each Machinery

Actual field working capacity and its efficiency in each practices of tractors such as land preparations are directly estimated on the basis of the results of various experiences made by Agricultural Mechanization Department (AMD). However, owing to limited experience on other machinery and equipment such as power tillers, reapers, and power sprayers, the efficiency are estimated by the references available in case of paddy cultivation in Japan and other asian countries.

(3) Total Coverage of Farm Machinery

In order to determine the most appropriate and economical number of machinery to be used in the project, a study was made on the cropping pattern and working conditions of farm machinery as mentioned before.

Land preparations:

The most critical part of land preparations will be graund nuts in November. It will be carried out 10,000 ac within half month (13 net working day). Mechanized land preparations should be covered by 50 percent, namely 5,000 ac, because cattle power would be able to cover another 50 percent in this season.

The land preparations consists of ploughing and first harrowing by tractors, and second harrowing by power tillers.

This mechanized power of land preparations will also be utilized for 10,000 ac of sesame in February, 5,000 ac of ground nuts in May, 5,000 ac of paddy (LIV) in May, 10,000 ac of paddy (HYV) in June, 5,000 ac of paddy (HYV) in July and 6,000 ac of cotton in October. Therefore, 46,000 ac of land preparation will be carried out per annum. It is about 40 percent of total cropping area in the Project Area.

Plant Protection & Fertilizer Application

Proposed work of the plant protection and fertilization will be undertaken by traditional ground spraying or dusting method. In this connection, power knapsack type sprayers equiped with long application pipe for powdery or granular type of agro-chemicals and fertilizers are selected in due consideration of the field conditions to be mostly under non-land-consolidation and small plot.

The utilization of power suprayers will be many times, for example, three times of additional fertilization and two times of agro-chemicals for paddy rice, eight times of agro-chemicals and one time fertilizer applications for cotton. Therefore, 55,000 ac should be covered within 10 days for one time application.

According to these considerations, actual required number and total coverage farm machinery are as shown in the following table.

C. Ownership of Farm Machinery

According to the agricultural development plan, farm machinery will be introduced to villagetract cooperatives. In this case, utilization of farm machinery such as cordination of working programme, procedures of rental arrangement, short distance from pooling base to working farm field, would be very convinience compared to direct contract services by the Tractor Station, because the village tract cooperatives, have small teritories and good communications among member farmers.

However, rental charge of farm machinery will become higher than Tractor Stations' tractors. Therefore, the Government should be set up a low interest loan and/or subsidy system towards introduced farm machinery.

Table 4C-7 Actual Required Number of Farm Machinery

	Covering Acreage	Working Days	Covering Acreage/day	Actual Efficiency/unit	Required Number	Standby	Total Unit
Plough (Ploughing)	5,000ac*	13 day	385ac	4ac/8hr	96	4	100
Harrow (Harroing)	5,000	13	385	8 /8	48	2	50
Tractor (Primover)	-	-	-	-	-	-	150
Tiller (Harrowing)	5,000	13	385	2 /8	193	7	200
Sprayer (Application)	53,000**	10	5,300	50 /8	106	14	120

* Half acreage of dry season ground nuts in November.

** Application acreage for one operation in the Paddy field.

Table 4C-8 Actual Coverage by Machinery

Operation \ Crops	Paddy (LIV)	Paddy (HYV)	G'nuts (Monsoon)	Sesame (Dry)	G'nuts (Dry)	L.S.Cotton	Sunflower	Gram	Total
Land Preparation	5,000	15,000	5,000	10,000	5,000	6,000	-	-	46,000
Plant Protection	(x3)54,000	(x3)105,000	(x2)12,600	(x2)48,000	(x2)20,000	(x8)48,000	(x1)3,000	(x1)13,000	303,600
Fertilizer Application	(x2)36,000	(x2)70,000	(x1)6,300	(x1)24,000	(x1)10,000	(x1)6,000	(x1)3,000	(x1)13,000	168,300

Table 4C-9 Farm Machinery Cost

(1) Investment Cost

Machinery	Unit No.	Cost per unit* ($)	Total cost* ($)	Remarks
Tractor	150	8,100	1,215,000	**
Disc plough	100	560	56,000	
Disc harrow	50	830	41,500	
Power tiller	200	2,300	460,000	**
Power sprayer	120	300	36,000	

* Market price ** Made in Burma

(2) Fixed Cost

Machinery	Purchasing Price ($)	Durable Period (Year)	Fiexed Cost Ratio * (%/year)	Fixed Cost ($/year)	Coverage per unit (ac)	Total cost per ac ($)	Remarks (Total coverage)
Tractor	8,100	8	20	1,620	613**	2.6	46,000 ac
Disc plough	560	5	24	134	460	0.29	46,000
Disc harrow	830	5	24	199	920	0.22	46,000
Power tiller	2,300	5	22	506	230	2.2	46,000
Power sprayer	300	5	20	60	3,933	0.015	471,900***

* Includes depreciation ratio, repare cost ratio, garage cost ratio, tax & other ratio.

** Average acreage of 100 unit tractors for 425 ac of coverage per unit and 50 unit tractors for 850 ac of coverage per unit.

*** See Table 2.

(3) Variable Cost

Operation	Machinery	Ope. hour per ac	Fuel Consumption/hr (ℓ)	Fuel/ac (ℓ)	Unit Cost ($)	Fuel Cost ($)	Oil*** Cost ($)	Variable cost/ac ($)
1. Ploughing	Factor + Plough	2	5.0*	10.0	0.15	1.5	0.45	1.95
2. Harrowing	Tractor + Harrow	1	4.0*	4.0	0.15	0.6	0.18	0.78
3. Harrowing	Power tiller	4	2.0*	8.0	0.15	1.2	0.36	1.56
4. Application	Power duster	0.2	1.0**	0.2	0.2	0.4	0.12	0.52

* Diesel Oil (light oil) ** Gasolin *** 30% of the fuel cost

(4) Total variable Cost

Operation	Variable cost/ac ($)	Total coverage (ac)	Total variable cost ($)
1. Ploughing	1.95	46,000	89,700
2. Harrowing	0.78	46,000	35,880
3. Harrowing (Tiller)	1.56	46,000	71,760
4. Application	0.52	471,900	245,388

(5) Rental Charges

Machinery & Equipment	Fixed Cost/ac ($)	Clerical charge/ac ($)	Rental Fee/ac ($)
Tractor	2.6	0.2	2.8
Plough	0.29	0.1	0.39
Harrow	0.22	0.1	0.32
Power Tiller	2.2	0.2	2.4
Power Sprayer	0.015	0.015	0.03

4C-3. Proposed Farming Practices

A. Serection of Varieties

Review and examine the data obtained from the experiments in the ARD and further referring to the results of present production in and around project area, the following varieties are selected as recommendable varieties to the project area for the present. These varieties will be re-examined for further selection and be confirmed, and moreover, other improved varieties will be newly introduced in future through the experiments in the project site.

Paddy (L.I.V.)	Swedinga, Yevawsein
Paddy (H.Y.V.)	Seintalay, IR-28
G'nuts	S.P. 121, M-9, M-10
Sunflower	Mahuya
Sesame	Hybrid, Hnanni
Gram	Shwedinga
L.S. Cotton	Stoneville 213, S.R.T.-1

B. Land Preparation

Land preparation will be started by the use of tractor with mounted disc plough or by cattle plough in regular. The pre-irrigation will be practiced to advance the ploughing, if necessary. In this work, some power tillers will be also required in certain extent where the soils are swampy consolidated in rainy season.

Harrowing will be required at least twice after the ploughing in order to make the careful soil preparation and land leveling. In the mechanized area, disc harrow attached to the tractor will be used for the first harrowing, and rotary harrowing will be carried out by power fillers or cattle harrowing for the second harrowing.

Following the harrowing work, furrow line will be made by cattle plough for seeding of upland crops.

As for the second cropping of the first crops the land preparation will be carried out immediately after the harvesting of the first crops.

C. Seeding

At present, there are three types of paddy cultivation methods broadly characterized by the seeding practice.

One is the ordinary transplanting method in which seedlings are prepared at the nursery bed and thereafter are transplanted into the main field. This method is being widely practiced in the world and it is generally accepted that the yield can be expected higher as compared with that of the direct sowing method, while a large labour force is required for the transplanting of seedlings.

Recently, transplanting machinery (so-called transplanter) have been developed in Japan and being popular among farmers. However, those still have a narrow suitability with the field conditions.

The second is also transplanting method which has been recently developed in Japan. Seedlings are prepared by the use of seedling boxes and thereafter those seedlings are broadcasted at randam spaces. In this method, labour requirement for transplanting is saved substantially and yield can be expected. However, it will require rather initial investment for preparation of seedling boxes.

The third is the direct seeding method. This method can be easily adopted by shorter labour requirement than others. While, it is required to prepare the land leveling with more severe conditions as compared with that for others. The yield by this method is less than others in general.

Taking into account the merits and demerits as mentioned above, the ordinaly transplanting method is proposed in this production programme.

The seeding rate for nursery bed will be at 32 kg per acre. Prior to the seeding, seeds will be selected by a salt-solution with 1.13 specific gravity and then treated by a chemical to control diseases. The seed used in this programme will be prepared through seed multiplication programme to be proceed in the Project Area.

Other upland crops will be sown directly in the main field with furrow lines except gram. The gram will be sown by broadcasting method in the paddy field before one month of paddy harvesting.

D. Fertilization

As recommended in the Table 4C-5, proper application of fertilizers is essential for the realization of the agricultural potential in the Project Area. According to the results of the detailed chemical analysis of soil, the nutrients necessary for proper crop production are not always sufficiently contained in the soil. Accordingly some amount of nitrogen and phosphorus and organic components are necessary to be applied.

On the basis of the chemical properties of soils, requirement of fertilizers for each crop are shown in Table 4C-6.
Some amount of organic fertilizers such as F.Y.M. or compost will be applied into the soil not only for improving the physical conditions of soils but also for supplying the nitrogen, humus and other minor elements in the soils.

Out of the total dosage of fertilizers, about one third of urea and all the T.S.P., potashium and organic fertilizers will be applied as the basic fertilizer. Remaining two third of urea will be applied divided into one to three times depend on the crops. Application of these are done by the use of power dusters for plant protection machinery.

E. Plant Protection

The proposed works will be undertaken by the traditional ground spraying and dusting method. In this connection, knapsack type power duster cum sprayers with long application pipe is selected in due consideration of the field conditions to be mostly small plot of farm. The power sprayer will be able to spray out such powdery or granular type of fertilizers and agro-chemicals.

F. Harvesting

Harvesting of crops will be carried out by the traditional sickles except Pilot Scheme Area of paddy rice where will be harvested by reapears. Because the Project Area has sufficient labour force through the year.

4C-4. Facilities and Personnel of Supporting Services

I. Vehicles

Extension & Training		
Motorcycle	4	
Bicycle	35	
Sub-total		$10,000

II. Sarary & Wages

	No.	@ (K)	Annual Amount (K)	Total Amount (K)
Extension & Training				
Ass. Ext. Officer	4	350	4,200	16,800
V.T. Ext. Agent	35	300	3,600	126,000
Sub-total				(K) 142,800

III. Warehouse

Warehouse	150 m^2	
Sub-total		(K) 75,000

4D-1. Main Dam Site

The main dam sites finding study was made along the course of South Nawin river prior to the feasibility stage by Irrigation Department of Burma in order to determine the best dam site from both the economic and technical points of view. Of these, the site situated approximately 0.3 miles downstream of the confluence of South Nawin and Dingy rivers was distinctly more favorable, taking into account the following basic considerations, than the other one.

- The dam site should be located possibly downstream of the river system to command the river basin as large as possible, in consideration of the full utilization of the water resources.
- The existing facilities such as village houses, roads and cultivated lands, etc., should be submerged at possibly minimum by the dam construction.
- The dam shall have a small chord-height ratio (dam length/dam height) in order to diminish the volume of embankment.
- The dam site shall provide enough reservoir elevation in order to supply the irrigation water to the Project area.
- The high embankment shall not be required in consideration on both geology and soil mechanics of embankment materials for the dam site.

From the above considerations, the proposed dam site is finally selected as the most suitable one near the Yatthit village which is located about three miles by road north-east of Paukkaung, Prome district.

The catchment area to the chosen dam site is 247 sq. miles (640 sq.km) and the reservoir will stretch north to south along the river valleys with rectangular shape when the dam is constructed.

4D-2. Main Dam Axis

Some alternative dam axes have been considered at the proposed dam site during the early stage of feasibility study, in order to diminish the embankment volume of the dam body.

After obtaining the data of geological investigations, the dam axis is at river valley and right bank was fixed from the viewpoints of geological and topographical conditions. As for the left bank, the dam axis should be located at possibly upstream where the ground surface elevation is slightly higher. In conclusion, the proposed dam axis as shown in the attached drawing is finally selected as the most favorable one taking into account the following technical considerations.

- An idea of aseismatic design should be considered to select the alignment of dam axis and it seems reasonable that a minimum radius of about 1,650 ft. will be adopted as an allowable curvature for the dam axis, in order to eliminate the concentration of tensile stress in earthquake judging from the experience obtained in Japan.
- The logs of borehole made on the immediately upstream of dam axis indicate that there exists a course gravel layer with maximum thickness of about 80 ft. This layer seems to be comparatively loose and it can be assumed that the coefficient of permeability is in the excess of 7×10^3 ft/year.
- It is desirable that the gravel layer should not be located below the dam base in order to construct the cut-off wall within the foundation of both the main dam and coffer dam.
- The spillway should be located on a remaining small hillock at the right bank due to the reducing of required bearing capacity for the base of structures.

4D-3. Geology of Main Dam

(a) General Geology

The geology of the project area consists of the Miocene series of sandstone and shale beds, so-called the Peguian Series, the Pliocene series of mostly sandstone beds known as the Irrawaddian Series and the Quaternary formations, as shown in Fig. 4D-1.

Most of irrigable areas of the Project comprise of alluvial plain which spreads out from north to south along the Ze river, the uppermost of Myitmaka River.

The diluvial fans develop along hill-foot strips fringing the alluvial plain.

The hilly area east of the plain, the western foothill of Pegu Yoma, consists of the aforesaid Irrawaddian sandstones and Peguian shales. The proposed dams, main and diversion, would be constructed onto these series.

(b) Engineering Geology of Main Dam

The main dam is proposed at two miles east of Paukkaung Town or 24 miles east of Prome Town, near the Yatthit village.

The topography around the site is very flat and relatively low. The river-bed situates nearly an elevation of 200 feet. River terraces formed widely along the South Nawin proper and Dingyi river, one of major tributaries, are around 250 ft elevation. Many independent hills form a summit level of about 280 ft. for one mile distance of both bank sides from the South Nawin river. The ridges exceed 300 ft elevation can be only seen 1.4 miles north and 1.7 miles south from the river.

Thirty-five (35) boreholes have been drilled reaching 3,470 linear ft (1,177 m) at the dam site. Eleven (11) test pits and a number of

auger drilling have been also made for soil material investigation.

In order to confirm the bearing capacity of bed rock, six lines of seismic refraction prospecting covering 2,590 m length has been carried out at both banks of dam site.

Fig. 4D-2 shows geological conditions of main dam site, obtained through the above investigations.

The bed rocks of the proposed dam site is supposed to be the upper Peguian Series. Irrawaddian sandstone which are soft, friable and loose, exposes at some 0.7 miles west of dam site near Yatthit village. The formation of dam site is, therefore, supposed to be the upper Peguian Series.

The bedding of bed rocks is, in general, dipping around 20 degrees toward the southwest. Due to coverings, folding and fault structures are unclear.

The sandstones of the dam site are fine to medium grained, composed chiefly of quartz. Compressive strength and specific gravity of sandstone are reported to be 3.8 to 20 kg/sq. cm and 2.62 to 2.65, respectively.

The shales are bluish gray when it is fresh. Its specific gravity is 2.60 to 2.65 and dry bulk density is 1.70 to 1.75 gr/cu.cm. Compressive strength of shale is reported to be 6.0 to 8.5 kg/sq. cm in dry condition and 1.5 to 13.9 kg/sq.cm in saturated condition.

Figs. 4D-3 to 4D-5 show the result of seismic prospecting as seen in these figures, the site consists only of two velocity layers. The top layer shows velocity of 0.45 to 0.5 km/sec indicating overburden and weathered bed rock layers of 5 to 15 m thick. The second layer indicates velocity range of 1.8-2.0 km/sec showing sound bed rocks.

According to velocity-bearing capacity relation as attached in Fig. 4D-6, the bearing capacity of bed rocks secured in the site is deemed to be 2.5 to 4.5 kg/sq.cm, and it seems only up to 14 m high gravity type concrete structure can be supported.

River-bed and terrace deposit cover the bed rocks widely.

The recent river-bed deposits are well-sorted fine to medium sand and 20 feet thick or less.

Moderately thick gravel layer deemed to be an old river-bed deposit is found out by the boreholes DH 4, 5, 6, 7 and 9. The maximum thickness is 80 ft (24 m) at the depths from 40 to 120 ft (12 to 36 m) in DH 9.

The gravel layer shows a lenticular spread of about 1,200 ft (360m) diameter at around the conjunction of the South Nawin and Dingyi rivers. The gravel layer is loose and medium density, overlain by bluish gray fine sand.

The terrace deposits are deemed, in general, to be not so thick and mostly composed of sandy materials. However, it is very hard to classify residual weathered overburden made from sandy bed rock with terrace deposits.

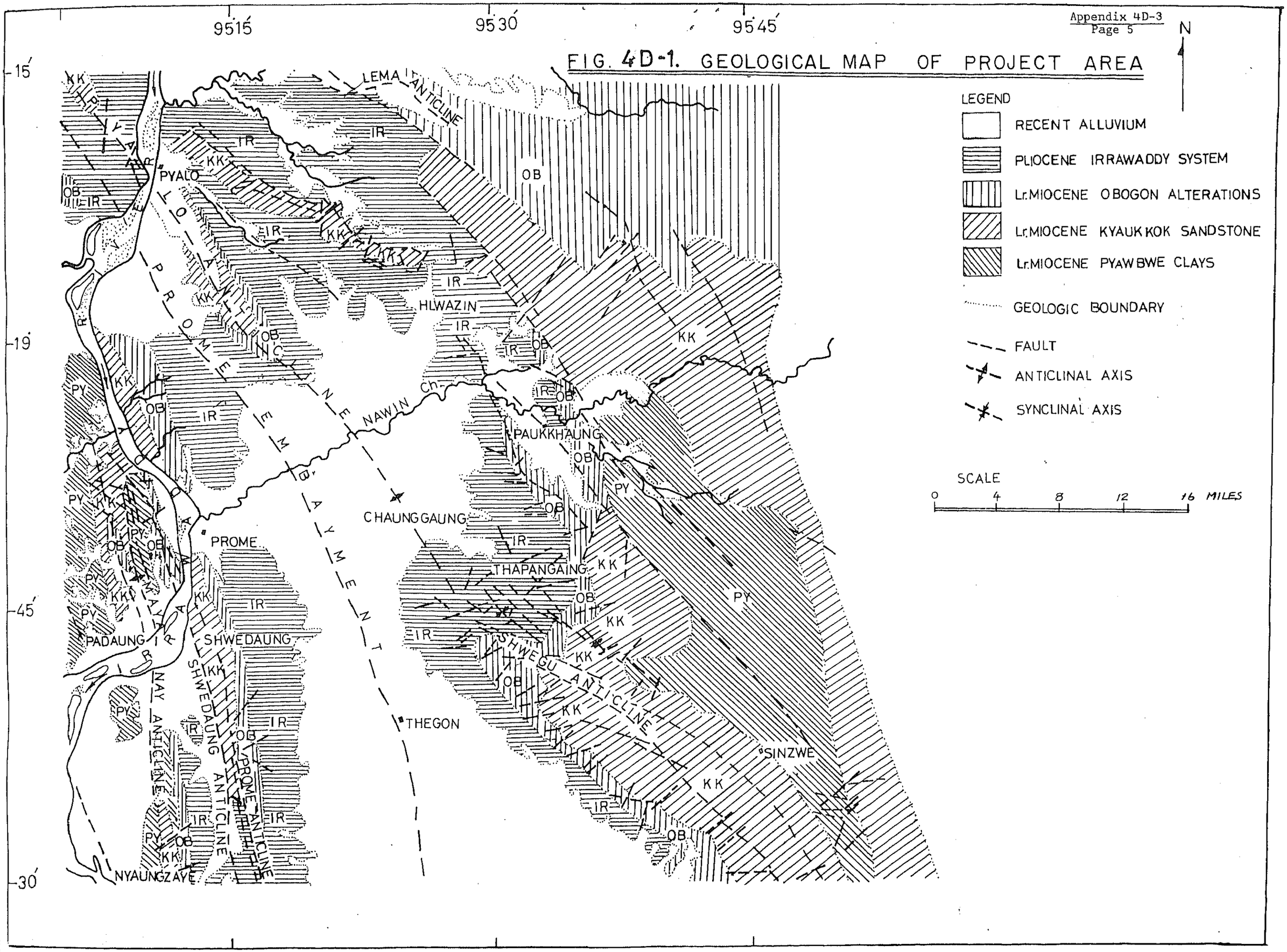
So far the drilling results are concerned, overburdens other than the river-bed deposits are composed of clayey materials on the right bank side showing up to 25 ft (7.5 m) and rather thick sandy materials on the left bank side indicating up to 60 ft thick (20 m).

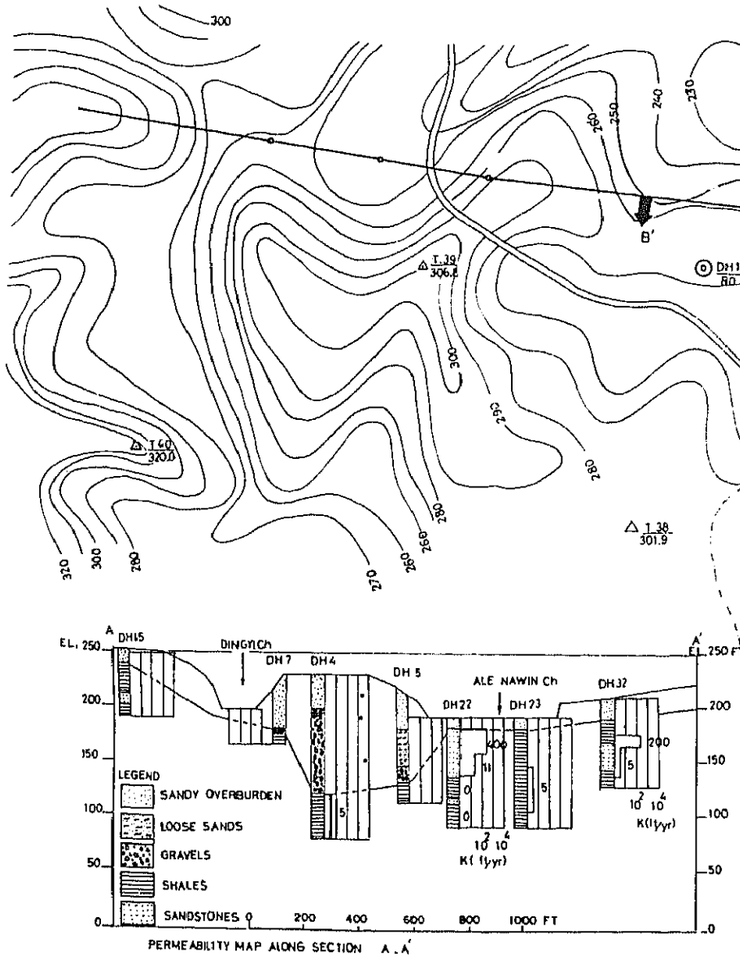
In-situ permeability tests conducted at bed rock sections of borehole indicate comparatively impervious nature as seen in the attached borehole logs Fig. 4D-7. Though the permeability of somewhat weaterhed portion of sandstone reaches some 500 ft per year (4.83×10^{-4} cm/sec), that of sound sandstone seems to be practically impervious showing five ft/yr. (4.83×10^{-6} cm/sec) or less.

An impervious property is also available at shale portion indicating from 280 ft/yr (2.71×10^{-4} cm/sec) at weathered zone to less than five ft/yr at sound facies.

The gravel layer at the conjunction point shows very high permeability ranging from 6,900 to 9,800 ft/yr (6.67 to 9.47×10^{-3} cm/sec,).

FIG. 4D-1. GEOLOGICAL MAP OF PROJECT AREA





PERMEABILITY MAP ALONG SECTION A-A'

FIG

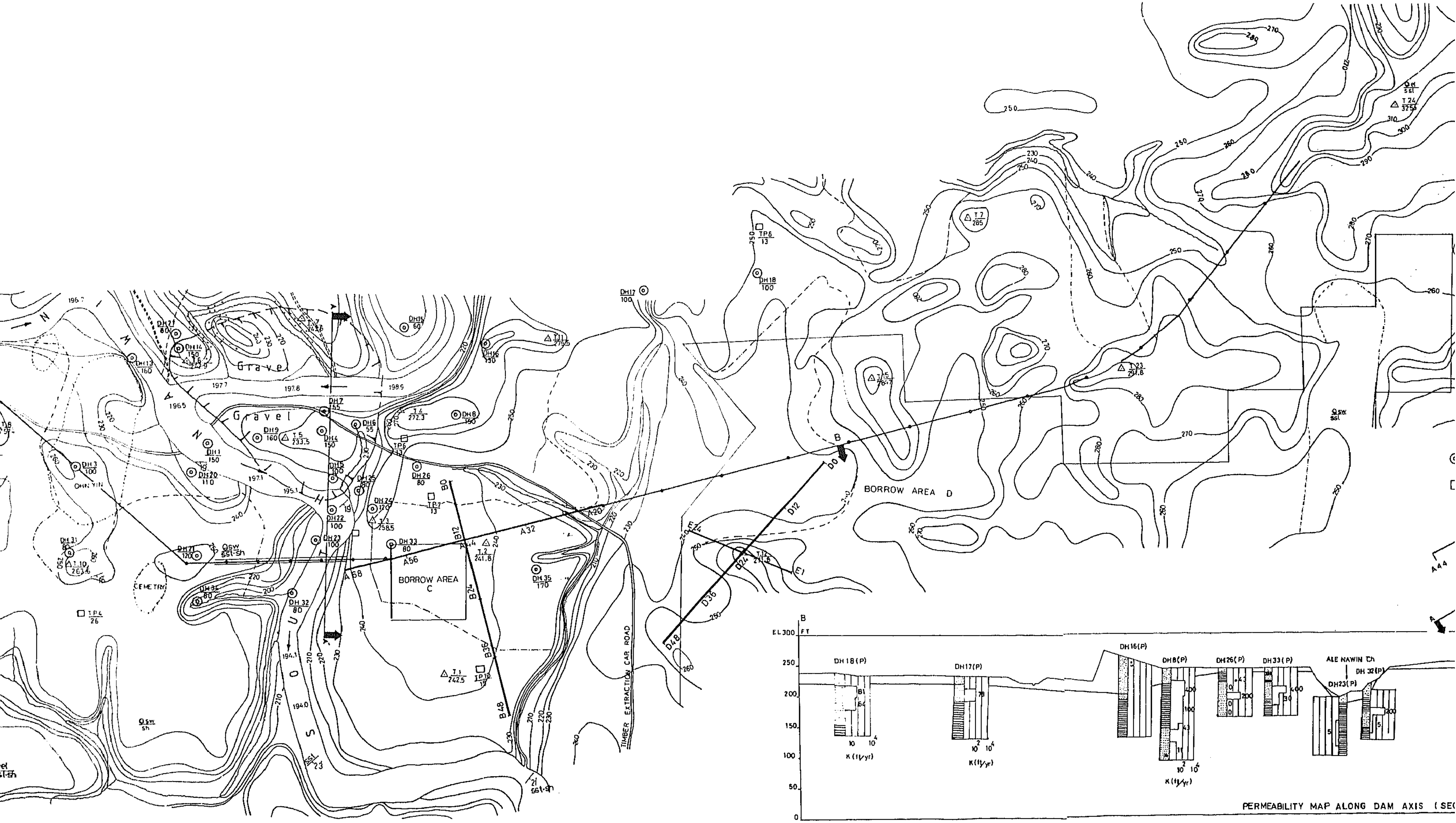
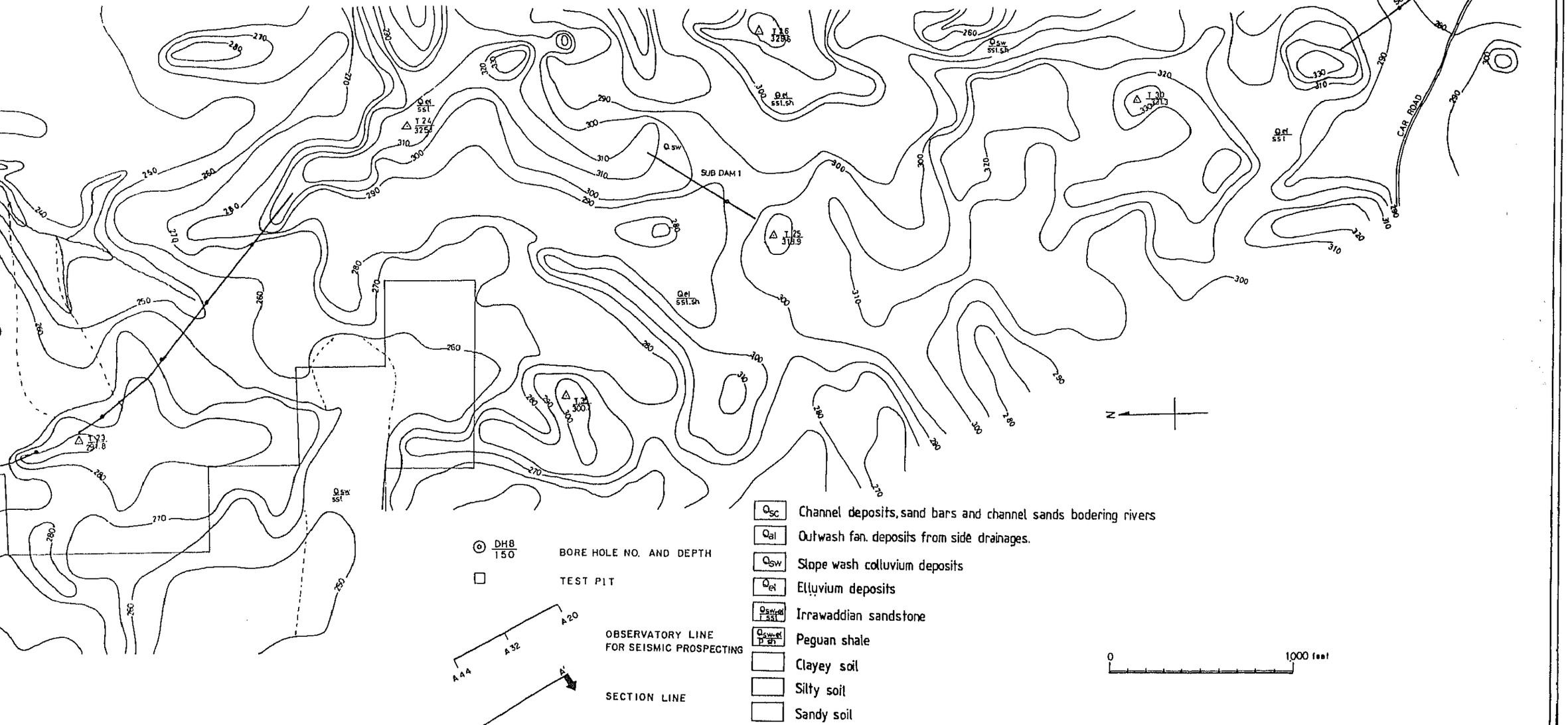
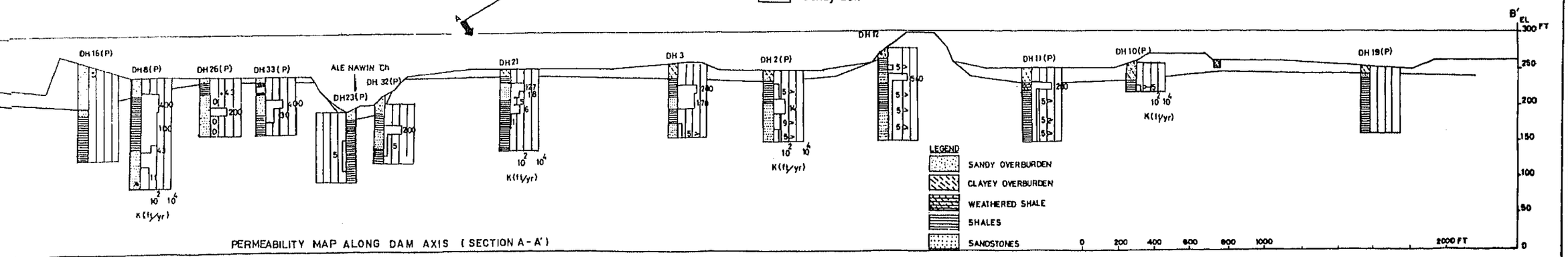

BORROW AREA C
BORROW AREA D
TIMBER EXTRACTION CAR ROAD
Gravel
CEMETRY
OHN YIN
ALE NAWIN Ch
EL 300 FT
K (ft/yr)
PERMEABILITY MAP ALONG DAM AXIS (SEC

FIG. 4D-2 GEOLOGICAL CONDITION ON MAIN DAMSITE



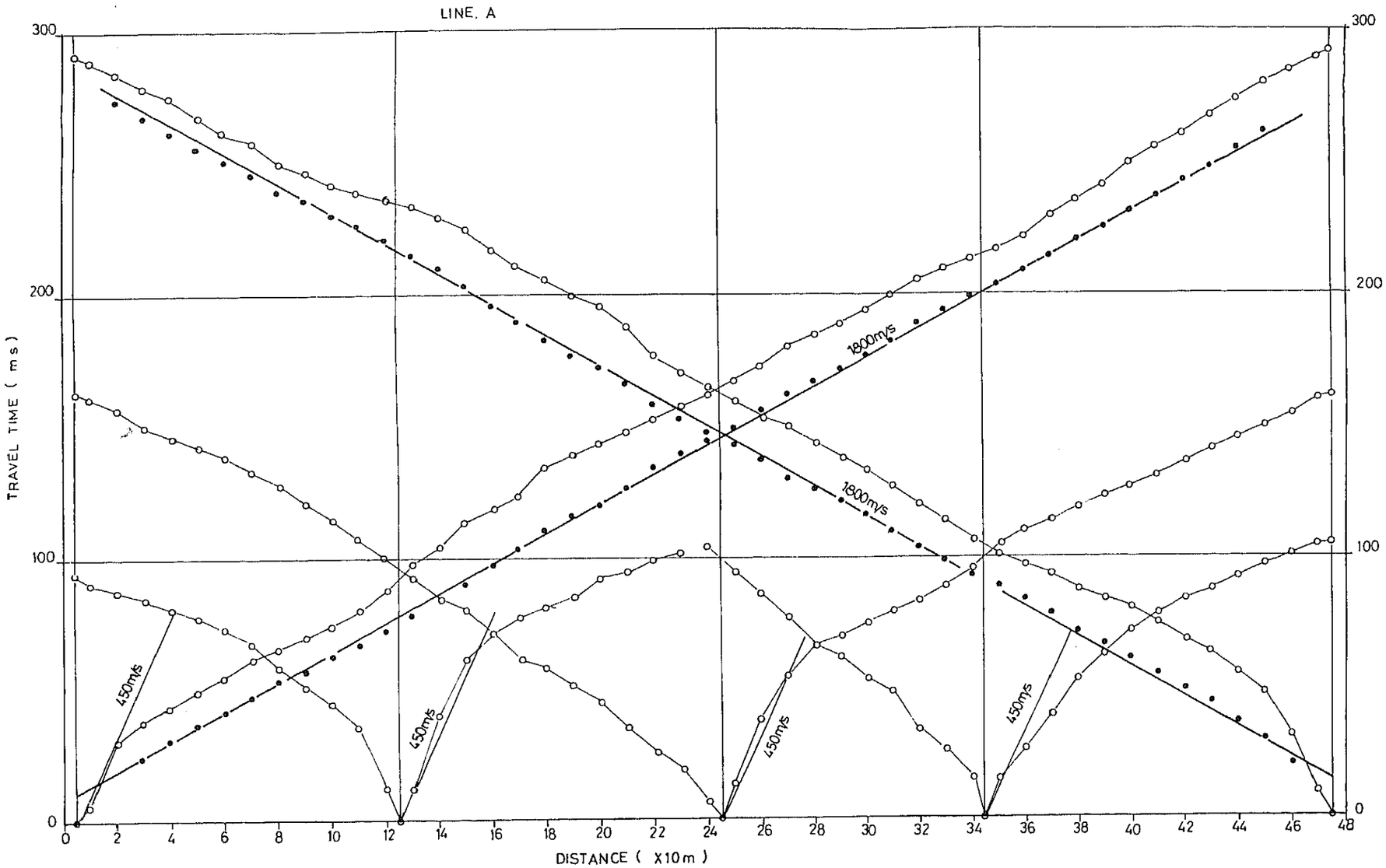


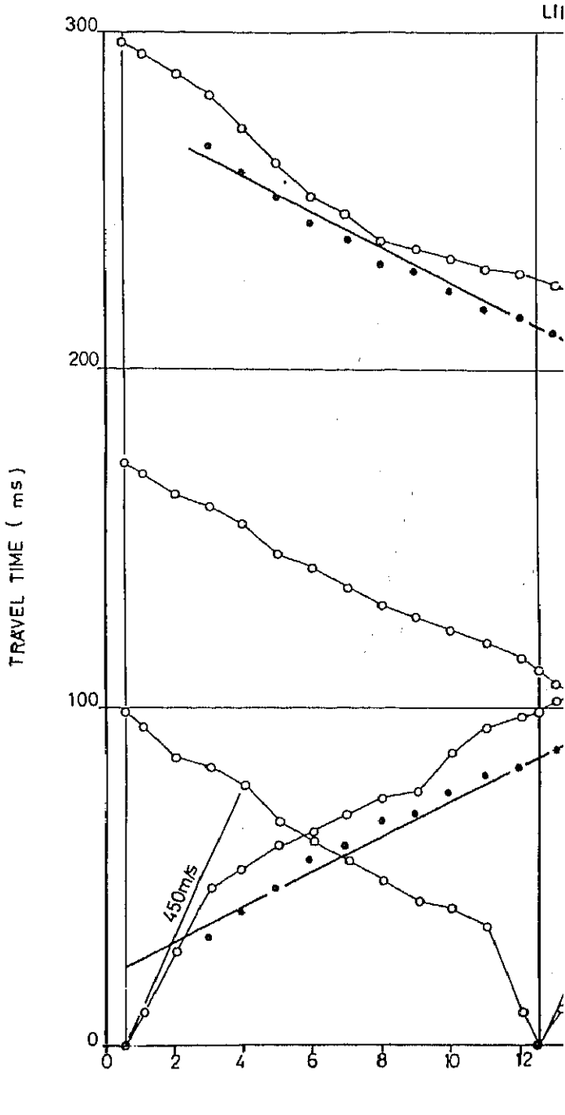
PERMEABILITY MAP ALONG DAM AXIS (SECTION A - A')

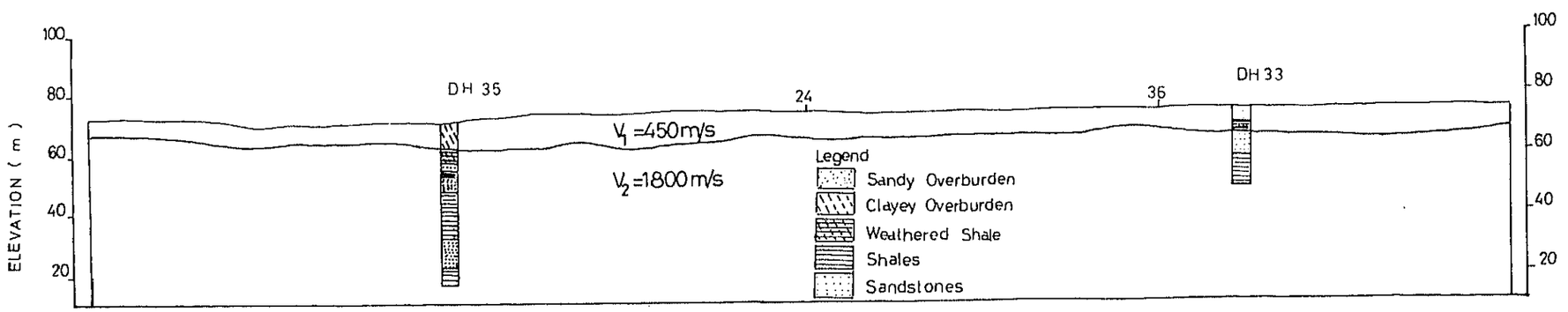
FIG 4D·3. SOUTH NAWIN IRRIGATION PROJECT SEISMIC PROSPECTING

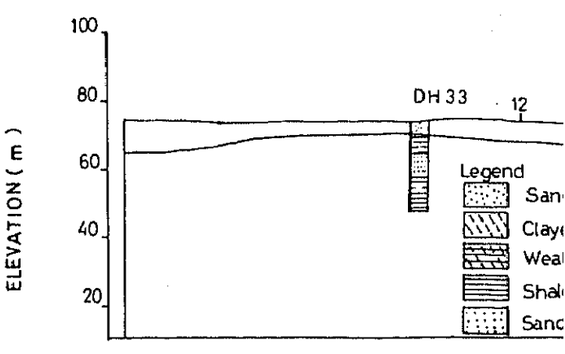
TIME TRAVEL RELATIONS AND VELOCITY LAYER STRUCTURE

LINE. A



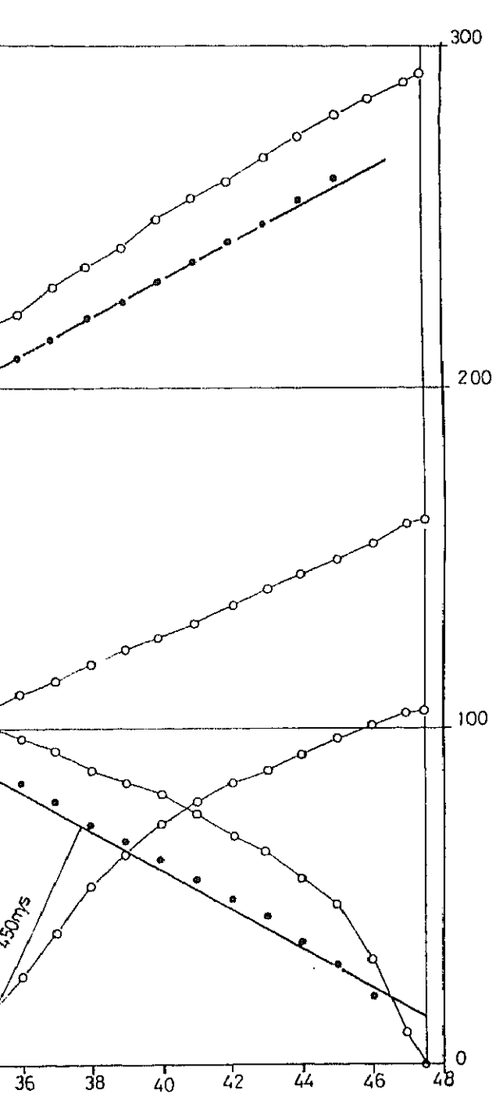


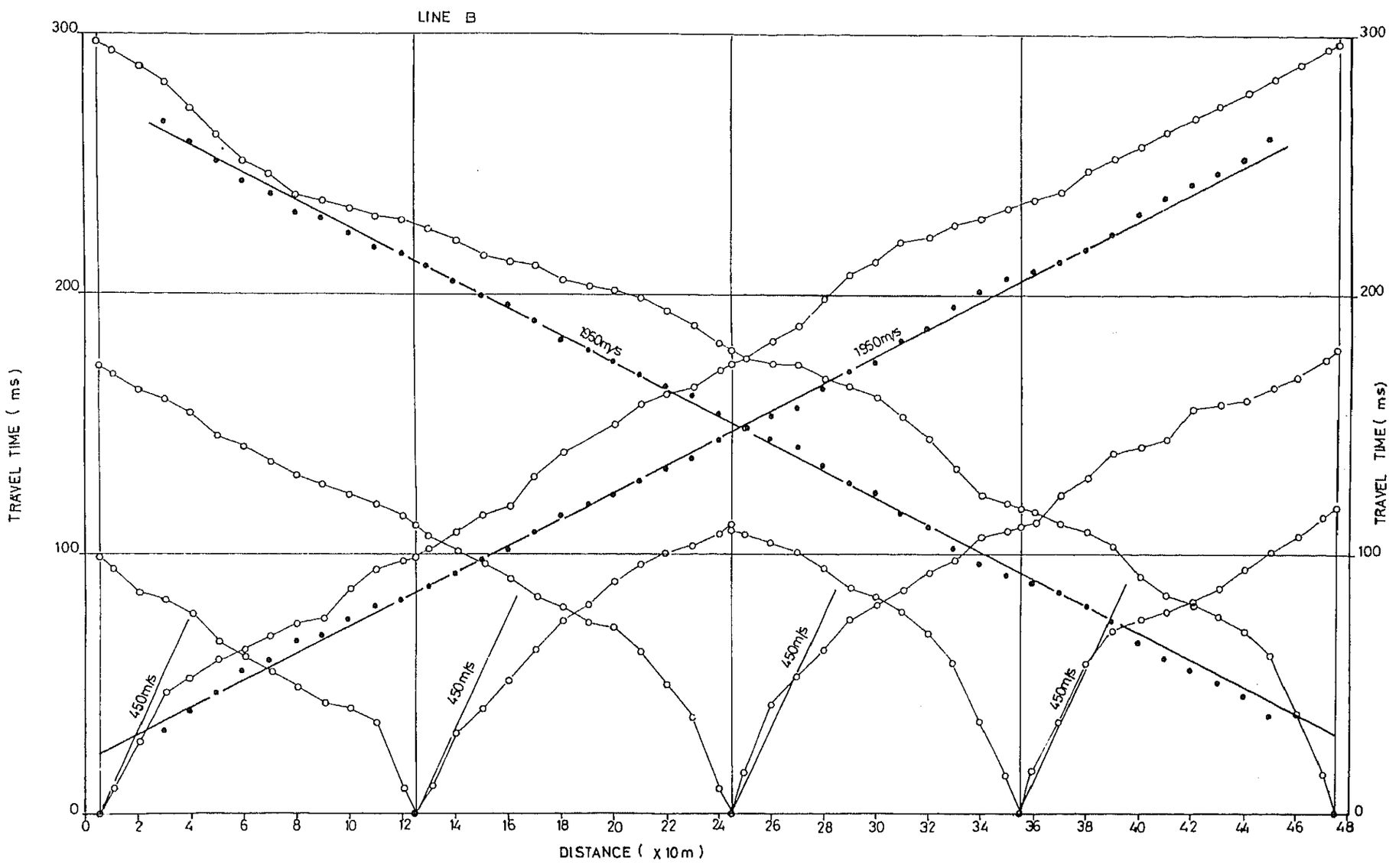


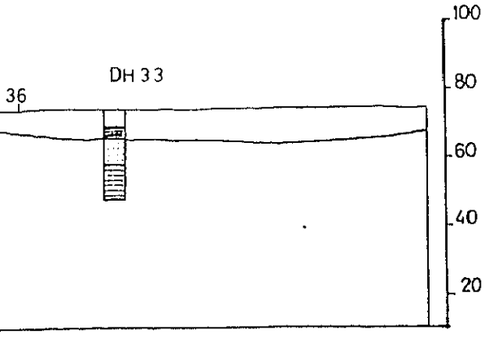


4D-3. SOUTH NAWIN IRRIGATION PROJECT SEISMIC PROSPECTING

TIME TRAVEL RELATIONS AND VELOCITY LAYER STRUCTURE







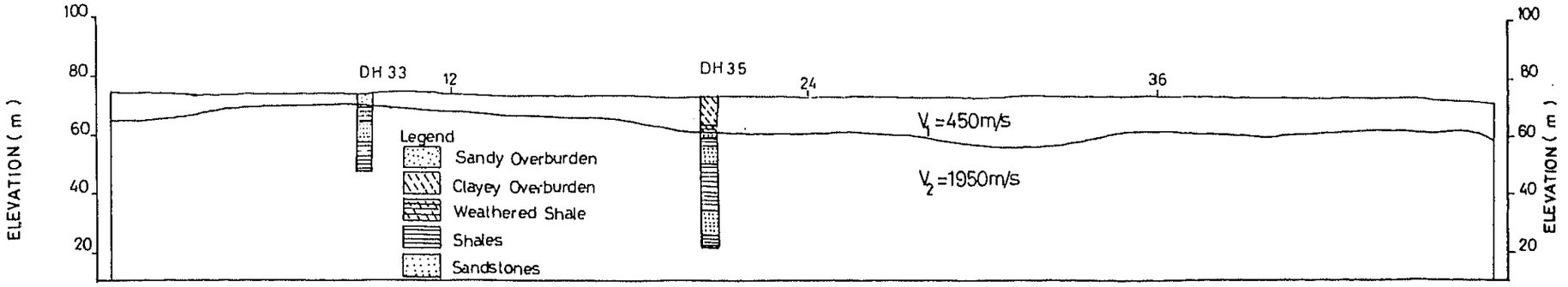
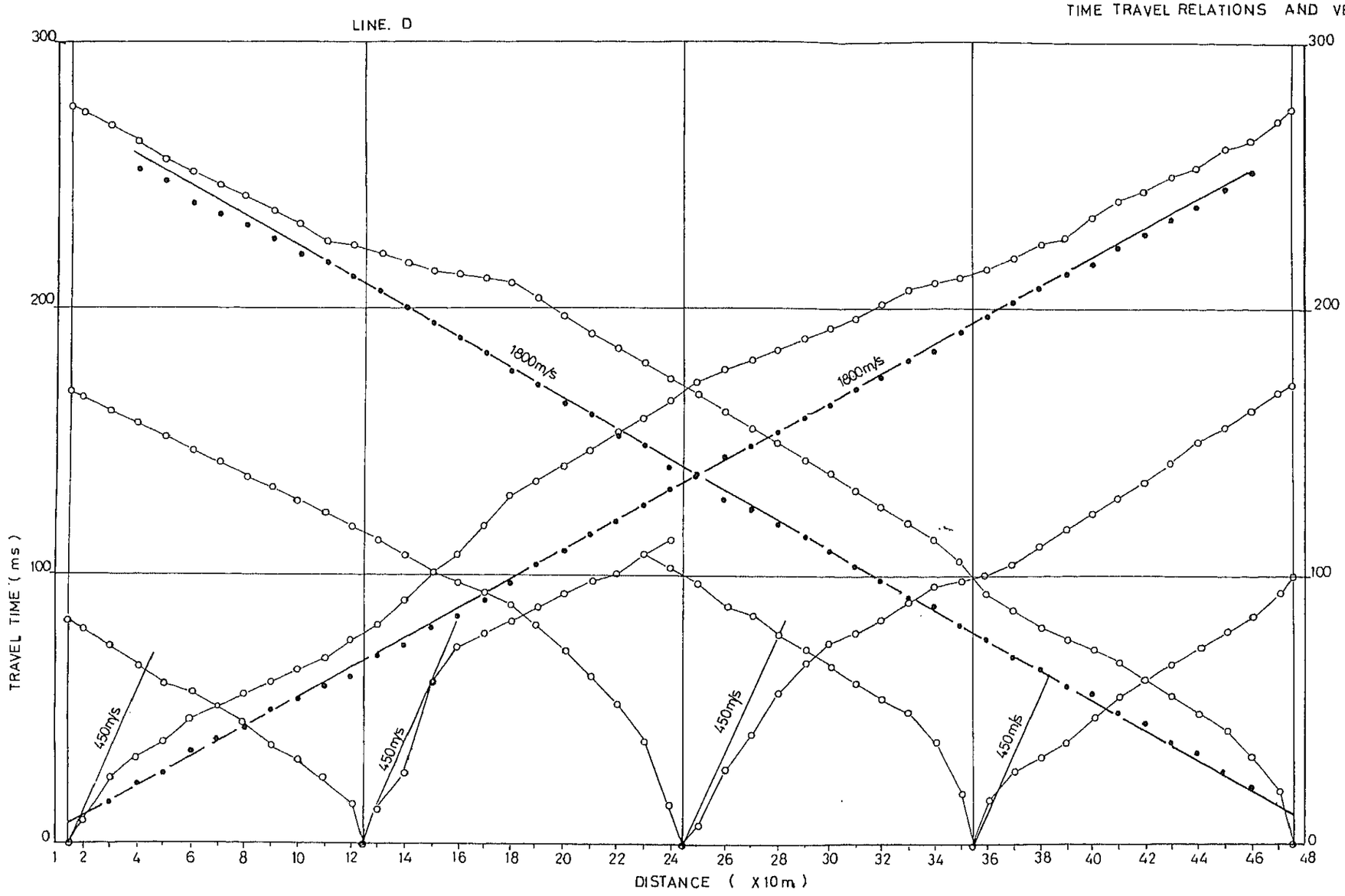
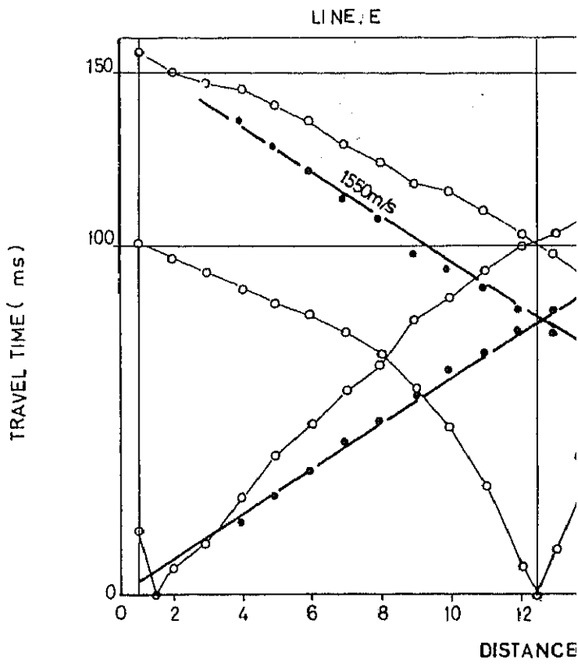
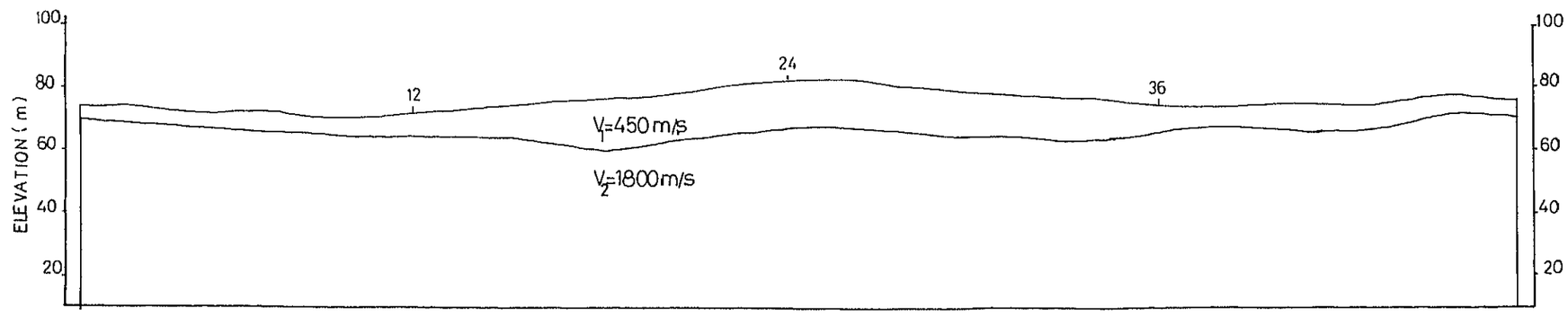


FIG. 4D-4. SOUTH NAWIN IRRIGATION PROJECT SEISMIC PROSPECTING

TIME TRAVEL RELATIONS AND VELOCITY LAYER STRUCTURE







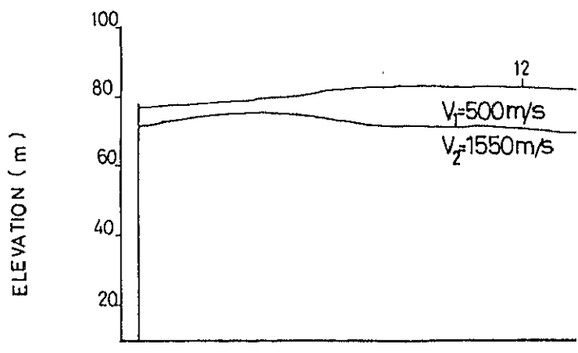
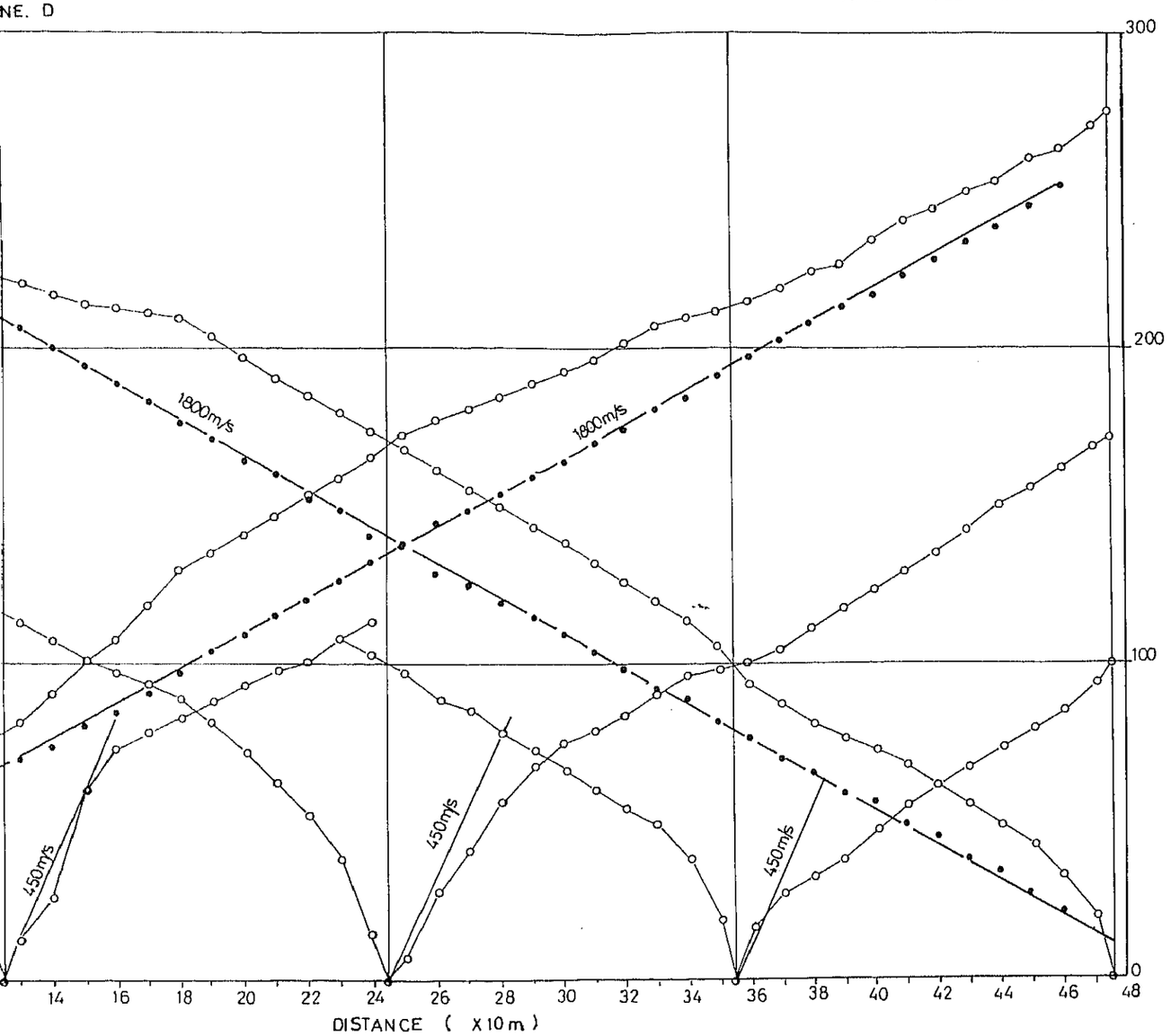


FIG. 4D-4. SOUTH NAWIN IRRIGATION PROJECT SEISMIC PROSPECTING

TIME TRAVEL RELATIONS AND VELOCITY LAYER STRUCTURE



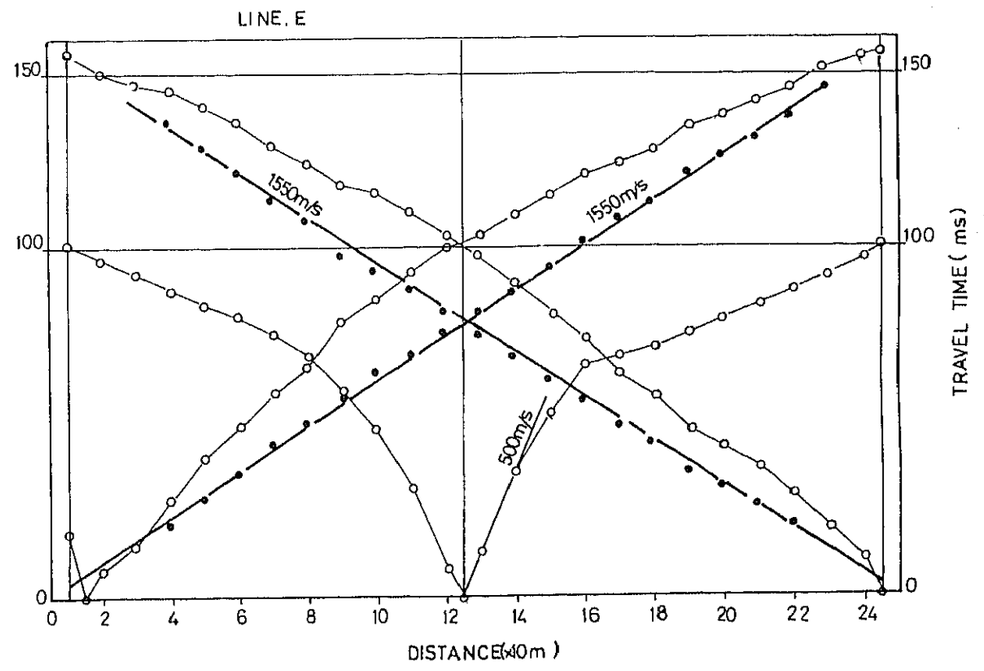
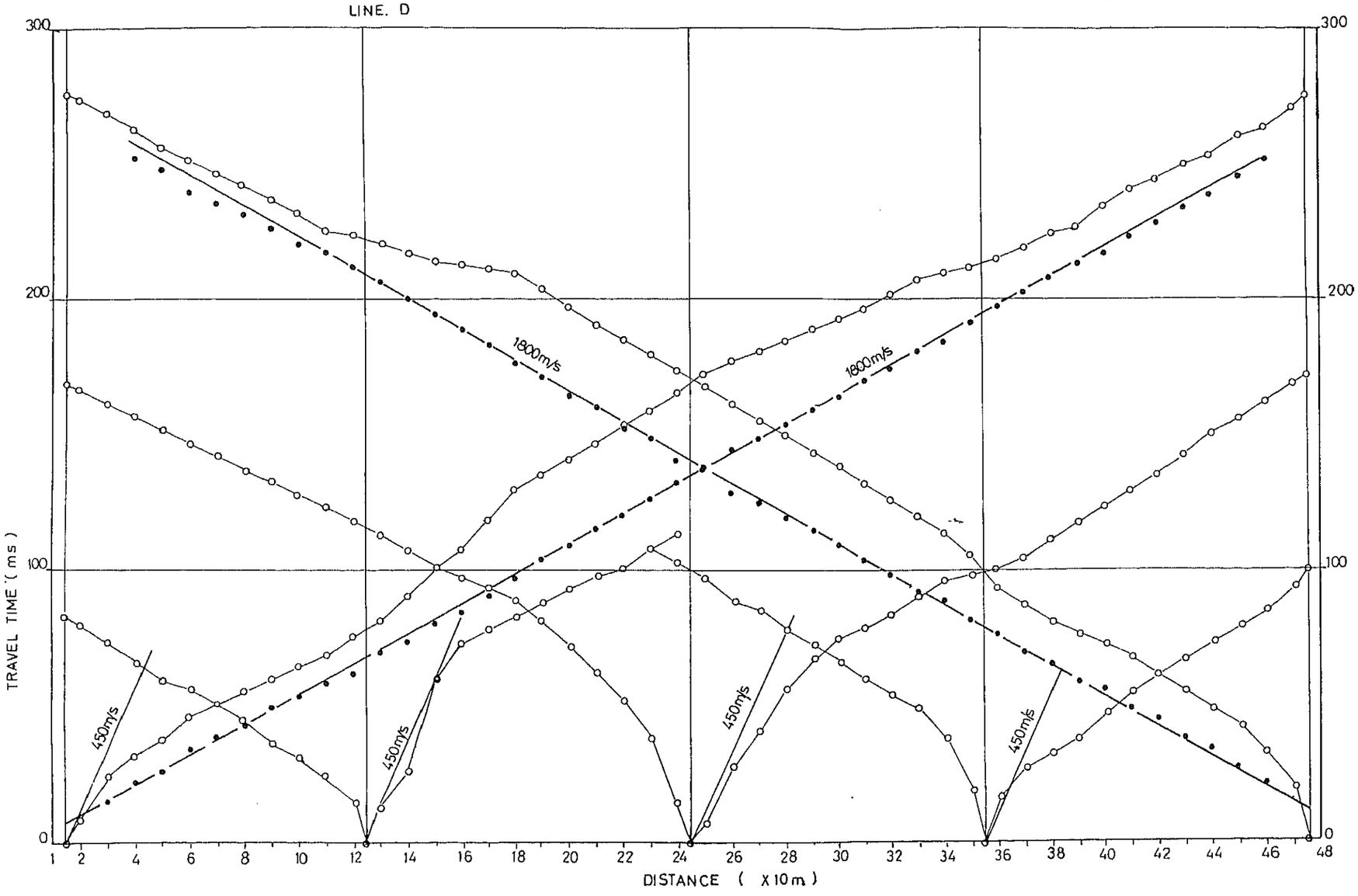
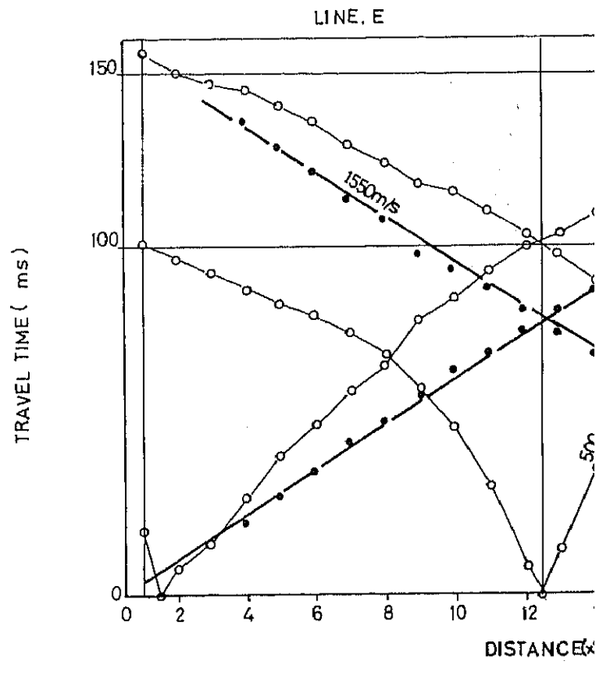
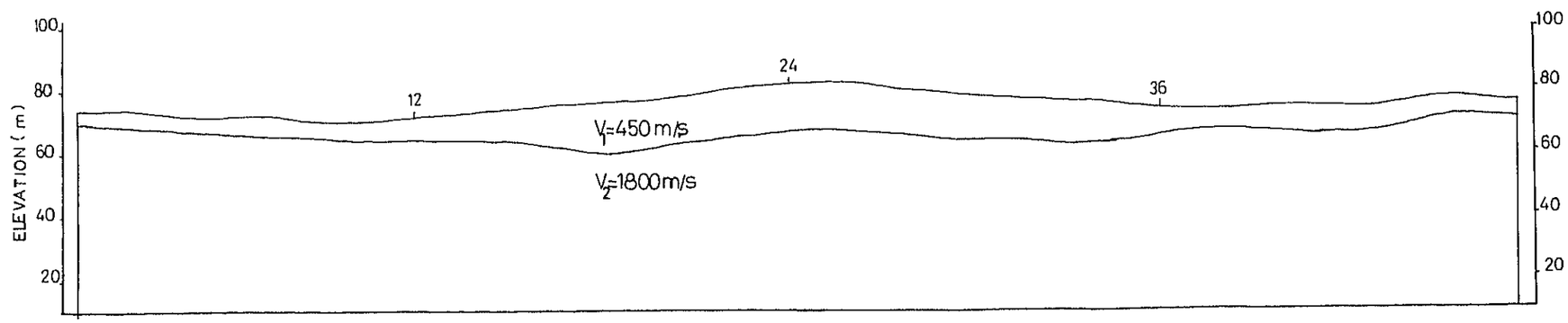


FIG. 4D-4. SOUTH NAWIN IRRIGATION PROJECT SEISMIC PROSPECTING

TIME TRAVEL RELATIONS AND VELOCITY LAYER STRUCTURE







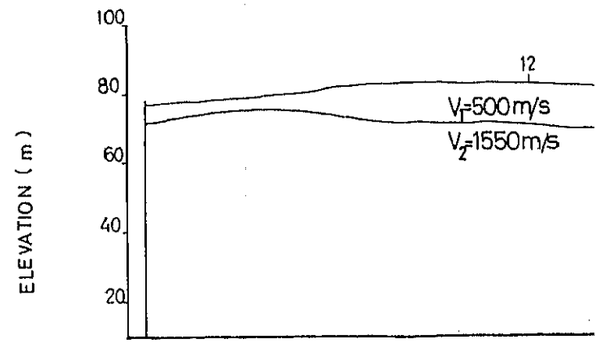
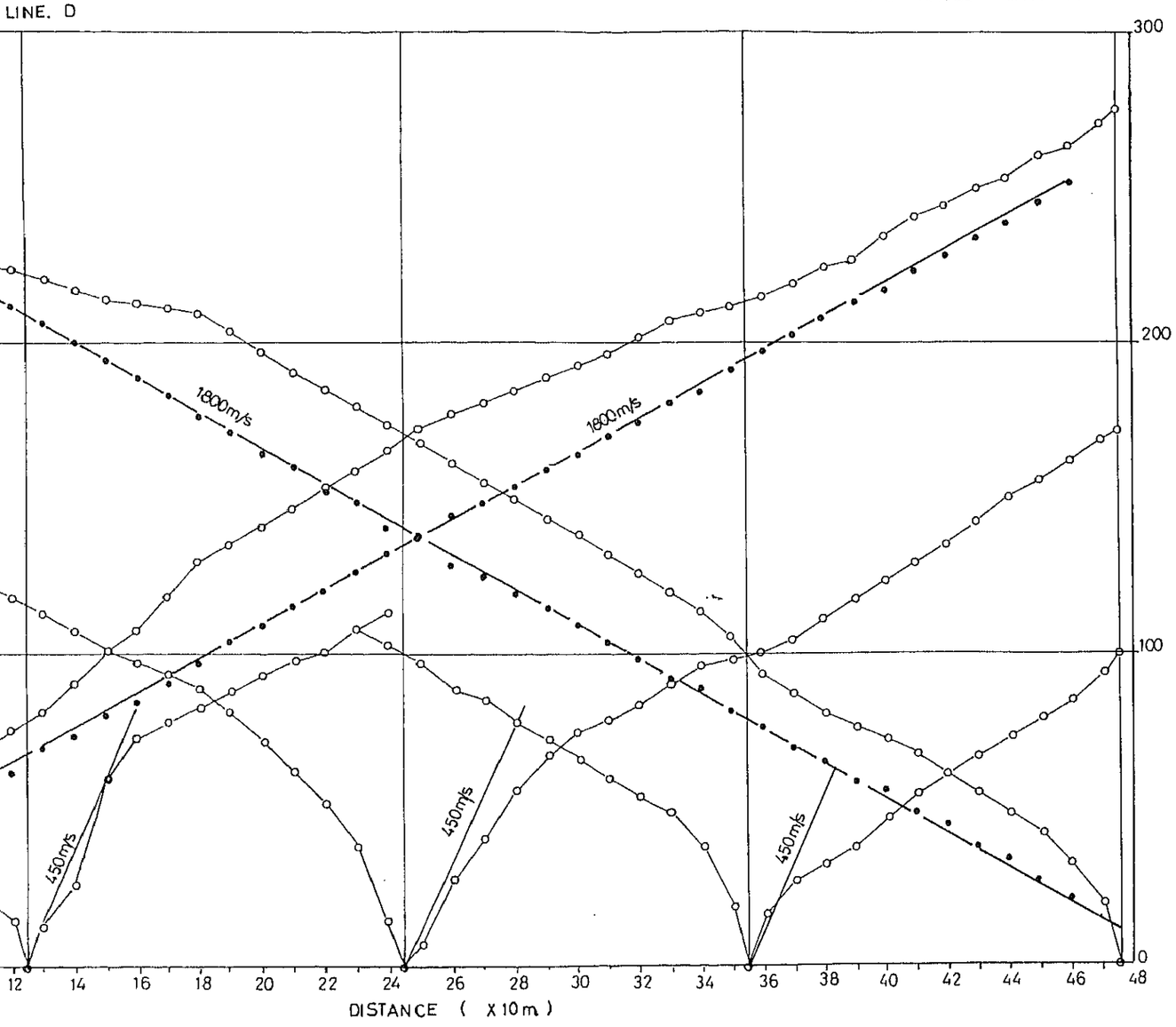
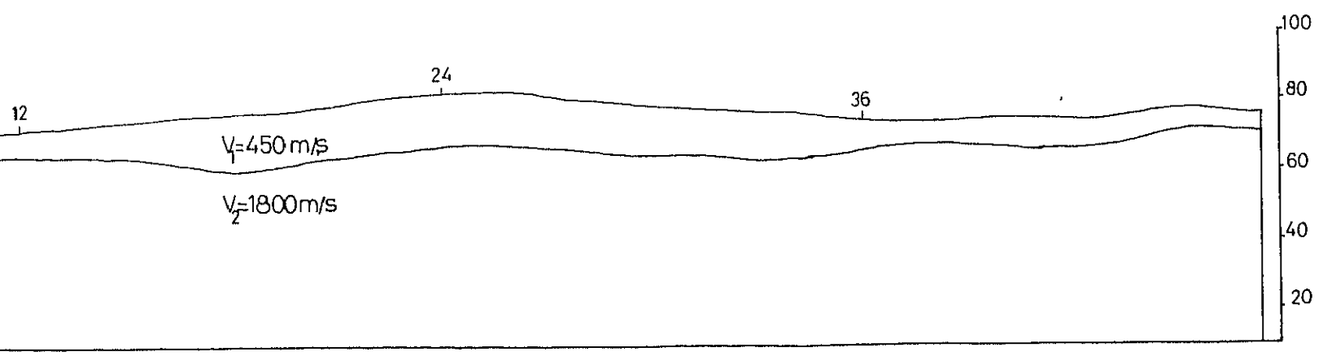
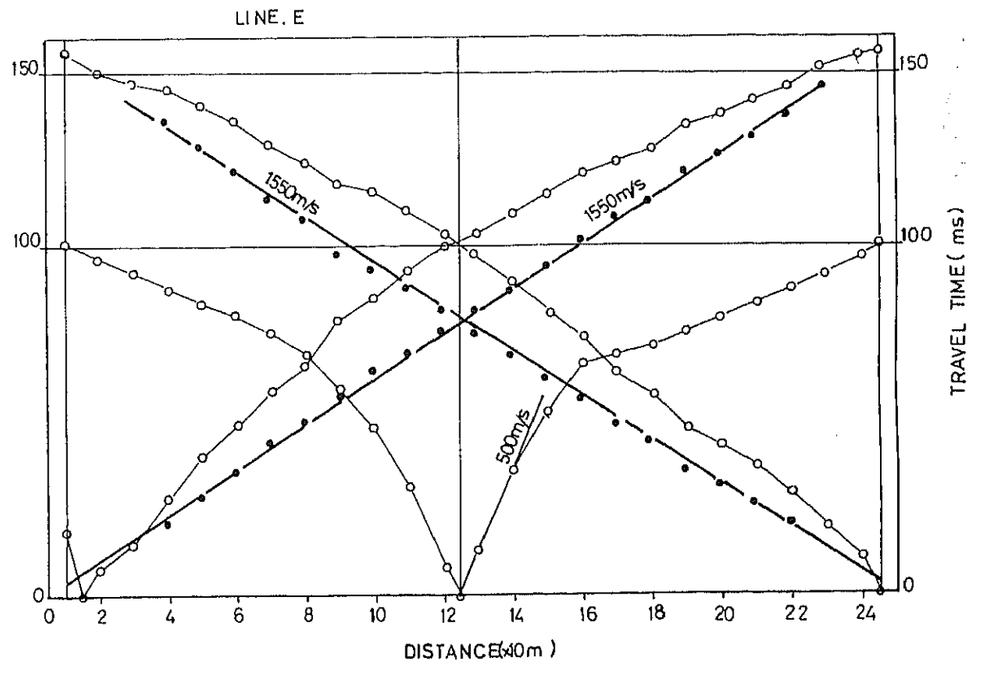


FIG. 4D-4. SOUTH NAWIN IRRIGATION PROJECT SEISMIC PROSPECTING

TIME TRAVEL RELATIONS AND VELOCITY LAYER STRUCTURE







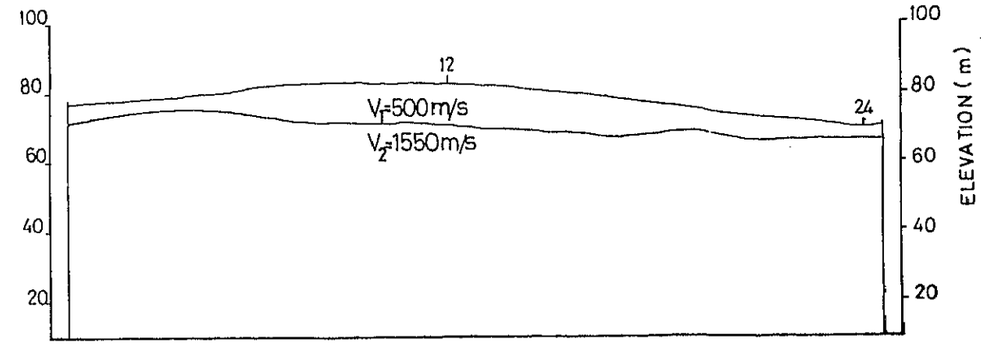


FIG. 4D-5 SOUTH NAWIN IRRIGATION PROJECT. SE

TIME TRAVEL RELATIONS AND VELOCITY LAYE

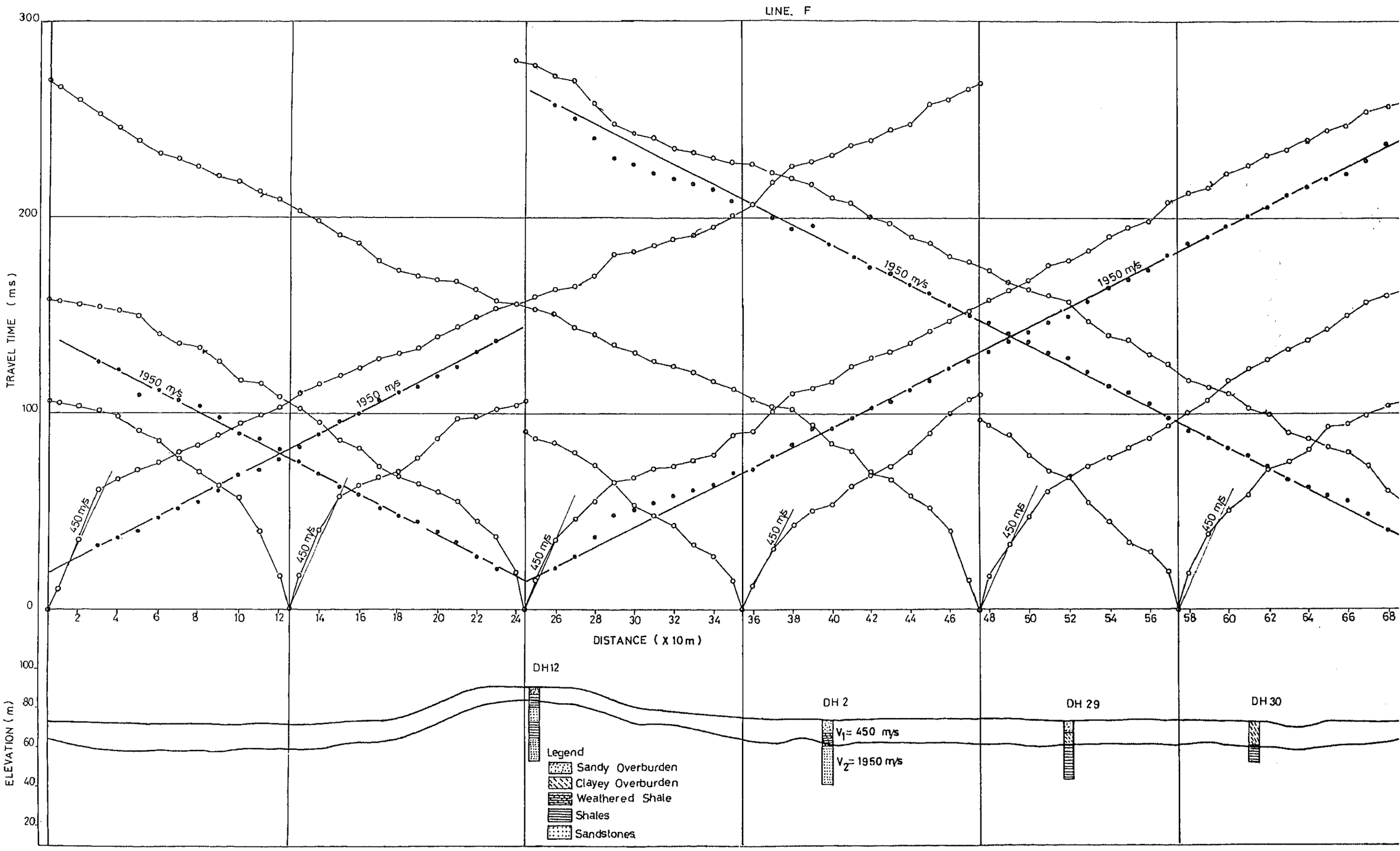
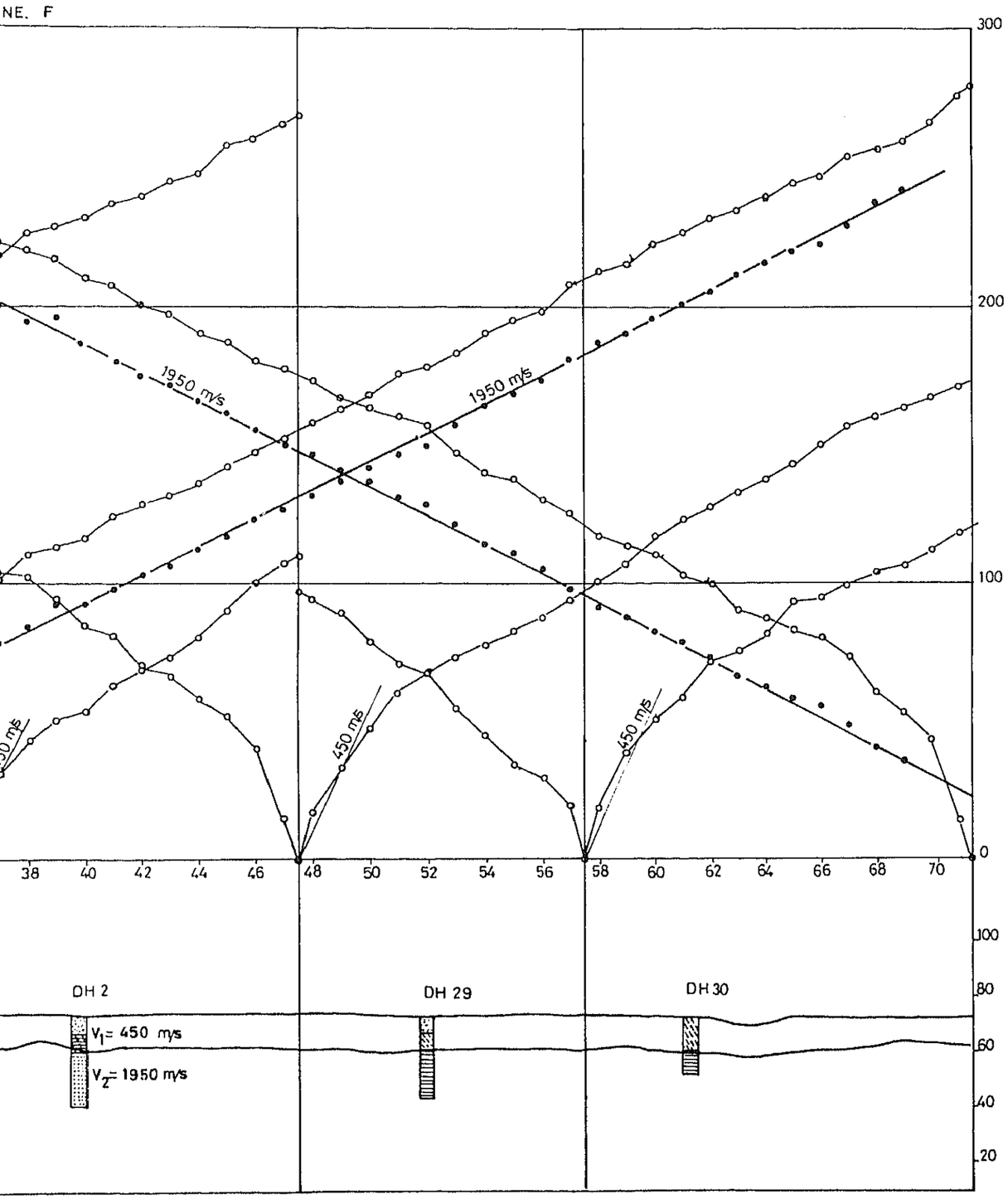


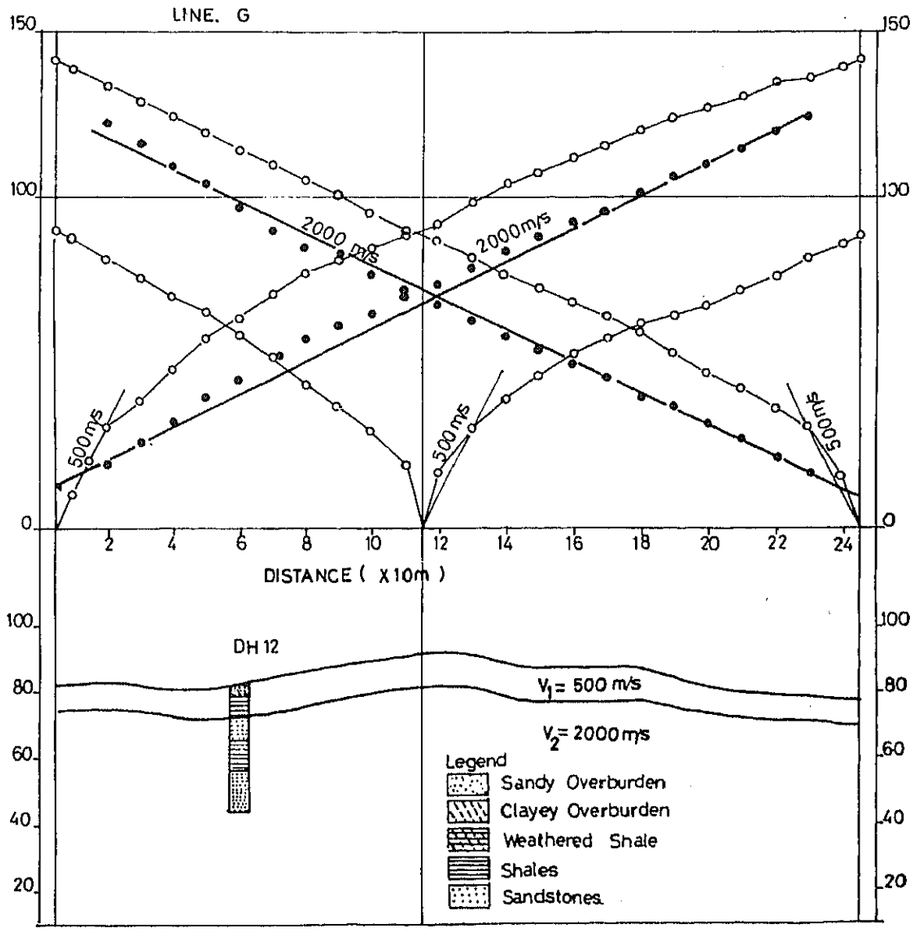
FIG. 4D-5 SOUTH NAWIN IRRIGATION PROJECT. SEISMIC PROSPECTING

TIME TRAVEL RELATIONS AND VELOCITY LAYER STRUCTURE



TRAVEL TIME (ms)

ELEVATION (m)



TRAVEL TIME(ms)

ELEVATION (m)

FIGURE 4D-6. RELATION CURVE BETWEEN DAM HEIGHT AND REQUIRED BEARING CAPACITY, SEISMIC VELOCITY

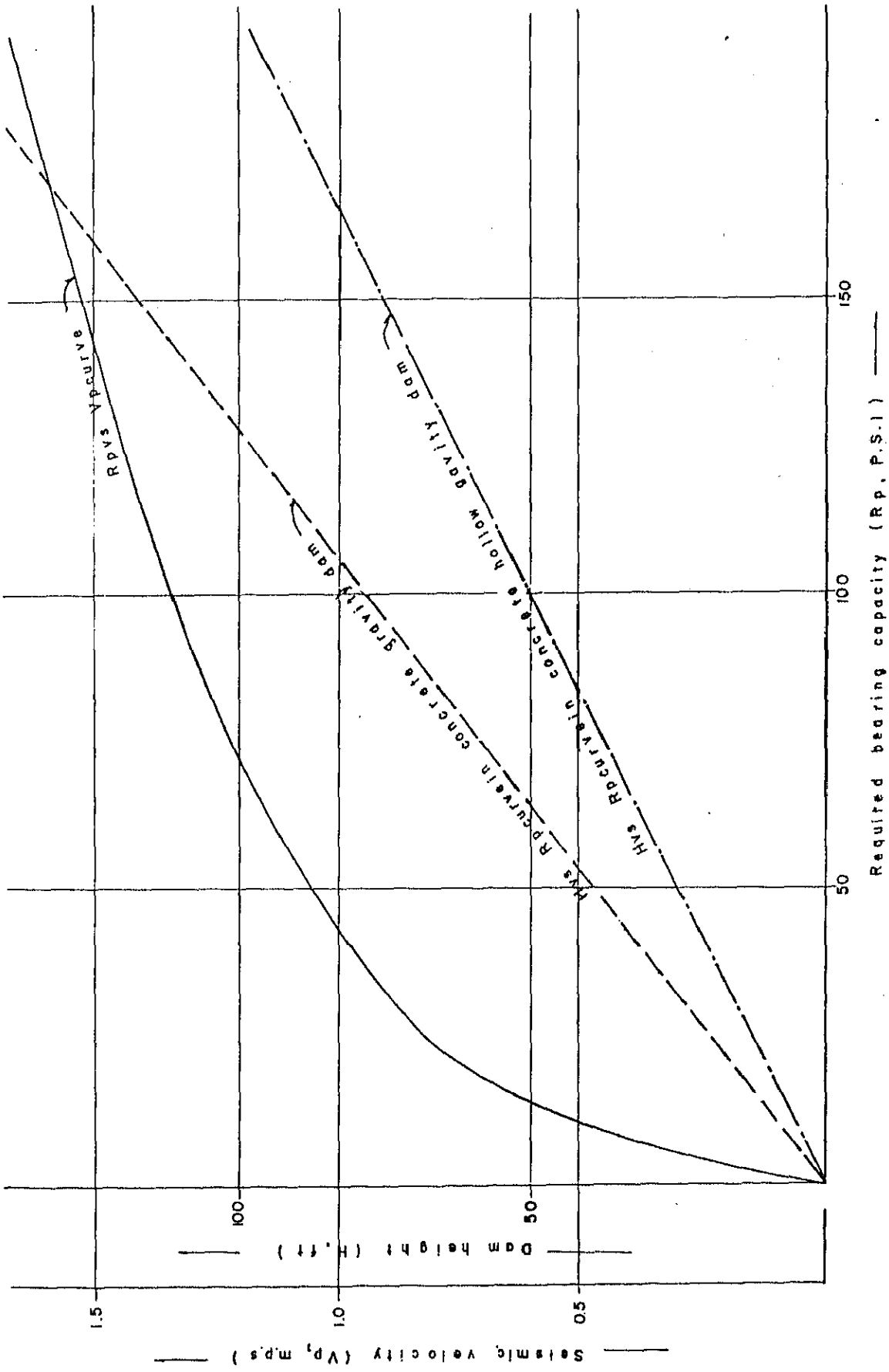


FIG. 4D-7(1)

GEOLOGICAL LOG OF DRILL HOLE

HOLE NO. DH No. 1 (DH1)

PROJECT: SOUTH NAWIN DAM PROJECT. LOCATION: CENTER OF NAWIN CHAUNG.
R.L. GROUND: ______ CO-ORDINATES: ______ ANGLE: ⊥ AZIMUTH: ______
SIZE HOLE: NX

ROCK TYPE	DESCRIPTION	RECOVERY	CORE LOSS	GRAPHIC LOG	STRUCTURES JOINTS, VEINS, FAULTS, ETC.	NOTES WATER LEVEL ETC.	PERCOLATION DEPTH FROM	TO	WATER	LOSS	PRESSURE	LENGTH OF TEST
CHANNEL SANDS	light greyish to greyish, fine to medium grained, micaceous & containing small gravels & silt particles.											
SHALE	Bluish colour, laminated, micaceous shale.											
SANDY SHALE	bluish, laminated fine grained, sands.											
SHALE	Bluish, laminated micaceous. sandstone 1½" band at 43'6" depth.											
SANDY SHALE	bluish laminated micaceous sandy shale											
SHALE	bluish laminated micaceous.											
SANDY SHALE	Bluish, micaceous laminated, contd. organic matter.											
SHALE	bluish, micaceous laminated, contd. organic matter and sandstone lenses											
SANDSTONE	greyish, fine grained micaceous, contd. shale lenses.											
SANDY SHALE	bluish micaceous contd. sandstone fragments.											

DRILL NO.: 6
TYPE: JOY 12-B
DRILLER: TOKE NA
COMMENCED: ______
COMPLETE: ______

LOGGED: ZAW WAI MYINT
SHEET NO.: ______
DRAWN: ______
CHECKED: ______
SUBMITTED: ______

VERT. SCALE: ______
SHEET ___ OF ___
DRAWING NO.: ______

FIG.4D-7(2)

GEOLOGICAL LOG OF DRILL HOLE

HOLE NO. S.H-2 DH 2

PROJECT: South Lawin Dam Project LOCATION
R.L.GROUND — CO-ORDINATES — ANGLE 90° AZIMUTH
SIZE HOLE 4x

ROCK TYPE	DESCRIPTION	STRUCTURES JOINTS, VEINS, FAULTS, ETC.	NOTES WATER LEVEL ETC.
clayey soil	brownish to brownish black, hard, cohesive, roots present		
Shale	Light brownish, brownish, light greyish and greyish blue, laminated, micaceous, contt weathered mica: sand stone fragments.	45 Dip	▽ 40'
Silty sand-stone	Light brownish yellowish brown and greyish, fine grained, micaceous, moderately cemented.		

DRILL NO. 6
TYPE Joy
DRILLER Toke Wa.
COMMENCED 24.4.74
COMPLETE 4.5.74
LOGGED Taw Win Myint
SHEET NO. 1
DRAWN Taw Win Myint
CHECKED
SUBMITTED
VERT. SCALE 1"-10'
SHEET OF
DRAWING NO.

GEOLOGICAL LOG OF DRILL HOLE

HOLE NO. S.H.N.3 DH 3

PROJECT: SOUTH NAWIN DAM PROJECT LOCATION
R.L.GROUND — CO-ORDINATES — ANGLE 90° AZIMUTH
SIZE HOLE NX

ROCK TYPE	DESCRIPTION	STRUCTURES JOINTS, VEINS, FAULTS, ETC.	NOTES WATER LEVEL ETC.
CLAYEY SANDY SOIL	Yellowish brown, fine grained, micaceous.		
SHALE	BROWNISH & BLUISH, LAMINATED, MICACEOUS.	Dip 46; Joint 81	
Silty sst	Yellowish to yellowish brown, fine grained, poorly to moderately cemented.		
Sandstone	Brownish to brownish blue, fine grained with blue clay; argillaceous. At 59'10" depth, bluish shale.	26 dip	
Shale	bluish, hard & compact, fine grained	Joint 83	
Shale	Bluish shale, At 78' depth, bluish argillaceous sst	31 dip	
Sst	Bluish coloured, laminated, argillaceous; with shale band		

DRILL NO. 6
TYPE Joy 12-B
DRILLER Jake Wa
COMMENCED 7.6.74
COMPLETE
LOGGED Tha Win Maung
SHEET NO. 1
DRAWN
CHECKED
SUBMITTED
VERT. SCALE 1"-10'
SHEET OF
DRAWING NO.

FIG.4D-7(3)

GEOLOGICAL LOG OF DRILL HOLE

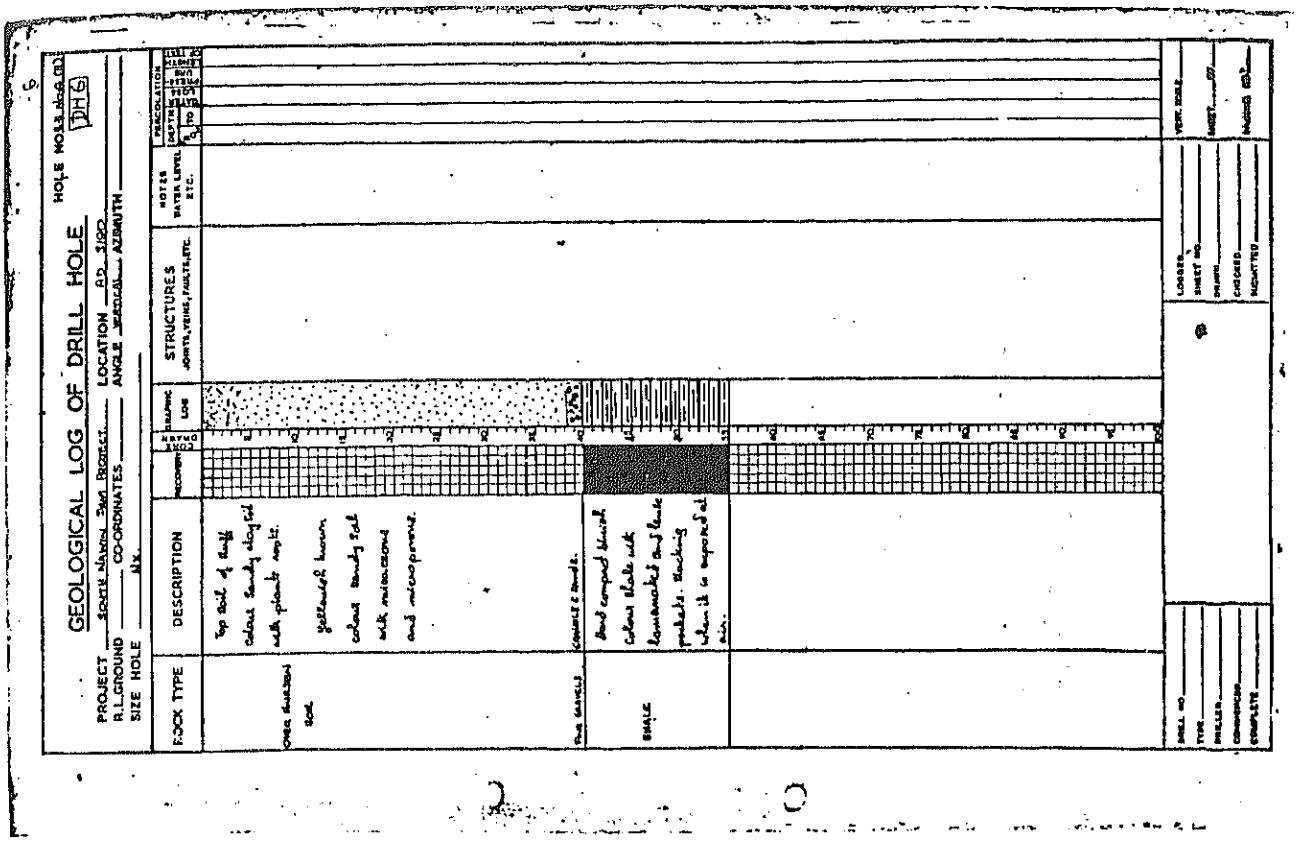
HOLE NO. B.U. No 4 — DH4

PROJECT: South Nawy Dam. LOCATION: R.D. 2900.
R.L. GROUND ______ CO-ORDINATES ______ ANGLE ______ AZIMUTH ______
SIZE HOLE ______

ROCK TYPE	DESCRIPTION	RECOVERY	CORE DEPTH	GRAPHIC LOG	STRUCTURES JOINTS, VEINS, FAULTS, ETC.	NOTES WATER LEVEL ETC.	PERCOLATION
Over burden soil	Yellowish grey colour (or) buff colour top soil. Yellowish colour sandy soil.		0–35				
Loose sands	Bluish grey colour loose sandy clay.		35–40				
Gravels	Fine to medium grade loose gravels 2 mm to 9 mm dia diameter.		40–100			Average K. of gravels ≈ 3000 ft/y.	
Gravels			100–110		110'		
Shale	Bluish grey colour argillaceous shale. Dipping 40° respective from core axis. Argillaceous shale are slacking when exposed at air.		110–150		40° ; 150'		← IMPERVIOUS SHALE K = 5 ft/y →

DRILL NO. ______		LOGGED ______	VERT. SCALE ______
TYPE ______		SHEET NO. ______	SHEET ____ OF ____
DRILLED ______		DRAWN ______	
COMMENCED ______		CHECKED ______	DRAWING NO. ______
COMPLETE ______		SUBMITTED ______	

FIG. 4D-7(4)


GEOLOGICAL LOG OF DRILL HOLE
HOLE NO. S.H. No. 6
DH 6
PROJECT South Navoi Dam Project
LOCATION
R.L. GROUND
COORDINATES
ANGLE
AZIMUTH
SIZE HOLE
N.S.
ROCK TYPE
DESCRIPTION
RECOVERY
GRAPHIC LOG
STRUCTURES JOINTS, VEINS, FAULTS, ETC.
NOTES WATER LEVEL ETC.
PERCOLATION
DRILL NO.
TYPE
DRILLER
COMMENCED
COMPLETE
LOGGED
SHEET NO.
DRAWN
CHECKED
SUBMITTED
VERT. SCALE
SHEET
DRAWING NO.

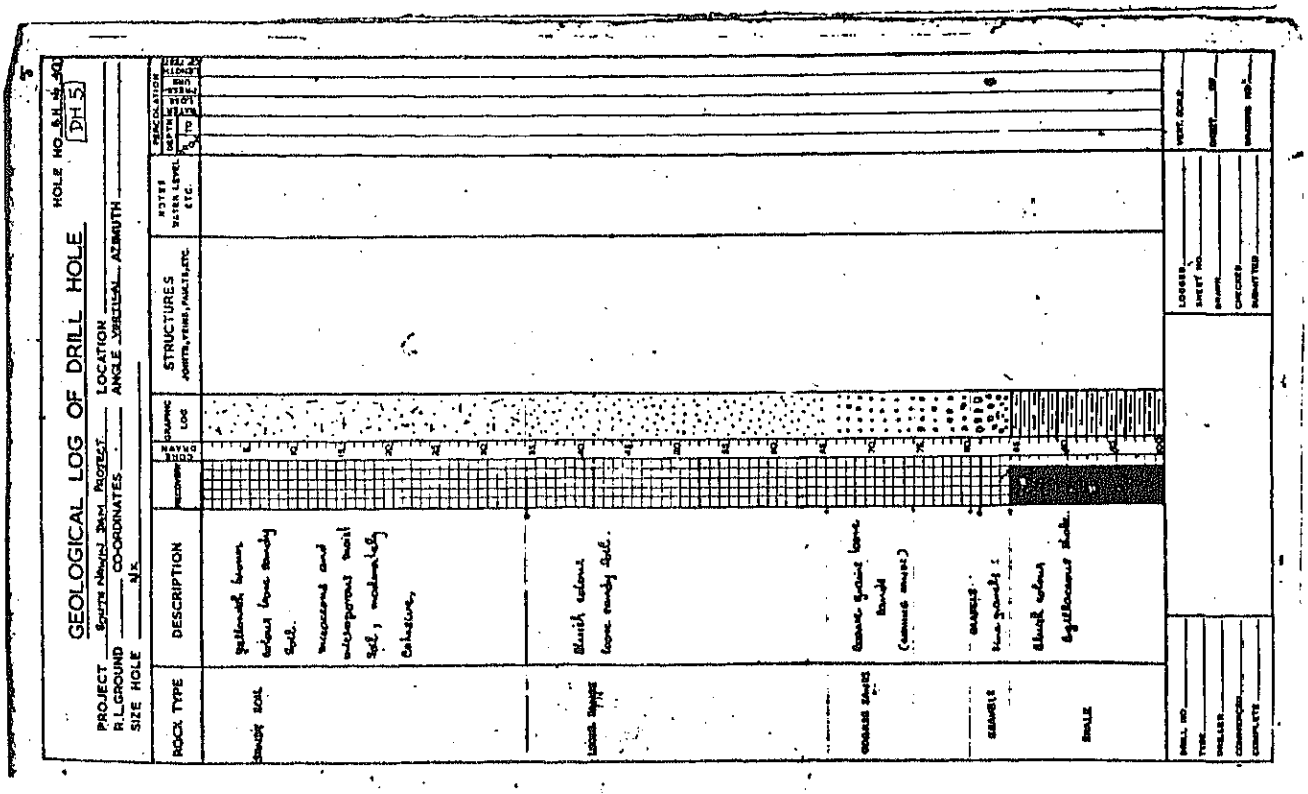
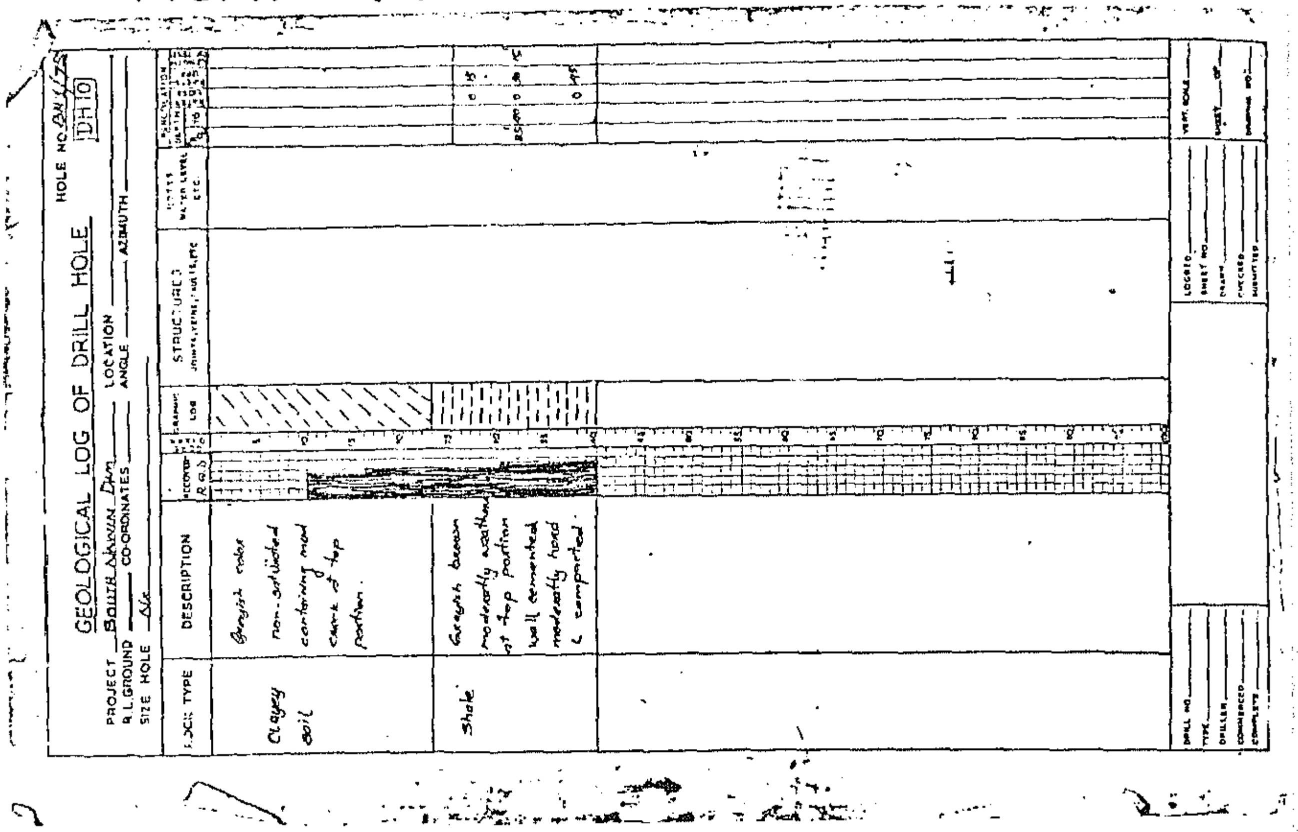

GEOLOGICAL LOG OF DRILL HOLE
HOLE NO. S.H. No. 5
DH 5
PROJECT South Navoi Dam Project
LOCATION
R.L. GROUND
COORDINATES
ANGLE VERTICAL AZIMUTH
SIZE HOLE
N.S.
ROCK TYPE
DESCRIPTION
RECOVERY
GRAPHIC LOG
STRUCTURES JOINTS, VEINS, FAULTS, ETC.
NOTES WATER LEVEL ETC.
PERCOLATION
DRILL NO.
TYPE
DRILLER
COMMENCED
COMPLETE
LOGGED
SHEET NO.
DRAWN
CHECKED
SUBMITTED
VERT. SCALE
SHEET
DRAWING NO.

FIG.4D-7(5)


GEOLOGICAL LOG OF DRILL HOLE
HOLE NO. DH10
PROJECT South Nawin Dam
R.L.GROUND
CO-ORDINATES
LOCATION
ANGLE
AZIMUTH
SIZE HOLE
ROCK TYPE
DESCRIPTION
STRUCTURES
JOINTS, VEINS, FAULTS, ETC
NOTES
WATER LEVEL ETC.
PERCOLATION
Clayey soil
Greyish color non-solidated containing mud cake at top portion.
Shale
Greyish brown moderately weathered at top portion well cemented moderately hard & compacted.

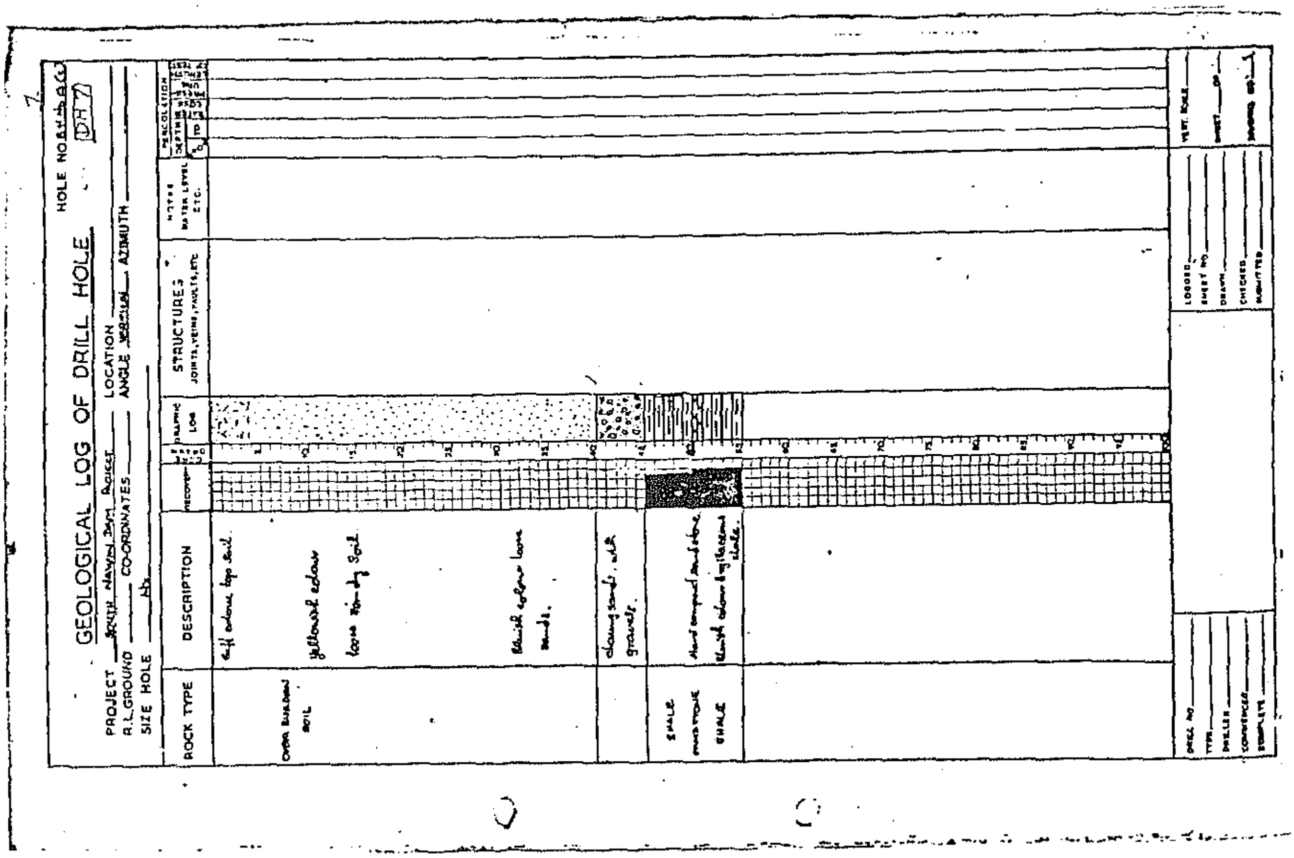

GEOLOGICAL LOG OF DRILL HOLE
HOLE NO. DH7
PROJECT South Nawin Dam Project
R.L.GROUND
CO-ORDINATES
LOCATION
ANGLE vertical
AZIMUTH
SIZE HOLE
ROCK TYPE
DESCRIPTION
STRUCTURES
JOINTS, VEINS, FAULTS, ETC
NOTES
WATER LEVEL ETC.
PERCOLATION
OVER BURDEN SOIL
SHALE
SANDSTONE
SHALE
Buff colour top soil.
Yellowish colour loose sandy soil.
Bluish colour loose sands.
clayey sands with gravels.
Hard compact sandstone.
Bluish colour argillaceous shale.

FIG.4D-7(6)

GEOLOGICAL LOG OF DRILL HOLE

HOLE NO. [illegible] DH8

PROJECT [illegible] LOCATION R.D 3300
R.L GROUND ______ CO-ORDINATES ______ ANGLE ______ AZIMUTH ______
SIZE HOLE NX

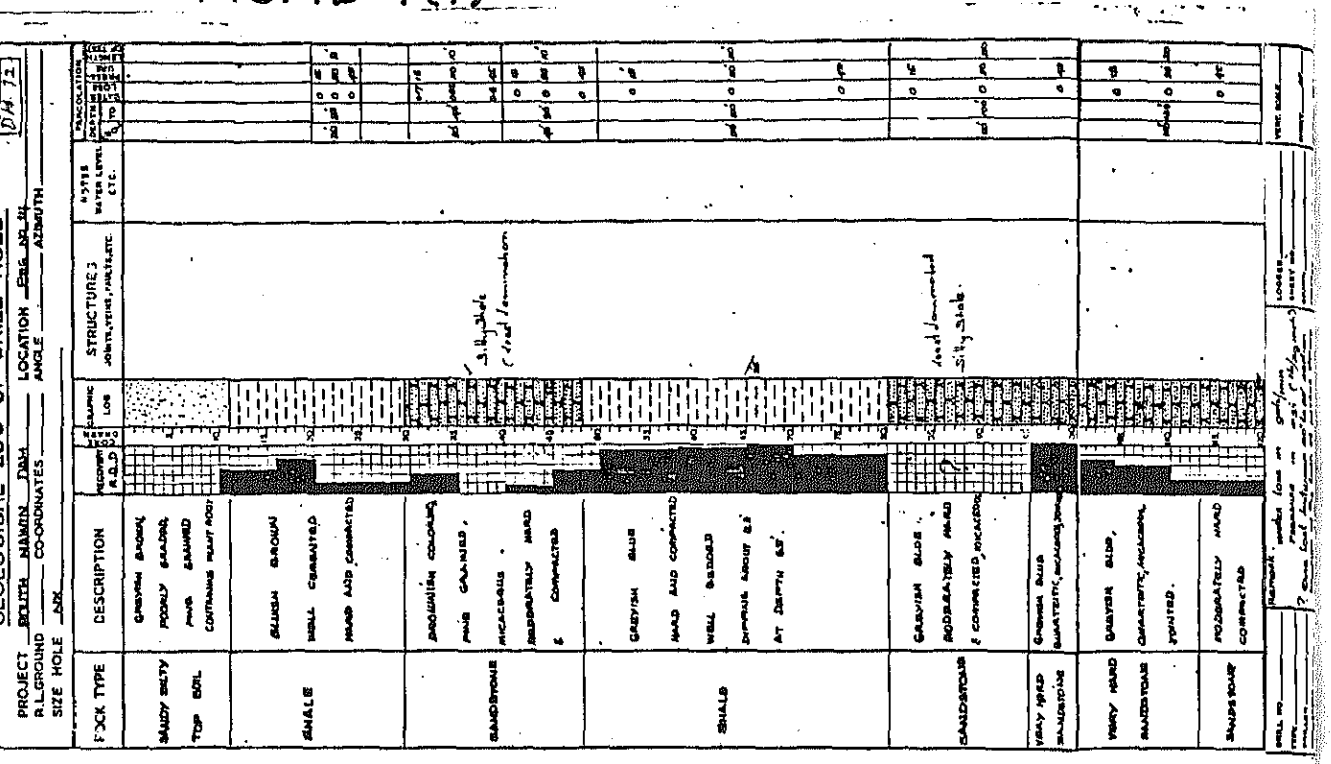
ROCK TYPE	DESCRIPTION	STRUCTURES JOINTS, VEINS, FAULTS, ETC	NOTES WATER LEVEL ETC.	PERMEATION DEPTH FROM	TO	WATER LOSS	PRESS.	LENGTH OF TEST
OVERBURDEN SOIL	yellowish brown colour sandy soil. Soil thickness is upto 27' depth.							
						7.2	10	
SANDY SHALE	yellowish brown colour weathered and micaceous sandy pockets and lenses are contain in it.			20	40	18	20	20
						6.5	30	
SHALE	Bluish grey colour shale; shale is hard and compact, sandy patches are in shale. Coefficient of permeability is nearly impervious at 50 p.s.i of pressure unit.	No joints. Two distinct joints have been seen in 72' and 78' dipping 70' and 40' from core axis		40	60	← IMPERVIOUS →	K = < 5 ft/year	20
						3.9	15	
				60	80	4.9	30	20
						7.4	45	
						1.20	10	
				80	100	7.8	20	20
						2.4	40	
SAND STONE	Bluish grey colour hard compact sand stone with fossils.			100	120	IMPERVIOUS	K = < 2 ft/yr.	20
SAND STONE	Bluish grey colour micaceous sand stone thin shale band are intercalation in the sand stone.					1.0	5	
						2.1	10	
				130	150	4.6	40	20
						7.4	60	

DRILL NO. ______
TYPE ______
DRILLER ______
COMMENCED ______
COMPLETED ______

LOGGED ______
SHEET NO. ______
DRAWN ______
CHECKED ______
SUBMITTED ______

VERT. SCALE ______
SHEET ___ OF ___
DRAWING NO. ______

FIG. 4D-7(7)


GEOLOGICAL LOG OF DRILL HOLE
HOLE NO. BH 5/75
DH 12
PROJECT SOUTH NAMMA DAM
R.L. GROUND
SIZE HOLE
LOCATION
ANGLE
AZIMUTH
CO-ORDINATES
ROCK TYPE
DESCRIPTION
RECOVERY %
GRAPHIC LOG
STRUCTURES
WATER LEVEL ETC.
PERCOLATION
SANDY SILTY TOP SOIL
SHALE
SANDSTONE
VERY HARD SANDSTONE
SANDSTONE

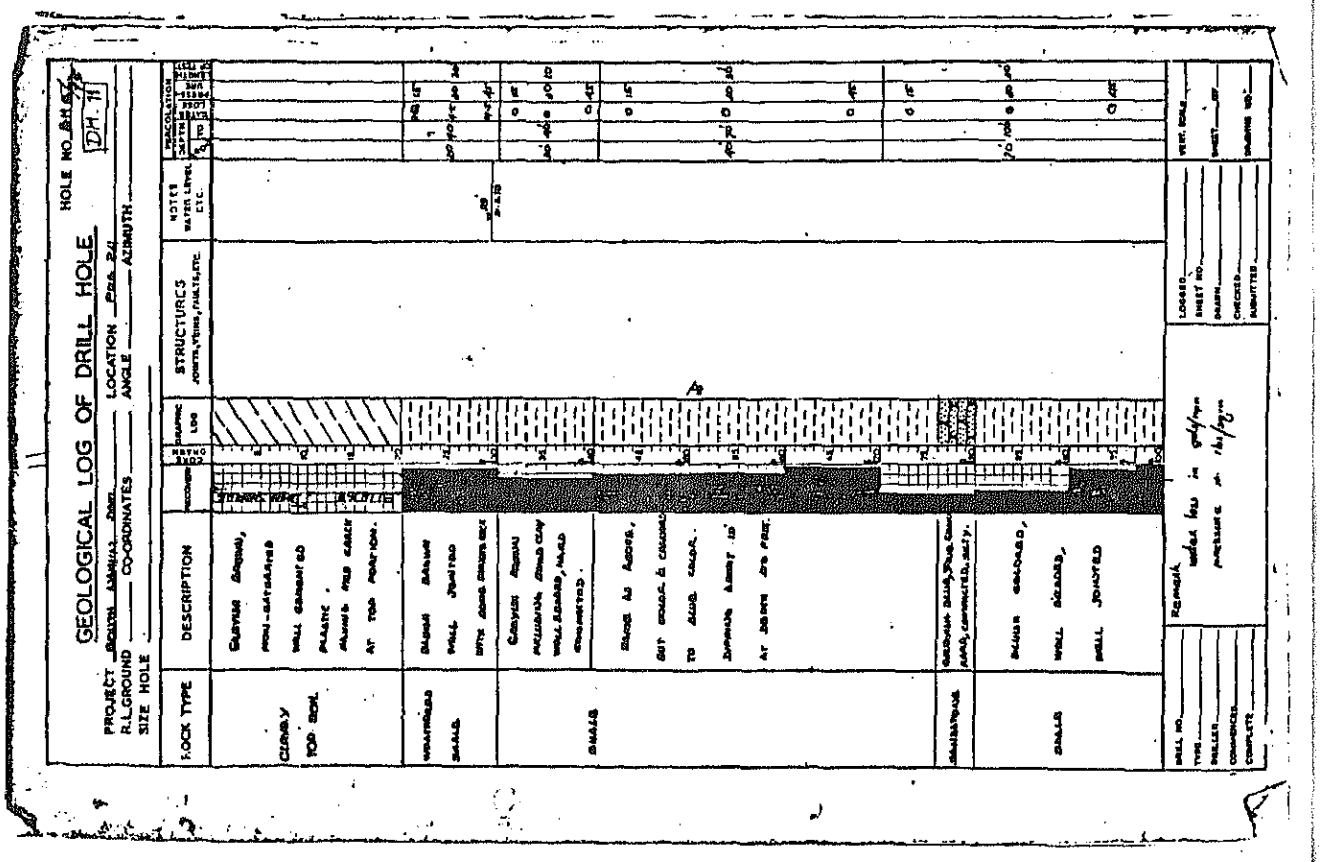

GEOLOGICAL LOG OF DRILL HOLE
HOLE NO. BH 5/75
DH 11
PROJECT SOUTH NAMMA DAM
R.L. GROUND
SIZE HOLE
LOCATION
ANGLE
AZIMUTH
CO-ORDINATES
ROCK TYPE
DESCRIPTION
RECOVERY %
GRAPHIC LOG
STRUCTURES
WATER LEVEL ETC.
PERCOLATION
CLAYEY TOP SOIL
WEATHERED SHALE
SHALE
SANDSTONE
SHALE

FIG. 4D-7(8)

13

GEOLOGICAL LOG OF DRILL HOLE

HOLE NO. BH4 [DH13]

PROJECT SOUTH HAWAN DAM LOCATION CHAWA ROD
R.L.GROUND ______ CO-ORDINATES ______ ANGLE ______ AZIMUTH ______
SIZE HOLE ______

ROCK TYPE	DESCRIPTION
CHANNEL SAND	BROWNISH, POROUS, PERMEABLE CONTAINING SMALL GRAVEL
SILTY SAND	FINE GRAINED, LOOSE BROWNISH.
SHALE	BLUISH GREY, WELL BEDDED CONSOLIDATED, COMPACTED, BRITTLE, MICACEOUS (MUSCOVITE) WELL CEMENTED, MOIST.
	WITH OCCASIONAL SILTY SAND BLUISH GREY. MOSTLY [illegible] BIOTITE MICA.
	HARD, COMPACTED, WELL GRADED, CONTAINING BIOTITE MICA.
SANDSTONE	BLUISH GREY, FINE GRAINED HARD AND COMPACTED, FOUND VERY HARD AND COMPACTED SANDSTONE BETWEEN 68' & 86'8" WELL JOINTED NEARLY HORIZONTAL
	SAME AS ABOVE, BUT SILT AMOUNT MORE THAN ABOVE PORTION, BRITTLE MODERATELY HARD AND COMPACTED. 4" THICK SHALE BAND AT DEPTH 98'.
SHALE	bluish grey, well bedded hard & compacted homogeneous. well cemented, moist micaceous. indistinct stratification dipping about 20° at 113' 6" depth
SHALE [illegible] & THIN SANDSTONE BAND	bluish grey, jointed hard & compacted dipping about 25°

STRUCTURES (JOINTS, VEINS, FAULTS, ETC.) — NOTES (WATER LEVEL ETC.) — PERCOLATION (DEPTH FROM / TO, WATER LOSS, PRESSURE, UNIT, LENGTH OF TEST)

DRILL NO. ______	LOGGED ______
TYPE ______	SHEET NO. ______
DRILLER ______	DRAWN ______
COMMENCED ______	CHECKED ______
COMPLETE ______	SUBMITTED ______

Remark
water loss in gals/min
pressure in lbs/sq in

VERT. SCALE ______
SHEET ____ OF ____
DRAWING NO. ______

FIG. 4D-7(9)

14

GEOLOGICAL LOG OF DRILL HOLE

HOLE NO. DH 14

PROJECT: South Nawin Dam LOCATION:
R.L. GROUND: CO-ORDINATES: ANGLE: Vertical AZIMUTH:
SIZE HOLE: NX

ROCK TYPE	DESCRIPTION	R.Q.D. RECOVERY %	CORE GRADE	GRAPHIC LOG	STRUCTURES JOINTS, VEINS, FAULTS, ETC.	NOTES WATER LEVEL ETC.	PERCOLATION
Top soil	Yellowish brown colour silty soil with plant roots.						
Sandy soil	Yellowish brown colour sandy soil					40' / 11-6-78	
Sands	Bluish colour loose sands with mica						
Coarse sands	Bluish colour coarse sands.						
Sandy shale	Arenaceous shale.						
Shale	Light greyish bluish blue, laminated micaceous, compact shale.						IMPERVIOUS.
Shale.	Bluish grey colour hard compact impervious shale.						

DRILL NO.: Joy 12 B.		LOGGED: [illegible]	VERT. SCALE:
TYPE: Diesel		SHEET NO.:	SHEET ___ OF ___
DRILLER: [illegible]		DRAWN: [illegible]	
COMMENCED:		CHECKED:	DRAWING NO.:
COMPLETE: 10-3-78		SUBMITTED:	

FIG. 4D-7(10)

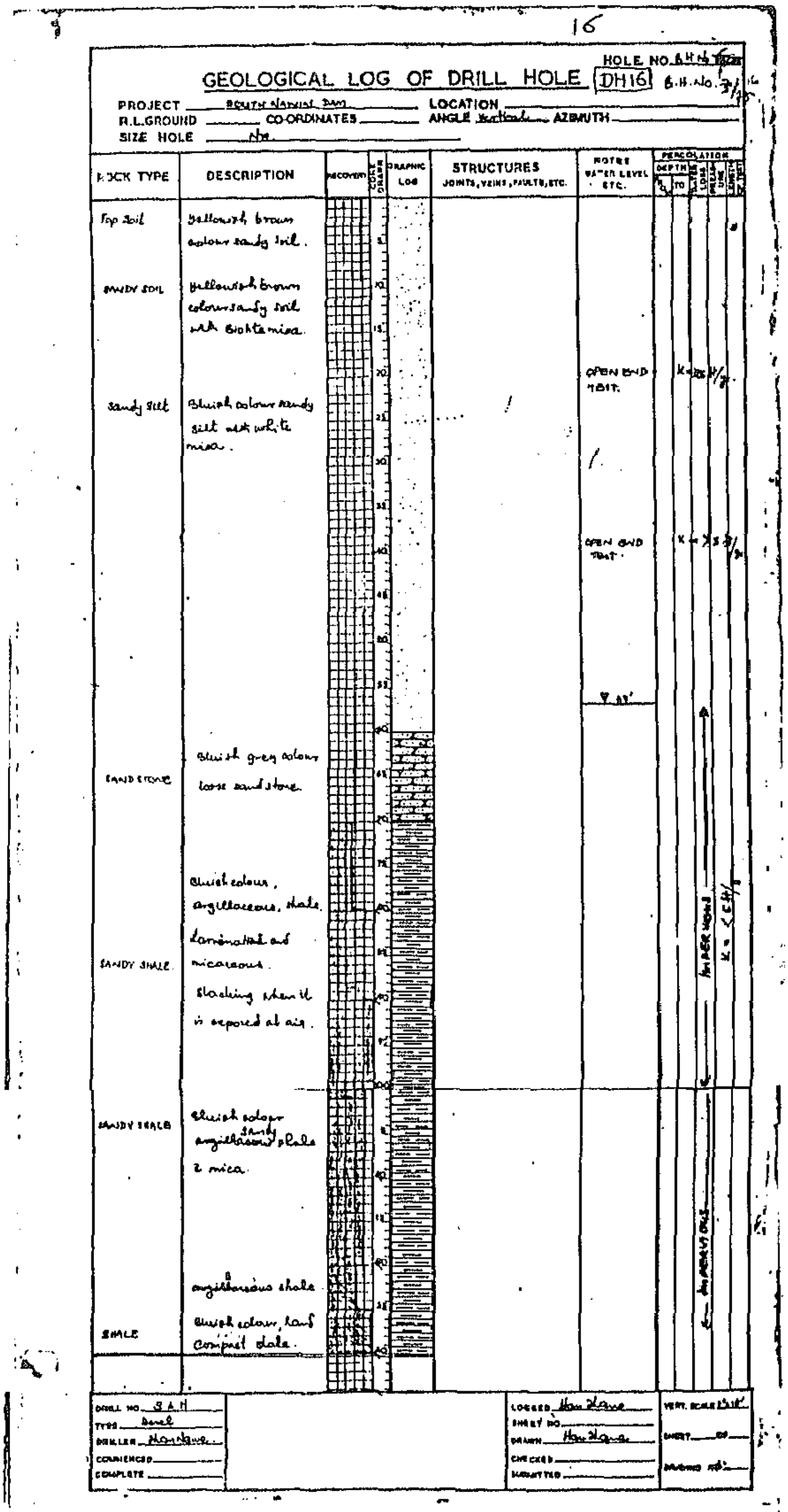
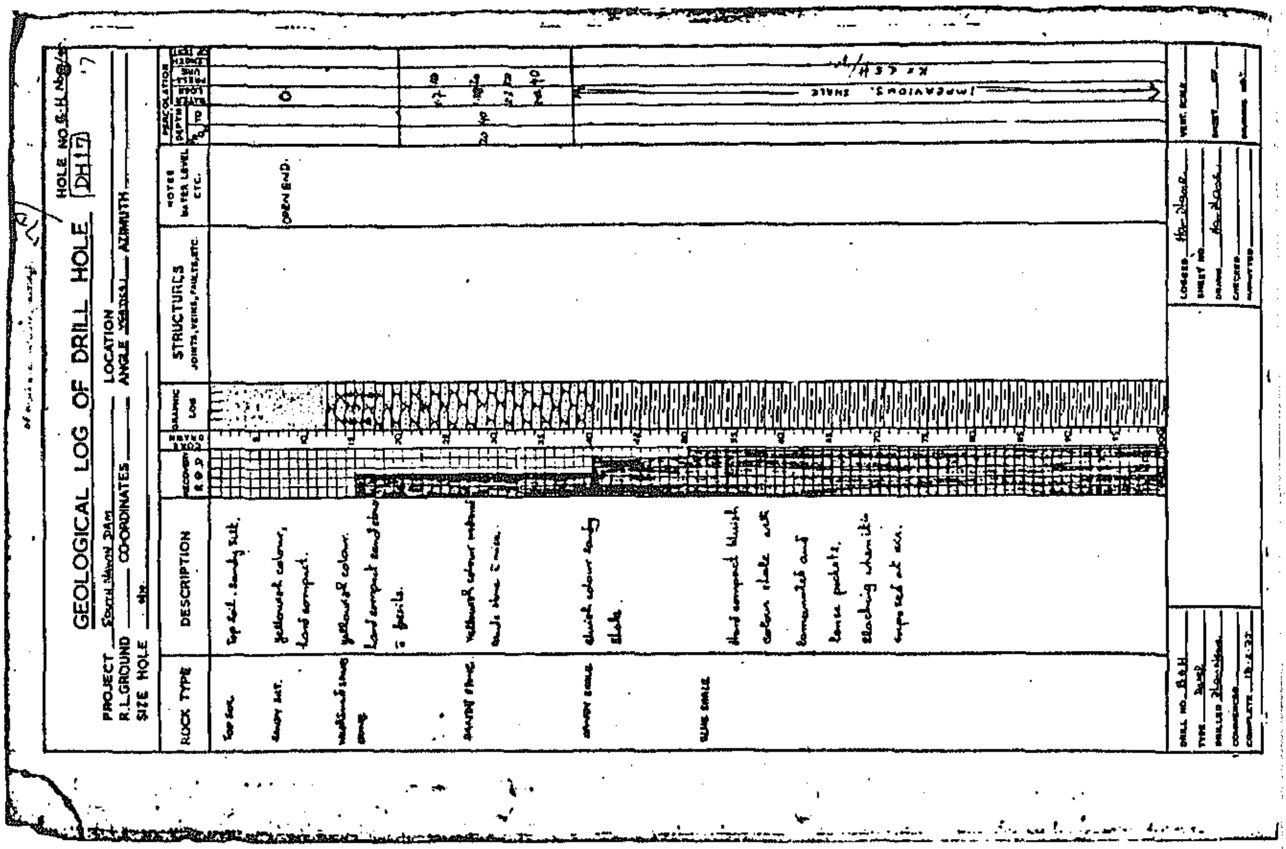

16
GEOLOGICAL LOG OF DRILL HOLE DH16
HOLE NO.
PROJECT
LOCATION
R.L.GROUND
CO-ORDINATES
ANGLE
AZIMUTH
SIZE HOLE
ROCK TYPE
DESCRIPTION
RECOVERY
GRAPHIC LOG
STRUCTURES
JOINTS, VEINS, FAULTS, ETC.
NOTES WATER LEVEL ETC.
PERCOLATION
DEPTH
TO
Top soil
yellowish brown colour sandy soil.
SANDY SOIL
yellowish brown colour sandy soil with biotite mica.
sandy silt
Bluish colour sandy silt with white mica.
OPEN END TEST.
OPEN END TEST.
SANDSTONE
Bluish grey colour loose sandstone.
SANDY SHALE
Bluish colour, argillaceous, shale laminated and micaceous. Slacking when it is exposed at air.
SANDY SHALE
Bluish colour sandy argillaceous shale & mica.
argillaceous shale
SHALE
Bluish colour, hard compact shale.
DRILL NO.
TYPE
DRILLER
COMMENCED
COMPLETE
LOGGED
SHEET NO.
DRAWN
CHECKED
SUBMITTED
VERT. SCALE
SHEET
DRAWING NO.

FIG.4D-7(11)


GEOLOGICAL LOG OF DRILL HOLE
HOLE NO B.H. No.
DH 17
PROJECT South Nawn Dam
R.L.GROUND
CO-ORDINATES
LOCATION
ANGLE Vertical
AZIMUTH
SIZE HOLE
ROCK TYPE
DESCRIPTION
RECOVERY R.Q.D.
GRAPHIC LOG
STRUCTURES JOINTS, VEINS, FAULTS, ETC.
NOTES WATER LEVEL ETC.
PERCOLATION
DEPTH
TO
Top soil. sandy silt.
yellowish colour, hard compact.
yellowish colour. hard compact sandstone fossils.
Yellowish colour material sand stone mica.
bluish colour sandy shale.
Hard compact bluish colour shale with laminated and lense pockets, slacking when it is exposed at air.
OPEN END.
IMPERVIOUS. SHALE
DRILL NO. B.H.
LOGGED
SHEET NO.
DRAWN
CHECKED
SUBMITTED
VERT. SCALE
SHEET
DRAWING NO.
COMMENCED
COMPLETE

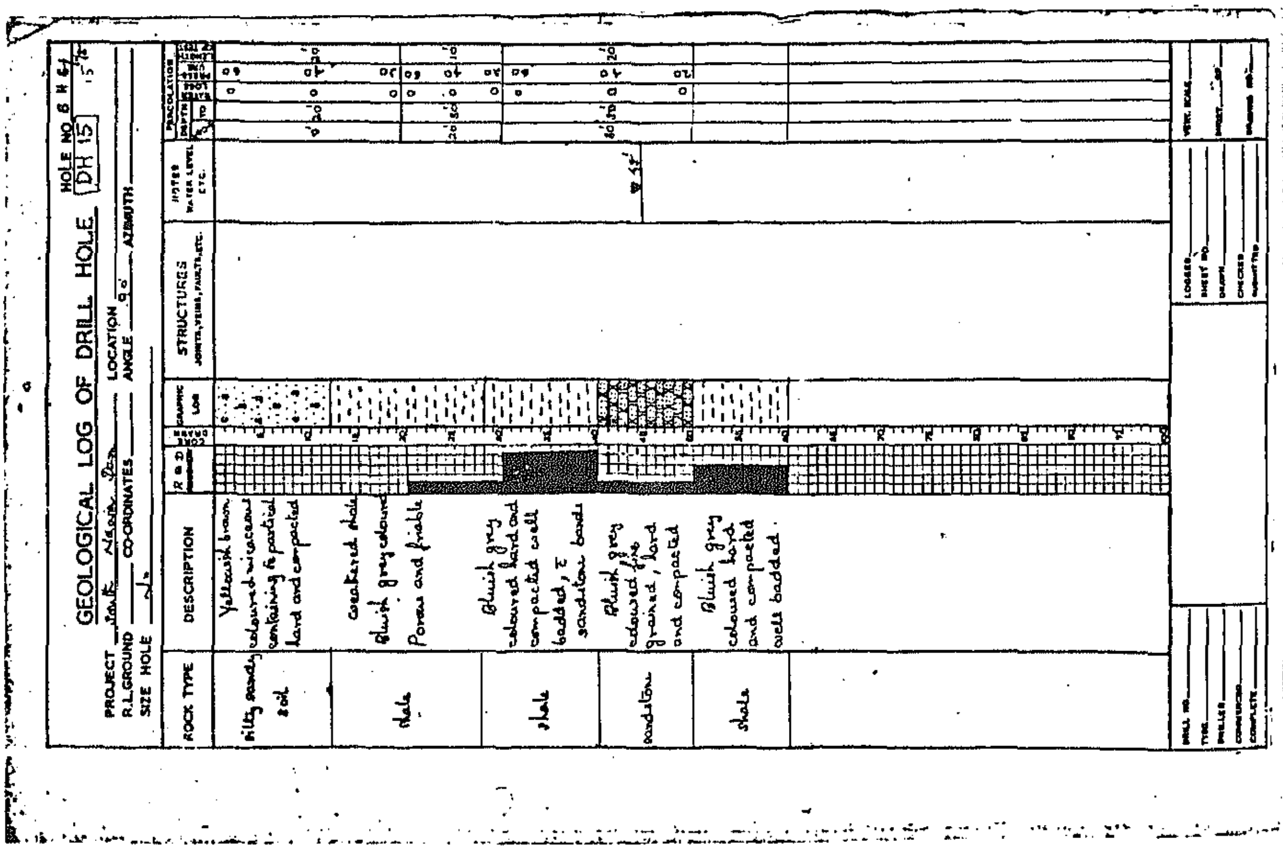
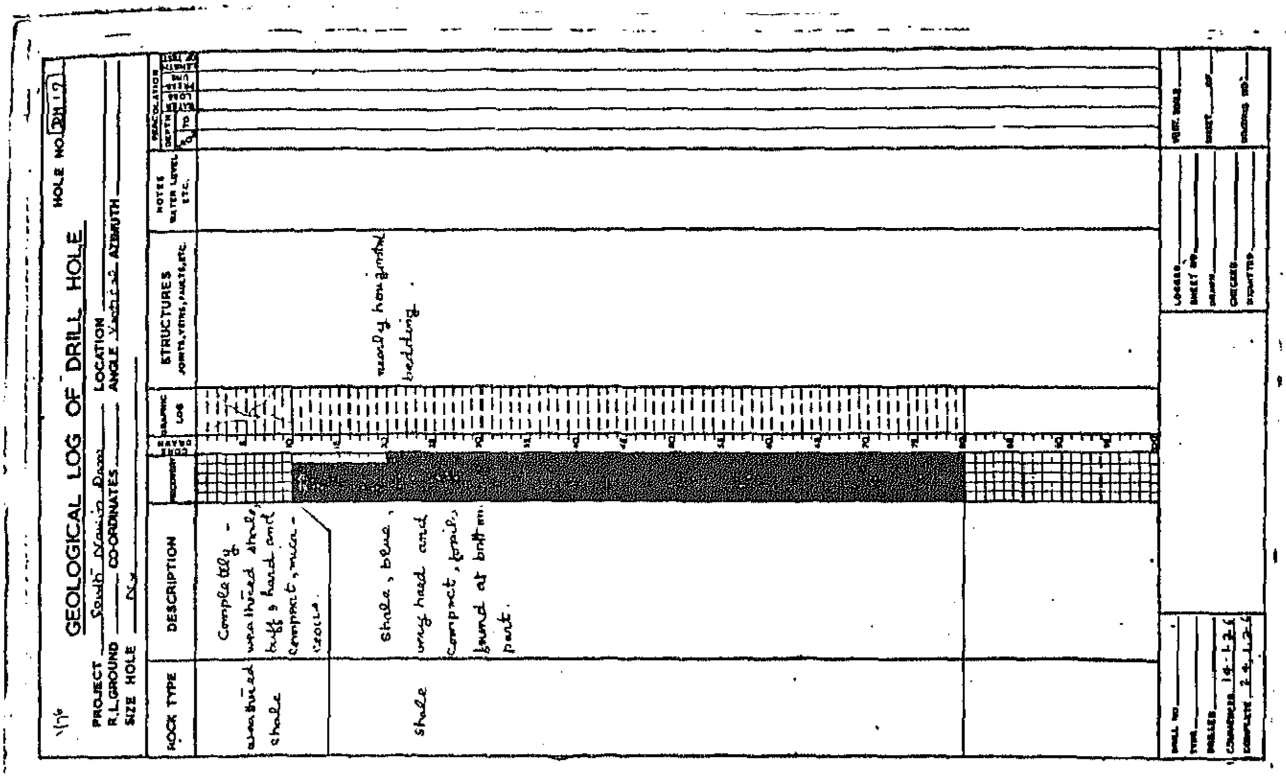

GEOLOGICAL LOG OF DRILL HOLE
HOLE NO B.H.
DH 15
PROJECT South Nawn Dam
R.L.GROUND
CO-ORDINATES
LOCATION
ANGLE 90°
AZIMUTH
SIZE HOLE
ROCK TYPE
DESCRIPTION
R.Q.D.
GRAPHIC LOG
STRUCTURES JOINTS, VEINS, FAULTS, ETC.
NOTES WATER LEVEL ETC.
PERCOLATION
DEPTH
TO
Silty sandy soil
Yellowish brown coloured micaceous containing fe partical hard and compacted
shale
weathered shale Bluish grey coloured Porous and friable
shale
Bluish grey coloured hard and compacted well badded, sandstone bands
sandstone
Bluish grey coloured fine grained, hard and compacted
shale
Bluish grey coloured hard and compacted well badded.
DRILL NO.
TYPE
DRILLER
COMMENCED
COMPLETE
LOGGED
SHEET NO.
DRAWN
CHECKED
SUBMITTED
VERT. SCALE
SHEET
DRAWING NO.

FIG. 4D-7(12)


GEOLOGICAL LOG OF DRILL HOLE
HOLE NO. DH 17
PROJECT South Nawin Dam
LOCATION
R.L.GROUND
CO-ORDINATES
ANGLE Vertical
AZIMUTH
SIZE HOLE Nx
ROCK TYPE
DESCRIPTION
RECOVERY
CORE DRAIN
GRAPHIC LOG
STRUCTURES JOINTS, VEINS, FAULTS, ETC.
NOTES WATER LEVEL ETC.
PERCOLATION
DEPTH
TO
weathered shale
Completely weathered shale, buff & hard and compact, micaceous.
shale
Shale, blue, very hard and compact, fossils found at bottom part.
nearly horizontal bedding.
DRILL NO.
TYPE
DRILLER
COMMENCED 14-1-26
COMPLETE 24-1-26
LOGGED
SHEET NO.
DRAWN
CHECKED
SUBMITTED
VERT. SCALE
SHEET OF
DRAWING NO.

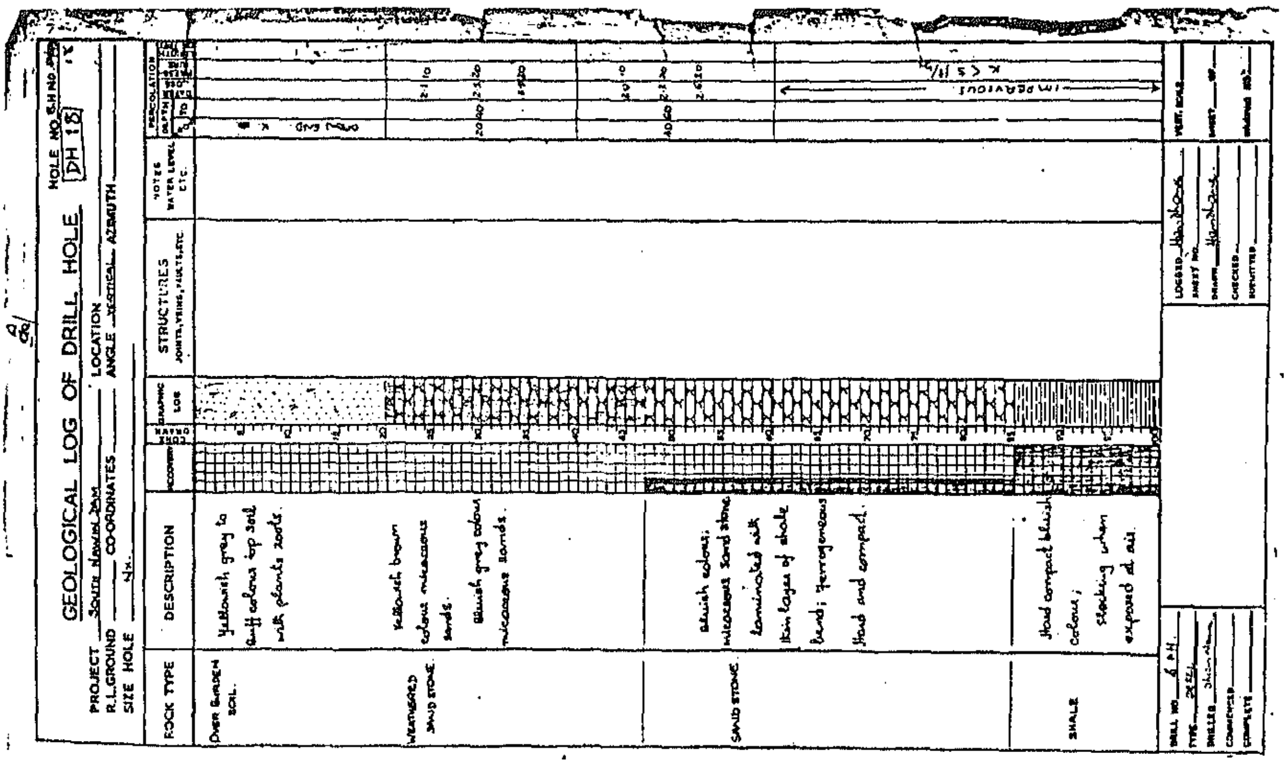
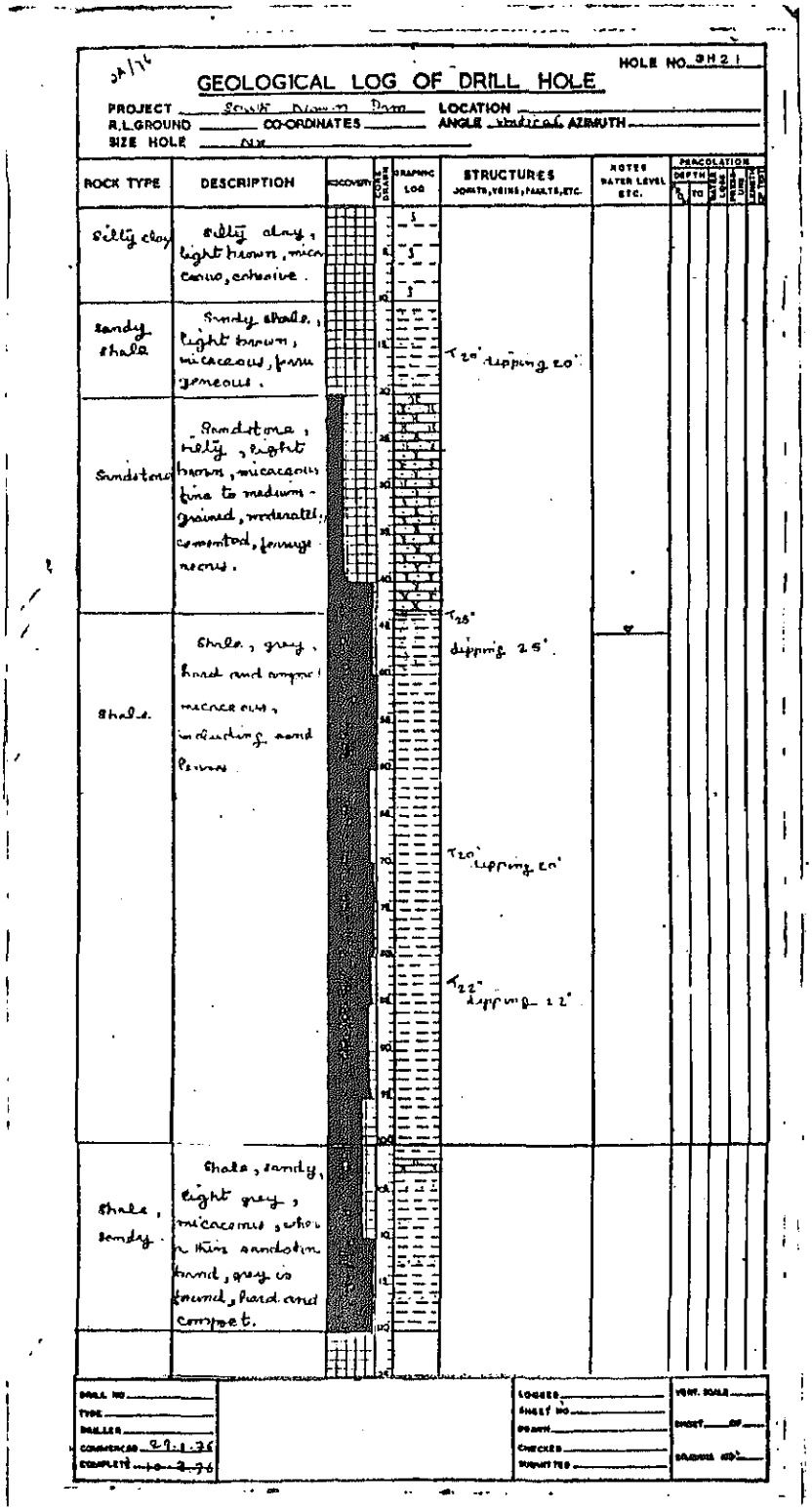

GEOLOGICAL LOG OF DRILL HOLE
HOLE NO. DH 18
PROJECT South Nawin Dam
LOCATION
R.L.GROUND
CO-ORDINATES
ANGLE Vertical
AZIMUTH
SIZE HOLE Nx.
ROCK TYPE
DESCRIPTION
RECOVERY
CORE DRAIN
GRAPHIC LOG
STRUCTURES JOINTS, VEINS, FAULTS, ETC.
NOTES WATER LEVEL ETC.
PERCOLATION
DEPTH
TO
OVER BURDEN SOIL.
Yellowish grey to buff colour top soil with plants roots.
WEATHERED SAND STONE.
Yellowish brown colour micaceous sands.
Bluish grey colour micaceous sands.
SAND STONE.
Bluish colour; micaceous sand stone laminated with thin layer of shale band; ferrogeneous. Hard and compact.
SHALE
Hard compact bluish colour; slacking when exposed at air.
OPEN END
20 40
40 60
2.1 10
2.5 20
2.0 10
2.3 20
2.6 20
IMPERVIOUS
K < 5 l/
DRILL NO. 6 AH.
TYPE DIESEL
DRILLER
COMMENCED
COMPLETE
LOGGED
SHEET NO.
DRAWN
CHECKED
SUBMITTED
VERT. SCALE
SHEET OF
DRAWING NO.

FIG. 4D-7(13)



GEOLOGICAL LOG OF DRILL HOLE

HOLE NO. BH 21

PROJECT South Down Dam LOCATION
R.L. GROUND CO-ORDINATES ANGLE Vertical AZIMUTH
SIZE HOLE NX

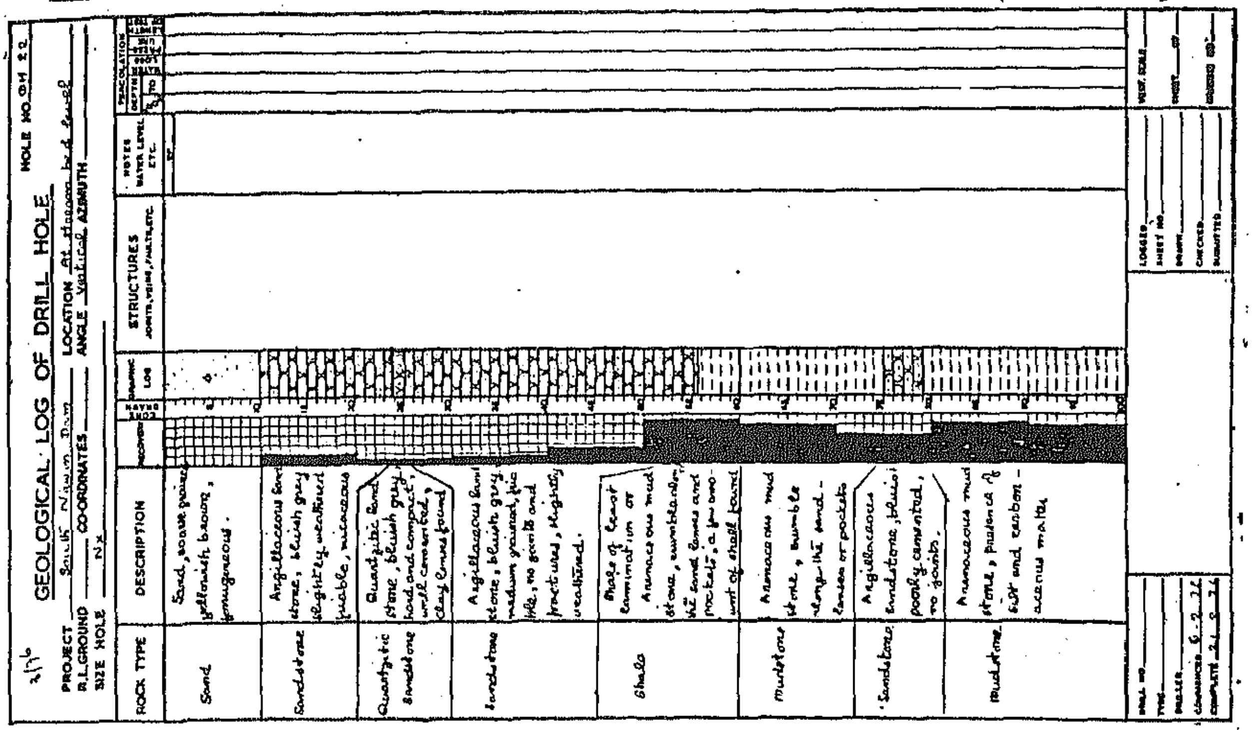
ROCK TYPE	DESCRIPTION	STRUCTURES JOINTS, VEINS, FAULTS, ETC.
Silty clay	silty clay, light brown, micaceous, cohesive.	
Sandy shale	Sandy shale, light brown, micaceous, homogeneous.	T 20° dipping 20°
Sandstone	Sandstone, silty, light brown, micaceous, fine to medium-grained, moderately cemented, homogeneous.	T 25° dipping 25°
Shale	Shale, grey, hard and competent, micaceous, including sand lenses.	T 20° dipping 20° T 22° dipping 22°
Shale, sandy	Shale, sandy, light grey, micaceous, thin sandstone band, grey is fractured, hard and competent.	

DRILL NO
TYPE
DRILLER
COMMENCED 29.1.76
COMPLETED ~~10.2.76~~

LOGGED
SHEET NO
DRAWN
CHECKED
SUBMITTED

VERT. SCALE
SHEET OF
DRAWING NO

FIG.4D-7(14)


2/76
GEOLOGICAL LOG OF DRILL HOLE
HOLE NO. DH 22
PROJECT South Nawin Dam
LOCATION At stream bed level
R.L.GROUND
CO-ORDINATES
ANGLE Vertical AZIMUTH
SIZE HOLE Nx
ROCK TYPE
DESCRIPTION
STRUCTURES JOINTS, VEINS, FAULTS, ETC.
NOTES WATER LEVEL ETC.
PERCOLATION
Sand
Sand, coarse grained yellowish brown, ferrugeneous.
Sandstone
Argillaceous sandstone, bluish grey slightly weathered friable, micaceous
Quartzitic Sandstone
Quartzitic sandstone, bluish grey, hard and compact, well cemented, clay lenses found
Sandstone
Argillaceous sandstone, bluish grey medium grained, friable, no joints and fractures, slightly weathered.
Shale
Shale of least lamination or Arenaceous mudstone, crumble along the sand lenses and pockets, a few amount of shell found
Mudstone
Arenaceous mudstone, crumble along the sand lenses or pockets
Sandstone
Argillaceous sandstone, bluish poorly cemented, no joints.
Mudstone
Arenaceous mudstone, presence of silt and carbonaceous matter
DRILL NO.
TYPE
DRILLER
COMMENCED 6.2.76
COMPLETE 21.2.76
LOGGED
SHEET NO.
DRAWN
CHECKED
SUBMITTED
VERT. SCALE
SHEET OF
DRAWING NO.

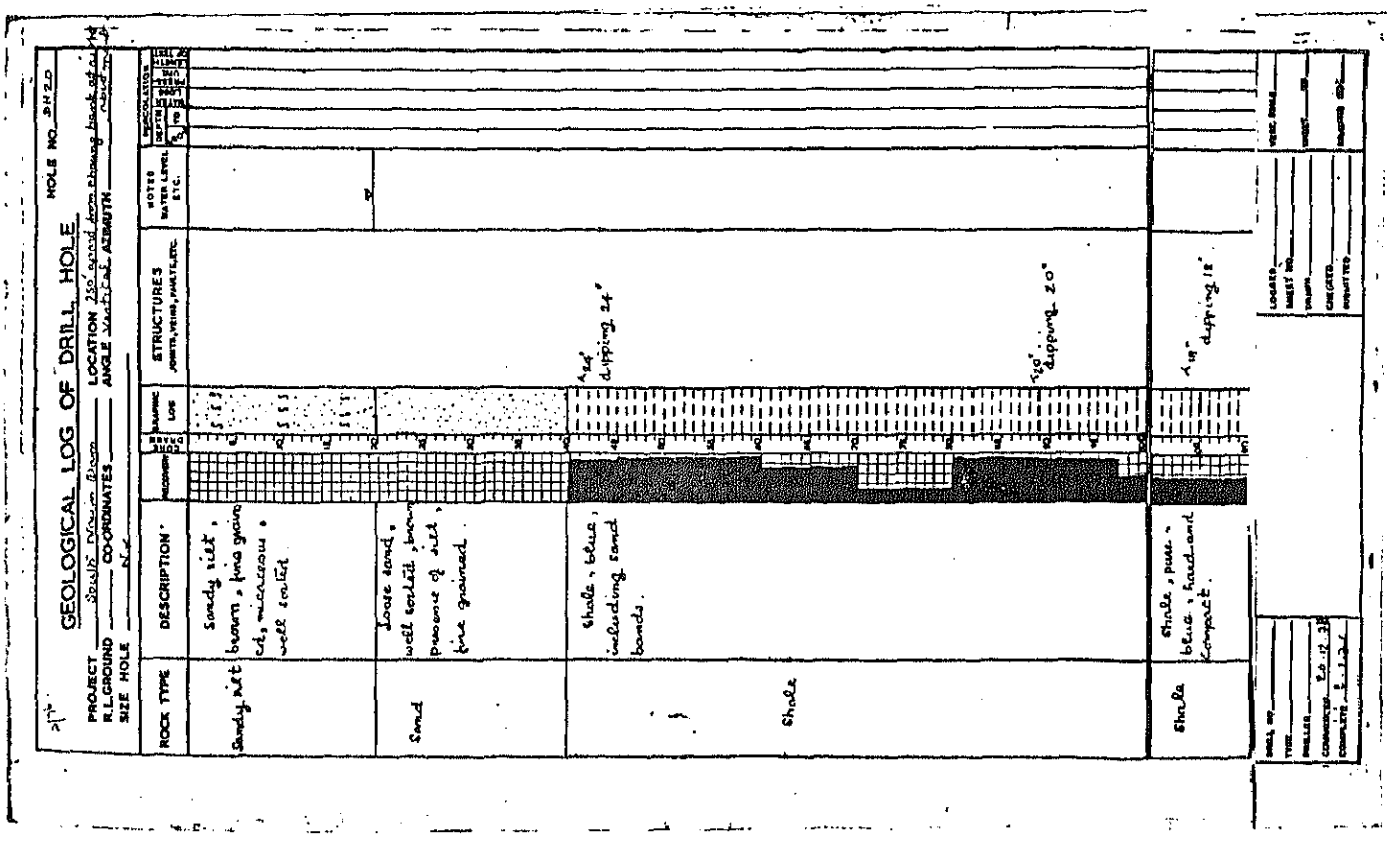
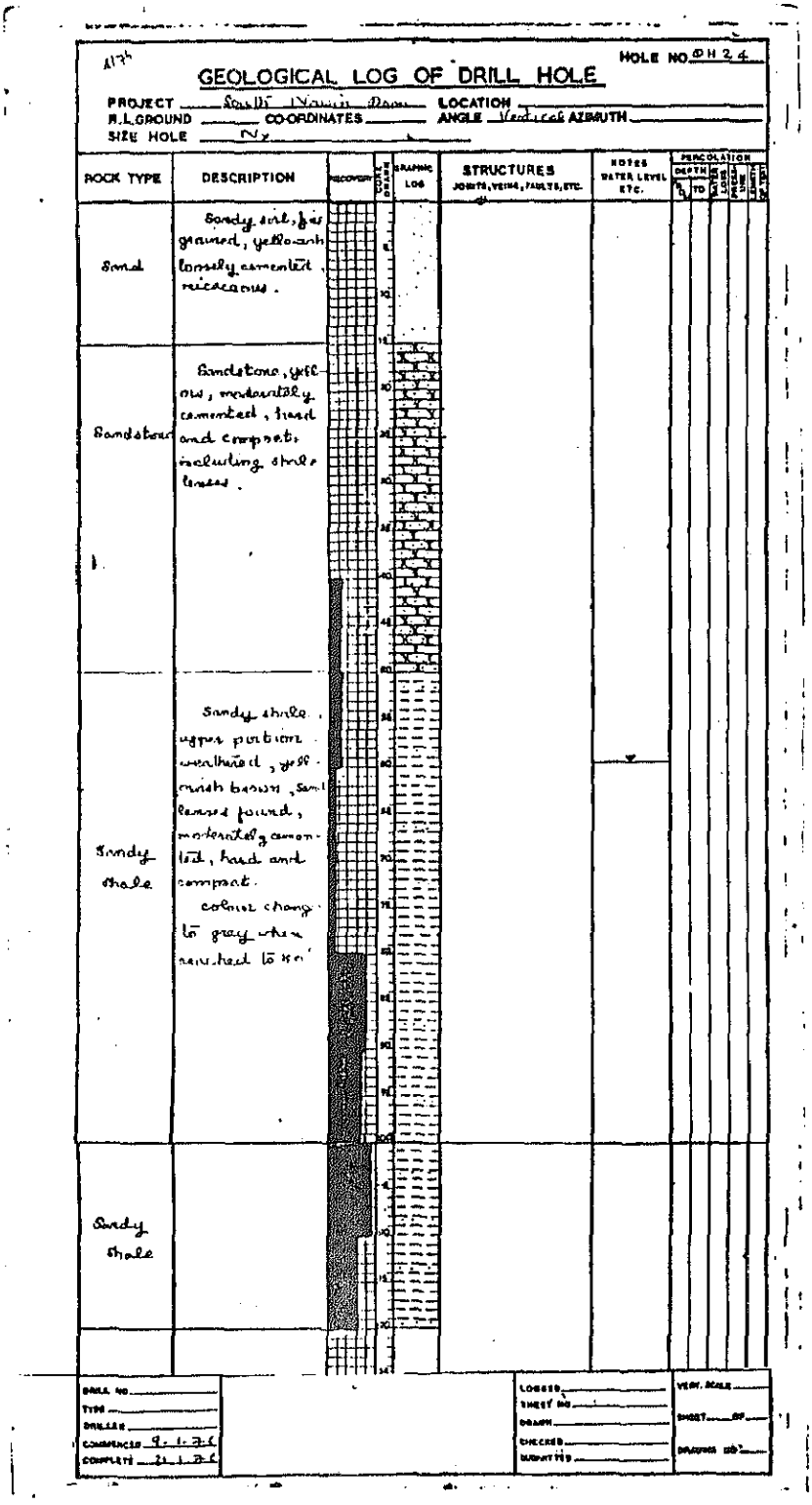

2/76
GEOLOGICAL LOG OF DRILL HOLE
HOLE NO. DH 20
PROJECT South Nawin Dam
LOCATION 250' apart from stream bank at about
R.L.GROUND
CO-ORDINATES
ANGLE Vertical AZIMUTH
SIZE HOLE Nx
ROCK TYPE
DESCRIPTION
STRUCTURES JOINTS, VEINS, FAULTS, ETC.
NOTES WATER LEVEL ETC.
PERCOLATION
Sandy silt
Sandy silt, brown, fine grained, micaceous, well sorted
Sand
Loose sand, well sorted, brown presence of silt, fine grained.
Shale
Shale, blue, including sand bands.
dipping 24°
dipping 20°
Shale
Shale, pure blue, hard and compact.
dipping 18°
DRILL NO.
TYPE
DRILLER
COMMENCED 20.12.75
COMPLETE 5.1.76
LOGGED
SHEET NO.
DRAWN
CHECKED
SUBMITTED
VERT. SCALE
SHEET OF
DRAWING NO.

FIG. 4D-7(15)



GEOLOGICAL LOG OF DRILL HOLE

HOLE NO. DH 2 4

PROJECT South Nowra Dam LOCATION
R.L. GROUND CO-ORDINATES ANGLE Vertical AZIMUTH
SIZE HOLE NX

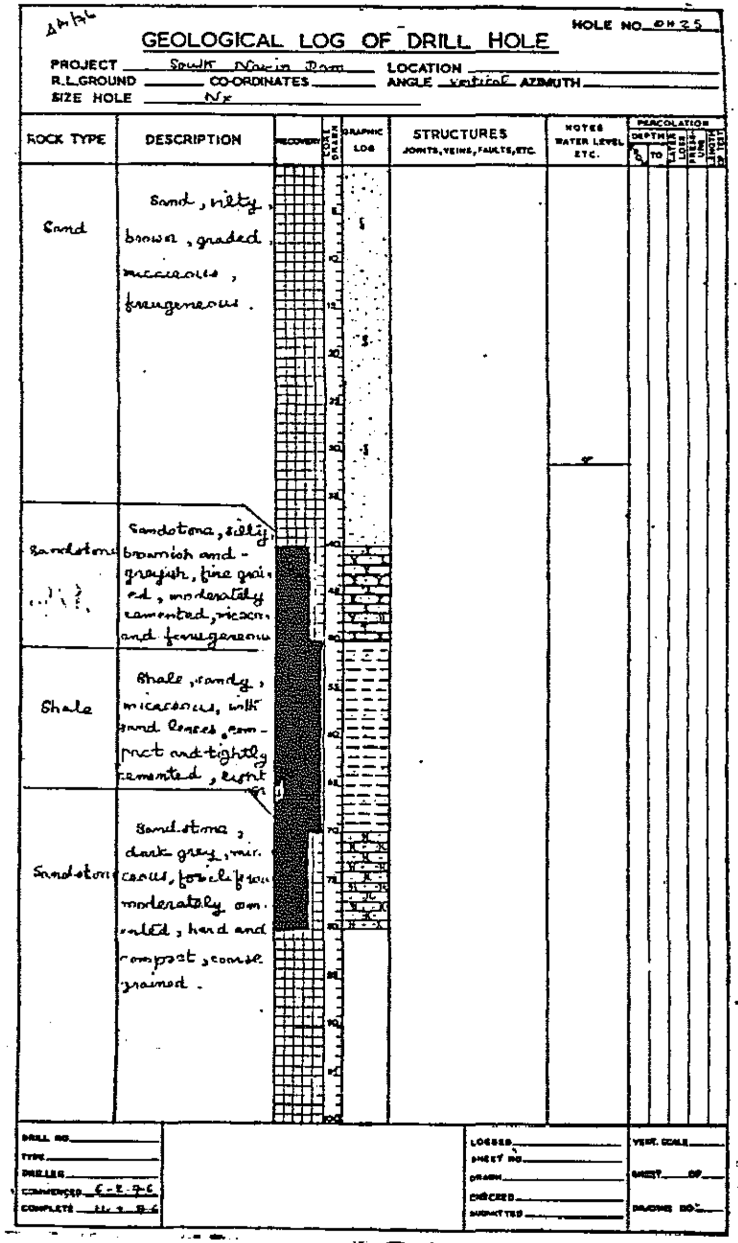
ROCK TYPE	DESCRIPTION	RECOVERY	GRAPHIC LOG	STRUCTURES JOINTS, VEINS, FAULTS, ETC.	NOTES WATER LEVEL ETC.	PERCOLATION DEPTH FROM	PERCOLATION DEPTH TO	WATER LOSS	PRESSURE	LUGEON VALUE
Sand	Sandy soil, fine grained, yellowish, loosely cemented, micaceous.									
Sandstone	Sandstone, yellow, moderately cemented, hard and competent including shale lenses.									
Sandy shale	Sandy shale, upper portion weathered, yellowish brown, sand lenses found, moderately cemented, hard and compact. colour change to grey when weathered to rock									
Sandy shale										

DRILL NO
TYPE
DRILLER
COMMENCED 9.1.76
COMPLETED 21.1.76

LOGGED
SHEET NO
DRAWN
CHECKED
SUBMITTED

VERT. SCALE
SHEET OF
DRAWING NO

FIG. 4D-7(16)


GEOLOGICAL LOG OF DRILL HOLE
HOLE NO. DH 25
PROJECT South Nowin Dam
LOCATION
R.L.GROUND
CO-ORDINATES
ANGLE vertical AZIMUTH
SIZE HOLE Nx
ROCK TYPE
DESCRIPTION
RECOVERY
CORE DRAWN
GRAPHIC LOG
STRUCTURES JOINTS, VEINS, FAULTS, ETC.
NOTES WATER LEVEL ETC.
PERCOLATION
Sand
Sand, silty, brown, graded, micaceous, ferrugeneous.
Sandstone
Sandstone, silty, brownish and greyish, fine grained, moderately cemented, micaceous and ferrugeneous
Shale
Shale, sandy, micaceous, with sand lenses, compact and tightly cemented, light
Sandstone
Sandstone, dark grey, micaceous, fossiliferous, moderately cemented, hard and compact, coarse grained.
DRILL NO.
TYPE
DRILLER
COMMENCED 6-2-96
COMPLETE 11-2-96
LOGGED
SHEET NO.
DRAWN
CHECKED
SUBMITTED
VERT. SCALE
SHEET OF
DRAWING NO.

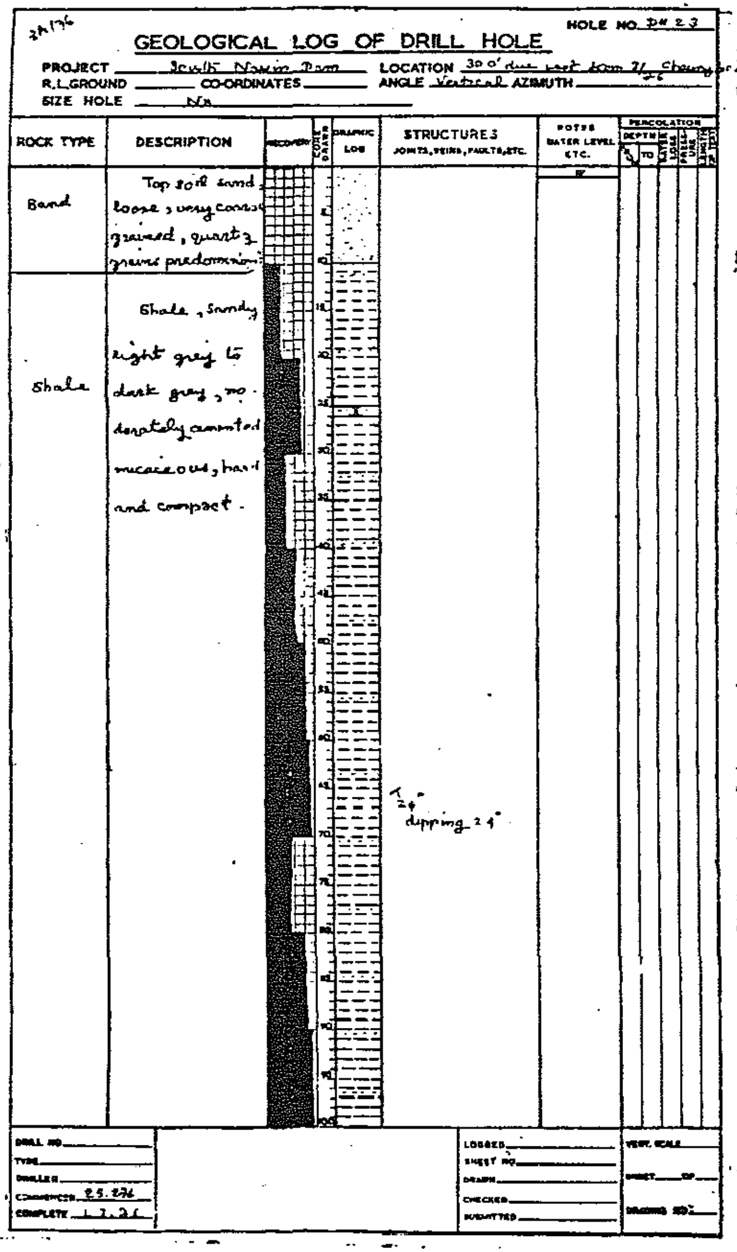
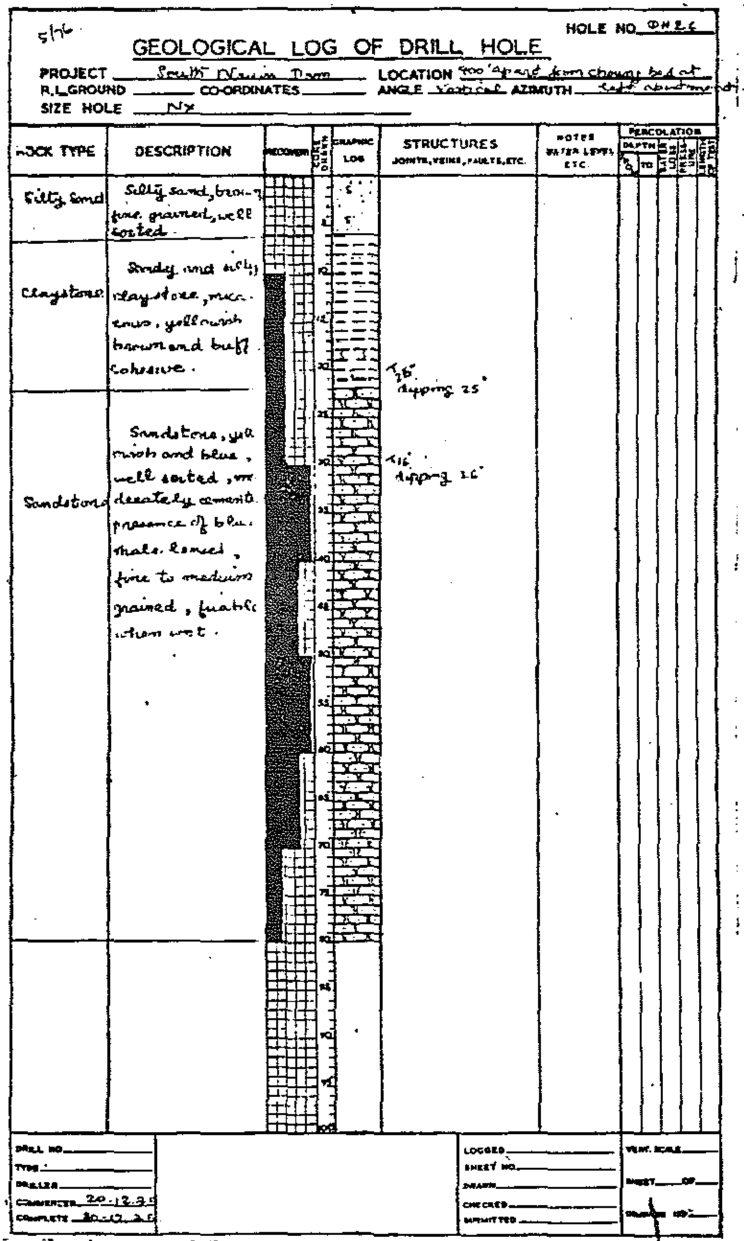

GEOLOGICAL LOG OF DRILL HOLE
HOLE NO. DH 23
PROJECT South Nowin Dam
LOCATION 300' due east from 21 Chaung
R.L.GROUND
CO-ORDINATES
ANGLE Vertical AZIMUTH
SIZE HOLE Nx
ROCK TYPE
DESCRIPTION
RECOVERY
CORE DRAWN
GRAPHIC LOG
STRUCTURES JOINTS, VEINS, FAULTS, ETC.
NOTES WATER LEVEL ETC.
PERCOLATION
Sand
Top soil sand, loose, very coarse grained, quartz grains predominant
Shale
Shale, sandy light grey to dark grey, moderately cemented micaceous, hard and compact.
dipping 24°
DRILL NO.
TYPE
DRILLER
COMMENCED 25.2.96
COMPLETE 1.3.96
LOGGED
SHEET NO.
DRAWN
CHECKED
SUBMITTED
VERT. SCALE
SHEET OF
DRAWING NO.

FIG.4D-7(17)


5/76
GEOLOGICAL LOG OF DRILL HOLE
HOLE NO. DH26
PROJECT South Nasia Dam
LOCATION 500' apart from chainage bed at
R.L.GROUND
CO-ORDINATES
ANGLE Vertical
AZIMUTH
SIZE HOLE NX
ROCK TYPE
DESCRIPTION
RECOVERY
CORE DIAM
GRAPHIC LOG
STRUCTURES JOINTS, VEINS, FAULTS, ETC.
NOTES WATER LEVEL ETC.
PERCOLATION
DEPTH
FROM
TO
Silty sand
Silty sand, brown fine grained, well sorted.
Claystone
Sandy and silty claystone, micaceous, yellowish brown and buff, cohesive.
dipping 25°
dipping 20°
Sandstone
Sandstone, yellowish and blue, well sorted, moderately cemented, presence of blue shale lensed, fine to medium grained, friable when wet.
DRILL NO.
TYPE
DRILLER
COMMENCED 20.12.75
COMPLETE 30.12.75
LOGGED
SHEET NO.
DRAWN
CHECKED
SUBMITTED
VERT. SCALE
SHEET OF
DRAWING NO.

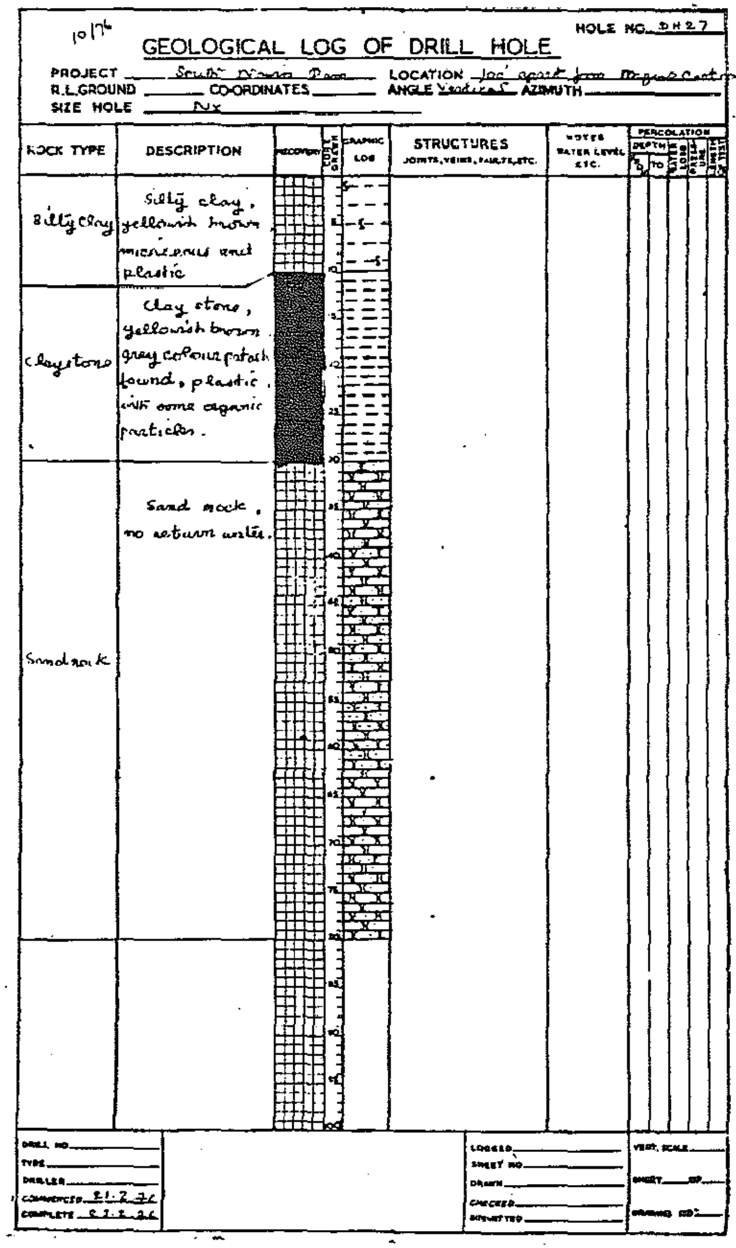
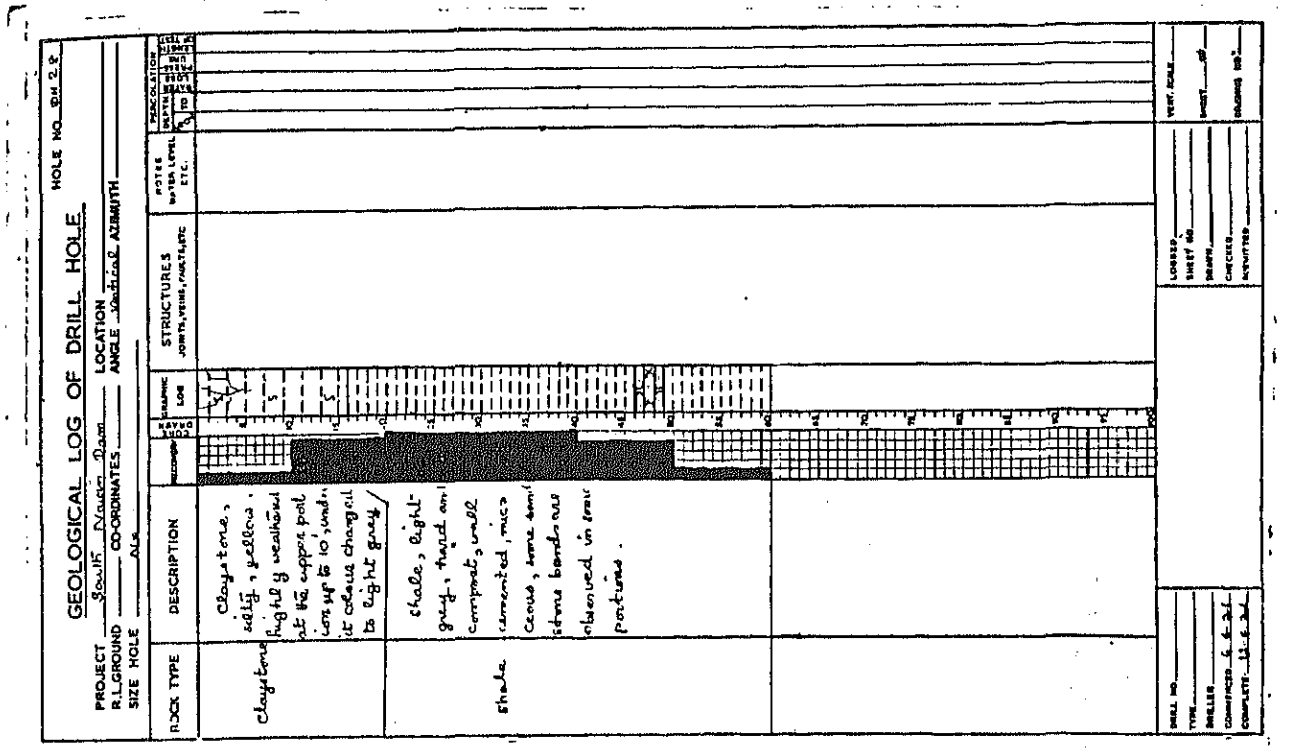

10/76
GEOLOGICAL LOG OF DRILL HOLE
HOLE NO. DH27
PROJECT South Nasia Dam
LOCATION 100' apart from Mogua Cent...
R.L.GROUND
CO-ORDINATES
ANGLE Vertical
AZIMUTH
SIZE HOLE NX
ROCK TYPE
DESCRIPTION
RECOVERY
CORE DIAM
GRAPHIC LOG
STRUCTURES JOINTS, VEINS, FAULTS, ETC.
NOTES WATER LEVEL ETC.
PERCOLATION
DEPTH
FROM
TO
Silty Clay
Silty clay, yellowish brown, micaceous and plastic
Claystone
Clay stone, yellowish brown, grey colour patch found, plastic, with some organic particles.
Sandrock
Sand rock, no return water.
DRILL NO.
TYPE
DRILLER
COMMENCED 21.2.76
COMPLETE 21.2.76
LOGGED
SHEET NO.
DRAWN
CHECKED
SUBMITTED
VERT. SCALE
SHEET OF
DRAWING NO.

FIG. 4D-7(18)


GEOLOGICAL LOG OF DRILL HOLE
HOLE NO. BH 2.2
PROJECT South Narin Dam
R.L.GROUND
SIZE HOLE
LOCATION
CO-ORDINATES
ANGLE Vertical AZIMUTH
ROCK TYPE
DESCRIPTION
RECOVERY
RAYMOND LOG
DRILLING LOG
STRUCTURES JOINTS, VEINS, FAULTS, ETC
NOTES WATER LEVEL ETC.
PERCOLATION
Claystone
Shale

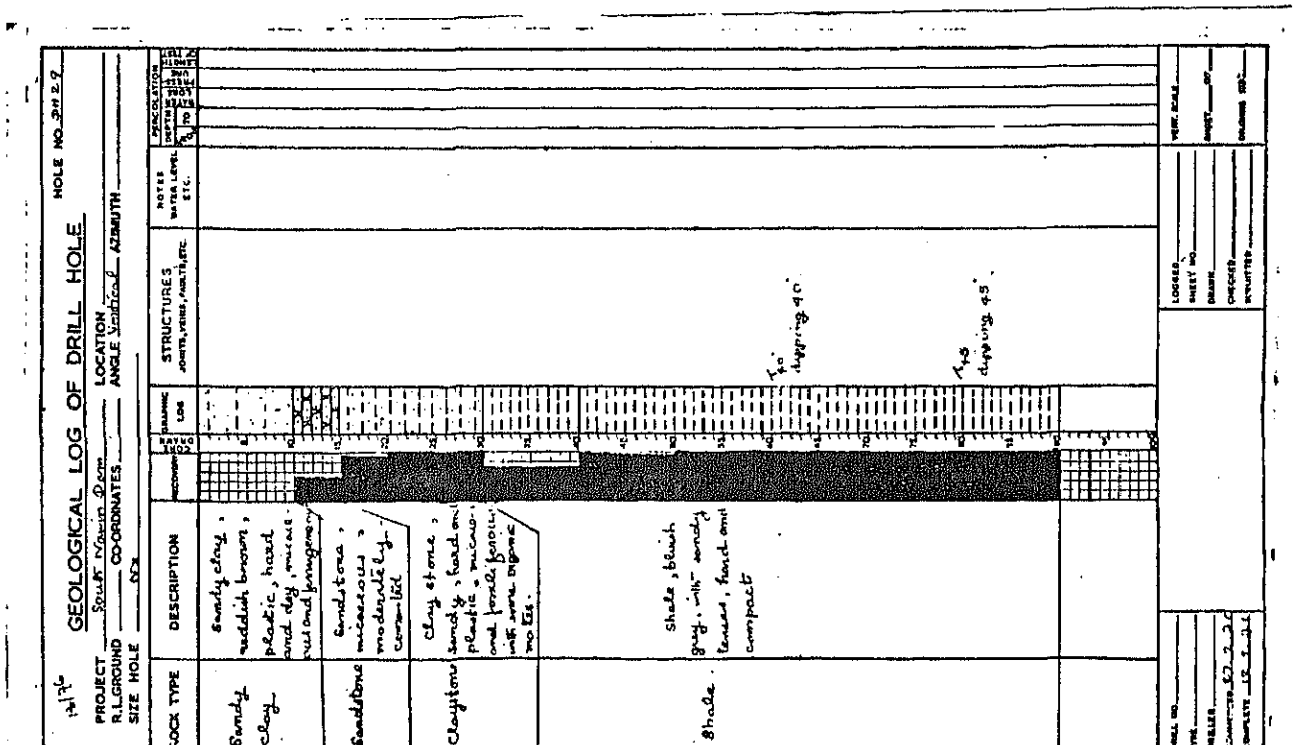
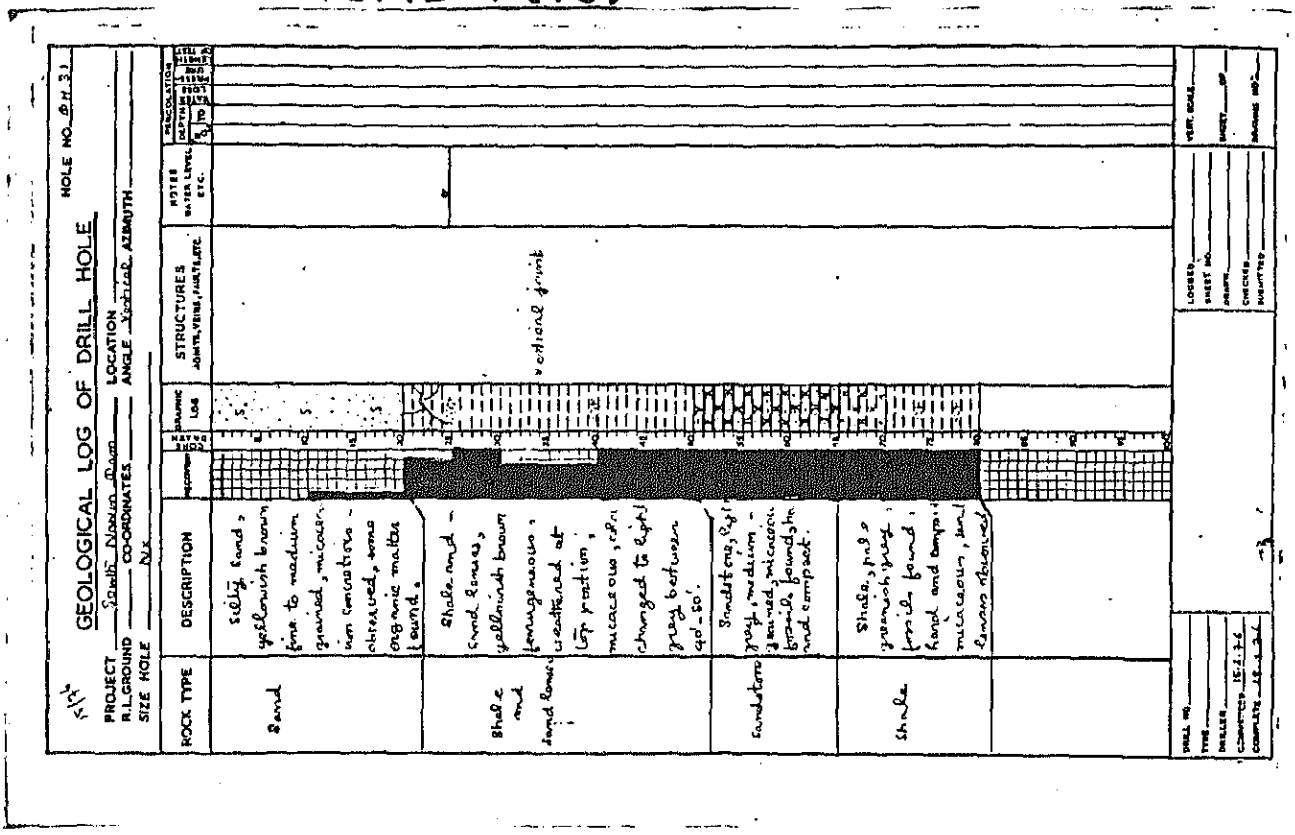

GEOLOGICAL LOG OF DRILL HOLE
HOLE NO. BH 2.2
PROJECT South Narin Dam
R.L.GROUND
SIZE HOLE
LOCATION
CO-ORDINATES
ANGLE Vertical AZIMUTH
ROCK TYPE
DESCRIPTION
RECOVERY
RAYMOND LOG
DRILLING LOG
STRUCTURES JOINTS, VEINS, FAULTS, ETC
NOTES WATER LEVEL ETC.
PERCOLATION
Sandy clay
Sandstone
Claystone
Shale
dipping 40°
dipping 45°

FIG.4D-7(19)


GEOLOGICAL LOG OF DRILL HOLE
HOLE NO. BH 31
PROJECT South Nawan Dam
R.L.GROUND
SIZE HOLE
COORDINATES
LOCATION
ANGLE Vertical AZIMUTH
ROCK TYPE
DESCRIPTION
RECOVERY
GRAPHIC LOG
STRUCTURES
NOTES
PERCOLATION
Sand
Shale and sand
Sandstone
Shale
vertical joints

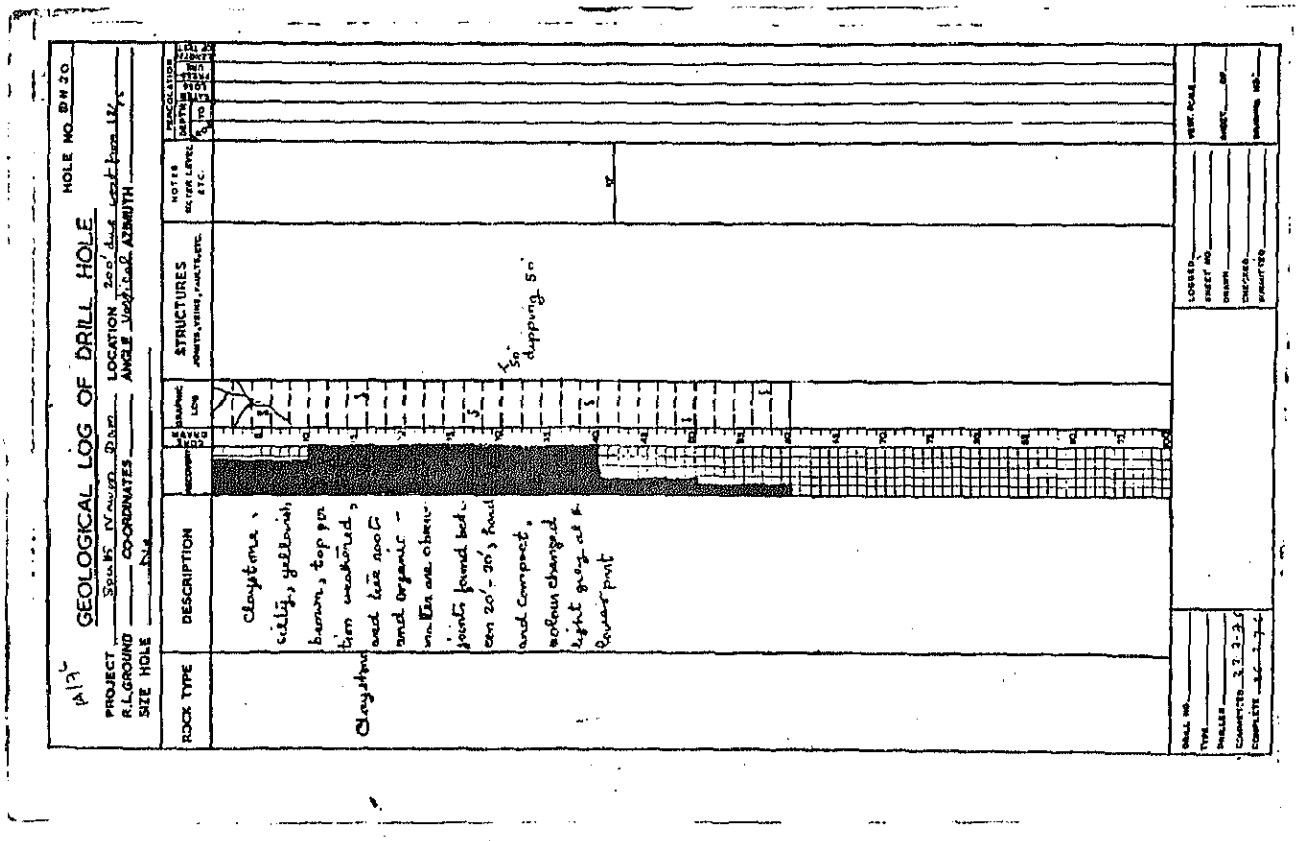

GEOLOGICAL LOG OF DRILL HOLE
HOLE NO. BH 20
PROJECT South Nawan Dam
R.L.GROUND
SIZE HOLE
COORDINATES
LOCATION 200' due east from
ANGLE Vertical AZIMUTH
ROCK TYPE
DESCRIPTION
RECOVERY
GRAPHIC LOG
STRUCTURES
NOTES
PERCOLATION
Clayshale
50° dipping S.

FIG.-4D-7(20)

GEOLOGICAL LOG OF DRILL HOLE

HOLE NO. DH 33

PROJECT: South Dawn Dam LOCATION: 300' due west from DH NO 41
R.L.GROUND: CO-ORDINATES:
ANGLE: Vertical AZIMUTH:
SIZE HOLE: NX

ROCK TYPE	DESCRIPTION	STRUCTURES (JOINTS, VEINS, FAULTS, ETC.)	NOTES, WATER LEVEL ETC.
Silty Sand	Silty sand, brown, fine grained containing mica flakes.	N Value 17 36, 40 38, 56 55, 69 99, 31	
Claystone	Claystone, silty, plastic, hard and compact, micaceous		
Sandstone	Sandstone, silty, micaceous, brown		
Siltstone	Siltstone, dark brown, micaceous, weathered, a little sandy.		
Sandstone	Sandstone, light brownish and yellowish brown, fine to medium grained, silty, micaceous	Joint of dipping 52°, at 45'.	
Sandstone + Shale	Sandstone and shale intercalated, hard and compact, micaceous.		
	Shale, light grey, hard and compact, having sand lenses or pockets, moderately cemented.		

DRILL NO. TYPE DRILLER COMMENCED 12.1.2.C COMPLETE 20.1.74
LOGGED SHEET NO. DRAWN CHECKED SUBMITTED
VERT. SCALE SHEET OF DRAWING NO.

GEOLOGICAL LOG OF DRILL HOLE

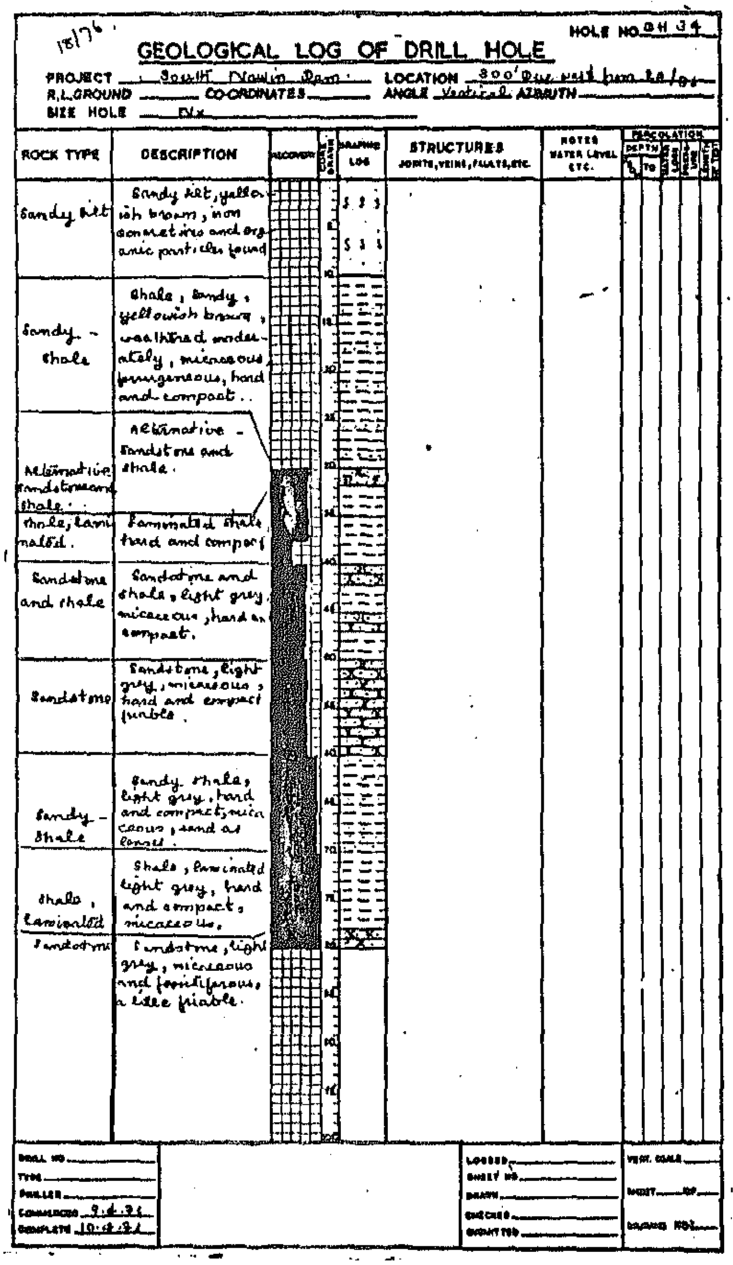
HOLE NO. DH 32

PROJECT: South Dawn Dam LOCATION: 300' from 1/2 (Chainage bed Pass)
R.L.GROUND: CO-ORDINATES:
ANGLE: Vertical AZIMUTH:
SIZE HOLE: NX

ROCK TYPE	DESCRIPTION	STRUCTURES (JOINTS, VEINS, FAULTS, ETC.)	NOTES, WATER LEVEL ETC.
Sand	Sand, light brown, loose, fine to medium grained, ferrugineous and micaceous.		
Shale	Sandy shale, blue, hard and plastic, presence of silt and mica flakes, containing gravel in some portions.		
Sandstone	Sandstone, bluish grey, soft and friable, fine grained, presence of shale lenses.	22°, dipping 22°	
Shale	Sandy shale, blue, fine grained, micaceous.		

DRILL NO. TYPE DRILLER COMMENCED 26.1.74 COMPLETE
LOGGED SHEET NO. DRAWN CHECKED SUBMITTED
VERT. SCALE SHEET OF DRAWING NO.

FIG. 4D-7-(21)


HOLE NO. DH 34
GEOLOGICAL LOG OF DRILL HOLE
PROJECT South Nowin Dam
LOCATION
R.L.GROUND
CO-ORDINATES
ANGLE Vertical
AZIMUTH
SIZE HOLE
ROCK TYPE
DESCRIPTION
RECOVERY
CORE GRAPHIC LOG
STRUCTURES JOINTS, VEINS, FAULTS, ETC.
NOTES WATER LEVEL ETC.
PERCOLATION
DEPTH
TO
Sandy silt
Sandy silt, yellowish brown, non concretions and organic particles found
Sandy - shale
Shale, sandy, yellowish brown, weathered moderately, micaceous, ferrugineous, hard and compact.
Alternative sandstone and shale.
Alternative - sandstone and shale.
Shale, laminated.
Laminated shale hard and compact
Sandstone and shale
Sandstone and shale, light grey, micaceous, hard and compact.
Sandstone
Sandstone, light grey, micaceous, hard and compact
Sandy - shale
Sandy shale, light grey, hard and compact, micaceous
Shale, laminated
Shale, laminated light grey, hard and compact, micaceous.
Sandstone
Sandstone, light grey, micaceous and fossiliferous, a little friable.
DRILL NO.
TYPE
DRILLER
COMMENCED 9.4.91
COMPLETE 10.4.91
LOGGED
SHEET NO.
DRAWN
CHECKED
SUBMITTED
VERT. SCALE
SHEET ___ OF ___
DRAWING NO.

7-1337 (8-72) Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET .... OF ....

FEATURE: Foundation Test — PROJECT: South Nawin Dam Project — STATE: Pegu Division

HOLE NO. 1/79 DH35 — LOCATION: Right bank of Sandwin Creek — GROUND ELEV. .... — DIP (ANGLE FROM HORIZ.): 90°

COORDS. N. .... E. ....

BEGUN .... FINISHED: 29.6.79 — DEPTH OF OVERBURDEN: 30' — TOTAL DEPTH: 170' — BEARING ....

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: 35'3" (29.6.79) — LOGGED BY: U Soe Myint Aung — LOG REVIEWED BY ....

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

▽ GWL 35'3" (29.6.79)

Drilling Equipment

(1) S & H Drill No.12 trailer mounted

(2) John Bean Pump No.11

(3) Hydraulic feed Rotary drilling from 0'–170' Depth.
(a) Nx M T.C. Bit
(b) 10' Nx M Double tube core barrel.

(4) Nx casing drive shoe used for casing driving – Nx casing is driven down to 55' depth.

Drill Fluid: Stream water

Driller: U Than Nwe

TYPE AND SIZE OF HOLE: Core Drill Hole, Size Nx M

CORE RECOVERY (%) (top to bottom): 80, 100, 60, 100, 90, 80, 40, 100, 40, 60, 50, 80, 60, 80, 90, 100, 85, 95, 80, 75, 75, 80, 100, 100, 75, 85

PERCOLATION TESTS

Depth From (P, Ca, or Cs) (feet)	Depth To (feet)	Loss (G.P.M.)	Pressure (P.S.I.)	Length of Test (Min.)
10' Single Packer	25'	1.7	5	15'
		0.21	10	15'
		while testing, water runs outside the casing		
25' Single Packer	40'	8.2	10	15'
		12.1	20	15'
		12.5	30	15'
		12	20	15'
		8.2	10	15'
40' Single Packer	55'	10.42	20	15'
		12.12	30	15'
		12.85	40	15'
		11.5	30	15'
		10.4	20	15'
55' Single Packer	70'	4.2	20	15'
		6.16	30	15'
		5.2	40	15'
		6.1	30	15'
		4.2	20	15'
70' Single Packer	85'	0.02	20	15'
		0	30	15'
		0	40	15'
		0	30	15'
		0	20	15'
85' Single Packer	100'	0	20	15'
		0	30	15'
		0	40	15'
		0	30	15'
		0	20	15'
100' Single Packer	120'	0	20	20'
		0	30	20'
		0	40	20'
		0	30	20'
		0	20	20'
120' Single Packer	135'	0	20	15'
		0	30	15'
		0	40	15'
		0	30	15'
		0	20	15'
135' Single Packer	150'	0	20	15'
		0	30	15'
		0	40	15'
		0	30	15'
		0	20	15'
150' Single Packer	170'	0	20	20'
		0	30	20'
		0	40	20'
		0	30	20'
		0	20	20'

CLASSIFICATION AND PHYSICAL CONDITION

Depth (feet)	Classification and Physical Condition
0' to 30'	Top soil, Heavy clay, yellowish brown coloured, highly plastic & soft, hard under dry condition, compact & well cemented, including yellowish silt patches & slightly micaceous.
30' to 40'	Weathered shale, light gray coloured, sandy, carbonaceous, hard & compact, well cemented & slightly micaceous.
40' to 45'	Sandstone, reddish brown, fine grained, moderately cemented, hard & slightly friable, & fine mica flakes in 20%.
45' to 50'	
50' to 55'	Sandy shale, light bluish grey coloured, with clay well bedded, intercalated with fine grained sand, hard & compact.
	Sandstone, reddish brown coloured, fine to medium grained, ferruginous, hard & compact, & fine mica flakes in 40%. Sandstone, colour changes to bluish, gray & shaly.
	Shale, light to dark bluish grey coloured, with clay well bedded, including with a little amount of fine grained sand pocket shape, hard & compact, lightly cemented.
100' to 119'	Pure Shale, bluish gray coloured, hard & compact, pieces of fossils are found at some places, & fine mica flakes in 20%.
119' to 150'	Sandstone, bluish grey coloured, fine to medium grained, hard & compact, moderately cemented, friable under dry condition, with pieces of fossils, & mica flakes 40%, shaly at some places.
150' to 170'	Shale, light gray coloured mixed with fine grained sandstone, hard & compact, moderately cemented.

EXPLANATION

CORE LOSS / CORE RECOVERY

Type of hole .... D = Diamond, H = Reyatollite, S = Shot, C = Churn
Hole sealed .... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) .. Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) .. Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) .. Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE .... PROJECT .... STATE .... SHEET .... OF .... HOLE NO. ....

GPO 863-041

4D-4. Construction Materials on Main Dam

(a) Earth Materials on Main Dam

Impervious earth materials are deemed to be easily borrowed from wherever near by the proposed main dam site.

So far on-foot survey and test pit excavations indicated, surface geology of the right bank terrace of the main dam site consists mainly of clayey soil layer. According to soil logs of test pit and auger holes, most of proposed borrow areas on the left bank terraces of the main dam site is composed of sandy clay and clayey sand materials.

A series of soil mechanical tests have been performed before the feasibility study on the earth materials taken from the proposed borrow areas of the main dam site. Table 4D-1 and Fig. 4D-8 show the results of the said tests.

As are clear in those illustrations, the most materials belong to CL in the unified classification, i.e., low to medium plastic clayey material. Fig. 4D-9 concludes the relationship between moisture content and dry density, shearing strength, permeability.

From viewpoint of moisture-density relation, two groups can be divided. The maximum density of the first group concentrates around 100 lb/cu.ft. (1.60 ton/cu.m) and that of the second group is about 112 lb/cu.ft (1.79 ton/cu.m). It is deemed that the sand content of the second group is higher than the first group. The densities of specimen prepared for the mechanical test are not recorded. However, supposing that those are at the maximum one, trends of mechanical properties are seen as shown in the figure,i.e., the friction angle and permeability increase the cohesion decreases, in accordance with increasing the moisture content.

The design values for the Sezongon Dam body of the North Nawin Project are plotted onto the figure. Most of values are very similar

to the material in the South Nawin Project except the design moisture content.

Two additional test pits TP-10 and TP-11, have been recommended to be dug and to take samples for the proper soil tests on the both bank sides, as shown in the attached location map. Fig. 4D-10 illustrates test pit logs for TP-10 and TP-11, respectively. Small soil samples for the field moisture content test have been taken from each three feet depth of the pits. The test results are shown in the log indicating around 20%. The date of excavation of pits and sampling were mid-May, 1979, late dry season. Therefore, the moisture content of excavated layers are deemed to be somewhat higher than that in mid-dry season. A large bulk sample has been taken from each pit covering whole depth for a series of soil mechanical tests.

The test items performed are as follows:

- Physical tests -
  - Field moisture content test,
  - Specific gravity test,
  - Gradation analysis,
  - Consistency test;
- Dynamic tests -
  - Proctor compaction test (with 25, 30 and 35 blows),
  - Direct shear test (at the maximum dry density, Field moisture content and 95% dry density in wet or dry side),
  - One dimensional consolidation test (at the maximum dry density and field moisture content or 95% dry density in dry side);

The test results are shown in Table 4D-2 and Fig. 4D-11 and conclusively in Fig. 4D-12, respectively.

As seen in those illustrations, the materials from TP-10 and TP-11 are CL and CH, respectively, plastic clayey material. The material from TP-10 is more silty than that from TP-11. The content of silt and clay of this material reaches 75%, sufficiently impervious. The both materials, therefore, can be applied as impervious embanking material. The material from TP-11 is highly plastic, compressive and poorly workable. As for an embanking material, therefore, the material from TP-10 is deemed to be more desirous rather than that from TP-11.

The both materials are deemed to be the representative materials in the job site. However, more detailed investigations and tests are required in order to decide selective utilisation of both materials.

(b) Sand and Gravel Materials

Sand and gravel materials suitable for fine aggregate of concrete and filter-drain of fill dam are very hard to borrow from nearby the job sites. Since the river sand is, as stated previously, well sorted and relatively fine, it is deemed to be unsuitable for the said purposes.

The materials might be borrowed, as the North Nawin Project does, from the river-bed deposits of Irrawaddy near Pyalo village, Aunglan Township, 25 miles north of Prome and some 60 miles far from the main dam site.

Fig. 4D-13 shows gradation range of said sand and gravel materials. Proper soil mechanical tests on the materials have not been made yet.

(c) Rock Material and Coarse Concrete Aggregate

Rock material is available from a mountain body at Leyge Baung point near Ngettawe village, three miles south west-west of Paukkaung town. Very hard and sound sandstone rock might be obtained for enough amount from newly established quarry site at this point.

Near Kyaung Ywa village, four miles north-east of the main dam site, outcrops of hard sandstone are proposed also as quarry. However, Leyge Baung quarry is deemed to be more convenient considering from accessibility and future utility for other purposes.

Judging from rock quality, coarse concrete aggregate may be produced from the proposed quarry.

Rock test has not been performed yet.

Table 4D-1 Results of Soil Mechanical Test for Main Dam before Feasibility Study

No.	Area	Field Moisture Content (%)	Natural Bulk Density (lb/cf)	Specific Gravity (g/ccm)	Gradation (%)				Consistency			Compaction		Direct Shear		Permeability (K)
					Clay	Silt	Sand	Gravel	LL (%)	PL (%)	PI	OMC (%)	MDD (lb/cf)	Cohesion (kg/scm)	Friction Angle (deg.)	(ft/yr)
1	B	-	-	2.69	50.36	29.92	19.92	-	41.45	22.37	19.08	16.50	111.7	0.55	21-48	0.0147
2	C	-	-	2.69	37.60	5.40	57.00	-	24.25	15.05	9.20	14.40	114.0	0.30	21-48	0.0222
3	D1	-	-	2.67	27.57	18.97	51.22	2.24	30.07	15.79	14.28	14.40	100.0	0.42	20-48	0.0084
4	D2	-	-	2.66	37.54	5.69	65.86	1.00	34.66	20.40	14.26	17.60	99.0	0.25	26-34	0.0178
5	E1	-	-	2.68	15.64	35.36	49.00	-	27.10	23.68	3.42	14.60	100.8	0.25	30-58	0.0614
6	E2	-	-	2.67	15.38	19.38	63.44	1.80	27.10	18.07	9.03	17.80	97.0	0.25	33-01	0.294
7	F1	-	-	2.67	28.37	19.67	50.56	1.40	27.80	16.03	11.77	12.80	101.2	0.30	24-14	0.0091
8	F2	-	-	2.66	27.81	20.29	51.30	0.60	26.90	18.44	8.46	15.00	99.8	0.40	24-14	0.0443
9*	SN2	11.27	118.6	2.74	45.52	43.23	11.20	-	52.30	29.24	23.06	-	-	0.50	26-34	-
10	SN5	-	-	2.69	12.84	55.24	31.92	-	41.50	20.99	20.51	17.00	108.0	0.40	21.48	0.0267
11	TR1	-	-	2.59	4.60	13.44	81.96	-	42.70	21.56	21.14	14.80	110.7	0.20	33-01	10.90
12*	TR2	5.46	102.3	2.65	6.08	18.40	75.52	-	16.00	10.37	15.63	-	-	0.20	30-58	-

* undisturbed sample

Table 4D-2 Results of Soil Mechanics Tests on TP-10, TP-11, TP-1 and TP-2

Sample No.	TP10			TP11			TP1			TP2		
Condition / Items	95%Dd (dry)	OMC	95%Dd (wet)	FMC	OMC	95%Dd (wet)	FMC	OMC	95%Dd (wet)	FMC	OMC	95%Dd (wet)
FMC (%)		21.0			19.7			22.8			6.4	
Sp.Gr.(gr/ccm)		2.66			2.68			2.69			2.65	
Gradation												
Clay (%)		44.1			78.0			77.8			14.8	
Silt (%)		31.4			17.4			18.2			17.4	
Sand (%)		24.5			4.6			4.0			67.8	
Gravel (%)		-			-			-			-	
Consistency												
LL (%)		33.7			56.0			67.5			25.6	
PL (%)		18.5			28.0			29.1			15.7	
PI		15.2			28.0			38.4			9.9	
Unified Classification		CL			CH			CH			CL	
Moisture-Density Relations												
25-Blow MC(%)	13.0	16.6	21.2	19.7	22.0	28.4	22.8	21.4	26.4	6.4	13.6	17.7
Dd(lb/cf)	101.5	106.8	101.5	94.0	95.3	90.5	95.3	95.6	90.8	105.0	114.5	108.8
30-Blow MC(%)	-	14.6	-	-	20.0	-	-	20.0	-	-	12.2	-
Dd(lb/cf)	-	108.3	-	-	97.5	-	-	97.5	-	-	116.3	-
35-Blow MC(%)	-	14.6	-	-	18.8	-	-	19.2	-	-	12.0	-
Dd(lb/cf)	-	109.0	-	-	99.8	-	-	99.0	-	-	118.1	-
Direct Shear												
Cohesion (kg/scm)	0.50	0.60	0.50	0.65	0.70	0.80	0.75	0.80	0.90	0.25	0.25	0.30
Frict.Angle (degree)	21-48	18-56	15-34	14-48	11-19	11-00	18-33	11-19	10-00	24-54	25-35	25-35
Consolidation												
Mv (scm/kg)												
Ef.Load 1kg	0.0258	0.0264	-	0.0932	0.0731	-	0.0932	0.0698	-	0.0360	0.0234	-
Ef.Load 8kg	0.0094	0.0065	-	0.0118	0.0045	-	0.0187	0.0088	-	0.0090	0.0078	
Cv (scm/min)												
Ef.Load 1kg	0.308	0.388	-	0.140	1.408	-	0.231	1.073	-	0.189	0.330	-
Ef.Load 8kg	1.384	1.748	-	0.635	0.642	-	0.384	0.885	-	1.125	0.821	-
Permeability (ft/yr)	0.089	0.0124	0.0301	imp	imp	imp	imp	imp	imp	0.184	0.0190	0.0378

Fig.4D-8 CLASSIFICATION OF SOIL

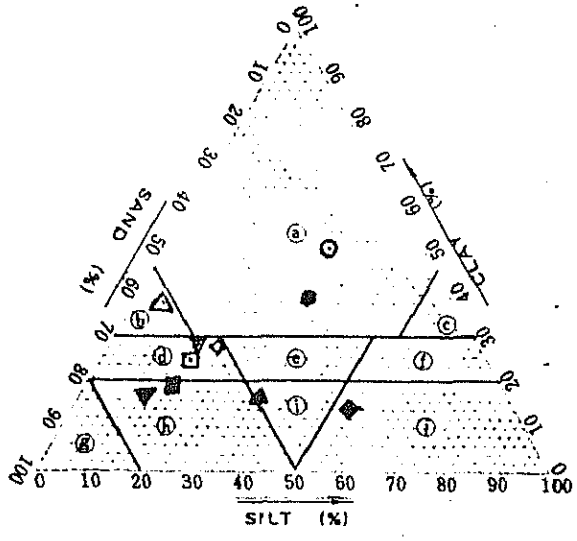
PROJECT ..... DATE .....

SITE No. ..... SITE ENGINEER .....

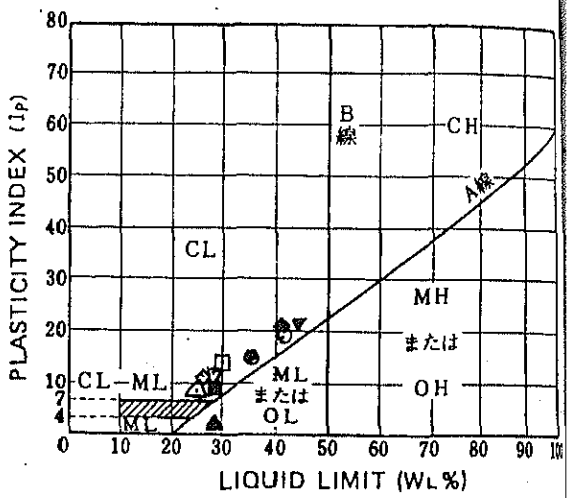
SAMPLE No.	DEPTH	GRAVITY	MOISTURE RATIO	CONSISTENCY			4.76 mm Residual Ratio %	Unified Soil Classification	
				WL (%)	WP (%)	IP			

A TRIANGULAR DIAGRAM

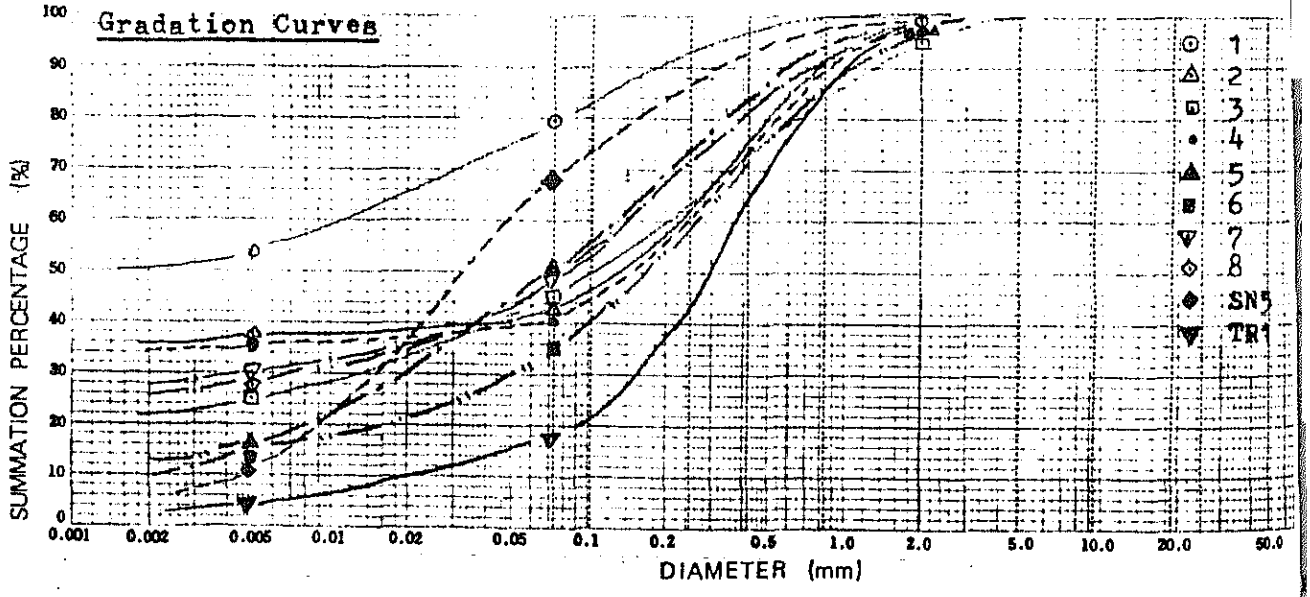
a C
b SC
c SiC
d SCL
e CL
f SiCL
g S
h SL
i L
j SiL



B PLASTICITY CHART



C GRADATION ANALYSIS CURVE



COLLOID	CLAY	SILT	SAND	GRAVEL
0.001	0.005	0.074	2.0	

SAMPLE No.	2000μ %	420μ %	74μ %	5μ %	GRAVEL %	SAND %	SILT %	SAND CLAY %	MAX mm	D60 mm	D30 mm	D10 mm	Uc	U'c

Note: $U_c = D_{60}/D_{10}$ $U'_c = (D_{30})^2 / (D_{60} \cdot D_{10})$

Fig. 4D-9 Relationship between Moisture Content & Dry Density Shearing strength, Permeability of Main dam before Feasibility Study

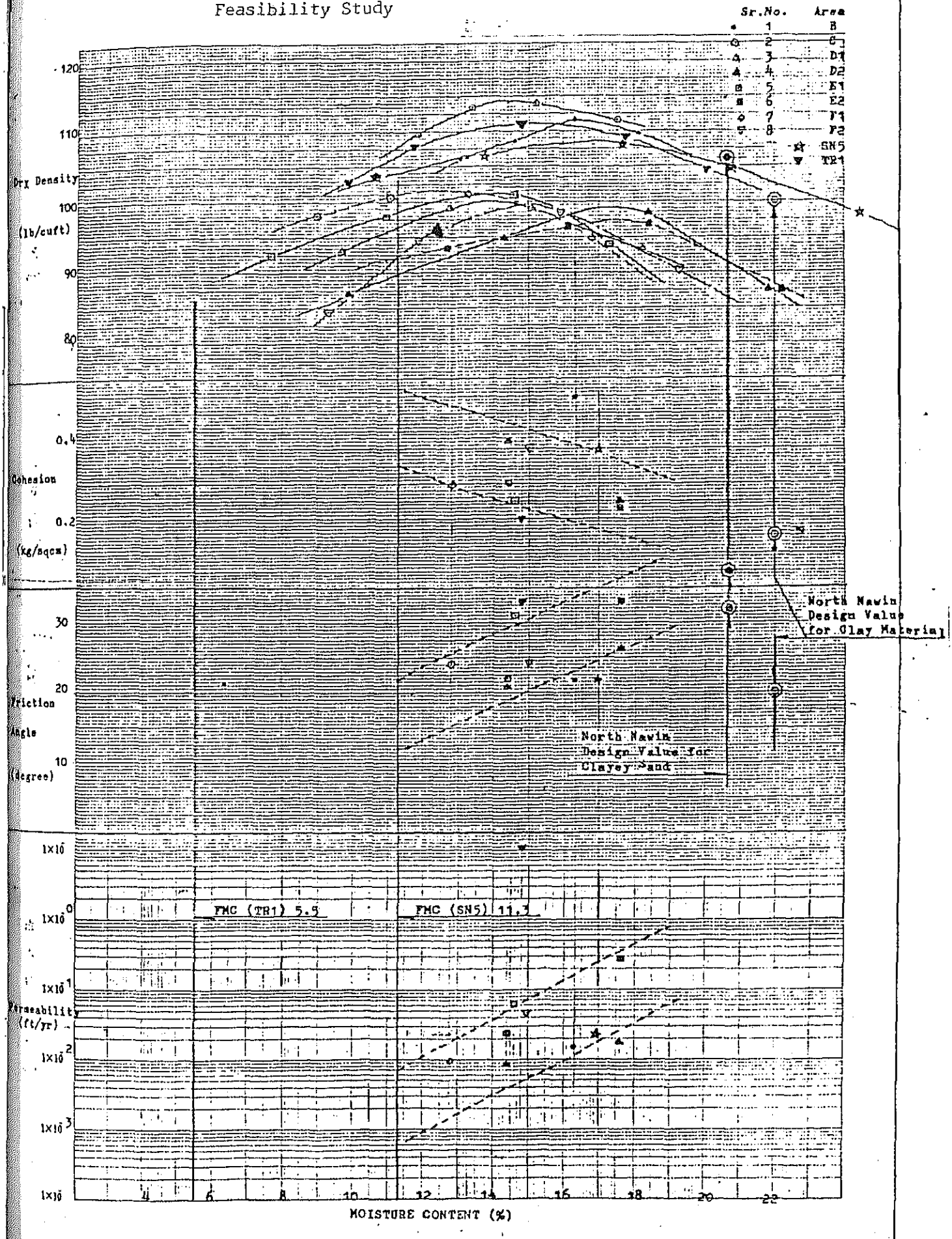


Fig. 4D-10. Test Pit Log on TP-10 & TP-11

TEST PIT LOG

South Nawin Irrigation Project Main dam site

Test Pit No. TP10

No groundwater was reached.

Depth (ft)	Description	Log	Samples	Field Moisture Content (%) 10 20
	Clayey Top Soil, greyish brown, hard and compact, well cemented, slightly moistened, unsaturated, dense, having mud cracks at top portion soft and plastic under wet condition			
5	Silty Clay, yellowish grey, contained yellowish silt patches, slightly plastic and soft under wet condition, moistened, unsaturated, firm dense, slightly micaceous and occured numerous root and peats			
10	Silty Clay, bluish grey, moulded, slightly plastic, moderately cemented, firm and compacted, moistened and dense			
15				

TEST PIT LOG

South Nawin Irrigation Project Main Dam Site

Test Pit No. TP11

No groundwater was reached.

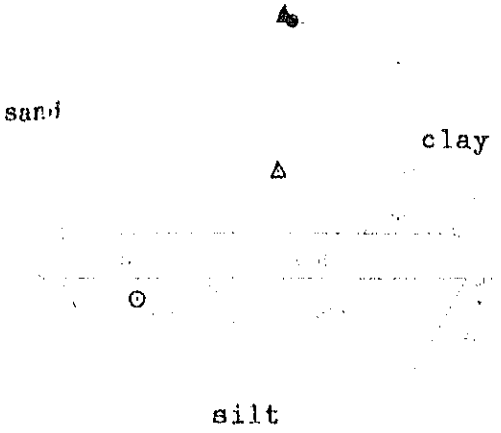
Depth (ft)	Description	Log	Samples	Field Moisture Content (%) 10 20
	Clayey Top Soil greyish brown, dry hard and compacted, highly plastic and soft under wet condition, slightly moistened, dense and well cemented			
5	Heavy Clay, bluish grey, hard and compact, slightly plastic, unsaturated, well cemented including ferrogenous by pocket shape			
10	Silty Clay, greyish brown, stiff and compact, slightly plastic and moistened, well cemented, dense and include slight ferrogenous			
15				

Fig. 4D-11 Soil Classification on TP-10, 11, 1 & 2

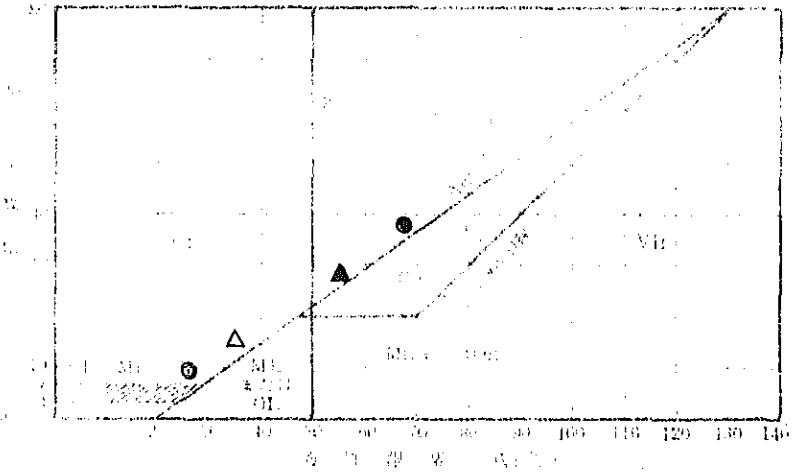
South Nawin Irrigation Project
Main and Diversion Dam Sites

Sample		Depth(ft)	Sp.Gr.	FMC	Consistency			
TP10	△	0 ~ 15	2.66	21.0	33.7	18.5	15.2	CL
TP11	▲	do	2.68	19.7	56.0	28.0	28.0	CH
TP1	●	do	2.69	22.8	67.5	29.1	38.4	CH
TP2	○	do	2.65	6.4	25.6	15.7	9.9	CL

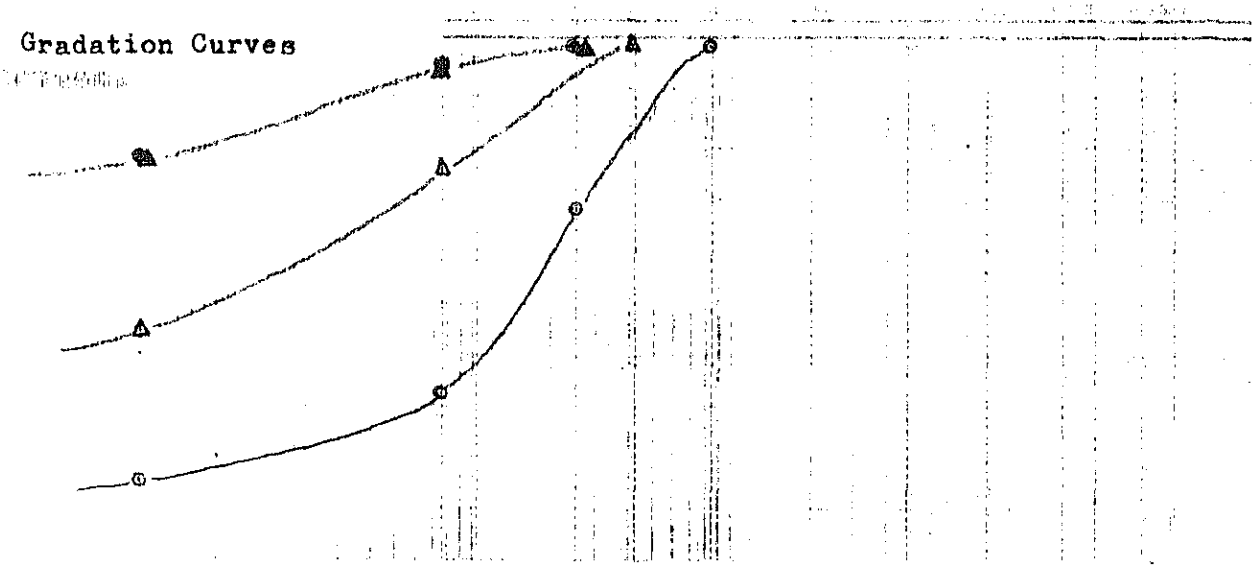
Triangle Coordinates



Plasticity Chart



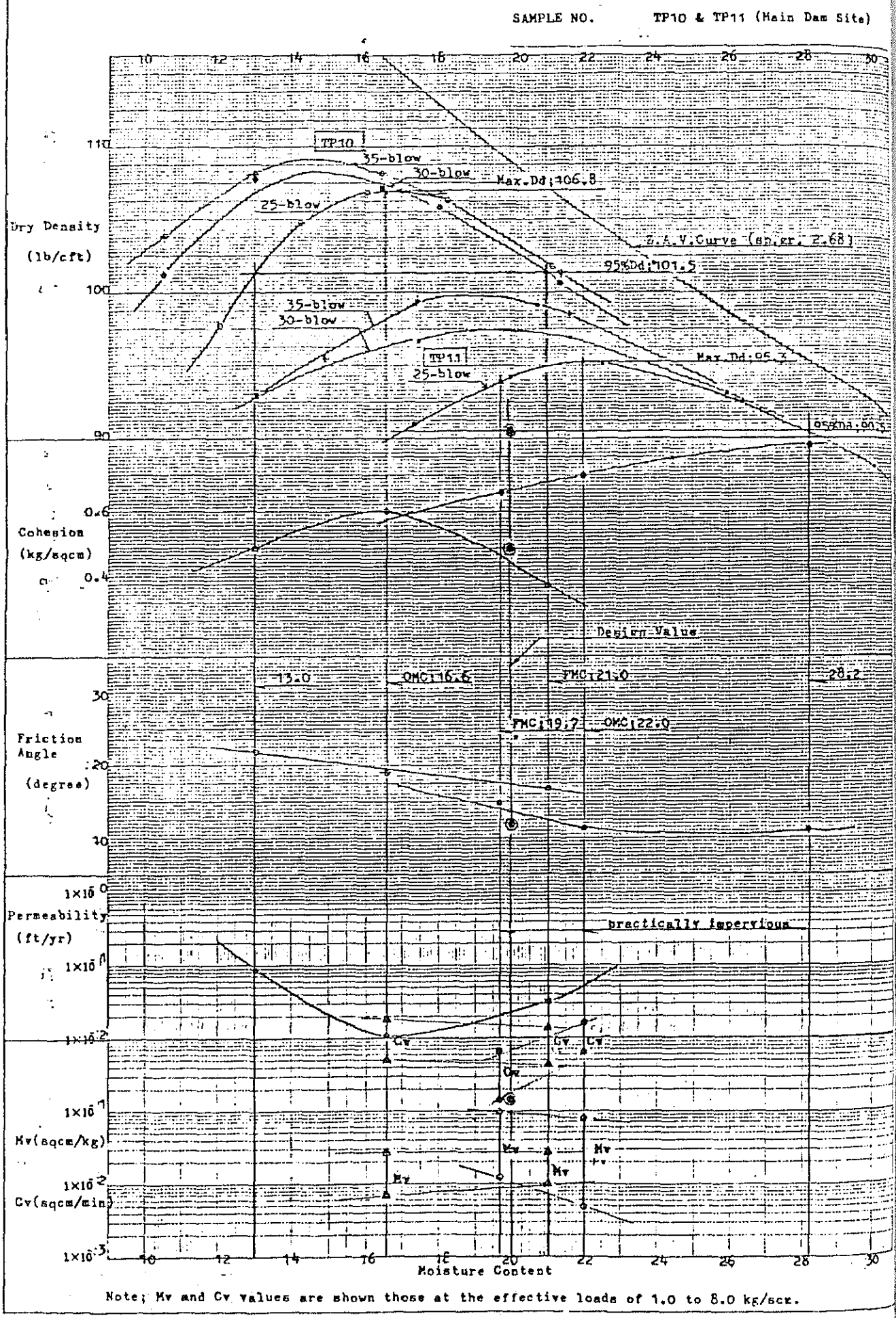
Gradation Curves



試験深度 m	通過率%	通過率%	通過率%	%	%	%	最大径 mm	60 % 径 mm				

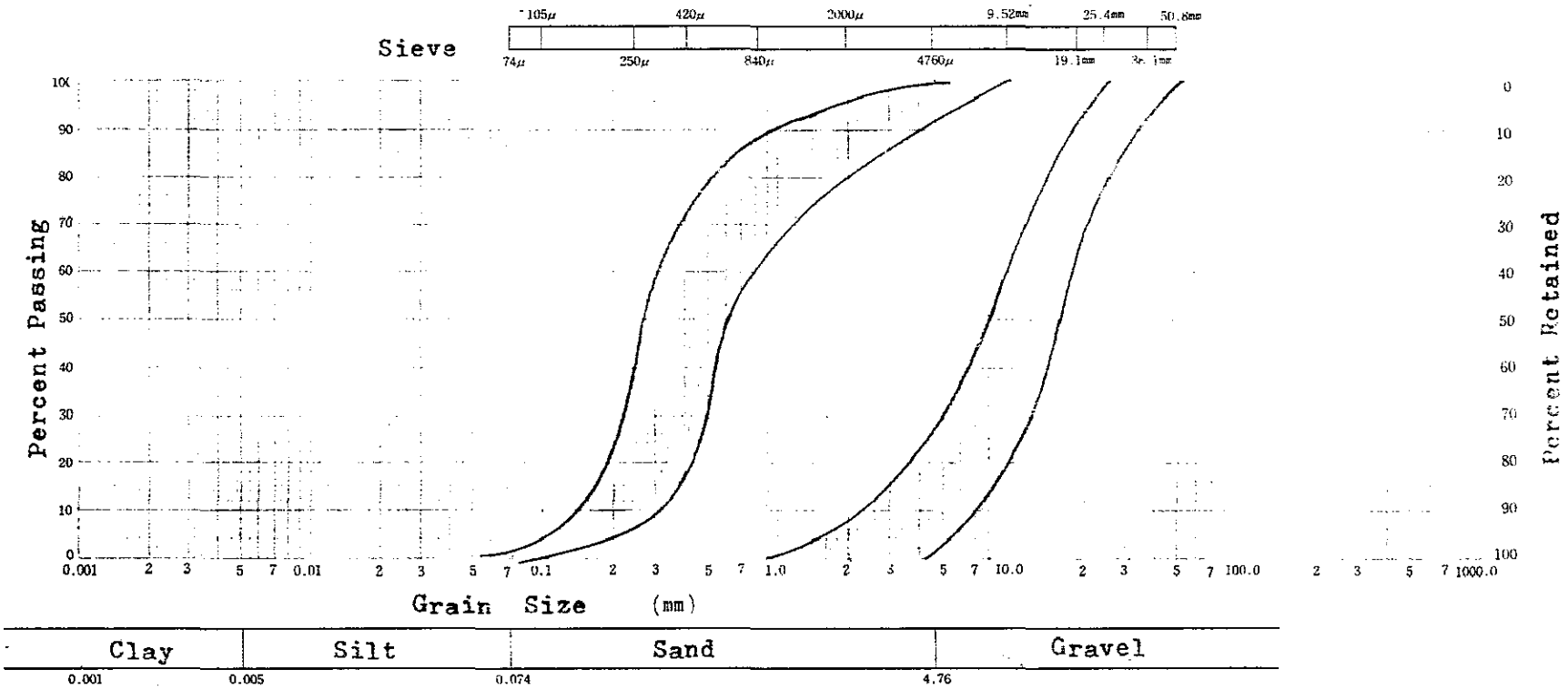
$U_c = D_{60}/D_{10}$ $U_c' = D_{30}^2/D_{60} \cdot D_{10}$

Fig. 4D-12. RELATIONSHIP BETWEEN MOISTURE CONTENT/DRY DENSITY, COHESION, FRICTION ANGLE, PERMEABILITY, CONSOLIDATION ON TP-10 AND TP-11



Note; Mv and Cv values are shown those at the effective loads of 1.0 to 8.0 kg/sqcm.

Fig. 4D-13. GRADATION CURVES FOR SAND AND GRAVEL MATERIALS



4D-5. Dam Type on Main Dam

At the proposed main dam site, two different types of the dam such as combined and fill were considered from the viewpoints of topographical, geological and hydrological conditions. The combined type dam is to have a concrete gravity section in the river channel portion where the spillway is located and fill section on both the left and right abutments.

According to the results of reservoir operation and sediment analysis studies, the height of South Nawin dam was assumed at about 136 ft. from the deepest impervious zone base at the river-bed.

The combined type dam was first considered as the most suitable to the profile of dam axis and management of the flood. For the concrete gravity section of the combined type dam, the bed rock shall be safe against normal and tangential component forces transmitted by the dam body. Fig. 4D-6 which is prepared from the results of stress analysis gives the relationship between the dam height and the required bearing capacity in the bed rock, and also shows the relationship between the required bearing capacity and the seismic velocity of the bed rock.

The results of seismic exploration executed at both the abutments are presented in the following table:

Velocity-layers (mile/sec)	Depth (ft)	Geological Conditions
Top layer (0.28-0.31)	16.4 - 49.2	Overburden and weathered bed rocks.
Second layer (1.12-1.24)	Below surface layer	Sound bed rocks

The above table shows that the seismic velocity of bed rock is too low than that of the required one due to the height of dam (Refer to Fig. 4D-6).

Moreover, according to the Engineering Geological Report on South Nawin Damsite by Geological Section of Irrigation Department, the compressive strength of Upper Peguan sandstone is between 142.2 to 284.4 lb/sq. in. and the dry shale is in the range of 85.3 to 120.9 lb/sq. in. and that of water saturated is 21.3 to 28.0 lb/sq. in.

As a result, it is very difficult to construct the concrete section in the river channel portion judging from the above-mentioned poor lithic properties of bed rock, therefore, the combined-type dam is not to be considered.

As far as the fill-type dam, the loads from dam body is transmitted to a wider area of foundation than those of concrete section of the combined type dam, and therefore, the fill-type dam can be built safely.

The above-mentioned conclusion is adopted for dams of more than about 46 ft. of height, while for lower dams, the combined-type dam may be found feasible.

As far as fill-type dam is concerned, a homogeneous type was given preference over zone and facing types on the basis of the available information, that is, the comparatively good quality and abundantly distributed impervious material can be obtained from nearly borrow areas, in favorable economic conditions of exploitation. On the other hand, there are no available pervious and rock materials in the vicinity of the dam site.

Homogeneous structure of the dam body was mainly sub-divided into two zones taking into account the difference of gradation texture of embankment materials and execution of economic embankment. The one is impervious zone which is classified in CL and CH group compacted by tamping roller and the other is random zone compacted by pneumatic-tire roller. The location of impervious zone was selected at the center of dam body in consideration on aseismatic design for the

dam body, soil mechanics properties of the embankment materials and the economical utilization of coffer dam as a part of main dam.

In conclusion, an earth-fill type of fill dam having central impervious zone with crest elevation at 308 ft was selected as the most suitable type for the main dam and the typical section is shown in the attached drawings.

This typical section is decided sufficiently in detail to estimate the construction cost on the feasibility study level.

4D-6. Freeboard and Dam Crest Elevation of Main Dam

The crest elevation of the non-overflow section of dams must be equal to the maximum water surface level plus freeboard. Freeboard shall be determined considering the wave due to wind and earthquake, rise of water surface level caused by unexpected accident in operating the spillway gate, and type and importance of dams.

The freeboard can be obtained by applying the following formula in consideration of the above-mentioned factors according to the Design Criteria for Dams which was established by Japanese National Committee on Large Dams.

$$Hf \geqq (R \text{ or } {}^{he}/_{2}) + ht + hs$$

Where, Hf -- freeboard of dam.
R -- height of wave due to wind.
he -- height of wave due to earthquake.
ht -- rise of water level due to unexpected accident in operating spillway gate, standard value ht is 1.64 ft adopted.
hs -- addition of allowance according to type and importance of dam, standard value hs is 3.28 ft adopted for fill-type and zero for concrete type dam.

(a) Height of Wave due to Wind

There is a number of formulas available for evaluating wave height due to the wind as a function of the wind speed and fetch distance, but in this case, the evaluation shall be based on the S.M.B. (Sherdrup-Munk-Breschneider) method. For inclined upstream face, Figure 4D-14 can be referred to in estimating rise of water uprushing on to the face of dams.

The figure combines the height and length of the significant wave obtained from the S.M.B. method, with the relation between the upstream slope and its surface material and the ratio of water uprush on to the slope to the wave height which is obtained from the Saville method.

In order to obtain the height of wave due to wind at the main and diversion dam sites, the wind speed of 44.75 mph in 10 minutes on an average is to be assumed taking into accoun the observed data of mean wind speed in Prome station.

(b) Height of Wave due to Earthquake

The height of wave due to earthquake can be evaluated from the following formula by Seiichi Sato, which gives a relatively large value compared with other formulas.

$$he = \frac{K.\tau}{2\pi} . \sqrt{g.Ho}$$

Where, he -- height of wave at upstream face of the dam due to earthquake.
K -- horizontal seismic coefficient and adopted by 0.12.
τ -- period of seismic wave and adopted by 1.0 second.
g -- gravitational acceleration.
Ho -- depth of reservoir and adopted by 29.0 m.

(c) Freeboard

Estimated freeboard of the main dam is presented in the following table. The upstream surface of the main dam is formed with hand placed riprap by the materials obtained from the quarry site, therefore, an intermediate value at the smooth slope and the rock zone slope in Fig. 4D-14 was adopted as the height of wave due to wind.

Fetch (ft)	R (ft)	Ho (ft)	he (ft)	ht (ft)	hs (ft)	Freeboard (ft)
30,000	4.60	95	1.06	0	3.28	7.88 ≒ 7.9

(d) Dam Crest Elevation

The main dam is constructed not only for irrigation but also for hydro-electric power, however, the storage capacity for hydro-electric power purpose is some percent of total storage capacity, therefore, almost storage water is used for both irrigation and hydro-electric power purposes.

According to the result of spillway studies, a rising height of water surface from the full storage level due to release of the design flood discharge at the spillway was decided to 5.3 ft and its corresponding water surface elevations are tabulated as follows:

Water Level	Storage Capacity ($\times 10^3$ ac-ft)	Water Surface Elevation (EL. ft)	Area of Water Surface ($\times 10^3$ ac)
Max. water	356.00	300.3	-
Full water	287.00	295.0	11.2
Dead Water/1	27.79	252.0	2.0

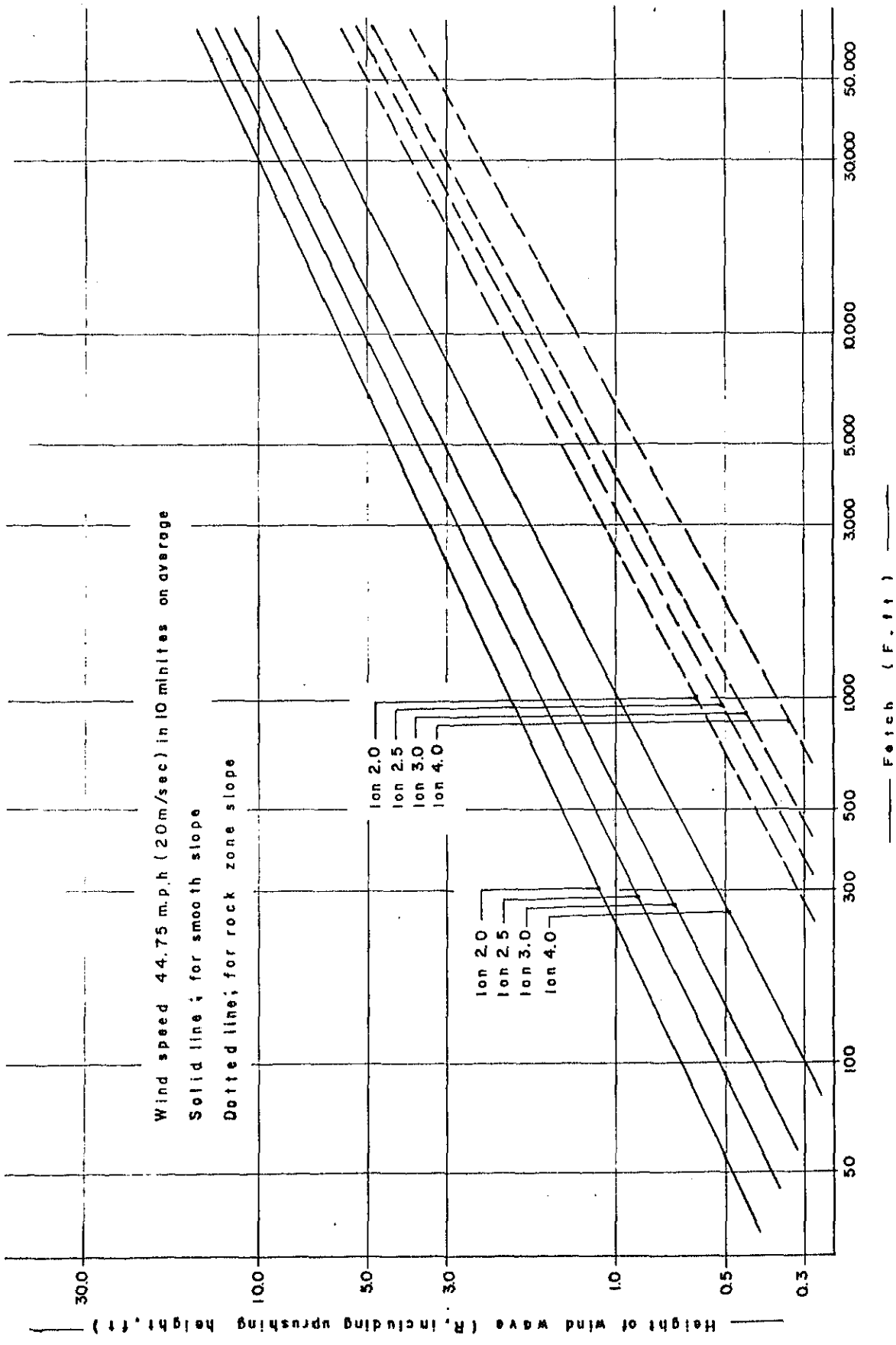
NOTE: /1 -- Dead water level (refer to paragraph of "Sediment Storage in Reservoir").

From the above table, the main dam crest elevation without extra-bank can be obtained by adding the freeboard to maximum water surface, as follows:

Dam Crest Elevation, EL 300.3 + 7.9 = EL. 308.2 ft ≒ EL 308 ft.

This elevation seems to be reasonable value taking into account the applicability and restriction of topographic feature at the dam site.

FIGURE 4D-14 HEIGHT OF WIND WAVE (BY S.M.B & SAVILLE)



4D-7. Stability Analysis of Main Dam

Stability of the dam body means that a soil mass with skeleton stress and pore pressure can keep its equilibrium state in resisting to the external forces. Taking into account the above-mentioned condition, the stability anlysis is made by effective stress method where the pore pressure was considered.

There are two situations for pore pressure; the one is due to unsteady flow in the course of embankment and immediately after completion of embankment, and the other is due to steady flow at full or rapid drawdown condition of the reservoir.

(a) Design Values

Design values of density and shearing strength to be used for stability anlysis of the dam body vary with the moisture contents and degree of compaction by the roller.

The design values of impervious and random materials for the main damshould be decided accordingly to the results of soil test, however, some of values of them and the values of rock material, the estimations are made on the data which have been obtained through various past soil test in similar nature.

(1) Impervious Materials

Taking into account the property of soil mechanics, field moisture content and the dam scale, the dry density for impervious material should be controlled at about 95 percent of the maximum density of compaction test.

From the above considerations, the design values of density and shearing strength are determined from the results of soil tests executed in 1976 and 1979, and are shown in the following table. However, the design values of shearing strength was decided from 80 percent of direct shear test values at the field moisture level considering the mechanism of testing equipment.

Density			Shearing Strength		Permeability Coefficient
γd /1	γt /2	γsat /3	ϕ /4	C /5	
(lb/cu.ft.)	(lb/cu.ft)	(lb/cu.ft)	(°)	(lb/sq. in)	(ft/year)
90.5	108.6	119.2	15°00'	7.11	0.1
(ton/cu.m)	(ton/cu.m)	(ton/cu.m)		(ton/sq.m)	(cm/sec)
1.45	1.74	1.91	15°00'	5.0	9×10^{-7}

NOTE: /1 -- dry density; /2 -- wet density; /3 -- saturated density
/4 -- angle of internal friction; /5 -- cohesion

$$\gamma d = \frac{Gs}{(1 + e)} \; ; \; \gamma t = \gamma d(1 + \frac{M.C.}{100}), \; \gamma sat = \frac{(Gs + e)}{(1 + e)}, \; e = \frac{Gs - \gamma d}{\gamma d}$$

Gs -- specific gravity; e -- void ratio; Mc -- moisture content

(2) Random Material

Since the random zone is embanked with excavated materials at lower layer of the borrow areas and spillway, various materials should be mixed with ranging from fine clayey materials to coarse sandy materials. However, it can be assumed that the soil mechanics properties of these materials are almost equal to the impervious one.

For the design values of density and shearing strength, the same values of impervious material can be quoted for the random material taking into account the sampling depth and situation of testing specimen.

(3) Rock Material

Since effective test has not been executed for determination of the design values of rock material, the estimation is made based on the data obtained from the past tests in Japan, and the results are shown as follows: