APPENDIX II GEOLOGY AND DAM CONSTRUCTION MATERIALS

CHAPTER 1 GEOLOGY

1.1 General

The study area is located between the Central Luzon Plain and the Western Cordillera. An agricultural land zone is in the south-west of the Plain, and the proposed dam site and reservoir are on the vicinity of the Western Cordillera known as the Zambales Range.

The Central Luzon Plain extends from Manila on the south to Lingayen Gulf on the north. The Plain consists of flat alluvial materials which are composed mostly of loosely compacted gravel, sand and clay originated from volcanic tuff and pyroclastics.

The West Cordillera extends two parallel mountain ranges from Bataan, northward to Pangasinan Province. The rocks in the mountain ranges, in general, are volcanic extrusives and the south-eastern part of the range including the dam site are largely formed by pyroclastics.

Geology of the proposed reservoir area is composed of pyroclastic of the Pliocene - Pleistocene period such as volcanic breccia containing various ratio of gravels. In the upstream of the reservoir, lapilli tuff and tuff breccia are dominantly distributed. At the dam site area, tuff breccia with rhyolite gravels and agglomerate are predominant.

The general geological map is shown in Fig. 2.1.

1.2 Geological Investigations

During the Feasibility study stage, the following geological investigations were done in cooperation with the staff of NIA.

1) Core Drillings

Proposed Gumain Dam Site	:	18 holes, 1,086.03 m
Alternative Dam Site	:	2 holes, 100.20 m
Quarry Site	:	4 holes, 200.70 m
Borrow Area	:	3 holes, 79.70 m
Proposed Gumain Diversion Dam Site	:	2 holes, 40.10 m
Total	:	29 holes, 1,506.73 m

2) Standard Penetration Tests

Proposed Gumain Dam Site	:	47 nos.
Alternative Dam Site	:	8 nos.
Borrow Area	:	4 nos.
Total	:	59 nos.

3) Water Pressure Tests

Proposed Gumain Dam Site	:	181 nos.
Alternative Dam Site	:	7 nos.
Total	:	188 nos.

4) Seismic Prospectings

Proposed Gumain Dam Site	:	9 lines, 8,145 m
Alternative Dam Site	:	6 lines, 4,030 m
Quarry Site	:	3 lines, 1,820 m
Borrow Area	:	1 line, 1,010 m
Total	:	19 lines, 15,005 m

The detailed quantities of geological investigations are shown in Table 2.1 and 2.2, and the location is illustrated on Fig. 2.2.

1.3 Geology at Gumain Dam Site

1.3.1 Dam Site

The proposed dam site is located at the gorge downstream of the confluence of two tributaries of the Gumain river and the dam axis would be laid at about 350 m from the confluence. On this dam axis, the river bed has an elevation of 60 m, width of about 100 m, and a gradient of about 1 to 100. The left bank has a cliff with a height of about 100 m and then rises at about 45° of average slope toward the plateau on elevation 170 - 200 m. And the right bank rises at about 30° toward the plateau on elevation 150 - 160 m. A width-to-height ratio of dam site is about 4, when a top elevation of dam is about 160 m. If the top of dam will be raised, width-to-height ratio will increase extremely due to continuity to saddle dam on the right abutment.

Geology of the proposed reservoir area and dam site along the Gumain river is composed of pyroclastic of the pliocene - pleistocene. By association with size and content ratio of gravels and pyroclastic rocks are classified as follows:

Classification of Pyroclastic Rocks in the Proposed Dam Site Area

Ratio of Gravels	%	Gravel Size	Name of Rock	
(few)	0-5	Granule	Tuff	Tuff ... Sandy and muddy tuff in general Lithic tuff ... an indurated deposit of volcanic ash in which the fragments are composed of previously formed rocks ... acidic, non porous and medium sandy tuff Pumice tuff ... a light colored cellular, glassy rock having the composition of rhyolite ... white, muddy and porous tuff
Small	5-30	Granule Pebble	Lapilli tuff	
Medium	30-80	Granule Cobble	Tuff breccia	Tuff breccia ... included angular volcanic bomb into the matrix of tuff and the fragments of andesite Agglomerate ... included round volcanic bomb into the matrix of tuff and the fragments of andesite Rhyolitic facies ... composed of gravels of rhyolite, Diorite porphyry and Navadite with the matrix of lithic tuff, pumice tuff and fragments of rhyolite group
Large	80-100	Pebble Boulder	Volcanic breccia	

The upper stratum of the right abutment consists of moderately weathered to fresh tuff breccia with rhyolite facies. Gravels in the rhyolite facies are composed mostly of pebble to boulder size, partly white acid rhyolite and partly diorite porphyry. Matrix is moderately cemented with tuff and fragments of rhyolite. This tuff breccia is also distributed on the both banks around the dam site.

The left abutment, the river bed and the lower stratum of the right abutment are composed mostly of agglomerate and partly tuff breccia with andesite facies. Agglomerate and tuff breccia are moderately weathered to fresh, massive and slightly jointed. Most of the joints are tight and with no apparent fillings. Gravels in the agglomerate are mainly hard to partly porous andesite having a diameter of 10 to 20 cm. Rock matrix is well cemented with tuff. In this stratum pumice tuff is found and shows lense structure with maximum thickness of about 10 m (DH-8). Pumice tuff is yellow white in color, light weight, and soft hardness when weathered.

Overburden layers are composed of alluvial deposits, talus deposits, residual soils and extensively weathered rocks. At the river bed, alluvial deposits consist of well-compacted mixture of sands, gravels and boulders which originated mainly from hard andesite and basalt with maximum thickness of about 8 m. Talus deposits, residual soils and extensively weathered rock are distributed with an average depth of 5 m to 10 m at dam site area, but lacking at steep slopes such as in the lower portion of left abutment.

The geological conditions mentioned above are shown in Fig. 2.3 and 2.4.

Around the dam site area, dips of bedding planes for the upper stratum are almost horizontal (0 - 5°). However, the lower stratum shows a monocline having a trend of 5 to 15° south-east dipping obliquely toward the downstream.

A series of faults and joints are found around the dam site, and lineaments are also found from observation of aerial photographs. In the proposed reservoir, faults crossing the river partly, columnar joints at interval of about 100 m and a few platy-joints along the flow beddings are observed. These faults and joints are considered not to have any serious problems on the dam and reservoir planning since most of them are crossing against river channels and their scales are relatively small.

Many of the great outcrops are observed around dam site area, and most of them are massive rocks without open cracks. Reflecting the massive structure, foundation rocks of the dam site area have relatively low permeability. Actually, K value, the coefficient of permeability obtained from water pressure test on the foundation rocks shows 10^{-5} cm/sec order or less except for moderately weathered rocks. K value of moderately weathered rocks, within a depth about 20 m from surface, becomes large such as 10^{-4} cm/sec order. Results of water pressure tests are summarized in Table 2.3. Water pressure tests at the overburden layers were not conducted because of their loose structure, but K value of these layers is anticipated to be more than 10^{-3} cm/sec from outcrop observation.

Approximate Permeability of Foundation Rock in Lugeon Value

Foundation Rock	Weathered Bed Rock (Upper zone)	Fresh Rock (Lower zone)	Outcrops	Remarks
Pumice tuff	18 - 23 Lu	2 - 3 Lu	Large	With potential to piping
Tuff	-	1 - 2	Small	Compacted
Agglomerate	10 - 20	1 - 10	Middle	
Tuff breccia	10 - 20	2 - 10	"	
Rhyolitic facies	5 - 10	2 - 8	"	Matrix cemented
Volcanic breccia	3 - 10	1 - 6	Large	Cracky, jointful

Pumice tuff has normal resistance against piping. But concerning to weathered pumice tuff, it is deemed to be friable and to indicate low resistance against piping. Drilling works at the dam site area revealed the presence of pumice tuff as shown below:

Presence of Pumice Tuff

Location	Drill No.	Top Ele. (m)	Depth (m)	Remarks
Left Abutment	DH-1	173.80	24.00 - 27.05	Mixed with Tf
	DH-2	193.29	53.00 - 55.50	Consolidated
	DH-4	171.40	63.50 - 66.70	Non core
	DH-10	122.00	13.10 - 17.70	Mixed with Agl.
	DH-12	168.46	38.00 - 42.25	Impervious
	DH-13	164.52	20.90 - 24.90	Clearly consolidated
	DH-14	118.00	21.60 - 23.40	
	DDH-1	147.00	17.10 - 26.00	Clearly
Right Abutment	DH-8	158.54	25.55 - 36.50	Clearly
	DH-9	190.18	5.25 - 6.00	Mixed with another tuff
	ADH-17	115.00	17.10 - 23.30	
	DDH-3	144.00	6.95 - 7.55	

Based on the above result and detailed ground investigation, two pumice tuff layers, each one at both abutments, were indicated. Considering the thickness of pumice tuff at each drill hole, pumice tuff layers are considered to have lense structures.

Drillings at the river bed (DH-5 and DH-6) encountered artesian pressure at around 16 - 20 m depth. On the other hand, ground water level in drilling holes on both sides is very deep, about 60 to 70 m below the ground surface.

Ground Water Level at the Dam Site

(Unit: m)

Location	Drilling Hole No.	Collar Elevation	Depth of W.L.	Elevation of W.L.	Remarks
Left Abutment	DH-1	173.80	48.90	124.90	
	DH-2	193.29	66.45	126.84	
	DH-3	173.59	56.55	117.04	
	DH-4	171.40	none (76.00)	(95.40)	
	DH-10	122.00	- (58.90)		Unknown
	DH-11	173.73	31.00	142.73	
	DH-12	168.46	none (45.00)	(123.46)	
	DH-13	164.52	38.30	126.62	
	DH-14	118.00	39.50	78.50	
	DDH-1	147.00	30.40	116.60	
	Spring 1 (Upstream)	140.00	0	140.00	Near DH-1
	" 2	140.00	0	140.00	"
	" 3	150.00	0	150.00	Bo. PASBOL
Right Abutment	DH-7	138.22	68.50	69.72	
	DH-8	158.54	none (70.20)	(88.34)	
	DH-9	190.18	66.00	124.18	
	ADH-17	115.00	56.00	59.00	
	AHD-18	154.43	66.95	87.48	
	DDH-3	144.00	none (50.20)	(93.80)	
	Spring (Downstream)	140.00	0	140.00	Located between ADH-18 and DDH-3

Remarks: ( ): Bottom depth or elevation of drilling hole

This water condition which is conductive to piping, will pose a problem on water storage. The foundation treatment will be needed to minimize possible leakage.

At the left bank, percentage of core recovery of drill holes of DH-2 and DH-12 are very low. This may be associated with the presence of fault structure. The location of DH-2 is on the saddle which conforms and is coincide with lineament from aerial photograph. Considering the above geological condition and low water table, some amounts of leakage are expected.

A seismic exploration at the dam site shows that the ground is divided into three zones by velocities of elastic wave propagation. Velocity zones are roughly correlated with the ground conditions as follows:

Results of Seismic Exploration at the Dam Site

	Zone	Velocity (km/s)	Approximate Geology	Thickness	
Both Abutments	I	0.4 - 0.7	Top soil, tauls and residual soil	Right bank Left bank	4 - 5 m 2 - 3 m
	II	0.9 - 1.5	Weathered or cracky rocks	Right bank Left bank	15 - 28 m 10 - 15 m
	III	1.6 - 2.0	Slight weathered and jointed rocks		
River Bed	I	0.8 - 1.35	Upper zone or river deposit	3 m	
	II	1.8 - 2.5	Lower zone of river deposit	4 - 5 m	
	III	3.1 - 3.3	Fresh and solid rock		

The elastic velocity of the foundation shows relatively small value considering for the sake of low formation of the underground water.

Zone I and II velocity layers are of sand and gravel, and are very thin (5 m) at 40 m upstream from the line A - A'. Then, they become gradually thick to the upstream from there. The thickest is about 14 m at near the B - B' line. The low velocity zone, that has discontinuity and small velocity comparing around zones, shows 0.9 - 1.3 km/s. This zone suggests the existence of the fault breccia or local weathered zone.

The low velocity zone found on the line C135 - C175, G215 - G225, and H30 - H60 are just located on the lineament confirmed by aerial photograph. The low velocity zones on the line A960 - A1010, B825 - B990, C520 - C545 and E550 - E580 are considered to be rows of some fault breccias and weathered veins.

Location of the Lower Velocities Zone at the Dam Site

Left Bank	River Bed	Right Bank
C135 - C175	G215 - G225	C1050 - C1060
C385 - C438		A960 - A1010
C520 - C545		A410 - A420
A90 - A100		B825 - B990
F940 - F950		B1150 - B1210
H30 - H60		E550 - E580

Remarks: E580: E; Line name
580; Distance from beginning point (m)

1.3.2 Alternative Dam Site

The alternative dam axis is laid at about 650 m downstream from the axis of the originally proposed dam. This site is located at the narrow gorge with cliffs. The river bed has an elevation of 57 m and a width of about 100 m. Relative heights of both abutments from river bed are about 90 m. From the above topographical condition, the dam site could impound water of less than 70 MCM.

Many of the great outcrops are found at the cliffs and massive agglomerate - tuff breccia are predominant around this dam site. From the results of drilling and test pit works, plateaus of both abutments are capped by rhyolite facies, similar to those of the originally proposed dam site.

Geophysical structure is also similar to the upstream dam site and dips of bedding planes is a monocline having a slightly oblique trend toward the downstream. The pumice tuff is also present in the foundation of this dam site. Rock quality of the foundation is the same as of the upstream dam site. Geological profile at this dam site is shown in Fig. 2.5.

Foundation rocks of the dam site have relatively low permeability. It ranges 1 - 5 Lugeon value except for weathered rocks from water pressure test. Seismic exploration in the alternative dam site shows that the ground is divided into following zones:

Results of Seismic Exploration at the Alternative Dam Site

	Zone	Velocity (km/s)	Approximate Geology	Thickness (m)
Both Abutments	I	0.6 - 0.8	Top soil, tallus and residual soil	2 - 3
	II	1.0 - 1.6	Weathered or crack rocks	Left bank 23 Right bank 15
	III	2.0	Slightly weathered and jointed rocks	
River Bed	I	0.5	Upper zone of river deposit	4
	II	2.0	Lower zone of river deposit	
	III	Not obtained for the thick river deposit		

1.3.3 Quarry Site and Borrow Area

Q-1 quarry site was first selected at the upstream part of the proposed dam site. It is located at the right bank of northern tributary of the Gumain river, about 800 m upstream of the confluence of tributaries. Geology of Q-1 site is dominated by lapilli tuff and tuff breccia with andesitic facies which are widely distributed in the proposed reservoir area. Lapilli tuff in the Q-1 quarry site is composed mostly of tuff matrix from the drilling result (QDH-1) located in the center of the quarry site. Tuff breccia in this site is laid below 40 m from surface and has high content ratio of fairly hard andesitic gravels. Drilling cores of QDH-3 located in the southern margin of Q-1 quarry site are composed of hard rhyolite and medium hard tuff breccia. Gravelly group of tuff breccia are considered to be occupied about half of the whole quantity in Q-1 site.

Q-2 quarry site was selected at the left bank of Gumain river about 1 km downstream from the proposed dam site. From the field reconnaissance, geology of Q-2 site is considered to be composed of tuff breccia or folcanic breccia alternated with lapilli tuff. But according to the drilling result of QDH-2 and QDH-4, Q-2 site are mostly composed of lapilli tuff. And Q-2 site is not recommended for the quarry site.

The comparison, the results of seismic exploration at the quarry sites are shown in the next page:

Results of Seismic Exploration at Q-1 and Q-2 Quarry Sites

Approximate Geology	Q - 1		Q - 2	
	Velocities Zoned (km/s)	Thickness (m)	Velocities Zoned (km/s)	Thickness (m)
Residual soil/ decomposed rock	0.5 - 1.0	5	0.5 - 1.2	3
Medium weathered rock			1.2 - 1.8	7
Slightly weathered or cracky rock	2.0	20 - 35	2.15	
Fresh and solid rock	3.0	-	-	-

Borrow area is located in the gentle slope near the left abutment. Impervious material in the borrow area is obtained from overburden layer, namely residual soils and totally weathered rock of agglomerate or tuff breccia with rhyolite facies. The thickness of the layer available for impervious embankment is about 3 to 5 m based on the observations of test pits, drilling cores and seismic exploration.

Results of core drilling (BDH-2) and the seismic exploration (line Q-Q') indicated a good source of rock materials beneath. It contains large and plenty of gravel of andesite and rhyolite, and the thickness of velocity layer (1.2 - 1.6 km/s) is below 15 m. As far as quality of rock, borrow area I is also suitable as the quarry site.

1.4 Geology at Diversion Dam Sites and Diversion Canal Routes

1.4.1 Proposed Gumain Diversion Dam Site

A new diversion dam site is located at about 2.6 km downstream from the proposed Gumain dam site. Tuff breccia - lapilli tuff is exposing at right abutment and terrace deposit is broadly expanding at left abutment. By two core drilling works executed at river site, more than 20 m of sand and gravel layer was ascertained. The layer mainly consists of pebble to cobble size, partly big boulder as shown in Fig. 2.6. The layer of 3.7 m depth from surface (at BN-2) seems to be loose deposit, and deeper layer than the above seems to consist of well consolidated sand.

1.4.2 Foundation of Existing Diversion Dam Sites

(1) Caulamang Diversion Dam Site

The upstream of the dam is filled with newly deposited materials which are mainly consisted of loose gravels and sands, excessively containing silty sands. The left abutment and foundation of the dam form terrace deposit formed by flooding of the Caulamang river. The terrace deposit consists of sand and gravel layer containing many andesite gravels with a size of 2 to 3 cm diameter, and it is well graded and compacted. The clay seams are not intercalated into this terrace deposit.

(2) Gumain Diversion Dam Site

Sediment in the reservoir of the diversion dam is comparatively small. There exist gravelly water deposits along the stream and sandy loose deposits on the both banks. The foundation of diversion dam seems to be well compacted terrace deposit, which still remains on the both banks. Ground water level is comparatively high around the existing canal near the dam site. This is considered that the deposit thereof consists of fine sand which has higher retention than gravel.

(3) Porac Diversion Dam Site

The both abutments of the diversion dam form terrace with comparatively large height. The foundation of the dam is terrace deposit and it is composed of sand with few clayey soil. A volume of sedimented sand in the upstream of the dam is relatively small, but many clayey or silty deposits are observed along the river stream.

1.4.3 Foundation of Proposed Diversion Canal Routes

(1) Porac Diversion Canal

The proposed Porac diversion canal starts from new Gumain diversion dam site and runs about 1 km along the left bank of the Gumain river. After that, the canal turns its route into the left abutment which consists of terrace deposit having its height of about 25 m. The terrace is sloping down gradually to the east and finally spreading into the Pampanga delta. The bed materials of the left bank of the Gumain river consist of well compacted pebble and cobble except for top soil. The terrace deposit consists of mostly fine to medium sand, partly gravel to pebble which are well consolidated. The alluvial plain of the Pampanga delta having its elevation of 30 m to 37 m is composed of well graded gravel and sand except for loose silty sand in the surface layer. Generally, the foundation of the canal route has a enough bearing capacity but poor graded sands loosened by the fractuation of ground water level are observed at the crossing point of the river.

(2) Caulamang Diversion Canal

The canal route runs through the right bank deposit of the Gumain river and the deposit contains much of soft clayey soil. The canal route from this section to around 1 km downstream passes along the foot of high terrace cliff which contains well graded sand to cobble size materials and have a enough bearing capacity for canal construction. The last section of about 2 km of the canal runs through river plain composed of well grade and compacted sand, gravel and alternation of them.

1.5 Study of Seismic Coefficient

The earthquake records to analyze a seismic acceleration were taken from the data file published by PAGASA. This data file shows the records during earthquakes with a Richter's magnitude of more than 4.0 from 1907 to 1980, and reliably describes the date of occurrence, approximate location and depth of epicenter and magnitude for earthquakes in and around the Philippines.

Table 2.4 shows a list of violent earthquakes (magnitude more than 5.0) that occured within a radius of 300 km from the proposed dam site, and epicenters of violent earthquakes are plotted in Fig. 2.7. Among violent earthquakes, significant earthquakes that might have affected the dam were selected under the following definition.

$M \geq 5.0$, when $\Delta \leq 100$ km

$M \geq 6.0$, when $100 \text{ km} < \Delta \leq 300$ km

where, M: Magnitude in Richter's scale

Δ: Distance from epicenter (km)

Selected significant earthquakes are listed in Table 2.5 with results of maximum acceleration estimated by one of Iwasaki's formulae. Iwasaki's formulae are derived through earthquake analysis on various geological foundations in Japan where earthquake circumstance is similar to the Philippines. The formula used in this study is applied to the Deluvium foundation with thickness of less than 25 m, since well compacted sandy gravels with 8 m thickness are deposited in the river bed at the proposed dam site.

The formula is as follows:

$$\alpha m = \frac{9}{10} \times 108 \times 10^{0.202 M} \times (\Delta + 30)^{-0.813}$$

where, αm: Maximum acceleration (gal)

Based on the statistical analysis on non-annual exceedence series data, the corelation between maximum acceleration is shown in Table 2.5 and return period is plotted on a logarithm paper as shown in Fig. 2.8. The maximum acceleration of 100 gal was obtained graphically for a return period of 100 years which is practical from the stand point of project life.

While, the basin of the Gumain river contains many valuable and important facilities such as villages, town and military airforce base which cannot be jeopardized by the construction of new dam. Therefore, the dam must be designed and constructed safely under any earthquakes concerned.

Considering the above circumstances and that several projects in the Philippines including the Pampanga Delta Project have adopted the seismic coefficient of 0.12, it is recommended that the design seismic coefficient of 0.12 is adopted for this project.

CHAPTER 2 DAM CONSTRUCTION MATERIALS

2.1 General

The proposed Gumain dam is of a center core type fill dam having the dam height of about 100 m. It is therefore needed to utilize soils, sands, gravels and rocks in the vicinity of the dam site for dam embankment and construction of appurtenant concrete structures. The field investigations were carried out to determine the most favorable sites for material sources from the viewpoint of quality and quantity. Based on the results of the field investigations, the laboratory tests were performed at NIA-UPRIIS laboratory and private laboratory (DRILL TECH INC.) in accordance with the guidance of JICA study team.

2.2 General Description of Construction Materials

2.2.1 Impervious Materials

Three borrow areas were selected around the proposed dam site. A material of each borrow area is sandy or gravelly clay containing moderately to extremely weathered fragments of bed rocks. There are not much differences in the soil properties found in each borrow area. Borrow area II and III are located too close to avoid some disturbances during dam construction and both borrow areas have small volume. Accordingly, borrow area I which would provide sufficient volume for impervious embankment use, was decided to be used and to be tested in detail. According to the results of sub-surface observations by digging test pits, core drillings and seismic exploration, the mean thickness of soil layer was estimated to be around 3 to 5 m. In general, it is thick on the gentle slope, while thin on the steep slope.

2.2.2 Pervious Rock Materials

Two quarry sites were selected around the dam site and investigated by drilling, seismic prospecting, geological mapping, etc. After observation of drilling core, analysis of geological characteristics of rocks and study of prospecting volume, Q-1 site was decided to be utilized as the quarry site of the dam. Q-1 site is located on the right bank of northern tributary of Gumain river, and is 0.5 km apart from the dam site as shown in Fig. 2.9.

2.2.3 Sand and Gravel (Filter and Concrete Aggregates)

Along the Gumain river, there exist many river bed deposits consisting of sands, gravels, boulders, etc. The Gumain river gradually spreads the width of the river bed toward the downstream according to the decrease of the river bed gradient. At the upstream of Summer Place, river bed deposits contain many cobbles and boulders with little sands, and going downstream away from Summer Place, it increases the content ratio of sand in the

river bed. Filter materials could be obtained from the river bed of downstream of Summer Place, and four potential filter deposits were selected as shown in Fig. 2.10. Out of these, F-1 site was selected for filter or concrete aggregate materials site since it has shortest distance from dam site and sufficient volume.

2.3 Prospective Quantities

2.3.1 Impervious Materials

From the viewpoints of location and soil properties, Borrow Area I is proposed to be used for the embankment of impervious materials. Judging from the results of soil tests and sub-surface investigations, suitable impervious materials that have higher compaction density are spread on the gentle slopes. And their available depths are expected to be 3 m to 5 m beneath the organic top soil layer. As the Borrow Area I has about 70,000 m^2 except steep slopes, a prospective quantity was estimated to be about 2.8 MCM. This amount is quite sufficient for the required impervious embankment volume of about 0.7 MCM.

2.3.2 Pervious Rock Materials

The investigation of drilling works indicated that the rock Q-1 site was less weathered and harder than that of Q-2 site. A content ratio of hard andesite fragment in Q-1 site was judged to be considerably high through various geological investigations. Therefore, it was determined that the quarry site for the dam would be Q-1 site. Based upon the results of geological investigation and analysis, the upper portion of Q-1 site is mainly composed of lapilli tuff and in the lower portion, tuff breccia predominates. The former rock would be applied to inner shell of the dam and the latter could be utilized for outer shell.

Available quantity of each rock is calculated in the following table:

(Unit: MCM)

	Lapilli Tuff	Tuff Breccia	Total Volume
Case 1	1.7	2.4	4.1
Case 2	4.4	4.4	8.8
Case 3	8.0	7.4	15.4

The location of excavation area is shown in Fig. 2.9.

2.3.3 Sand and Gravel Materials

The river bed deposits of F-1 area are recommended to be utilized as sand and gravel materials of filter zone and concrete aggregates since it has the shortest hauling distance and the biggest volume among four river bed deposits as mentioned in the previous paragraph. The obtainable quantity of sand and gravel materials from F-1 area is about 5,8 MCM. The river bed deposits contain some amount of big boulders more than 20 cm in diameter. Those are mostly consisted of hard andesite or basalt. Boulders are favorable to the rip-rap material for the upstream slope of the dam.

The content ratio of big boulders in the river bed materials would be approximately 30% in weight and 15% in volume.

2.4 Location of Samplings and Laboratory Tests

2.4.1 Location of Samplings

Three borrow areas for soil materials were selected by the field investigation, from upstream the Borrow Area I and II in the left bank, and Borrow Area III in the right bank. Twenty three test pits and thirty auger holes were excavated at these areas and soil samples were taken from each test pit. In the Borrow Area I, core drilling of 80 m and seismic exploration of 1,010 m in length were done to investigate the geological stratum of the borrow areas.

Two quarry sites for pervious materials were selected near the dam site. In the quarry sites of Q-1, core drilling of 100 m and seismic exploration of 380 m in length were made. Meanwhile, in the quarry site of Q-2, core drilling of 100 m and seismic exploration of 1,440 m in length were done to investigate the geological stratum of the quarry sites.

Along the Gumain river, there exist many river bed deposits consisting of sands, gravels and boulders. Filter and concrete materials would be obtained from the river bed downstream of the Summer Place and four potential areas of F-1 to F-4 were selected. F-1 area, located just downstream of the Summer Place, is the most promising area since it has the shortest haul distance to the dam and has also the widest area. Therefore, physical tests for filter materials were conducted taking the samples from F-1 area.

The location of samplings for the above-mentioned construction materials is shown in Fig. 2.2.

2.4.2 Laboratory Tests

The following tests were carried out for construction materials:

1) For soil materials

- Specific gravity of soil particles
- Grain size analysis
- Natural moisture content
- Plastic limit test
- Liquid limit test
- Compaction test
- Triaxial compression test, U-U and C-U
- Consolidation test
- Permeability test

2) For pervious materials

- Specific gravity test and water absorption test
- Compression test
- Soundness test

3) For filter and concrete materials

- Specific gravity test and water absorption test
- Grain size analysis
- Soundness test

In addition to the above, triaxial compression tests were carried out to know a shearing strength and rigidity of foundation rocks. The items of laboratory test performed are summarized in the Table 2.6 to 2.8. Samples collected from each material site were tested in NIA - UPRIIS laboratory and private laboratory (Drill Tech) under Japanese Industrial Standard (JIS) and ASTM.

2.5 Results of Laboratory Tests

2.5.1 Impervious Materials

(1) Physical Properties

The physical properties of impervious materials are shown in Table 2.9 to 2.10 and Fig. 2.11.

Soils of Borrow Area I are classified into GC and SC according to the United Soil Classification. Generally, GC and SC soils are favorably utilized for embankment materials of relatively high dams because of:

i) imperviousness after enough compaction, ii) fairly high shear strength in both saturated and unsaturated conditions, iii) considerably small settlement, and iv) fair workability.

Specific gravity of soil particles is 2.75 on an average ranging 2.68 to 2.83. This indicates normal value and not to contain organic matters. Average natural moisture contents are 21.5% in dry season and 26.9% in rainy season, respectively. Above results seem to be considerably high judging from field investigation. This may be caused by a small quantity of sample tested. The weight of moisture content test was reportedly about 20 g. This weight is too small to know the moisture content for soil of clay to gravel.

Plastic Index (PI) is 18 on an average ranging from 10 to 20. It indicates that the impervious materials are highly plastic, therefore resistible enough against piping. Gradation curves of grain size analysis are shown in Fig. 2.12. The content ratio of gravel (larger than 4.76 mm) ranges mostly from 45% to 85%. Gravels in the soils mainly consist of moderately to extremely weathered and fairly friable rock fragments. Therefore, gravels in the impervious materials will be easily crushed into small size during the embankment works, and the final content ratio of gravel in the embankment be presumed to be from 20% to 30%.

(2) Compaction and Permeability

The compaction tests were performed in accordance with the method of JIS standard.

The results are shown in the following table:

Borrow Area		Max. Dry Density $\gamma_{d\,max.}$ (g/cm^3)	Optimum Moisture Content W_{opt} (%)	Natural Moisture Content W_f - Optimum Moisture Content W_{opt} (%)
Area I	TP-1	1.670	19.4	-2.9
	2	1.585	22.6	-2.7
	3(A)	1.715	18.8	-
	3(B)	1.485	25.0	-10.1
	TP-4	1.275	37.0	-3.5
	5	1.395	29.0	-6.2
	6	1.630	20.4	-5.8
	7	1.370	32.2	2.9
	8	1.425	29.0	-12.2
	22	1.500	24.0	-4.2

Maximum dry density of compaction test is between 1.3 g/cm^3 and 1.7 g/cm^3, and 1.5 g/cm^3 on an average as shown in Fig. 2.13. Comparing natural moisture content (Wn) with optimum moisture content (Wopt), Wn is mostly about 3% drier than Wopt in dry season. In the wet season Wn is expected to be almost the same value of optimum moisture condition. This natural moisture condition suggests that impervious materials would need to add water during actual embankment works, especially in dry season. If the embankment works are made at the considerably drier condition, probably there would occur undesirable problems; lacking of imperviousness, rapid differential settlement being conductive to hydrofracturing after immersion by reservoir water, etc.

Standard permeability tests on disturbed samples were conducted at more than 95% of maximum dry density. The coefficient of permeability is in order of 10^{-7} cm/sec or less which shows sufficient imperviousness for embankment use.

(3) Consolidation

As for the sample in Borrow Area I, consolidation tests were done on two kinds of density. One was at maximum density with optimum moisture content and the other was at 95% of maximum density with optimum moisture content (Wopt) or wetter moisture content than Wopt. Each sample was tested for both saturated and unsaturated conditions. The test results are shown in Table 2.11.

The coefficient of consolidation (Cv) is one of the index to estimate the degree of pore pressure produced in the embankment under construction. Cv of both saturated and unsaturated samples is in the order of 10^{-3} cm^2/sec, and is considerably low. This indicates that some amounts of pore pressure would remain in the impervious embankment after completion of dam when wet materials are used. However, field moisture content of impervious material is almost optimum. Therefore, negligible pore pressure would remain in actual dam construciton.

A compression index (Cc) shows the resistance of soil against settlement. For the large scale dam such as Gumain dam, compression index of embankment is recommendable to be less than 0.15. To obtain Cc of 0.15, the soil materials in Borrow Area I would have higher dry density of more than 1.5 t/m^3. A yield stress of consolidation (Pc) is also one of index about the resistance against settlement. The maximum stress in the Gumain dam is about 20 kg/cm^2. To surpass the above stress, the dry density of embankment is also recommendable to be larger than 1.5 t/m^3.

For the differences between Pc and Cc under saturated and unsaturated test conditions, samples with low degree of saturation show the tendency to become weak and to increase the settlement rapidly after immersion into water. Accordingly during the actual embankment construction, it is needed to add some water into materials to avoid making embankment dryer with low degree of saturation.

(4) Shearing Strength

The results of triaxial compression tests under the unconsolidated and undrained (u-u) condition, and the consolidated and undrained (c-u) condition are summarized below.

	u - u		c - u	
	Cu (kg/cm^2)	ϕu (Degree)	C' (kg/cm^2)	ϕ' (Degree)
γd = 1.6 - 1.7 t/m^3 (High density group)	1.1 - 1.4	15° - 17°	0.1 - 0.3	14° - 19°
γd = 1.26 - 1.36 t/m^3 (Low density group)	0.8 - 1.3	10° - 16°	0.1 - 0-5	13° - 19°
Note	Total stress analysis		Effective stress analysis	

The relations between dry density and internal friction angle and cohesion are shown in Fig. 2.14.

As for the shearing strength of u-u test, the internal friction angle slightly increases in accordance with increase of dry density, but cohesion is almost constant. At the c-u test, however, both of internal friction and cohesion could not be clearly correlated with dry density. As shown in the above table, there are no differences of shearing strength between the high density group and low density group. Meanwhile both density groups have characteristics, that u-u strength is stronger than c-u strength. This tendensy is contrary to the general conception, but will occur in the following cases:

i) Initial moisture content of sample is dryer than Wopt and process of saturation in c-u test induces weakening of shear strength. This characteristics is also observed in the consolidation test, and

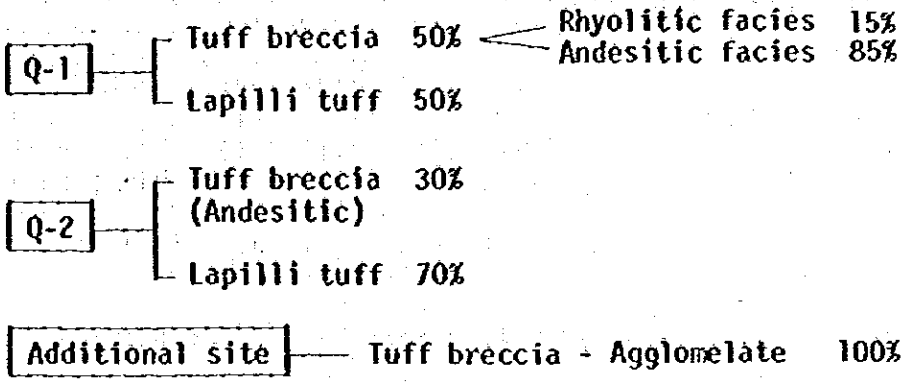
ii) Consolidation time is not enough for c-u test by lacking the accuracy of private laboratory. Some samples which have wetter moisture contents, shows weaker shear strength of c-u than that of u-u. This must cause lacking of consolidation.

Comparing the test result with standard or experienced strength, most of results of c-u test would be considered to be lower strength than actual strength. Taking into consideration the above tendencies, it is recommended to mainly use the results of u-u for the design value.

2.5.2 Pervious Materials

Two proposed quarry sites and one additional site were selected near the dam site. Q-1 site is on the right bank of northern tributary of the Gumain river, 0.5 km apart from the dam site. Q-2 site is on the left bank of the Gumain river, 1 km downstream of the dam site. And the additional quarry site is located on the hill in the Borrow Area I. Each location is shown in Fig. 2.2.

After observation of drilling cores and outcrops, and analysis of seismic prospecting, geological formations of quarry sites are as follows:



As for a quality of rock, the additional quarry site would produce harder rock materials than that of Q-1 and Q-2 quarry sites. However, since the additional site is located in Borrow Area I, it is inferior to the other quarry sites concerning to the workability and quantity.

Comparing Q-1 and Q-2 quarry sites, Q-1 site would produce andesite rock, that is favorable as rock materials, and prospective volume of weathered weak lapilli (or lithic) tuff in Q-1 site would be also smaller than in Q-2 site. Therefore, Q-1 site is judged to be suitable for the quarry site among three quarry sites.

Physical properties of lapilli tuff materials (drill core) in Q-1 site are as follows:

- Specific gravity : 2.27
- Absorption : 10.7 %
- One dimensional compression strength: 120 - 250 kg/cm^2

Generally, the rock materials for high dam are required to have the following qualities:

- Apparent specific gravity : more than 2.5
- Water absorption : less than 3%
- Compression strength : more than 700 kg/cm^2

Judging from the test results, lapilli tuff materials do not satisfy as the rock materials. Accordingly, these materials would not be able to be used as the upstream rip-rap which demands high durability, and are recommended to be utilized in the downstream of dam embankment or upstream inner shell. However, the rock consisting mostly of andesite fragment can be acceptable to be used for upstream outer shell since andesite fragments show fairly high compression strength as shown in Table 2.12.

2.5.3 Sand and Gravels

The gradation curves of filter materials are shown in Fig. 2.15. These materials are of well-grade with proper amount of gravels and sands. The content ratio of fine particles (Rp) passing #200 sieve (0.074 mm mesh) is only about 0.5% or less. It is generally said that the ability of filter drainage would be spoiled when a filter material have more than 5% of Rp. The results of gradation tests show fairly small Rp, and therefore the proposed materials are suitable as the filter of the dam embankment.

As for the coarse aggregate of concrete, the following guide line is shown in the Japanese standard:

- Apparent specific gravity : more than 2.5
- Water absorption : less than 3%
- Chemical durability ($MgSO_4$ solution) : less than 18%

Comparing the results of test with the above guide line, most of samples do not pass the item of apparent specific gravity but satisfies other items.

Judging from the above results and examples used these materials for concrete in local construction actually, the filter materials are also capable to be utilized for concrete aggregate.

2.6 Design Value of Dam Materials

Based on the results of field investigations and laboratory tests discussed in the previous paragraphs, the design values of the Gumain dam were determined as described below:

2.6.1 Impervious Materials (Zone 1 - Core)

1) Density (Unit weight)

- Dry density $\gamma d = 1.48\ t/m^3$ (on an average)
- Water content $W = 27\%$ (on an average)
- Specific gravity $Gs = 2.75$ (on an average)

- Void ratio $e = \frac{Gs \times \gamma w}{\gamma d} - 1 = \frac{2.75 \times 1.0}{1.48} - 1 = 0.86$

- Wet density $\gamma t = \gamma d \times (1 + \frac{W}{100}) = 1.48 \times (1 + \frac{27}{100})$

$= 1.88\ t/m^3$

- Saturated density $\gamma sat = \frac{Gs + e}{1 + e} \times \gamma w = \frac{2.75 + 0.86}{1 + 0.86} \times 1$

$= 1.94\ t/m^3$

2) Shearing Strength

Usually a design value of shearing strength for soil materials is decided by the result and analysis of c-u triaxial test. As mentioned before, the results of c-u test on the impervious materials were suspected to have some inaccuracies in consolidation process and to show low strength. Then, as for the impervious material of Gumain dam, the design value of shearing strength was determined by the results of u-u triaxial test.

The shearing strength (total stress analysis) of u-u test is summarized below:

- Group of $\gamma d = 1.6 - 1.7\ t/m^3$

$c = 13.5\ t/m^2$, $\phi = 14.0°$

- Group of $\gamma d = 1.3 - 1.4\ t/m^3$

$c = 11.0\ t/m^2$, $\phi = 14.0°$

Judging from the consistency and hardness of compacted soils, cohesion (c) of above results shows somewhat large. The modification factor of 0.8 is recommendable to apply to the result of cohesion. Accordingly, the design value for impervious materials at $\gamma d = 1.5\ t/m^3$ were determined as follows:

- Cohesion $c = \frac{(13.5 \times 0.8 + 11.0 \times 0.8)}{2} = 9.8 = 9.0\ t/m^2$

- Angle of internal friction $\phi = 14.0°$

2.6.2 Pervious Transition Materials (Zone 2)

1) Density

- Specific gravity of rock material
  $Gs' = 2.05$ (on an average)
- Absorption $Qp = 8\%$ (on an average)
- Void ratio $e = 0.2$ (estimated)
- $Yt = \dfrac{Yd(1 + \frac{Qp}{100}) + Yd}{2}$

$$Yd = \frac{Gs'}{1+e} \times Yw = \frac{0.25}{1+0.2} \times 1.0 = 1.71 \text{ t/m}^3$$

$$\therefore Yt = \{1.71 \times (1 + \frac{8}{100}) + 1.71\} \times \frac{1}{2}$$

$= 1.78$ t/m^3 (mean value of saturated and dry rocks)

- $Ysat = \dfrac{(G' + e)}{1+e} \times Yw = \{\dfrac{2.05 + 0.2}{1 + 0.2}\} \times 1 = 1.88$ t/m^3
- $Ysub = 0.88$ t/m^3

2) Shearing Strength

- $\phi = 36°$ (estimated from physical properties)
- $C = 0$ t/m^3 (estimated from physical properties)

2.6.3 Pervious Rock Materials (Zone 3)

1) Density

- $Gs' = 2.3$ (estimated from physical properties)
- $e = 0.3$ (estimated)
- $Qp = 3\%$ (estimated)
- $Yd = \dfrac{Gs'}{1+e} \times Yw = 1.77$ t/m^3

- $\gamma t = \frac{\gamma d(1 + \frac{Qp}{100}) + \gamma d}{2}$ = 1.80 t/m^3 (mean value of saturated and dry rocks)

- γsat = 2.00 t/m^3

- γsub = 1.00 t/m^3

2) Shearing Strength

- ϕ = 38° (estimated)

- C = o (estimated)

2.6.4 Rip-Rap Materials (Zone 4)

The rip-rap materials are of andestic or basaltic cobble and boulder selected from river bed deposit.

1) Density

- Gs' = 2.5 (estimated)

- e = 0.4 (estimated)

- Qp = 3% (estimated)

- γd = 1.79 t/m^3

- γt = 1.82 t/m^3

- γsat = 2.07 t/m^3

- γsub = 1.07 t/m^3

2) Shearing Strength

- ϕ = 40° (estimated)

- C = 0 (estimated)

2.6.5 Filter Materials and Concrete Aggregates

The laboratory tests for filter materials and concrete aggregates were carried out as shown in the following table.

Filter Deposit	Grain Size Analysis Passing (%) #4	#200	Uc (D60/D10)	Specific Gravity (for Coarse)	Absorption (for Coarse) (%)	Soundness (for Coarse)
F-1	27.17	0.04	32.6	2.21 - 2.56	1.56 - 3.36	3.11
F-2	35.18	0.44	79.2		2.74	1.35

The durability test (Soundness test) was done by using the magnesium sulphate. For concrete aggregates, especially required high quality of coarse aggregates may be defined as follows according to the guide line of JSCE.

- Specific gravity : more than 2.5
- Water absorption : less than 3%
- Chemical durability : less than 12%

Judging from the results of laboratory test, the gravel from river deposit of F-1 site is almost usable as the coarse aggregate in quality except for site and clay content ratio.

On the other hand, the criteria for filter materials is given by the following descriptions from the relation with core materials.

1) $\frac{\text{15\% grain size of filter material}}{\text{15\% grain size of core material}} > 5$

2) $\frac{\text{15\% grain size of filter material}}{\text{15\% grain size of core material}} < 5$

3) It is desirable that gradation curve of filter materials is approximately parallel to that of the core materials.

4) If the core material contains coarse material, i) and ii) shall be applied to the materials under 25 mm size.

5) Filter materials shall not be cohesive and not contain more than 5% fine passing No.200 (0.074 mm) sieve.

The results of gradation test of river deposit of F-1 site indicate that the sands in F-1 site can be used as the filter material.

CHAPTER 3 RECOMMENDATIONS

3.1 Geological Investigations

Geological investigations of the dam site at the stage of F/S mainly depended on the core drilling and seismic prospecting. Formation of geological properties of permeability, elevation of water table, etc., were obtained by the above investigations. But precise rock profile in the deep foundation such as degree of weathered or cementation, content ratio of gravel, hardness of sane matrix and so on, could not be obtained because of low recovery of drilling. Before construction of the dam, more detailed investigations especially by test adit should be excuted. Not only precise observation of foundation but also bearing test in the test adit also should be performed.

Recommendable location of test adit at dam site is described below:

(Unit: m)

Item	Location	Ground Level	Target Length	Remarks
Test Adit No.1	Right abutment	70.0	40	River bed
" No.2	Right abutment	105.0	50 - 90	Boundary of rhyolite and agglomerate, pumice tuff
" No.3	Left abutment	105.0	40	Pumice tuff, to DH-4
" No.4	Quarry site I	150.0	50	To QDH-1
" No.5	Quarry Site I	140	70	To QDH-3, boundary of rhyolite and tuff breccia
" No.6	Upstream right abutment	135	90	To DH-8

3.2 Dam Construction Materials

(1) Impervious Materials

Both of the results of physical and mechanical soil tests had some inaccuracies mainly owing to inadequate apparatus. Confirmation of soil test on representative materials in Borrow Area I is recommended before the construction of dam. Borrow Area I has vast area and could not fully grasp available depth and volume of impervious materials. Additional test pitting or drilling is also recommendable.

(2) Pervious Materials

Mechanical properties of pervious materials seriously affect the stability and economy of the dam. Material tests, especially shearing test, on the pervious rocks (lapilli tuff and tuff breccia) obtainable from the test adit in Q-1 quarry site should be performed by using large-size apparatus.

(3) Filter Materials

F-1 site for filter material and concrete aggregate widely spreads along the Gumain river. Since there exist very wide terrace deposits neighboring to the river, drilling and seismic prospecting investigations are recommended on the terrace to confirm the formation of geology and depth of sandy materials.

Table 2.1 QUANTITY OF CORE DRILLINGS

Location	Hole No.	Collar EL. (m)	Completed Depth (m)	Number of S.P.T. (nos.)	Number of W.P.T. (nos.)
Proposed Gumain Dam Site	DH-1	173.80	52.97	5	10
	DH-2	193.29	70.00	8	19
	DH-3	173.59	70.27	3	16
	DH-4	171.40	76.00	-	22
	DH-5	61.40	70.60	-	3
	DH-6	64.00	70.00	-	2
	DH-7	138.22	86.60	-	20
	DH-8	158.54	70.20	6	8
	DH-9	190.18	70.00	-	20
	DH-10	122.00	58.90	8	3
	DH-11	173.73	34.50	4	4
	DH-12	168.46	45.00	3	1
	DH-13	164.52	40.02	2	7
	DH-14	118.00	40.35	4	7
	ADH-15	64.01	50.37	-	14
	ADH-16	67.00	50.25	-	-
	ADH-17	115.00	60.00	-	4
	ADH-18	154.43	70.00	4	21
Alternative Dam Site	DDH-1	147.00	50.00	4	1
	DDH-3	144.00	50.20	4	6
Quarry Site	QDH-1	204.45	50.40	-	-
	QDH-3	157.96	50.10	-	-
	QDH-2	137.83	50.00	-	-
	QDH-4	132.28	50.20	-	-
Borrow Area	BDH-1	167.05	20.20	-	-
	BDH-2	213.10	39.20	-	-
	BDH-3	163.03	20.30	4	-
Proposed Gumain Diversion Dam Site	BNo.1	47.30	20.10	-	-
	BNo.2	44.10	20.00	-	-
Total			1,506.73	59	188

Remarks: S.P.T. = Standard Penetration Test
W.P.T. = Water Pressure Test

Table 2.2 QUANTITY OF SEISMIC PROSPECTINGS

Location	Exploration Line	Length m
Proposed Gumain Dam Site	A - A'	1,100
	B - B'	1,150
	C - C'	1,210
	D - D'	605
	E - E'	660
	F - F'	990
	G - G'	880
	H - H'	880
	a - a'	670
Alternative Dam Site	I - I'	1,270
	J - J'	960
	K - K'	530
	L - L'	400
	M - M'	430
	N - N'	440
Quarry Site	O - O'	380
	P - P'	500
	R - R'	940
Borrow Area	Q - Q'	1,010
Total	19 lines	15,005

Remarks: Spacing of receiving points

Line a - a', I - I'; 5 m
Others ; 10 m

Equipment: OYO Model PS-10, 12 channels x 2

Table 2.3(1) SUMMARY OF WATER PRESSURE TESTS

Dr. No.	El. Top (m)	Top-Bottom (m)	W.L. (m)	P (kg/cm2)	K (cm/s)	Lu
OH-1	173.80	22.0 - 25.0	48.90	1.8, 3.5, 5.3	leakage	
		25.0 - 28.0		2.1, 4.2, 6.3	"	
		28.0 - 31.0		2.1, 4.2, 6.3	"	
		31.0 - 34.0		2.5, 4.9, 7.4	"	
		34.0 - 37.0		2.8, 5.6, 8.8	"	
		37.0 - 40.0		2.8, 5.6, 8.8	"	
		40.0 - 43.0		7.5, 10.7, 14.2	1.25×10^{-4}	11.7
		43.0 - 46.0		7.8, 11.0, 14.5	1.2×10^{-4}	6.8
		46.0 - 49.0		3.5, 7.0, 10.5	leakage	
		49.0 - 52.0		8.6, 12.1, 15.6	3.5×10^{-5}	1.0
OH-2	193.29	13.0 - 16.0	66.45	3.7, 5.8, 7.9	2.6×10^{-5}	2.4 (*)
		16.0 - 19.0		4.1, 6.2, 8.3	4.6×10^{-5}	4.0 (*)
		19.0 - 22.0		4.4, 6.5, 8.6	4.4×10^{-5}	3.8 (*)
		22.0 - 25.0		4.7, 6.8, 8.9	2.9×10^{-5}	2.5 (*)
		25.0 - 28.0		5.0, 7.1, 9.2	4.3×10^{-5}	3.8 (*)
		28.0 - 31.0		5.3, 7.4, 9.5	5.6×10^{-5}	4.9
		31.0 - 34.0		5.6, 7.7, 9.8	3.4×10^{-5}	3.0
		34.0 - 37.0		7.3, 10.8, 14.3	6.3×10^{-5}	6.3
		37.0 - 40.0		7.5, 11.0, 14.6	7.9×10^{-5}	9.7
		40.0 - 43.0		7.9, 11.4, 14.9	6.8×10^{-5}	7.8
		43.0 - 46.0		8.2, 11.7, 15.2	7.4×10^{-5}	7.7
		46.0 - 49.0		8.5, 12.0, 15.5	5.9×10^{-5}	2.4
		49.0 - 52.0		8.8, 12.3, 15.8	6.0×10^{-5}	1.8
		52.0 - 55.0		9.1, 12.6, 16.1	7.2×10^{-5}	6.7
		55.0 - 58.0		9.4, 12.9, 16.4	7.2×10^{-5}	8.7
		58.0 - 61.0		9.7, 13.2, 16.7	5.9×10^{-5}	5.4
		61.0 - 64.0		10.0, 13.5, 16.7	5.5×10^{-5}	3.9
		64.0 - 67.0		10.3, 13.8, 17.3	2.8×10^{-5}	4.7
		67.0 - 70.0		11.0, 14.5, 18.0	3.0×10^{-5}	3.3
OH-3	173.59	22.0 - 25.0	56.55	4.35, 6.1, 7.87	9.0×10^{-5}	8.2 (*)
		25.0 - 28.0		5.0, 7.1, 9.3	4.1×10^{-5}	3.4
		28.0 - 31.0		5.3, 7.4, 9.5	1.2×10^{-5}	9.6
		31.0 - 34.0		6.0, 8.4, 10.9	1.3×10^{-4}	11.1
		34.0 - 37.0		6.6, 9.4, 12.6	6.0×10^{-5}	3.1
		37.0 - 40.0		6.9, 9.7, 12.9	2.1×10^{-5}	1.4
		40.0 - 43.0		7.6, 10.7, 14.2	1.5×10^{-4}	11.3
		43.0 - 46.0		7.6, 11.0, 14.5	3.2×10^{-5}	1.8
		46.0 - 49.0		8.5, 11.7, 15.6	2.3×10^{-5}	2.7
		49.0 - 52.0		8.8, 12.3, 15.9	5.4×10^{-5}	6.4
		52.0 - 55.0		9.1, 12.6, 16.2	5.7×10^{-5}	4.8
		55.0 - 58.0		9.4, 12.9, 16.5	4.8×10^{-5}	1.2
		58.0 - 61.0		9.4, 12.9, 16.5	4.4×10^{-5}	6.3
		61.0 - 64.0		9.4, 12.9, 16.5	5.6×10^{-5}	2.9
		64.0 - 67.0		9.4, 12.9, 16.5	2.4×10^{-5}	1.6
		67.0 - 70.0		9.4, 12.9, 16.5	2.0×10^{-5}	0.9
OH-4	171.40	10.5 - 13.5	None	2.4, 3.1, 2.8	2.2×10^{-4}	17.6 (*)
		13.5 - 16.5		3.0, 4.1, 5.1	1.3×10^{-4}	11.1 (*)
		16.5 - 19.5		3.7, 4.7, 6.1	2.4×10^{-5}	2.0 (*)
		19.5 - 22.5		4.0, 5.0, 6.4	1.9×10^{-4}	15.6 (*)
		22.5 - 25.5		4.6, 6.4, 8.1	1.9×10^{-4}	15.3 (*)
		25.5 - 28.5		5.3, 7.4, 9.5	1.5×10^{-4}	12.5
		28.5 - 31.5		5.6, 7.7, 9.8	7.9×10^{-5}	6.5

Table 2.3(2) SUMMARY OF WATER PRESSURE TESTS

Dr. No.	El. Top (m)	Top-Bottom (m)	W.L. (m)	P (kg/cm2)	K (cm/s)	Lu
DH-4	171.40	10.5 - 34.5	None	6.2, 8.7, 11.1	4.1 x 10^{-5}	3.4
		34.5 - 37.5		6.9, 9.7, 12.9	2.4 x 10^{-5}	1.6
		37.5 - 40.5		7.2, 10.0, 13.2	3.0 x 10^{-5}	2.2
		40.5 - 43.5		7.8, 11.0, 14.5	2.5 x 10^{-5}	1.8
		43.5 - 46.5	76.7	8.1, 11.3, 14.8	6.9 x 10^{-5}	5.0
		46.5 - 49.5		8.8, 12.3, 15.8	1.5 x 10^{-5}	0.95-1.0
		49.5 - 52.5		9.1, 12.6, 16.1	2.1 x 10^{-5}	1.2
		52.5 - 55.5		9.4, 12.9, 16.4	2.7 x 10^{-5}	1.2
		55.5 - 58.5		9.7, 13.2, 16.7	2.7 x 10^{-5}	2.1
		58.5 - 61.5		10.0, 13.5, 17.0	1.1 x 10^{-5}	0.3
		61.5 - 64.5		10.3, 13.8, 17.3	7.0 x 10^{-6}	0.5
		64.5 - 67.5		10.6, 14.1, 17.6	7.9 x 10^{-5}	1.8
		67.5 - 70.5		10.9, 14.4, 17.9	3.4 x 10^{-5}	2.0
		70.5 - 73.5		11.1, 14.7, 18.2	1.2 x 10^{-5}	0.8
		73.5 - 76.5		11.5, 15.0, 18.5	4.3 x 10^{-5}	2.5
DH-5	61.40	7.5 - 10.5	0	1.0, 1.7, 2.5	7.6 x 10^{-5}	6.1 (*)
		10.5 - 13.5		1.4, 2.5, 3.5	6.1 x 10^{-5}	5.0 (*)
		13.5 - 16.5		1.7, 2.8, 4.2	4.2 x 10^{-5}	3.5 (*)
DH-6	64.0	14.5 - 17.5	0	1.8, 2.9, 4.3	1.3 x 10^{-4}	11.6 (*)
		17.5 - 20.5		1.8, 2.9, 4.3	1.7 x 10^{-4}	15.1 (*)
DH-7	138.22	10.0 - 15.0	68.5	2.6, 3.6, 4.7	1.2 x 10^{-4}	8.5 (*)
		15.0 - 20.0		3.4, 4.5, 5.9	7.3 x 10^{-5}	5.3 (*)
		20.0 - 25.0		4.3, 6.1, 7.8	3.0 x 10^{-5}	2.2 (*)
		25.0 - 30.0		5.1, 7.3, 9.4	2.5 x 10^{-5}	1.7
		30.0 - 35.0		6.0, 8.5, 10.9	5.9 x 10^{-6}	0.4
		35.0 - 40.0		6.9, 9.7, 12.8	7.4 x 10^{-6}	0.8
		40.0 - 45.0		7.7, 10.9, 14.4	1.0 x 10^{-5}	0.9
		45.0 - 50.0		8.6, 12.1, 15.6	8.3 x 10^{-5}	0.9
		50.0 - 53.0		8.8, 12.3, 15.8	8.7 x 10^{-6}	1.7
		53.0 - 56.0		9.1, 12.6, 16.1	8.4 x 10^{-6}	1.4
		56.0 - 59.0		9.4, 12.9, 16.4	2.4 x 10^{-5}	5.2
		59.0 - 62.0		9.7, 13.2, 16.7	1.3 x 10^{-5}	2.3
		62.0 - 65.0		10.0, 13.5, 17.0	2.1 x 10^{-5}	4.6
		65.0 - 68.0		10.3, 13.8, 17.3	3.1 x 10^{-5}	6.2
		68.0 - 71.0		10.5, 14.0, 17.5	2.2 x 10^{-5}	2.8
		71.0 - 74.0		10.5, 14.0, 17.5	4.7 x 10^{-5}	6.5
		74.0 - 77.0		10.5, 14.0, 17.5	4.4 x 10^{-5}	5.9
		77.0 - 80.0		10.5, 14.0, 17.5	2.0 x 10^{-5}	2.9
		80.0 - 83.0		10.5, 14.0, 17.5	8.8 x 10^{-6}	1.3
		83.0 - 86.0		10.5, 14.0, 17.5	8.3 x 10^{-6}	1.1
DH-8	158.54	31.50- 36.50	None	6.2, 8.6, 11.1	3.9 x 10^{-5}	2.7
		36.50- 41.50		6.7, 9.1, 11.6	3.6 x 10^{-5}	3.0
		41.50- 46.50		7.5, 10.3, 13.5	2.8 x 10^{-6}	0.3
		46.50- 51.50		8.0, 10.8, 14.0	3.7 x 10^{-6}	0.3
		51.50- 56.50		9.2, 12.7, 16.3	6.2 x 10^{-6}	1.1
		56.50- 61.50		9.7, 13.2, 16.8	4.0 x 10^{-6}	0.4
		61.50- 66.50		10.2, 13.7, 17.3	1.5 x 10^{-6}	0.5
		66.50- 70.20		10.7, 14.2, 17.7	4.3 x 10^{-6}	0.6

Table 2.3(3) SUMMARY OF WATER PRESSURE TESTS

Dr. No.	El. Top (m)	Top-Bottom (m)	W.L. (m)	P (kg/cm^2)	K (cm/s)	Lu
DH-9	190.18	10.0 - 13.0	66.0	2.4, 3.1, 5.3	2.4×10^{-4}	19.4 (*)
		13.0 - 16.0		3.1, 3.8, 5.2	1.8×10^{-4}	14.7 (*)
		16.0 - 19.0		3.4, 4.1, 5.5	1.4×10^{-4}	11.4 (*)
		19.0 - 22.0		4.0, 5.8, 7.6	8.6×10^{-5}	7.0 (*)
		22.0 - 25.0		4.3, 6.1, 7.9	2.0×10^{-4}	16.0 (*)
		25.0 - 28.0		5.0, 7.1, 9.2	6.9×10^{-5}	5.7
		28.0 - 31.0		5.3, 7.4, 9.5	7.1×10^{-5}	5.9
		31.0 - 34.0		5.9, 8.4, 10.9	7.5×10^{-5}	6.1
		34.0 - 37.0		6.6, 9.4, 12.6	4.0×10^{-5}	2.8
		37.0 - 40.0		6.9, 9.7, 12.9	4.4×10^{-5}	5.2
		40.0 - 43.0		7.6, 10.7, 14.2	4.6×10^{-5}	7.7
		43.0 - 46.0		7.9, 11.0, 14.5	9.6×10^{-5}	7.6
		46.0 - 49.0		8.5, 12.0, 15.5	1.0×10^{-4}	7.3
		49.0 - 52.0		8.8, 12.3, 15.8	7.6×10^{-5}	5.9
		52.0 - 55.0		9.1, 12.6, 16.1	4.2×10^{-5}	6.4
		55.0 - 58.0		9.4, 12.9, 16.4	3.7×10^{-5}	5.5
		58.0 - 61.0		9.7, 13.2, 16.7	3.9×10^{-5}	5.9
		61.0 - 64.0		10.0, 13.5, 17.0	3.1×10^{-5}	1.8
		64.0 - 67.0		10.3, 13.8, 17.3	3.7×10^{-5}	5.2
		67.0 - 70.0		10.4, 13.9, 17.4	2.0×10^{-5}	1.7
DH-10	122.0	13.0 - 16.0	None	3.4, 4.0, 5.8	2.5×10^{-4}	17.9 (*)
		16.0 - 19.0		3.6, 4.7, 6.1	2.9×10^{-4}	23.5 (*)
		19.0 - 22.0		4.3, 6.0, 7.8	2.5×10^{-4}	20.3 (*)
DH-11	173.73	16.15- 19.5	31.0	3.4, 4.4, 5.9	1.3×10^{-4}	9.4 (*)
		19.5 - 24.5		4.1, 5.9, 7.6	1.0×10^{-4}	7.1 (*)
		24.5 - 29.5		5.6, 7.7, 9.8	1.3×10^{-4}	9.0
		29.5 - 34.5		5.9, 8.4, 10.9	8.8×10^{-5}	6.1
DH-12	168.46	21.0 - 26.0	None	—	1.95×10^{-3}	—
DH-13	164.52	19.0 - 22.0	38.3	4.1, 5.8, 7.6	5.8×10^{-6}	0.5 (*)
		22.0 - 25.0		4.4, 6.1, 7.9	6.2×10^{-6}	0.5 (*)
		25.0 - 28.0		5.0, 7.1, 9.2	3.0×10^{-5}	2.5
		28.0 - 31.0		5.3, 7.4, 9.2	2.8×10^{-5}	2.4
		31.0 - 34.0		5.9, 8.4, 10.9	3.1×10^{-5}	2.7
		34.0 - 37.0		6.6, 9.4, 12.5	2.6×10^{-5}	2.2
		37.0 - 40.0		6.9, 9.7, 12.9	1.5×10^{-5}	1.3
DH-14	118.0	6.6 - 11.6	39.5	1.9, 2.6, 3.3	3.0×10^{-5}	2.6 (*)
		11.6 - 16.6		2.7, 3.8, 4.8	5.4×10^{-5}	4.7 (*)
		16.6 - 21.6		3.6, 4.9, 6.4	4.0×10^{-5}	3.5 (*)
		21.6 - 26.6		4.5, 6.3, 8.0	3.3×10^{-5}	2.8
		26.6 - 31.6		5.3, 7.4, 9.5	2.8×10^{-5}	2.4
		31.6 - 36.6		6.1, 8.7, 11.1	1.4×10^{-5}	1.2
		36.6 - 40.5		6.9, 9.8, 12.6	3.2×10^{-5}	2.8
ADH-15	64.01	8.0 - 11.0	0	0.8, 1.5, 2.2	6.2×10^{-5}	5.2 (*)
		11.0 - 14.0		1.2, 2.2, 3.3	1.5×10^{-4}	12.1 (*)
		14.0 - 17.0		1.5, 2.6, 4.0	6.8×10^{-5}	5.6 (*)
		17.0 - 20.0		1.5, 2.6, 4.0	6.7×10^{-5}	5.5 (*)
		20.0 - 23.0		1.9, 3.6, 5.4	7.3×10^{-5}	6.0 (*)
		23.0 - 26.0		1.9, 3.6, 5.4	1.8×10^{-4}	14.6 (*)

Table 2.3(4) SUMMARY OF WATER PRESSURE TESTS

Dr. No.	El. Top (m)	Top-Bottom (m)	W.L. (m)	P (kg/cm^2)	K (cm/s)	Lu
ADH - 15	64.01	26.0 - 29.0	0	2.2, 4.3, 6.5	8.6×10^{-5}	7.0 (*)
		29.0 - 32.0		2.6, 5.0, 7.5	5.3×10^{-5}	4.4 (*)
		32.0 - 35.0		2.6, 5.0, 7.5	1.1×10^{-4}	8.8 (*)
		35.0 - 38.0		2.9, 5.8, 8.9	5.7×10^{-5}	4.7 (*)
		38.0 - 41.0		2.9, 5.8, 8.9	4.0×10^{-5}	3.3 (*)
		41.0 - 44.0		3.3, 6.5, 10.0	5.3×10^{-5}	4.3
		44.0 - 47.0		3.6, 7.2, 10.7	5.2×10^{-5}	4.3
		47.0 - 50.0		3.6, 7.2, 10.7	5.5×10^{-5}	4.5
ADH - 17	115.0	33.0 - 36.0	56.0	5.3, 7.1, 8.8	3.1×10^{-6}	0.3
		36.0 - 39.0		5.9, 8.1, 10.2	1.1×10^{-6}	0.1
		39.0 - 42.0		6.6, 9.1, 11.5	1.9×10^{-5}	1.7
		42.0 - 45.0		7.3, 10.1, 12.9	2.3×10^{-5}	2.0
ADH - 18	154.43	7.0 - 10.0	66.95	1.7, 2.4, 3.1	1.2×10^{-4}	10.3 (*)
		10.0 - 13.0		2.4, 3.4, 4.5	9.3×10^{-5}	8.0 (*)
		13.0 - 16.0		3.0, 4.1, 5.5	1.0×10^{-4}	8.9 (*)
		16.0 - 19.0		3.3, 4.4, 5.8	1.1×10^{-4}	9.6 (*)
		19.0 - 22.0		4.0, 5.7, 7.5	7.6×10^{-5}	6.6 (*)
		22.0 - 25.0		4.3, 6.0, 7.8	7.9×10^{-5} (7.3×10^{-5})	6.8 (*) (6.3)
		25.0 - 28.0		4.9, 7.0, 9.2	4.8×10^{-4}	41.2 (*)
		28.0 - 31.0		5.6, 8.0, 10.5	6.3×10^{-5}	5.5
		31.0 - 34.0		6.5, 8.3, 10.8	4.4×10^{-5}	3.8
		34.0 - 37.0		6.5, 9.3, 12.5	3.0×10^{-5}	3.4
		37.0 - 40.0		6.8, 9.6, 12.8	4.7×10^{-5}	5.1
		40.0 - 43.0		7.5, 10.7, 14.2	3.1×10^{-5}	3.2
		43.0 - 46.0		7.8, 11.0, 14.5	2.3×10^{-5}	2.3
		46.0 - 49.0		8.4, 12.0, 15.5	2.6×10^{-5}	3.8
		49.0 - 52.0		8.7, 12.3, 15.8	2.4×10^{-5}	3.0
		52.0 - 55.0		9.0, 12.6, 16.1	1.2×10^{-5}	1.5
		55.0 - 58.0		9.3, 12.9, 16.4	3.8×10^{-5}	3.3
		58.0 - 61.0		9.6, 13.2, 16.7	3.6×10^{-5}	5.3
		61.0 - 64.0		9.9, 13.5, 17.0	2.8×10^{-5}	3.8
		64.0 - 67.0		10.2, 13.8, 17.3	4.4×10^{-5}	3.1
		67.0 - 70.0		10.4, 13.9, 17.4	2.9×10^{-5}	4.0
DDH - 1	147.00	34.3 - 50.0	30.40	6.8, 10.4, 13.9	2.5×10^{-5}	1.1
DDH - 3	144.0	11.0 - 14.0	None	2.4, 3.5, 4.5	5.3×10^{-5}	4.3 (*)
		14.0 - 17.0		3.1, 4.1, 5.5	2.7×10^{-5}	2.2 (*)
		17.0 - 20.0		3.4, 4.4, 5.8	3.8×10^{-5}	3.1 (*)
		20.0 - 23.0		4.0, 5.8, 7.2	3.7×10^{-5}	3.0 (*)
		23.0 - 26.0		4.3, 6.1, 7.9	9.2×10^{-5}	7.6
		26.0 - 29.0		5.0, 7.1, 9.2	6.0×10^{-5}	4.9

Remarks: W.L.: Ground water level
P: Step of total pressure
K: Coefficient of permeability values at the maximum pressure
Lu: Lugeon value
(*): Lugeon value converted into pressure of 10 kg/cm^2

Table 2.4(1) VIOLENT EARTHQUAKES AROUND THE STUDY AREA (1907 - 1980)

Data No.	No.	Date	Epicenter (°) N	Epicenter (°) E	Δ (km)	Magnitude	D (km)
2	1	Mar. 18, 1907	14	123	295	7.6	-
39	2	Apr. 13, 1927	16 0/1	120 1/2	110	6 3/4	140
41	3	Apr. 19, 1927	16	120	120	6 3/4	100
43	4	Jun. 15, 1928	12 1/2	121 1/2	300	7.0	-
45	5	Aug. 5, 1928	16 0/1	119 1/2	150	150	-
67	6	Oct. 28, 1931	17 1/2	121 1/2	295	6 1/4	-
79	7	Jul. 18, 1932	14	120	125	6.0	100
80	8	Aug. 24, 1932	16 1/2	120 1/2	165	6 1/4	-
88	9	Mar. 3, 1933	15 1/2	120 0/1	70	6.5	120
92	10	Jun. 6, 1933	14	120	125	6 1/4	-
97	11	Sep. 20, 1933	13	121	230	6.5	100
106	12	Jul. 31, 1934	15 0/1	119 3/4	75	5.6	-
109	13	Nov. 26, 1934	14	120	125	6 1/4	-
112	14	Feb. 7, 1935	13 1/2	122 3/4	300	6.0	-
126	15	May 20, 1936	13 1/2	121 1/2	200	6.0	160
149	16	Aug. 20, 1937	14 1/2	121 1/2	125	7.5	-
185	17	May 6, 1939	13 1/2	121 1/4	190	6.5	110
196	18	Mar. 28, 1940	14 1/2	120 0/1	75	6 3/4	200
221	19	May 9, 1941	14	123	295	6 3/4	-
230	20	Apr. 28, 1942	13 1/2	121 0/1	180	7.7	-
425	21	Dec. 22, 1953	16	119	190	5 3/4	-
511	22	Feb. 14, 1956	17	120	225	6.2	-
523	23	Jul. 19, 1956	15 0/1	120 1/2	5	5 3/4	-
534	24	Oct. 23, 1956	13 1/2	120 1/2	170	6 3/4	100
539	25	Nov. 10, 1956	15 3/4	120 1/4	85	6.0	-
628	26	Feb. 9, 1958	13	121	230	5.9	-
716	27	Jul. 18, 1959	15 1/2	120 1/2	55	7.0	200
769	28	May 21, 1960	15 1/2	121 1/2	125	5.0	-
785	29	Aug. 31, 1960	13.8	119.9	150	5.4	24
792	30	Sep. 19, 1960	16	120	120	5.5	-
820	31	Feb. 26, 1961	16.1	121.6	170	6.1	32
828	32	Jun. 19, 1961	13 0/1	121 1/2	250	5.3/4	56
879	33	Jun. 30, 1962	16.4	122.3	250	5 3/4	-
903	34	Nov. 27, 1962	14.9	119.9	60	5.3	-
908	35	Dec. 21, 1962	15.9	121.8	175	5.0	-
921	36	Feb. 25, 1963	15.3	121.7	140	5.5	-
939	37	May 17, 1963	16 1/4	120 0/1	145	5.6	-
997	38	Mar. 26, 1964	13.87	120.77	130	5.3	122
1021	39	Jun. 22, 1964	13.67	120.55	150	5.1	72
1025	40	Jul. 9, 1964	15.36	119.67	90	5.3	48
1071	41	Nov. 30, 1964	13.8	120.8	140	5.0	207
1122	42	Apr. 3, 1965	13.82	119.91	145	5.0	68
1179	43	Sep. 10, 1965	13.96	120.87	125	5.0	149
1235	44	Jan. 10, 1966	13.81	120.72	135	5.3	133
1239	45	Feb. 3, 1966	16.66	119.93	190	5.3	71
1316	46	Aug. 15, 1966	13.28	121.36	215	5.5	24
1323	47	Aug. 28, 1966	13.73	120.84	150	5.0	114
1326	48	Aug. 30, 1966	13.4	120.8	185	5.3	86
1343	49	Oct. 11, 1966	13.98	120.74	120	5.1	104
1352	50	Dec. 20, 1966	14.57	122.17	190	5.3	32
1356	51	Jan. 15, 1967	13.78	120.71	140	5.4	170
1379	52	Mar. 28, 1967	17.02	122.43	305	5.1	76
1450	53	Oct. 12, 1967	17.27	121.83	290	5.5	41
1536	54	Jun. 6, 1068	14.9	119.9	60	5.3	53

Table 2.4(2) VIOLENT EARTHQUAKES AROUND THE STUDY AREA
(1907 - 1980)

Data No.	No.	Date	Epicenter (°) N	E	Δ (km)	Magnitude	D (km)
1538	55	Jun. 12, 1968	13.8	120 3/4	140	5.1	135
1553	56	Aug. 1, 1968	16.3	122.1	225	5.9	31
1556	57	Aug. 1, 1968	15.77	121.79	165	5.0	33
1564	58	Aug. 3, 1968	16.45	122.31	255	6.1	52
1568	59	Aug. 3, 1968	16.35	122.41	255	5.2	48
1569	60	Aug. 4, 1968	16.6	122 1/2	280	5.1	50
1579	61	Aug. 6, 1968	15.65	121.96	175	5.2	30
1581	62	Aug. 8, 1968	16.04	121.98	195	5.1	61
1583	63	Aug. 9, 1968	15.71	121.92	175	5.1	63
1584	64	Aug. 10, 1968	15.41	121.59	130	5.1	86
1586	65	Aug. 13, 1968	15.62	121.83	160	5.0	42
1587	66	Aug. 14, 1968	15.08	122.51	220	5.5	15
1593	67	Aug. 23, 1968	15.7	121.9	170	5.1	57
1596	68	Aug. 28, 1968	15.57	122.33	210	5.0	15
1597	69	Aug. 28, 1968	15.55	122.02	175	5.7	42
1598	70	Aug. 29, 1968	15.51	121.98	170	5.3	39
1600	71	Aug. 29, 1968	15.57	122.01	175	5.1	68
1602	72	Aug. 29, 1968	15.9	121 3/4	170	5.3	50
1606	73	Sep. 3, 1968	15 1/2	122.2	195	5.0	21
1610	74	Sep. 19, 1968	14.92	120.24	25	5.2	60
1611	75	Sep. 22, 1968	15.72	121.88	170	5.3	47
1614	76	Sep. 28, 1968	16.18	122.39	245	5.2	42
1628	77	Nov. 2, 1968	16.06	121.92	195	5.0	41
1630	78	Nov. 4, 1968	13.5	120 1/2	170	5.0	75
1636	79	Nov. 22, 1968	16.17	122.17	220	5.3	60
1646	80	Dec. 12, 1968	16.3	122.3	240	5.2	44
1652	81	Dec. 29, 1968	13.6	120.4	155	5.2	56
1776	82	Mar. 2, 1969	13.1	120.8	215	5.0	69
1777	83	Mar. 2, 1969	13.02	120.83	225	5.0	73
1805	84	Mar. 26, 1969	16.2	122.2	225	5.0	30
1834	85	May 15, 1969	16.04	121.87	190	5.0	62
1853	86	Jun. 10, 1969	13.2	121 1/2	230	5.1	17
1866	87	Jun. 25, 1969	13.46	120.33	175	5.0	60
1892	88	Sep. 4, 1969	16.37	119.56	175	5.0	60
1904	89	Oct. 6, 1969	14.99	120.11	35	5.6	66
1935	90	Dec. 23, 1969	13.84	120.66	125	5.3	127
1991	91	Feb. 6, 1969	12.69	121.93	300	5.3	34
2005	92	Mar. 4, 1969	13.6	120.5	155	5.1	69
2025	93	Mar. 29, 1969	13.94	120.67	120	5.3	121
2031	94	Apr. 6, 1969	13.97	120.37	115	5.2	88
2033	95	Apr. 7, 1969	15.78	121.71	160	6.5	40
2034	96	Apr. 7, 1969	15 1/2	122.4	215	5.6	47
2035	97	Apr. 7, 1969	15.4	121.8	150	5.1	48
2036	98	Apr. 7, 1969	15.68	121.85	165	5.5	22
2037	99	Apr. 7, 1969	15.53	121.86	160	5.5	33
2040	100	Apr. 7, 1969	15.49	121.78	150	5.2	33
2051	101	Apr. 7, 1969	15.38	121.83	150	5.1	9
2062	102	Apr. 8, 1969	15.38	121.63	130	5.2	4
2067	103	Apr. 8, 1969	15.59	121.72	150	5.3	31
2069	104	Apr. 8, 1970	15.4	121 3/4	145	5.7	7
2070	105	Apr. 8, 1970	15.31	121.88	155	5.1	0
2073	106	Apr. 8, 1970	15.42	121.93	165	5.1	34
2077	107	Apr. 8, 1970	15.55	121.85	160	5.3	26
2095	108	Apr. 12, 1970	15.08	122.01	165	5.8	25
2096	109	Apr. 12, 1970	15	122	165	5.1	18
2097	110	Apr. 12, 1970	15.21	122.04	170	5.5	18

Table 2.4(3) VIOLENT EARTHQUAKES AROUND THE STUDY AREA (1907 - 1980)

Data No.	No.	Date	Epicenter (°) N	Epicenter (°) E	Δ (km)	Magnitude	D (km)
2103	111	Apr. 12, 1970	15.7	122.51	220	5.4	32
2118	112	Apr. 12, 1970	15.08	122.05	170	5.0	29
2120	113	Apr. 12, 1970	15.12	122.05	170	5.1	39
2125	114	Apr. 12, 1970	15.07	122.51	220	5.4	26
2130	115	Apr. 12, 1970	15 1/4	122.4	210	5.0	33
2131	116	Apr. 13, 1970	15.26	122.24	190	5.2	5
2134	117	Apr. 15, 1970	15.11	122.71	240	5.6	50
2147	118	Apr. 22, 1970	15.37	121.03	70	5.1	46
2161	119	May 1, 1970	15.64	121.78	155	5.3	33
2165	120	May 6, 1970	15.71	121.76	160	5.1	41
2180	121	Jun. 16, 1970	15.1	122.0	165	5.1	19
2193	122	Jul. 10, 1970	13.93	120.42	120	5.5	89
2253	123	Nov. 21, 1970	15.01	120.13	35	5.5	53
2323	124	Apr. 29, 1971	13.0	122.31	300	6.0	90
2348	125	Jul. 2, 1971	15.9	120.3	100	5.0	-
2350	126	Jul. 4, 1971	15.604	121.876	165	5.5	30
2357	127	Jul. 20, 1971	15.4	120.0	65	5.4	-
2365	128	Aug. 20, 1971	13.7	121.1	160	5.5	-
2378	129	Oct. 12, 1971	14.1	122.5	240	5.2	-
2381	130	Oct. 27, 1971	17.3	120.4	250	5.5	-
2407	131	Jan. 14, 1972	13.4	121.0	190	5.1	126
2423	132	Feb. 19, 1972	12.78	121.22	260	5.1	14
2427	133	Feb. 24, 1972	13.7	121.5	185	5.3	-
2434	134	Mar. 16, 1972	16.2	121.6	180	5.4	25
2439	135	Mar. 28, 1972	13.4	120.8	185	5.0	165
2444	136	Apr. 14, 1972	14.892	119.736	80	5.0	47
2449	137	Apr. 25, 1972	13.4	120.5	180	7.0	50
2450	138	Apr. 25, 1972	13.8	120.3	135	5.3	-
2451	139	Apr. 25, 1972	13.524	120.522	165	5.4	33
2452	140	Apr. 25, 1972	13.6	120.5	160	5.3	-
2457	141	Apr. 26, 1972	13.6	120.7	160	5.2	-
2458	142	Apr. 26, 1972	13.1	121.0	220	5.4	-
2459	143	Apr. 26, 1972	13.4	120.8	185	5.2	-
2461	144	Apr. 26, 1972	13.175	120.348	205	5.0	50
2462	145	Apr. 26, 1972	13.1	120.8	215	5.1	-
2464	146	Apr. 26, 1972	13.4	120.9	185	5.2	-
2465	147	Apr. 26, 1972	13.231	120.301	200	5.1	56
2466	148	Apr. 26, 1972	13.4	120.9	185	5.5	-
2468	149	Apr. 26, 1972	13.3	119.3	225	5.2	-
2469	150	Apr. 26, 1972	13.8	120.7	140	5.0	-
2471	151	Apr. 26, 1972	13.3	120.7	190	5.5	-
2472	152	Apr. 27, 1972	13.4	120.8	185	5.7	-
2473	153	Apr. 27, 1972	13.437	120.444	175	5.2	56
2475	154	Apr. 27, 1972	13.19	120.43	200	5.4	45
2478	155	Apr. 27, 1972	13.2	120.8	205	5.0	-
2481	156	Apr. 29, 1972	13.5	120.7	170	5.3	-
2482	157	Apr. 30, 1972	13.2	120.7	200	5.5	-
2483	158	Apr. 30, 1972	13.5	120.6	170	5.9	25
2484	159	Apr. 30, 1972	13.609	120.496	155	5.3	66
2485	160	May 1, 1972	13.4	121.2	195	5.1	-
2490	161	May 8, 1972	13.6	120.8	160	5.1	-
2491	162	May 12, 1972	13.4	121.0	190	5.3	-
2495	163	May 17, 1972	13.359	119.882	195	5.9	37
2496	164	May 17, 1972	13.30	120.0	195	5.2	-
2498	165	May 22, 1972	16.599	122.290	260	6.9	34

Table 2.4(4) VIOLENT EARTHQUAKES AROUND THE STUDY AREA (1907 - 1980)

Data No.	No.	Date	Epicenter (°) N	Epicenter (°) E	Δ (km)	Magnitude	D (km)
2499	166	May 22, 1972	16.72±0.030	122.43±0.038	285	5.5	33
2504	167	May 22, 1972	16.7	122.5	285	5.2	33
2507	168	May 22, 1972	16.409	122.163	240	5.0	75
2508	169	May 23, 1972	16.6	122.5	280	5.2	-
2509	170	May 23, 1972	16.8	122.4	285	5.1	-
2519	171	May 25, 1972	16.382	122.518	265	5.1	36
2520	172	May 26, 1972	13.293	120.407	190	5.2	30
2521	173	May 26, 1972	13.33±0.024	120.40±0.030	185	5.3	-
2523	174	Jun. 1, 1972	16.70±0.040	122.33±0.047	280	5.2	-
2532	175	Jun. 12, 1972	16.7	122.5	285	5.5	40
2536	176	Jun. 19, 1972	13.338	120.335	185	5.3	49
2553	177	Aug. 3, 1972	13.442	120.348	175	5.3	33
2556	178	Aug. 28, 1972	13.35±0.055	120.25±0.070	180	5.3	60±10
2763	179	Mar. 15, 1973	13.937	120.357	120	5.2	113
2851	180	Jul. 18, 1973	14.925	119.855	65	5.1	56
2875	181	Aug. 23, 1973	16.444	121.977	225	5.1	64
2919	182	Oct. 7, 1973	16.23±0.063	122.20±0.082	240	5.0	-
2922	183	Oct. 9, 1973	16.2	122.6	265	5.5	-
2926	184	Oct. 25, 1973	12.86±0.022	120.22±0.026	130	5.7	53±6.5
2940	185	Nov. 21, 1973	13.452	121.015	185	5.1	39
2955	186	Jan. 7, 1974	16.7	120.2	185	5.5	-
2965	187	Feb. 9, 1974	16.2	120.1	135	5.5	-
2968	188	Feb. 12, 1974	13.523	120.458	165	5.5	74
2971	189	Feb. 19, 1974	13.909	122.116	215	6.1	17
2990	190	Mar. 22, 1974	17.081	119.713	240	5.1	34
3009	191	Apr. 16, 1974	13.6	120.9	165	5.6	100
3118	192	Oct. 22, 1974	13.4	120.5	180	5.7	-
3122	193	Nov. 3, 1974	15.017	122.67	235	5.1	33
3167	194	Feb. 1, 1975	13.044	120.23	220	5.0	33
3227	195	Apr. 29, 1975	13.7	120.8	150	5.6	-
3228	196	Apr. 29, 1975	12.6	121.6	295	5.7	-
3235	197	May 1, 1975	13.66±0.035	120.88±0.044	155	5.0	54
3236	198	May 1, 1975	13.624	120.768	160	5.1	48
3254	199	May 23, 1975	13.612	120.852	155	5.0	41
3275	200	Jun. 18, 1975	15	121	60	5.9	-
3279	201	Jul. 8, 1975	13.54±0.035	120.34±0.062	160	5.0	64
3322	202	Oct. 5, 1975	14.40	121.925	180	5.0	33
3328	203	Oct. 8, 1975	13.7	120.4	145	5.7	-
3560	204	Dec. 6, 1975	17.416	119.682	280	5.8	19
3561	205	Dec. 6, 1975	16	119	190	5.2	-
3617	206	Feb. 13, 1976	13.916	120.123	130	5.8	29
3681	207	May 2, 1976	13.58±0.031	122.34±0.045	260	5.2	57±76
3682	208	May 4, 1976	13.38	120.21	180	5.4	0
3683	209	May 5, 1976	14	121	125	5.2	0
3698	210	May 21, 1976	15	121	60	5.4	-
3706	211	May 28, 1976	15	123	270	5.5	-
3939	212	Sep. 22, 1976	13.7	120.8	150	5.8	50
4024	213	Dec. 5, 1976	17.37±0.034	120.8±0.052	265	5.2	43±72

Remarks: Δ: Distance from epicenter
D: Depth from the surface

Table 2.5 SIGNIFICANT EARTHQUAKES AFFECTING TO THE STUDY AREA (1907 - 1980)

No.	Date	Epicenter (°) N	Epicenter (°) E	Δ (km)	Magnitude	D (km)	αm (gal)
1	Mar. 18, 1907	14	123	295	7.6	-	36
2	Arp. 13, 1927	16 0/0	120 1/2	110	6 3/4	140	43
3	Apr. 19, 1927	16	120	120	6 3/4	100	41
4	Jun. 15, 1928	12 1/2	121 1/2	300	7.0	-	26
5	Aug. 5, 1928	16 0/1	110 1/2	150	6 1/4	-	28
6	Oct. 28, 1931	17 1/2	121 1/2	295	6 1/4	-	19
7	Jul. 18, 1932	14	120	125	6.0	100	28
8	Aug. 24, 1932	16 1/2	120 1/2	165	6 1/4	-	26
9	Mar. 3, 1933	15 1/2	120 1/2	70	6.5	120	50
10	Jun. 6, 1933	14	120	125	6 1/4	-	31
11	Sep. 20, 1933	13	121	230	6.5	100	24
12	Jul. 31, 1934	15 0/1	119 3/4	75	5.6	-	30
13	Nov. 26, 1934	14	120	125	6 1/4	-	31
14	Feb. 7, 1935	13 1/2	122 3/4	300	6.0	-	16
15	May 20, 1936	13 1/2	121 1/2	200	6.0	160	21
16	Aug. 20, 1937	14 1/2	121 1/2	125	7.5	-	57
17	May 6, 1939	13 1/2	121 1/4	190	6.5	110	27
18	Mar. 28, 1940	14 1/2	120 0/1	75	6 3/4	200	54
19	May 9, 1941	14	123	295	6 3/4	-	24
20	Apr. 28, 1942	13 1/2	121 0/1	180	7.7	-	50
21	Jul. 19, 1956	15 0/1	120 1/2	5	5 3/4	-	169
22	Oct. 23, 1956	13 1/2	120 1/2	170	6 3/4	100	33
23	Nov. 10, 1956	15 3/4	120 1/4	85	6.0	-	35
24	Jul. 18, 1959	15 1/2	120 1/2	55	7.0	200	73
25	Feb. 26, 1961	16.1	121.6	170	6.1	32	24
26	Nov. 27, 1962	14.9	119.9	60	5.3	-	31
27	Jul. 9, 1964	15.36	119.67	90	5.3	48	24
28	Jun. 6, 1968	14.9	119.9	60	5.3	53	31
29	Aug. 3, 1968	16.45	122.31	255	6.1	52	19
30	Sep. 19, 1968	14.92	120.24	25	5.2	60	50
31	Oct. 6, 1969	14.99	120.11	35	5.6	66	49
32	Apr. 7, 1969	15.78	121.71	160	6.5	40	30
33	Apr. 22, 1970	15.37	121.03	70	5.1	46	26
34	Nov. 21, 1970	15.01	120.13	35	5.5	53	47
35	Apr. 29, 1971	13.0	122.3	300	6.0	90	16
36	Jul. 20, 1971	15.4	120.0	65	5.4	-	31
37	Apr. 14, 1971	14.892	119.736	80	5.0	47	22
38	Apr. 25, 1972	13.4	120.5	180	7.0	50	36
39	May 22, 1972	16.599	122.290	260	6.9	34	27
40	Jul. 18, 1973	14.925	119.855	65	5.1	56	27
41	Feb. 19, 1974	13.909	122.116	215	6.1	17	21
42	Jun. 18, 1975	15	121	60	5.9	-	41
43	May 21, 1976	15	121	60	5.4	-	32

Remarks: Δ: Distance from epicenter

D: Depth from the surface

Table 2.6 TEST ITEMS FOR IMPERVIOUS MATERIALS

Area	Test Pit No.	Depth (m)	Specific Gravity	Grain Size Analysis	Field Moisture Content	Atterberg Limit	Compaction Test
I	TP- 1	0.4 - 2.5	O	O	O	O	O
	TP- 2	1.3 - 3.0	O	O	O	O	O
	TP- 3	1.0 - 2.0	O	O	O	O	O
	TP- 4	1.3 - 3.5	O	O	O	O	-
	TP- 5	0.3 - 3.0	O	O	O	O	O
	TP- 6	1.0 - 2.0	-	O	O	-	O
	TP- 7	0.2 - 3.5	O	O	O	O	O
	TP- 8	1.2 - 3.5	O	O	O	O	O
	TP-22	1.0 - 2.0	O	O	O	O	O
	TP-23	1.0 - 1.5	O	O	O	O	O
II	TP- 9	0.5 - 2.5	O	O	O	O	O
	TP-10	0.2 - 1.6	O	O	O	O	O
	TP-12	0.8 - 3.0	O	O	O	O	O
	TP-14	0.1 - 1.0	O	O	O	O	O
	〃	1.4 - 2.6	O	O	O	O	O
III	TP-15	0.1 - 2.5	O	O	O	O	O
	TP-16	0.2 - 1.3	O	O	O	O	O
	〃	1.3 - 3.0	O	O	O	O	O
	TP-17	0.7 - 3.0	O	O	O	O	O
	TP-18	0.1 - 0.7	O	O	O	O	O
	〃	0.7 - 2.6	O	O	O	O	O
	TP-21	0.4 - 3.0	O	O	O	O	O
	Total		21	22	22	21	21

Table 2.7 ITEMS OF SOIL MECHANICAL TEST

Test Pit No.	W (%)	Yd (g/cm^2)	Triaxial Compression Test		Permeability Test	Consolidation Test	
			u - u	$\bar{c}$ - $\bar{u}$		Unsaturated	Saturated
TP - 3	19.5	1.71	O	O	O	O	O
	22.3	1.62	O	O	O	O	O
	19.5	1.62	O	O	O	O	O
TP - 8	28.5	1.357	O	O	O	O	O
	31.9	1.289	O	O	O	O	O
	28.5	1.289	O	O	O	O	O
TP - 22	26.3	1.324	O	O	O	O	O
	29.0	1.257	O	O	O	O	O
	26.3	1.257	O	O	O	O	O

Table 2.8 TEST ITEMS FOR FILTER, ROCK AND FOUNDATION

Description	Specific Gravity and Absorption	Compression	Soundness	Grain Size Analysis	Field Density	Remarks
Filter Material	O	-	O	O	-	Gravel and Sand
Rock Material	O	O	O	-	-	Lapilly Tuff
Drilling Samples (foundation)						
DH-3 (13.42 m)	O	O		-	-	An.
DH-6 (24.15 m)	O	O	An. .... O	-	-	Angl.
DH-6 (38.15 m)	O	O		-	-	Angl.
DH-8 (33.89 m)	O	O	Angl.... O	-	-	Pumice Tuff
DH-8 (44.25 m)	O	O		-	-	An.
DH-8 (67.35 m)	O	O	Tuff. .. O	-	-	Angl.
DH-10 (34.50 m)	O	O		-	-	Angl.
DH-11 (10.40 m)	O	O		-	-	Rhyolite
River Bed	O	-	-	O	O	Gravel and Sand

Table 2.9 PHYSICAL PROPERTIES OF IMPERVIOUS MATERIALS (AREA I)

Test Pit No.	Depth (m)	Classification	Specific Gravity (for soil)	Water Content		Atterberg Limit			Gradation Analysis (%)			Specific Gravity (for coarse)	Absorption (for coarse) (%)
				Dry Season	Wet Season	L.L.	P.L.	P.I.	Gravel	Sand	#200 Passing		
TP-1	0.4-2.5	SC	2.83	16.5	-	32.75	20.82	11.93	46.0	30.3	23.7	1.41	9.7
2	1.3-3.0	GC	2.77	19.9	17.1	30.07	19.50	10.57	63.0	19.0	18.0	1.31	11.9
3	1.0-2.0	GC	2.75	14.9	34.2	43.50	24.65	18.85	57.4	19.4	23.2	1.32	13.1
4	1.3-3.5	SC	2.78	33.5	23.6	46.20	26.00	20.20	-	-	-	-	-
5	0.3-3.0	GC	2.75	22.8	24.3	47.15	28.04	19.11	87.4	4.4	8.2	1.36	15.1
6	1.0-2.0	GC	-	14.6	-	-	-	-	78.5	12.1	9.4	1.17	34.7
7	0.2-3.5	GC-CM	2.68	35.1	27.0	41.37	29.27	12.10	81.2	6.3	12.5	1.17	24.9
8	1.2-3.5	CL(-ML)	2.72	16.8	35.0	49.20	28.61	20.59	19.3	24.7	56.0	1.27	30.1
22	1.8	CH	2.73	19.8	-	58.80	29.26	29.54	1.1	42.8	56.1	-	-

Table 2.10 PHYSICAL PROPERTIES OF IMPERVIOUS MATERIALS (AREA II, III)

Test Pit No.	Depth (m)	Classification	Specific Gravity (for soil)	Natural Water Content (%)	Atterberg Limit			Gradation Analysis (%)		
					L.L.	P.L.	P.I.	Gravel	Sand	#200 Passing
Area II										
TP- 9	0.5-2.5	CL	2.77	25.17	34.20	27.05	7.15	11.7	16.9	61.0
TP-10	0.2-1.6	CH	2.75	26.03	55.00	32.71	22.29	-	34.2	59.0
TP-12	0.8-3.0	CH	2.80	25.54	50.50	27.39	23.11	9.3	13.8	64.0
TP-14	0.1-1.0	CL	2.74	16.15	37.80	19.54	18.26	11.3	25.1	54.0
"	1.4-2.6	CL	2.78	30.46	40.85	29.59	11.26	-	18.3	74.0
Area III										
TP-15	0.1-2.5	SC	2.74	14.48	32.65	20.11	12.54	21.1	40.8	32.0
TP-16	0.2-1.3	CL	2.75	17.87	27.85	16.15	11.70	-	45.6	50.0
"	1.3-3.0	SC	2.74	9.43	35.30	23.39	11.91	20.1	33.3	46.0
TP-17	0.7-3.0	CL	2.89	18.11	34.60	21.82	12.78	-	38.1	55.0
TP-18	0.1-0.7	SC	2.78	13.19	22.65	15.24	7.41	-	48.8	48.0
"	0.7-2.6	SC	2.75	11.33	33.70	21.66	12.04	11.5	32.7	46.0
TP-21	0.4-3.0	SC	2.71	28.00	35.50	21.93	13.57	19.9	30.9	41.0

Table 2.11 RESULT OF CONSOLIDATION TEST FOR IMPERVIOUS MATERIALS

Test Pit No.		W (%)	Yd (g/cm3)	Unsaturated Pc (kg/cm2)	Unsaturated Cc	Unsaturated $\overline{Cv}$ (cm2/sec)	Saturated Pc (kg/cm2)	Saturated Cc	Saturated $\overline{Cv}$ (cm2/sec)
TP-3	A	19.5	1.71	Pc > 10	0.10	1.6×10^{-3}	Pc > 10	0.10	1.5×10^{-3}
	B	22.3	1.62	5.0	0.19	1.3×10^{-3}	5.0	0.19	1.7×10^{-3}
	C	19.5	1.62	5.5	0.12	2.0×10^{-3}	3.5	0.15	2.8×10^{-3}
TP-11	A	28.5	1.357	5.8	0.26	1.5×10^{-3}	1.5	0.30	1.6×10^{-3}
	B	31.9	1.289	4.0	0.23	1.1×10^{-3}	1.0	0.26	1.5×10^{-3}
	C	28.5	1.289	1.2	0.32	1.2×10^{-3}	0.7	0.30	1.1×10^{-3}
TP-22	A	26.3	1.324	Pc > 10	0.21	8.2×10^{-4}	0.5	0.29	2.2×10^{-3}
	B	29.0	1.257	Pc > 10	0.28	7.9×10^{-3}	0.2	0.32	1.7×10^{-3}
	C	26.3	1.257	0.6	0.28	1.6×10^{-3}	0.4	0.32	1.2×10^{-3}

Table 2.12 RESULT OF PHYSICAL TEST FOR ROCK MATERIALS AND DAM FOUNDATION

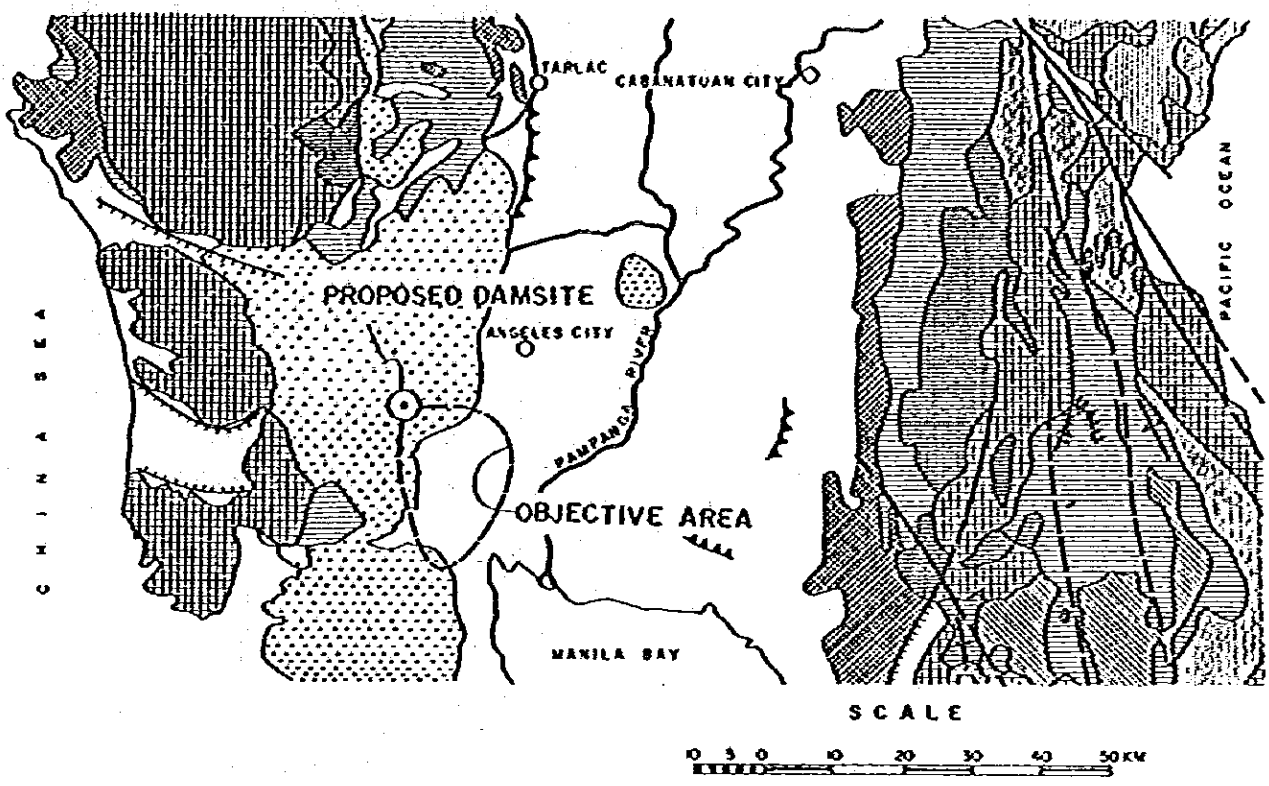
Items		Specific Gravity Gs'	Absorption (%)	Compression Test (kg/cm^2)	Soundness Test (%)	Remarks
Drilling Samples (foundation)						
DH-3	13.42 m	2.36	2.73	547 363	*0.25-1.54	An.
DH-6	24.15 m	1.93	16.26	46 57		Aggl.
	38.15 m	1.95	14.43	51 54 56		
DH-8	33.89 m	1.26	22.22	28 33		Tfb.
	44.85 m	2.15	2.38	1,085		An.
	67.85 m	2.30	10.71	99 108		Aggl.
DH-10	34.50 m	2.31	17.65	35 33		Aggl.
DH-11	10.40 m	2.00	2.70	212		Ry.
Quarry Site (Q-1)						
Block Sample		2.27	10.74	175 154 153	*0.42	Tfb. (Ardesitic)
QDH-1 and QDH-3		2.00	8.08	123		
		2.09	7.23	32		La. Tuf.
		1.99	7.14	92		
		2.10	6.58	248		Tfb.
		1.95	5.26	67		La. Tuf.
		2.00	9.76	50		

Remarks: *: Not reliable

TRIAXIAL COMPRESSION TEST RESULTS OF FOUNDATION

DH-6			CH-9		
Depth (m)	C (kgf/cm^2)	ø (°)	Depth (m)	C (kgf/cm^2)	ø (°)
-	3.0	27°30'	21 - 23	16.0	36°00'
32 - 35	16.0	32°00'	26 - 62	16.0	40°00'

Fig. 2-1 GEOLOGICAL MAP IN AND AROUND THE STUDY AREA



GEOLOGICAL SYMBOLS

- Formational boundary
- Anticlinal axis with plunge
- Overturned anticline
- Synclinal axis with plunge
- Overturned syncline
- Close fold
- High angle fault
  Dashed where inferred: arrow indicates strike-slip movement
- Normal fault
  Dashed where inferred: hachures on downthrown side
- Thrust fault
  Dashed where inferred: saw-teeth on overriding side

LEGEND

Sedimentary rock	Age	Igneous rock
	Quaternary	
	Pleistcene Pliocene	
	Tertiary	
	Paleocene Cretaceous	
	Cretaceous	
	Pre-Jurassic	

Sources: Bureau of Mines Philippines 1963

Fig.22 LOCATION MAP OF GEOLOGICAL AND SOIL MECHANICAL INVESTIGATION

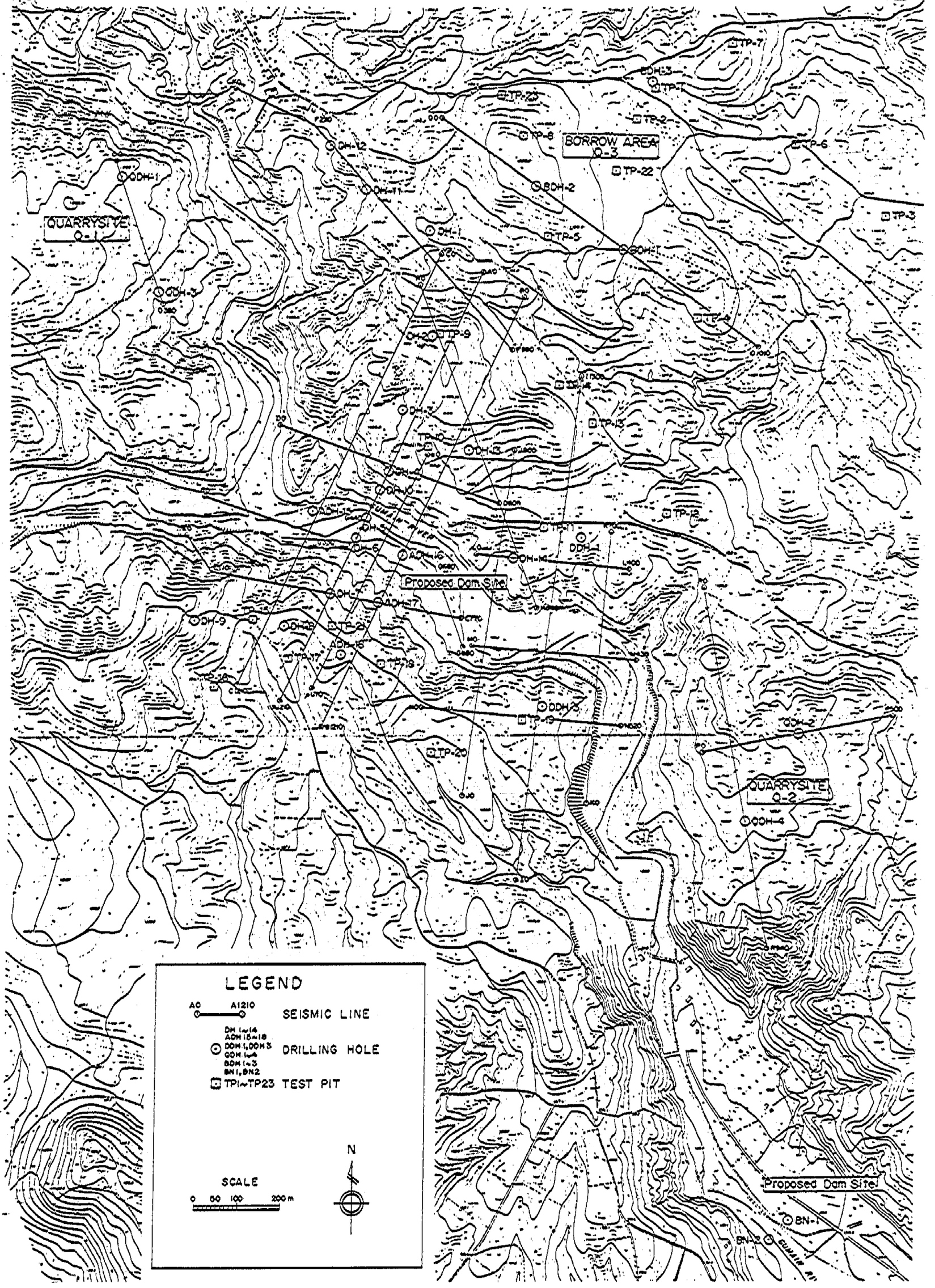
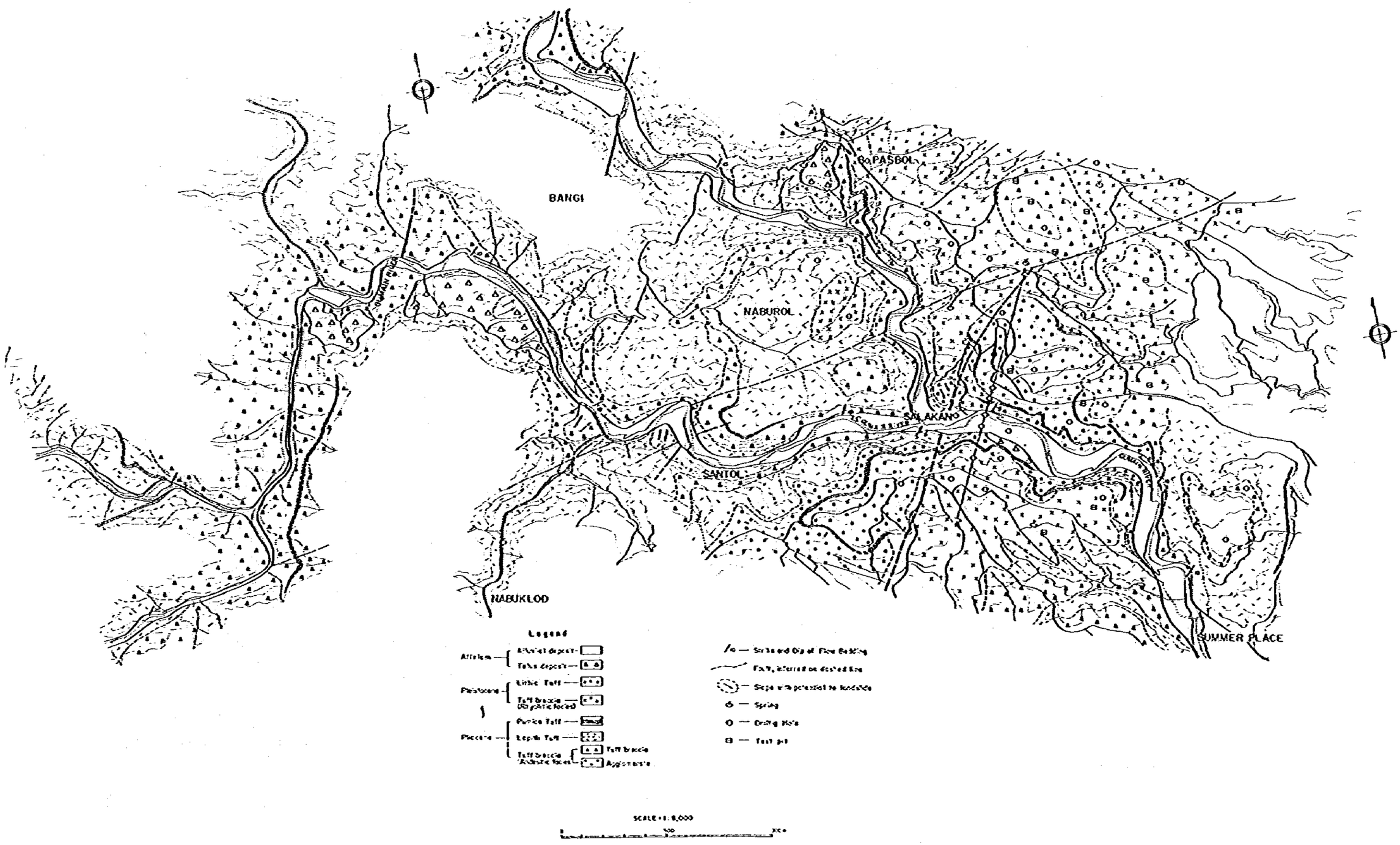


Fig.2.3 GEOLOGICAL MAP OF PROPOSED GUMAIN DAM SITE



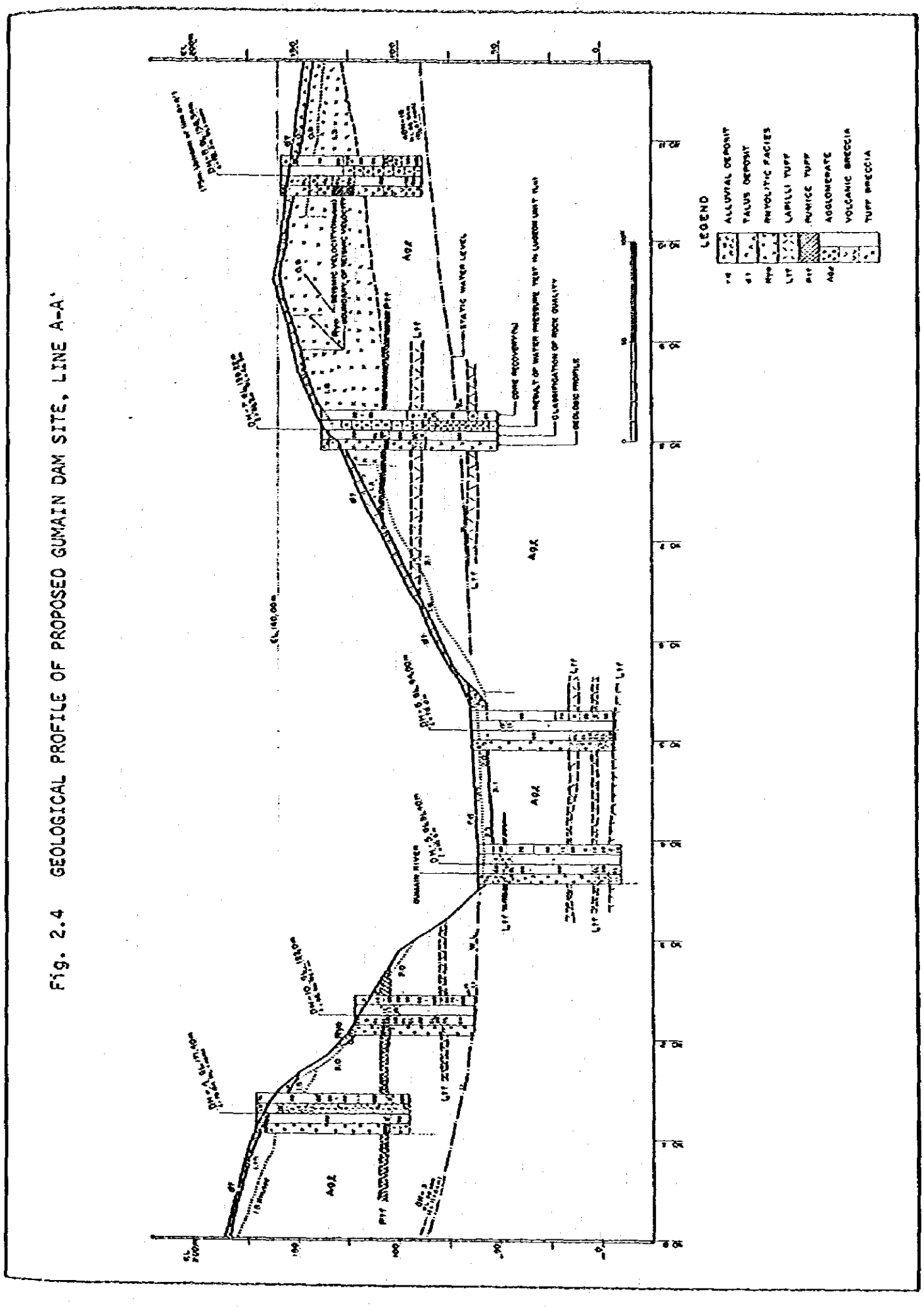


Fig. 2.4 GEOLOGICAL PROFILE OF PROPOSED GUMAIN DAM SITE, LINE A-A'

Fig. 2.5 GEOLOGICAL PROFILE OF ALTERNATIVE DAM AXIS

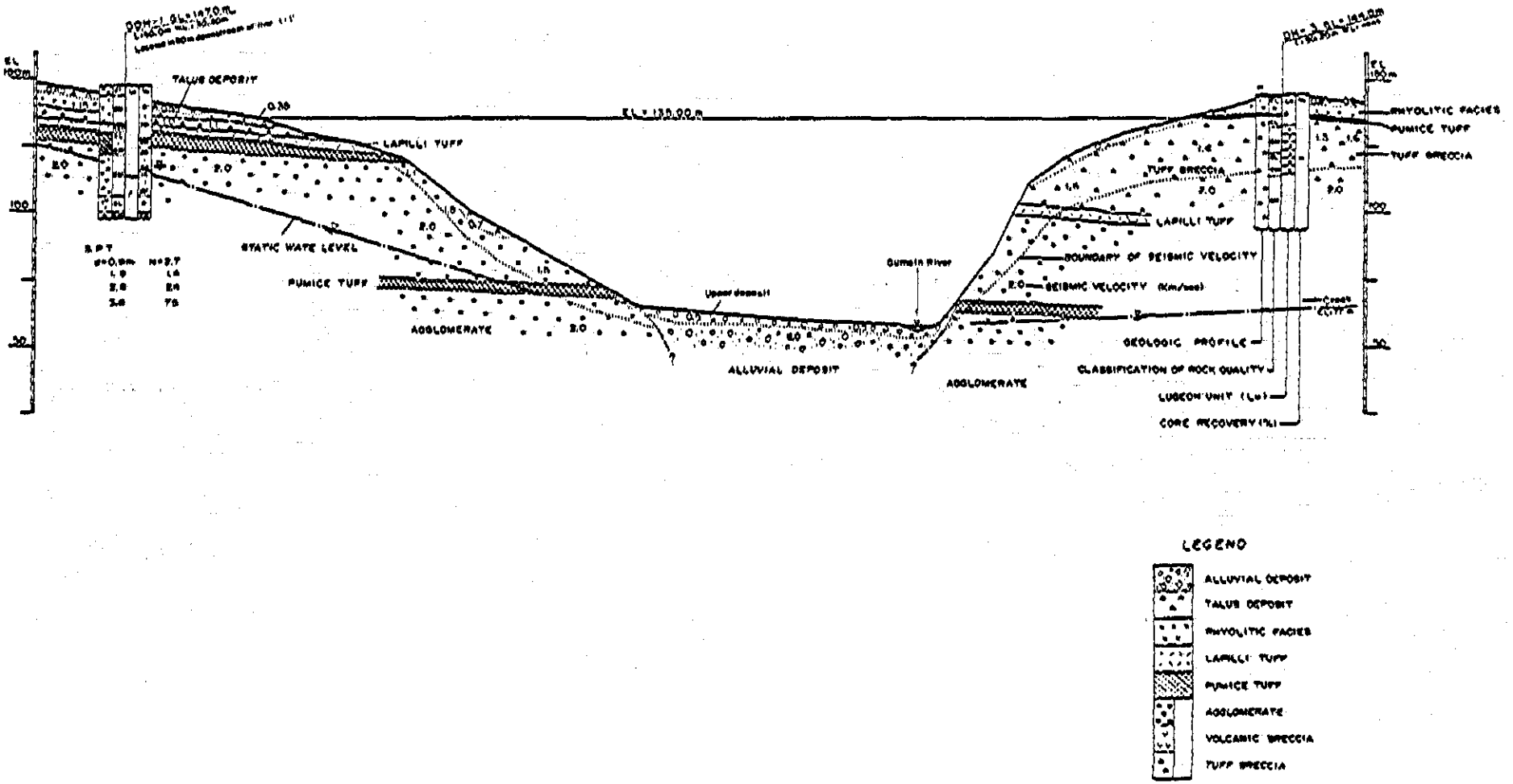


Fig. 2·6 GEOLOGICAL PROFILE OF PROPOSED GUMAIN DIVERSION DAM AXIS

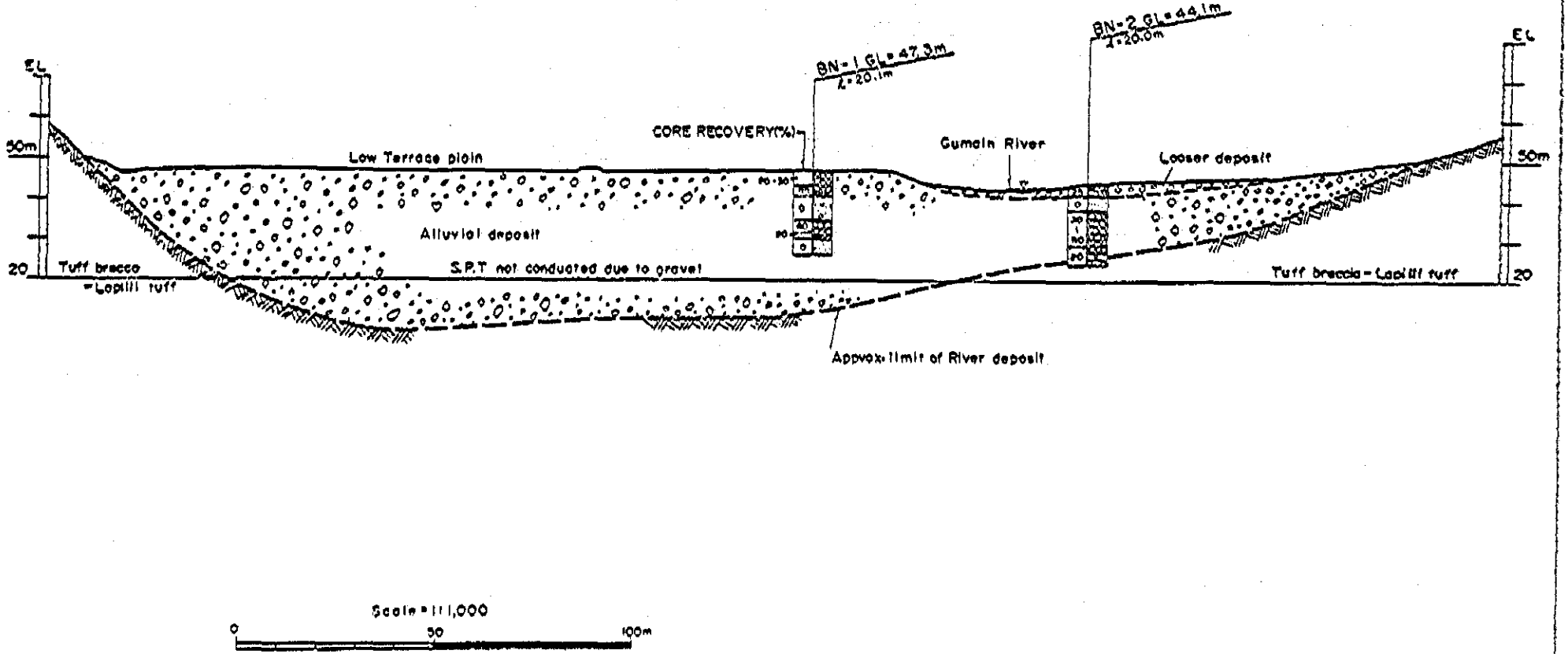
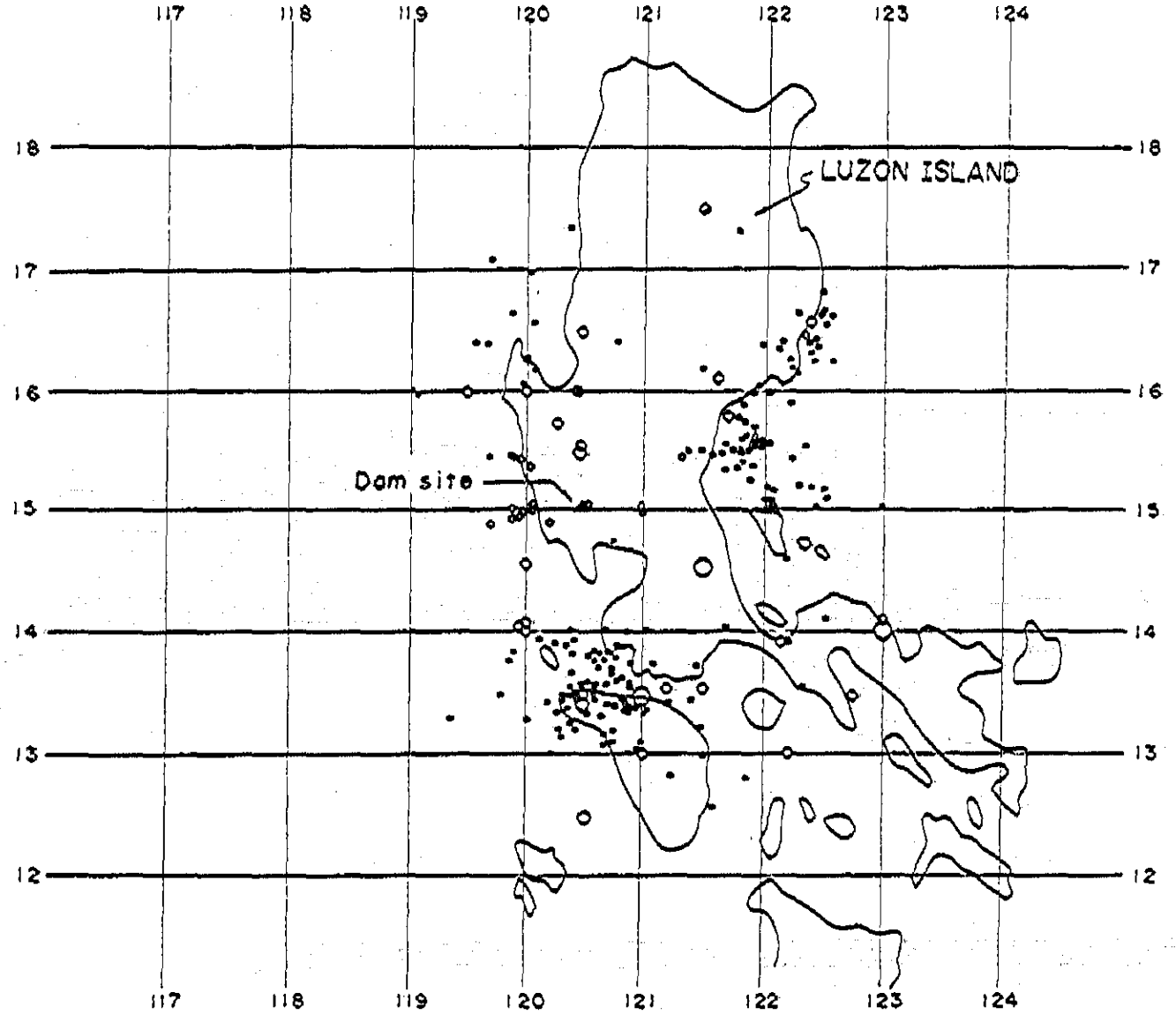


Fig. 2-7 SIGNIFICANT EARTHQUAKE EPICENTER MAP (1907 – 1980)
(Magnitude ≥ 5.0)



○ M > 7.5
○ 7.0 < M ≤ 7.5
○ 6.0 < M < 7.0
• 5.0 < M < 6.0 (affect damsite)
• 5.0 < M < 6.0 (not affect damsite)

Fig. 2·8 PLOTTING POSITION OF NON-ANNUAL EXCEEDENCE SERIES

Note: αm is calculated by Iwasaki Formula

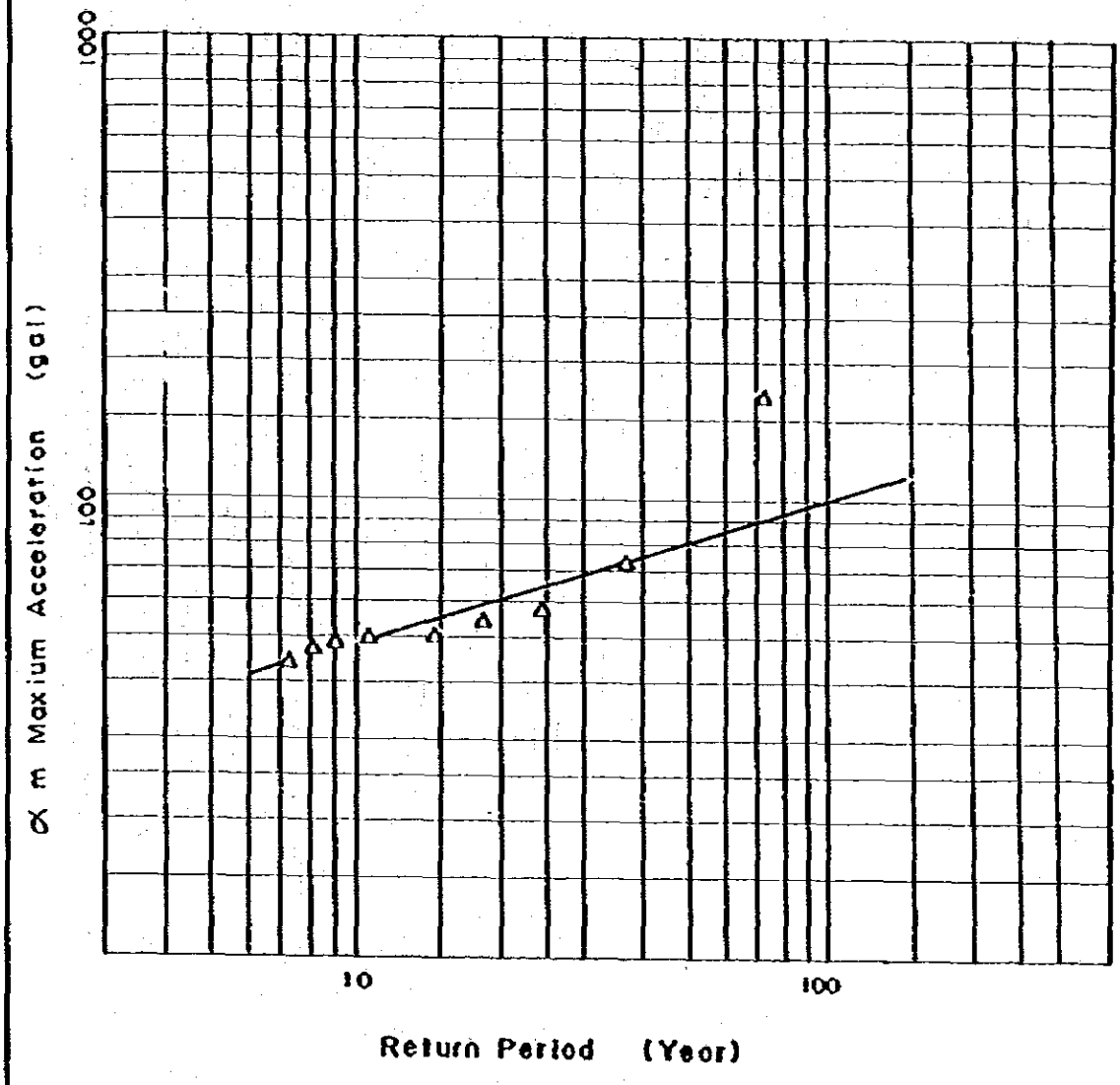
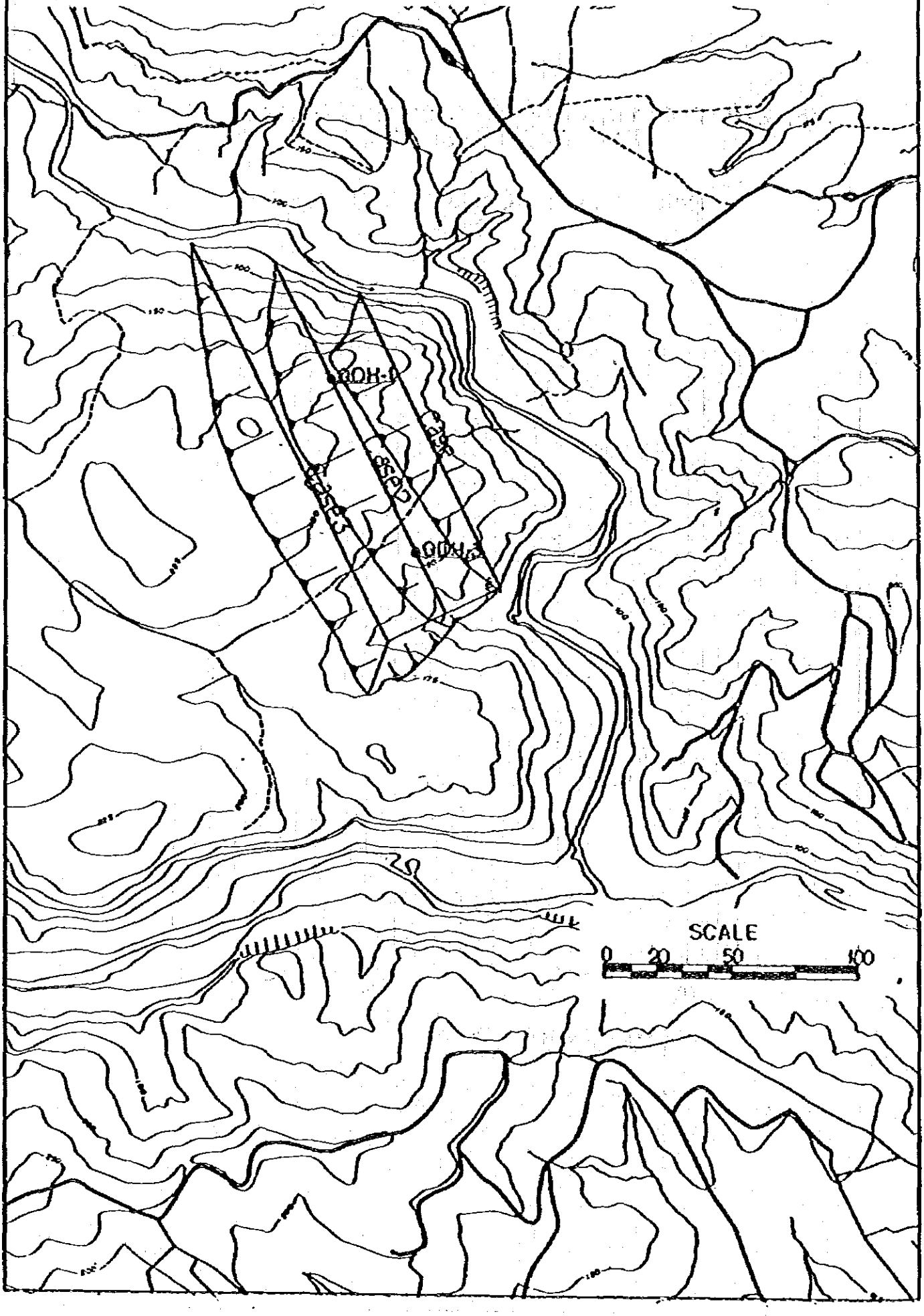


Fig. 2-9 LOCATION OF QUARRY SITE, Q-1



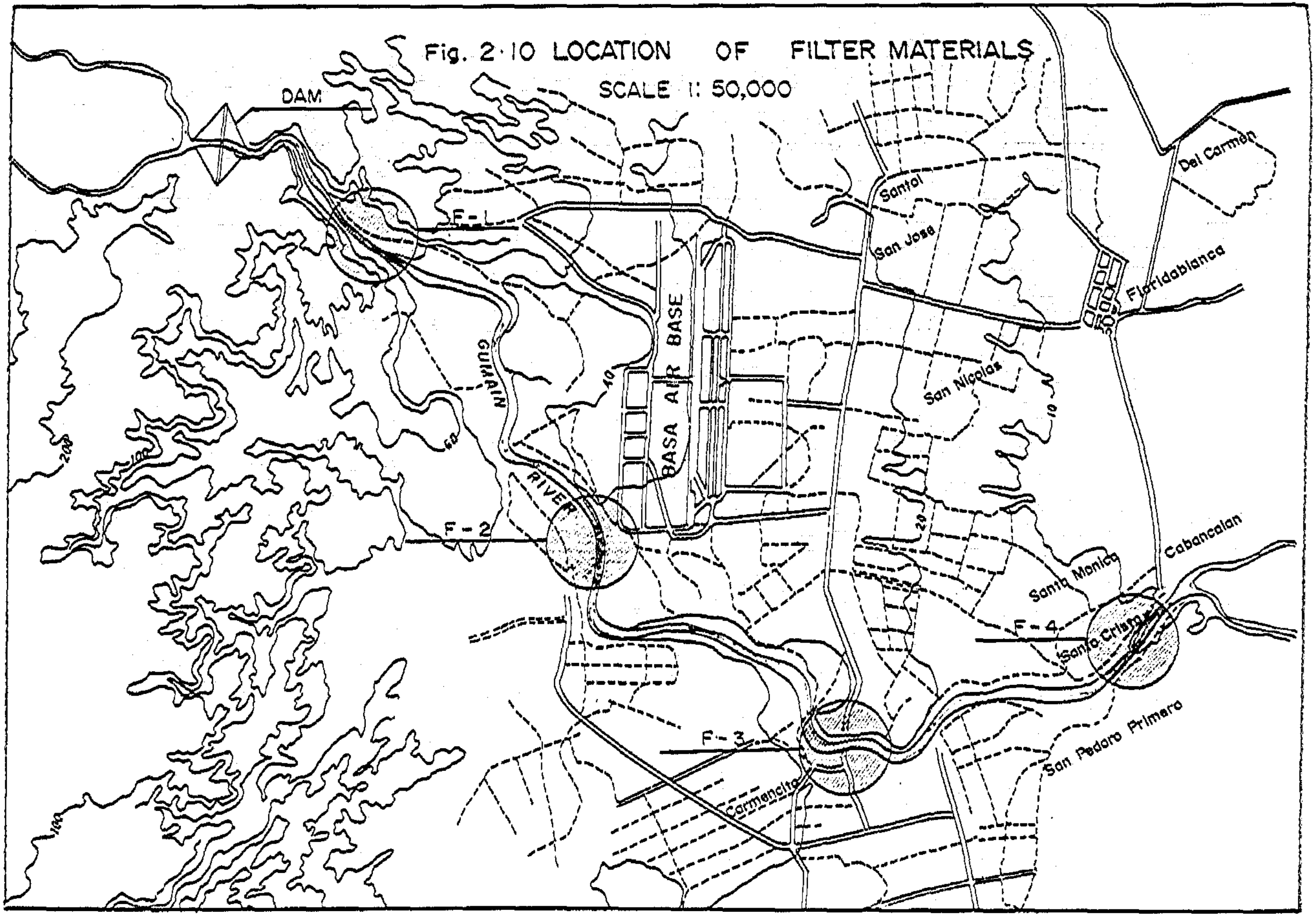


Fig. 2·10 LOCATION OF FILTER MATERIALS

SCALE 1: 50,000

Fig. 2·11 PHYSICAL PROPERTIES OF IMPERVIOUS MATERIALS

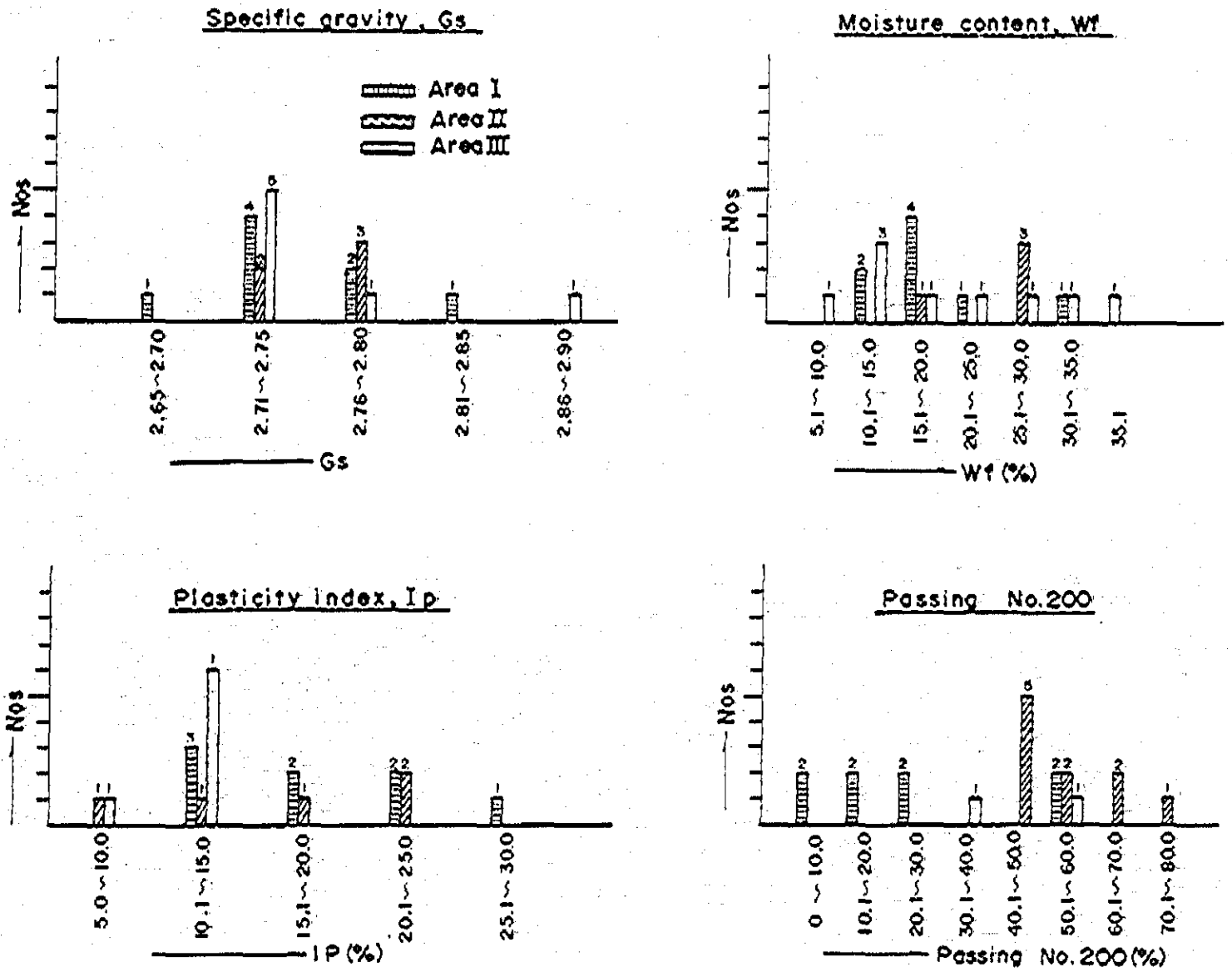


Fig. 2·12 PARTICLE SIZE ACCUMULATION CURVE OF IMPERVIOUS MATERIALS

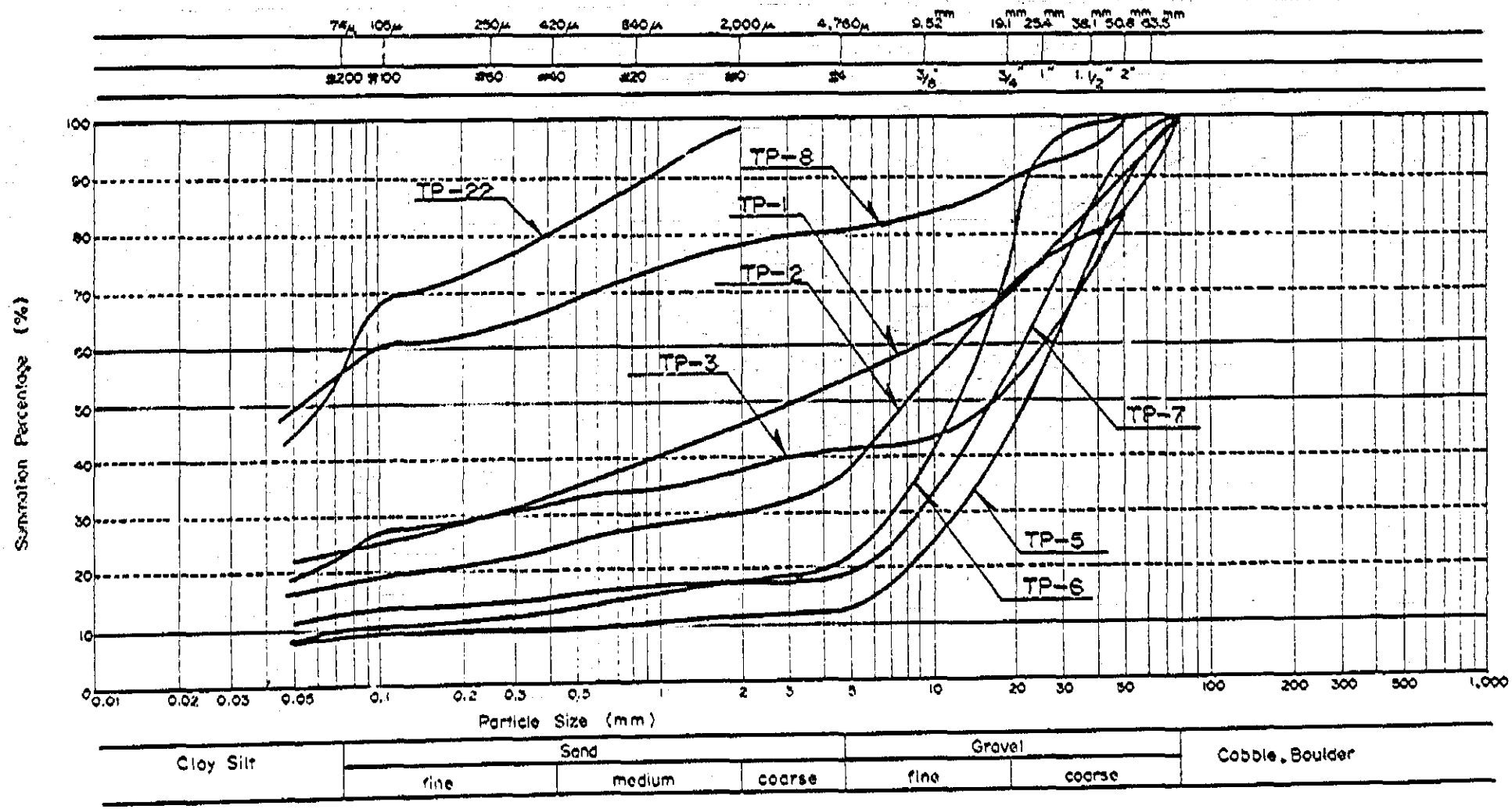


Fig. 2·13 DRY DENSITY—WATER CONTENT

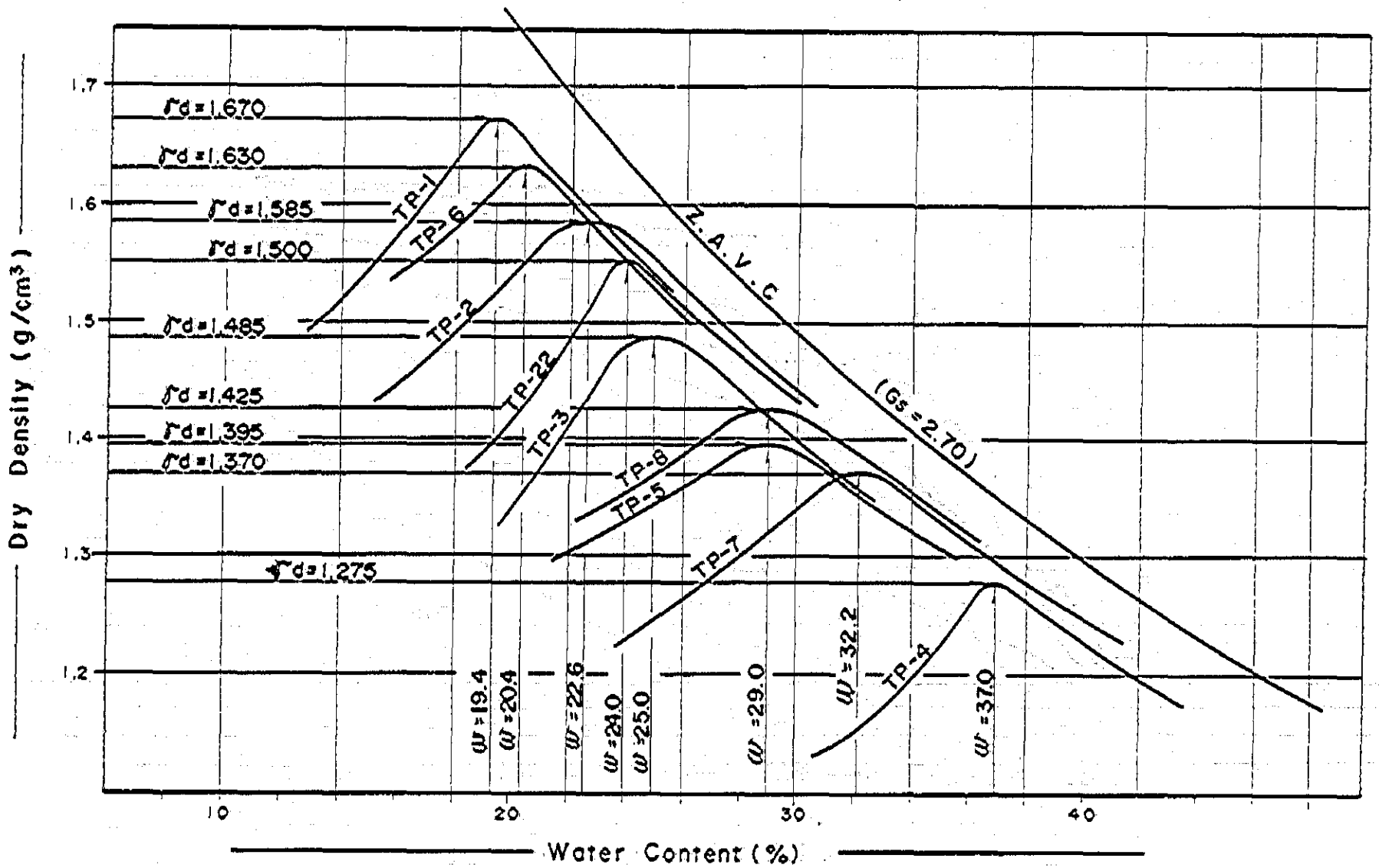


Fig. 2·14 RESULT OF TRIAXIAL COMPRESSION TESTS

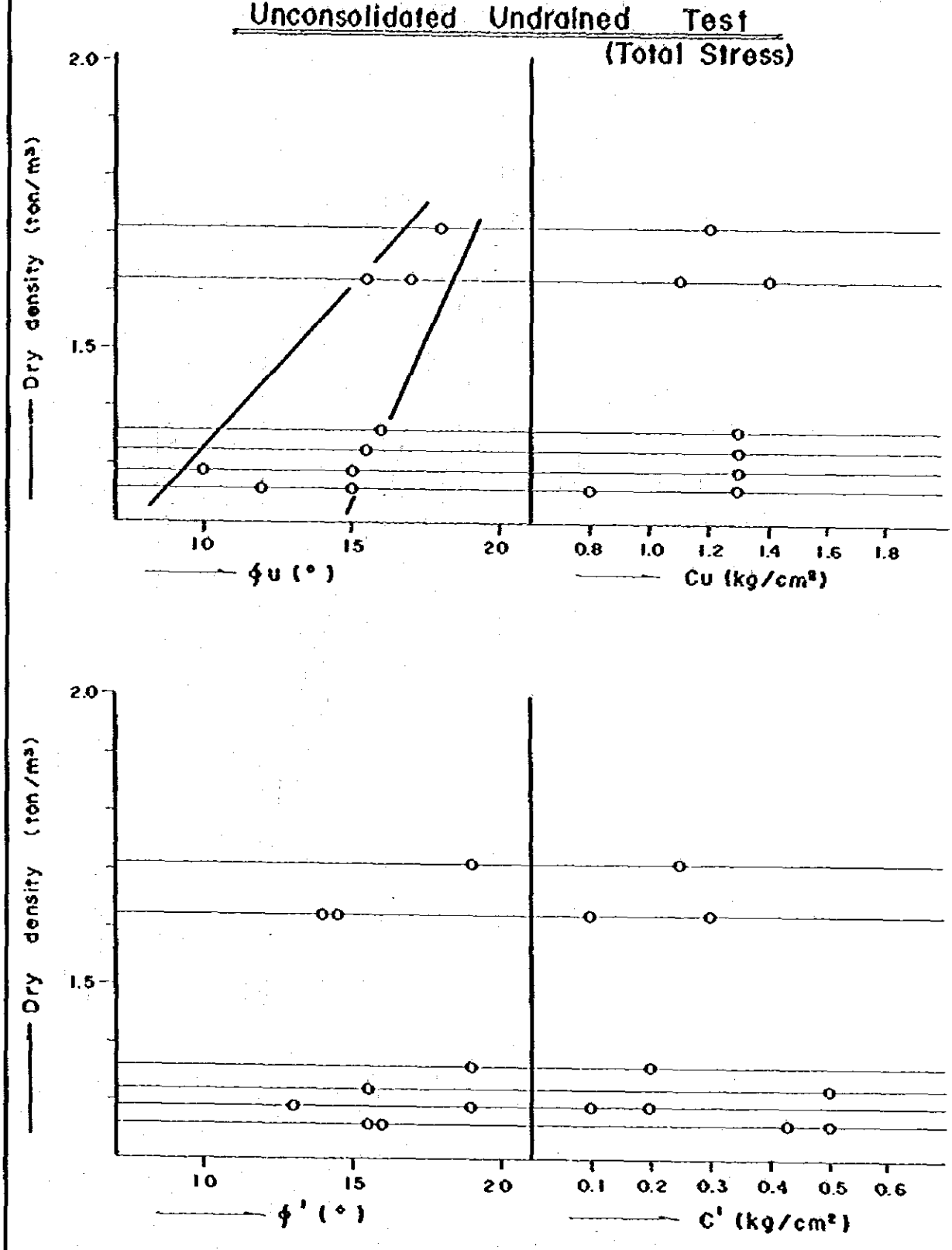
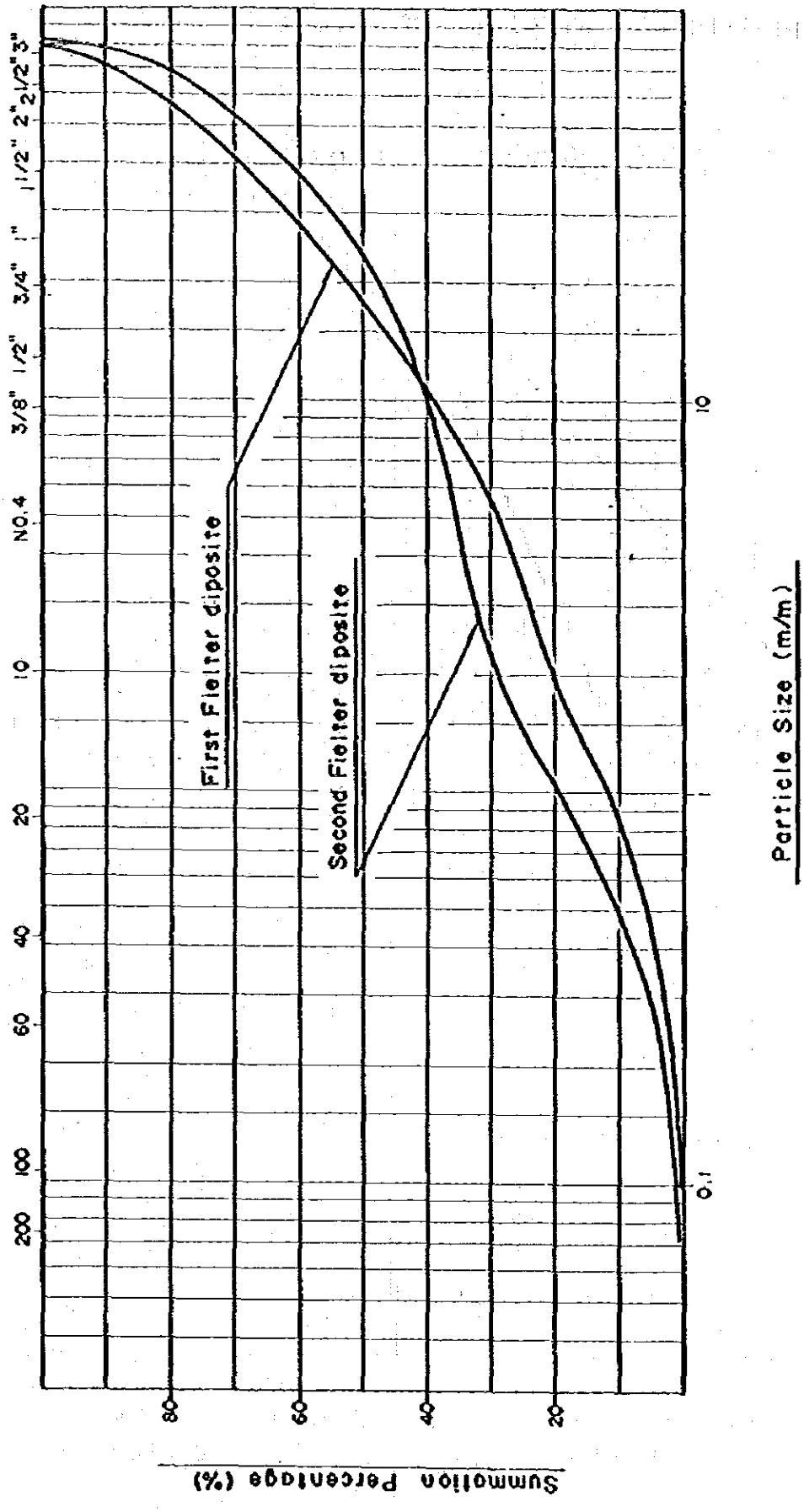


Fig 2·15 PARTICLE SIZE ACCUMULATION CURVE OF FILTER MATERIALS



APPENDIX III

SOILS AND LAND CLASSIFICATION

APPENDIX III SOILS AND LAND CLASSIFICATION

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APPENDIX III SOILS AND LAND CLASSIFICATION

CHAPTER 1 INTRODUCTION

To grasp soil characteristics and evaluate land capability for irrigation farming in the study area, field investigation on soils and the present land use condition as well as laboratory analysis were undertaken from January 5 to March 2, 1984, in colaboration with the Land Resources Utilization and Economics Division, Project Development Department (PDD), National Irrigation Administration (NIA). The study area covers a total area of 23,700 ha including the existing service area of two irrigation systems, operated and managed by NIA, which are Porac-Gumain Rivers Irrigation System, 14,275 ha in gross, and Caulaman River Irrigation System, 1,200 ha in gross.

As PDD, NIA had performed semi-detailed soil survey and laboratory tests in 1983 followed by preparation of soil, land use and land classification maps for the existing irrigation service areas aforementioned, undertaking of the field investigation was concentrated into an extension area of 8,225 ha, being a possibly beneficial area under the proposed irrigation development plan. In parallel with the PDD's soil survey, further, soil drainage investigations were carried out in the existing irrigation service area by the Investigation Division, PDD, NIA.

A 1:10,000 scale aerial photograph and a 1:4,000 scale newly prepared topographic map were used as a base map in the above semi-detailed soil survey. Traverses were made throughout the entire study area to delineate and map the different soil types and series. Randomly assigned soil auger borings with an average depth of up to 150 cm were made assessing thereat the different morphological and physical characteristics of the soil as to color, texture, drainage conditions, relief and parent materials. Through the field investigations done in 1983 and 1984, a total of 21 master pits and 102 auger holes including fertility test sites was dug, and collected 93 soil samples for morphological determination and 102 soil samples to determine nutrient requirement. Samples collected were sent to and analyzed at the NIA Soils and Water Laboratory in Muñoz, Nueva Ecija.

The soil profile descriptions are as compiled in Tables 3.1 (1) thru 3.1 (10) for the 10 master pits dug in the proposed extension area and in Tables 3.2 (1) thru 3.2 (11) for the 11 master pits dug in the existing irrigation service area. The results of laboratory tests on soil samples taken through the master pit surveys are as shown in Tables 3.3 (1) thru 3.3 (10) for the proposed extension area and in Tables 3.4 (1) thru 3.4 (11) for the existing irrigation service area. The results of additional tests are as shown in Tables 3.5 and 3.6 for the fertility test and in Tables 3.7 (1), 3.7 (2) and 3.8 for screening tests on soil samples.

CHAPTER 2 LAND USE

2.1 Location and Extent of the Study Area

The study area is located in the Provinces of Pampanga and Bataan and covers the Municipalities of Floridablanca, Guagua, Lubao, Santa Rita, Hermosa and Dinalupihan. It lies between 120°30' and 120°40' east longitude and 14°50' to 15°10' north latitude. It is situated on a vast tract of agricultural plain on the southwestern part of Pampanga river basin. Bounded on the north by the Porac and Potrero rivers, on the south and east by the National Highway Route 7 (Olongapo-Gapan road) and on the west by the Province of Zambales, it covers a total aggregate area of 23,700 ha.

Generally, the study area is topographically level to nearly level with slope ranging from 0 to 3%. Slight undulation occurs, as it extends toward the north-eastern peripheral part. Rivers and creeks dissect the entire study area prominent among which are the Porac, Gumain and Caulaman rivers that are all draining southeasterly.

Presently, a portion of the study area is irrigated by a national system with the north and south main canals served by the Porac and Gumain rivers, respectively. The Caulaman river which emanates from the Province of Pampanga irrigates a portion of the study area in the Municipalities of Dinalupihan and Bataan. Inadequate water, however, limits the irrigated area served by the aforesaid sources during the dry season resulting in the use of irrigation pumps by some farmers.

San Fernando, the provincial capital town and regional center, is 15 km away northeast of the study area. It is accessible through the newly built Olongapo-Gapan road which passes through the southeastern part of the study area. Project accessibility is facilitated by numerous municipal and barangay roads most of which are asphalted and well paved.

2.2 Present Land Use Condition

The present land use condition of the study area was confirmed by using newly prepared topographic maps with a scale of 1/4,000 and having a contour line of 1 m. In total, seven land use categories were identified and each areal extent was planimetrically measured.

According to the survey results as shown in Table 3.9, there exist paddy field of 11,900 ha, sugarcane field of 6,800 ha, perennial crop of 50 ha, grass/bush land of 300 ha, residential area of 1,300 ha and miscellaneous land of 3,350 ha including fish ponds of 270 ha in the whole study area. The land use map of the study area is compiled in Appendix XII. Generally, paddy cultivation prevails in the existing two irrigation service areas and sugarcane is predominantly grown in the proposed extension area as shown in Table 3.9. Out of the paddy field, irrigation water is presently supplied to 5,000 ha by the Porac-Gumain Rivers Irrigation System, 745 ha by the Caulaman River Irrigation System and 540 ha by communal irrigation systems. The remaining paddy field remains in rainfed condition and a part of which is provided with groundwater by installing small pumps.

CHAPTER 3 SOIL CLASSIFICATION

3.1 Soils of the Study Area

Only one soil groups was identified and mapped in the study area, being deribed from recent alluvial deposit and represented by the following four soil series:

1) San Fernando soil series,
2) La Paz soil series,
3) San Manuel soil series, and
4) Quingua soil series.

The entire floodplain of the study area are the main location of this soil group. Considered as one of the most fertile group of soils, the area is extensively planted to paddy rice and sugarcane with minor portions planted to vegetables. Soils of this group generally have fair to good internal drainage with level to gently undulating topography ranging from 0 to 3% in slope. The soil group depending on its physiographic location is generally subject from slight to severe seasonal flooding, most especially during heavy rains, significantly affecting crop yield in the process. Saline water intrusion in some parts of the study area indicates no salinity into surface soils thus having no effect on soils and crop growth.

Taking into account the surface soil texture, slope and fooding hazard, 11 soil mapping units were identified and delineated. The areal distribution of the respective units is as shown in Table 3.10. The soil classification is made for an area of 19,050 ha excluding the residential area and miscellaneous land. The soil map is compiled in Appendix XII.

3.2 Main Features of Soil Series

(1) San Fernando Soil Series

The soils of San Fernando series extend over the flat low-lying flood plain locating along the downstreams of the Guagua, Porac and Gumain rivers. The land covered with these soils is poorly drained and affected by flooding or ponding water during the wet season. The total land area amounts to 1,700 ha or 7.2% of the study area. At present, the land is used for paddy cultivation.

The horizon sequence of these soils consists of A/B/Cg. The A horizon is of dark gray to dark grayish black clay with a thickness of about 20 cm. The soils have strongly developed blocky structure. The B horizon is poorly drained due to its very heavy type of grayish brown clay, with few manganese concretions, having a depth range of 35 to 40 m.

In general, these soils have a moderately high inherent soil fertility and a neutral pH value as summarized in Table 3.11.

Based on the flooding hazard, three mapping units, SfA1, SfA2 and SfA3, are mapped. The typical soil profiles are as decribed in Tables 3.2 (1) and 3.2 (2).

(2) La Paz Soil Series

The soils of La Paz series extend over the flat to slightly depressed land on alluvial terrace developed along the Porac, Gumain, Caulaman and Balsic rivers. The land covered with these soils is well drained with an exceptive area along the upstream reaches of the Gumain river near the existing diversion dam. The extent of land area totals 5,550 ha or 23.4% of the study area. Presently, the land is grown with paddy rice in the slightly depressed portion and with sugarcane in the flat portion.

The horizon sequence of the soils is of A/B/C. The A horizon has a thickness of 25 to 30 cm with dark grayish brown or pale brown to dark grayish brown sandy loam. Structure is weakly developed granular or subangular blocky. The B horizon is composed of dark grayish brown sandy clay loam with granual structure. The C horizon is loamy sand in texture.

With regard to chemical properties, pH values show neutral as shown in Table 3.11. Inherent soil fertility appears poor.

Based on the slope and flooding hazard, three mapping units, LpA, LpA2 and LpB, are mapped. The typical soil profiles are as described in Tables 3.1 (2), 3.1 (8) thru 3.1 (10), 3.2 (7) and 3.2 (10).

(3) San Manuel Soil Series

The soils of San Manuel series extend over the flat to very gently undulating land on alluvial terrace, mainly situated between the Guagua river and the Gumain river. The land covered with these soils is well drained, a part of which especially adjacent to Floridablanca, is slightly affected by flooding water during the wet season. The total coverage of land shares 4,630 ha or 19.5% of the study area. At present, most of the land are cultivated for paddy rice.

The soils have the horizon sequence of A/B/C. The A horizon is of grayish brown silt loam or sandy clay loam with an average thickness of 25 cm. The soils have weakly developed sub-angular blocky or granular structure. The B horizon is dark grayish brown and silty to sandy clay loam in texture. The C horizon is of sandy loam.

The soils have a slightly acid pH value and a moderately high inherent soil fertility as shown in Table 3.11.

Based on the slope and flooding hazard, three mapping units, SmA, SmA1 and SmB, are mapped. The typical soil profiles are as described in Tables 3.1 (3), 3.1 (7), 3.2 (3), 3.2 (5), 3.2 (6) and 3.2 (9).

(4) Quingua Soil Series

The soils of Quingua series extend over the nearly level to very gently undulating land on alluvial terrace, locating along the middle reaches of the Porac river and the middle reaches to downstreams of the Gumain and Caulaman rivers. The lands covered with these soils are well drained, but depressed areas developed along the middle reaches of Guagua, Gumain and Balsic rivers and the Palcarangan creek are slightly affected by flooding water. The land area totals 7,170 ha or 30.3% of the study area. Presently, the land is predominately grown with paddy with minor proportion of sugarcane cultivation.

The horizon sequence of these soils consists of A/B/C. The A horizon is of dark brown sandy clay loam or brownish gray silt loam with moderately strong sub-angular blocky structure or granular structure. The thickness of this horizon is about 25 cm. The B horizon is dark grayish brown in colour and clay loam to loam in texture with weak granular structure. The C horizon has yellowish brown sandy loam.

The soils have a slightly acid to neutral pH value and a moderately high inherent soil fertility as summarized in Table 3.11.

Based on the flood hazard, two mapping units, QgA and QgA1, are mapped. The typical soil profiles are as described in Tables 3.1 (1), 3.1 (4) thru 3.1 (6), 3.2 (4), 3.2 (8) and 3.2 (11).

3.3 Infiltration Test

Results of infiltration test conducted from different soil texture throughout the whole study area show a wide gap of intake rate ranging from a low of 0.58 cm/hr to a high of 28.11 cm/hr. It can be considered that such wide gap is attributed to the texture and structure of the soil, the presence of high water table and in the use of cylinder infiltrometer itself. In swelling clay soils, the presence of large cracks within and surrounding the cylinder have an adverse effect in the intiltration rate sometimes giving unrealistic results. Data obtained reveal that heavy to medium textured soils have a low intake rate while light textured soils have high intake rates. The results of infiltration test conducted in various locations in the study area are summarized in Table 3.12.

CHAPTER 4 LAND CLASSIFICATION

4.1 General

The land classification survey covers a total area of 23,700 ha. Out of these, 19,050 ha were classified as arable land while 4,650 ha were non-arable land.

The main objectives of land classification survey are as follows:

1) To classify and identify land with potential for irrigation development,
2) To classify land into approximate land classes based on their existing limitations and potential productivity,
3) To collect and provide data necessary in the determination of land use, farm size, development layout for civil works and economic aspects of the project, and
4) To present obtained results in tabulations and maps.

The land classification survey was patterned after the U.S. Bureau of Reclamation land classification procedure purposely modified to suit local project conditions. It involves delineation and classification of arable land and non-arable land.

The areal extent of land class is as shown in Table 3.13. The land classification map is prepared for rice land including dual class land and for diversified cropland, compiled in Appendix XII.

4.2 Description of Major Land Classes

4.2.1 Rice Land

(1) Class 1R

Class 1R is first class land highly suitable for the production of paddy rice both during the wet and dry seasons. Land without soil and flooding problems and with slope range of 0 to 3% is classified under this class. A total area of 2,630 ha constituting 13.8% of the total arable land is mapped under this class mostly planted to paddy rice and sugarcane with some scattered areas devoted to vegetable production during the dry season.

(2) Class 2R

This class is good land moderately suited for the production of paddy rice but with lower productivity than Class 1R. The land has minor deficiencies in either soil, topography or drainage problems thereby affecting the yield of agricultural crops with moderate significance. A total area of 1,130 ha is mapped under this class constituting 5.9% of the total arable land.

(3) Class 3R

Class 3R is good land fairly suitable for paddy rice production. The land has serious deficiencies in either soil, topography or drainage which necessitates a lower productivity rating than class 2R. With improved farm management practices, it can be made to produce a fair and good yield both during the wet and dry seasons. Results of the survey show that 110 ha or 0.6% of the total arable land fall under this class.

4.2.2 Dual Class Land

(1) Class 1R (2)

This land has dual class land highly suitable for the production of rice and diversified crops. This land has restricted to well drained sub-surface drainage. With sub-surface drainage, it can be made to produce high yield of diversified crops during the dry season and high yield of paddy rice during the wet season. Survey results show that 11,430 ha fall under this class mostly planted to paddy rice and sugarcane with some minor portions planted to vegetables. It constitute 60.0% of the total arable land.

(2) Class 2R (2)

This class consists of good quality land lower than class 1R (2) in productivity, having moderate potential for the production of paddy rice and diversified crops both the during wet and dry seasons. Due to minor deficiencies in either soil, topography or drainage, it is downgraded below Class 1R (2) in productivity. A total area of 650 ha is classified under this class mostly devoted to paddy rice production with some patchy areas planted to vegetables. It constitute 3.4% of the total arable land.

4.2.3 Diversified Cropland

(1) Class 1

This class is highly productive land without any significant limitations for successful production of diversified crops. The land has level to gently sloping topography with a more or less loamy texture throughout. Due to its physiographic locations, there maybe seasonal inundation but damage to crops is quite negligible. Results of the survey show that 230 ha fall under this class constituting 1.2% of the total arable land.

(2) Class 2

This class consists of good quality land moderately suitable for diversified crop production. It is downgraded below class 1 in productivity due to minor limitations in soil topography or drainage. With good cultural management practices, it can be made to produce

good yield of diversified crops both during the wet and dry seasons. The land falling under this class is mostly located near the course of Porac river and its tributaries and in some scattered flood plains of the Study area. A total area of 1,900 ha is classified under this class representing 10.0% of the total arable land.

(3) Class 3

This class is land with serious physical limitations in soil, topography or drainage. It is limited in productivity and adaptability due to its serious physical defect. A total of 970 ha is classified as class 3 land.

4.2.4 Non-arable Land

This land is not suitable for irrigation development for failure to meet the minimum requirements of irrigation suitability, including class 6 and residential or built up areas. A total area of 4,650 ha is classified as non-arable land representing 19.6% of the whole Study area.

(1) Class M

Class M lands are those occupied by residential areas of those places undergoing or had undergone active stage of development. These consist 1,300 ha representing 28.0% of the total non-arable land.

(2) Class 6

Land falling under this class is classified not suitable for irrigation development due to severe physical limitations. The land includes rivers, creeks, streams, drainage channel, river wash, steeply sloping areas and roads. Class 6 lands have a total area of 3,350 ha.

Table 3.1(1) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. General Information

Master Pit No.: 1
Project: Gumain Reservoir
Photo No.: 37
Location: Saba, Hermosa, Bataan
Landform: alluvial terrace
Relief: nearly level
Land Use: sugarcane
Elevation: 3.5 m
Slope: 0 to 1%
Aspect: approximately 900 m west of Barangay Saba

Surface Drainage: good
Internal Drainage: good
Soil Drainage Class: well drained
Soil Parent Material: alluvial deposit
Soil Series/Type: Quingua
Land Class: $\frac{1R}{Sc11BY}$ (2do)

B. Profile Description

Sample No.	Depth (cm)	Profile Description
1-1	0-19	Dark grayish brown (10YR 4/2) dry; fine sandy clay loam; common fine to medium distinct yellowish brown (10YR 5/6) mottles; no concretions; moderately strong sub-angular blocky structure; slightly sticky, slightly plastic; common fine to medium roots; clear irregular horizon boundary.
1-2	19-37	Dark brown (10YR 3/3) dry; fine sandy clay loam; common fine distinct yellowish brown (10YR 5/8) mottles; weak angular blocky structure; slightly sticky, non-plastic; common fine to medium tubular pores; presence of patchy thin clay cutans along pores living and ped faces; common fine and few medium roots; abrupt smooth hirizon boundary.
1-3	37-95	Brown (10YR 4/3) moist; fine sandy loam; common fine to medium distinct yellowish brown (10YR 5/6) mottles; slightly compact, friable. Note: Water level at 95 cm depth.

Described By: T.C. Anyaya
R.A. Umagat

Date: February 7, 1984

Table 3.1(2) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. General Information

Master Pit No.: 2
Project: Gumain Reservoir
Photo No.: 33
Location: Balsic, Hermosa, Bataan
Landform: alluvial terrace
Relief: nearly level
Land Use: sugarcane
Elevation: 12 m
Slope: 0 to 1%
Aspect: approximately 2.4 km northeast of town of Dinalupihan

Surface Drainage: fair
Internal Drainage: good to excessive
Soil Drainage Class: good
Soil Parent Material: recent alluvial deposit
Soil Series/Type: La Paz
Land Class:

B. Profile Description

Sample No.	Depth (cm)	Profile Description
2-1	0-25	Very dark grayish brown (10YR 3/2) dry; fine sandy loam; few fine distinct yellowish brown (10YR 5/8) mottles; no concretions; weak sub-angular structure; friable; many fine to medium pores, common fine to very fine roots; clear wavy horizon boundary.
2-2	25-41	Grayish brown (10YR 5/2) dry; sandy loam; many medium distinct dark yellowish brown (10YR 5/8) mottles; no concretios; weak angular structure; friable; common fine to very fine roots, many fine to medium pores; abrupt smooth horizon boundary.
2-3	41-61	Brown (10YR 5/3) dry; loamy fine sand; common medium district yellowish brown (10YR 5/8) mottles; no concretions; granular structure; friable, few fine to very fine roots; diffused smooth horizon boundary.
2-4	61-81	Gray (10YR 5/1) dry; loamy sand; few fine distinct yellowish brown (10YR 5/8) mottles; granular structure; loose, absence of plant roots; diffused irregular horizon boundary.
2-5	81-100	Gray (10YR 6/1) dry; coarse sand; no mottles; single grain structure; diffused wavy horizon boundary.
2-6	100-140	Gray (10YR 5/2) moist; sand.

Described By: T.C. Anyaya
R.A. Umagat

Date: February 8, 1984

Table 3.1(3) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. General Information

Master Pit No.: 3
Project: Gumain Reservoir
Photo No.: 29
Location: Bodega, Dinalupihan, Bataan
Landform: alluvial terrace
Relief: flat or nearly level
Land Use: sugarcane
Elevation: 14 m
Slope: 0 to 2%
Aspect: approximately 1 km northwest of Barangay Pagalangang

Surface Drainage: good
Internal Drainage: well drained
Soil Drainage Class: well drained
Soil Parent Material: recent alluvial deposit
Soil Series/Type: San Manuel
Land Class: $\frac{IR}{SclIBY}$ (2do)

B. Profile Description

Sample No.	Depth (cm)	Profile Description
3-1	0-29	Dark grayish brown (10YR 4/2) wet; sandy clay loam; no mottlings observed; fine week granular structure; slightly sticky, slightly plastic, friable when moist; slightly hard when dry; few very fine discontinuous vertical open tubular pores, common fine roots observed; diffused smooth horizon boundary.
3-2	29-57	Very dark grayish brown (10YR 3/2) wet; sandyclay loam; few fine distinct reddish yellow (7.5YR 6/8) mottles; fine moderately granular structure; slightly sticky, slightly plastic when wet, slightly hard when dry; few fine open tubular pores, few fine roots observed; diffused smooth horizon boundary.
3-3	57-96	Very similar to horizon above except for a slight difference in color and density of pores observed; diffused smooth horizon boundary.
3-4	96-150	Brown (10YR-4/3) moist; sandy loam; common fine distinct reddish yellow (7.5YR 6/8) mottles; very fine weak granular structure; non-sticky, non-plastic when wet; very friable when moist; soft when dry; few fine open tubular pores; few fine roots observed.

Described By: B.B. Carpio Date: February 8, 1984

Table 3.1(4) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. General Information

Master Pit No.: 4
Project: Gumain Reservoir
Photo No.: 30
Location: Anon, Floridablanca, Pampanga
Landform: alluvial terrace
Relief: slightly undulating
Land Use: sugarcane
Elevation: 15 m
Slope: 0 to 2%
Aspect: approximately 500 m north of Barangay Anon

Surface Drainage: good
Internal Drainage: fair
Soil Drainage Class: fairly drained
Soil Parent Material: alluvial deposit
Soil Series/Type: Quingua
Land Class: $\frac{1R}{Sc118Y}$ (2do)

B. Profile Description

Sample No.	Depth (cm)	Profile Description
4-1	0-27	Dark brown (10YR 3/3) dry; silt loam; few fine faint reddish yellow (7.5YR 6/8) mottles; weak very fine granular structure; slightly sticky, slightly plastic when wet; very friable when moist; loose when dry; few fine open tubular pores; presence of many fine roots; diffused wavy horizon boundary.
4-2	27-73	Dark grayish brown (10YR 4/2) dry; silty clay loam; common medium distinct reddish yellow (7.5YR 6/8) mottles; moderately strong medium sub-angular structure; sticky, plastic when wet; firm when moist; slightly hard to hard when dry; common fine roots present; diffused smooth horizon boundary.
4-3	73-95	Dark yellowish brown (10YR 4/4) moist; silty clay loam; common fine to medium distinct reddish yellow (7.5YR 6/8) mottles; moderately strong fine to medium sub-angular structure; sticky, plastic when wet; firm when moist; slightly hard to hard when dry; few fine open tubular pores, firm fine roots present; diffused smooth horizon boundary.
4-4	95-140	Dark brown (10YR 5/3) moist; silty clay loam; few to common fine district reddish yellow (7.5YR 6/8) mottles; weak fine sub-angular blocky structure, sticky and plastic when wet; friable when moist; slightly hard when dry; common fine open tubular pores; very few fine rooots present.

Described By: B.B. Carpio Date: February 9, 1984

Table 3.1(5) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. General Information

Master Pit No.: 5
Project: Gumain Reservoir
Photo No.: 25
Location: Gutad, Floridablanca, Pampanga
Landform: alluvial terrace
Relief: nearly level
Land Use: sugarcane
Elevation: 19 m
Slope: 0 to 1%
Aspect: approximately 300 m north of Barangay Gutad

Surface Drainage: fair
Internal Drainage: fair
Soil Drainage Class: fair
Soil Parent Material: recent alluvial deposit
Soil Series/Type: Quingua
Land Class: $\frac{1R}{Sc1IBY}$ (2do)

B. Profile Description

Sample No.	Depth (cm)	Profile Description
5-1	0-26	Light brownish gray (10YR 6/2) dry; silt loam; few fine faint yellowish brown (10YR 5/6) mottles; no concretions; granular structure; slightly sticky, slightly plastic when wet; friable when moist; many fine to medium roots; diffused wavy horizon boundary.
5-2	26-55	Very dark grayish brown (10YR 3/2) dry; clay loam; few fine faint brownish yellow (10YR 6/8) mottles; no concretions; granular structure; slightly sticky, slightly plastic when wet; presence of patch thin layer of clay cutans along ped faces, sub-angular blocky structure; diffused wavy horizon boundary.
5-3	55-90	Brown (10YR 4/3) dry; silty clay loam; common fine district yellowish brown (10YR 5/8) mottles; no concretions; slightly plastic when wet; friable when moist; moderately weak sub-angular blocky structure; few fine to very fine roots; clear smooth horizon boundary.
5-4	90-112	Yellowish brown (10YR 5/4) dry; sandy clay loam; common medium distinct yellowish brown (10YR 5/6) mottles; no concretions; compact, friable; absence of plant roots; granular structure; diffused smooth horizon boundary.
5-5	112-140	Dark yellowish brown (10YR 3/4) moist; sandy loam; friable; granular structure.

Described By: T.C. Anyaya Date: February 9, 1984

Table 3.1(6) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. General Information

Master Pit No.: 6
Project: Gumain Reservoir
Photo No.: 24
Location: Dampe, Floridablanca, Pampanga
Landform: alluvial terrace
Relief: slightly undulating
Land Use: sugarcane
Elevation: 20 m
Slope: 0 to 2%
Aspect: approximately 750 m southwest of Barangay Dampe

Surface Drainage: fair
Internal Drainage: good
Soil Drainage Class: well drained
Soil Parent Material: recent alluvial deposit
Soil Series/Type: Quingua
Land Class: $\frac{1R}{Sc1IBY}$ (2do)

B. Profile Description

Sample No.	Depth (cm)	Profile Description
6-1	0-19	Dark yellowish brown (10YR 4/4) dry; sandy clay loam; no mottlings; no concretions; friable, weak medium sub-angular blocky structure; slightly sticky, slightly plastic when wet; few fine open tubular pores; common to many fine roots observed, diffused smooth horizon boundary.
6-2	19-45	Dark grayish brown (10YR 4/8) moist; loam; no mottlings observed; weak fine granular structure; slightly sticky, slightly plastic when wet; friable when moist; slightly hard when dry; few fine open tubular pores; few fine roots present; gradual wavy horizon boundary.
6-3	45-84	Yellowish brown (10YR 5/8) moist; sandy loam; no mottlings; weak fine granular structure; slightly sticky, non-plastic when wet; very friable when moist; few fine open tubular pores; few very fine roots present; diffused smooth horizon boundary.
6-4	84-150	Dark yellowish brown (10YR 4/6) moist; loamy sand; no mottlings; single grain structure, non-sticky, non-plastic when wet; loose when dry; few fine open tubular pores; very few fine roots present.

Described By: B.B. Carpio Date: February 13, 1984

Table 3.1(7) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. General Information

Master Pit No.: 7
Project: Gumain Reservoir
Photo No.: 19
Location: Pabanlag, Floridablanca, Pampanga
Landform: alluvial terrace
Relief: nearly level
Land Use: sugarcane
Elevation: 25 m
Slope: 0 to 1%
Aspect: approximately 1.6 km northwest of Barangay Carmencita

Surface Drainage: fair
Internal Drainage: good
Soil Drainage Class: well drained
Soil Parent Material: recent alluvial deposit
Soil Series/Type: San Manuel
Land Class: $\frac{1R}{Sc1IBY}$ (2do)

B. Profile Description

Sample No.	Depth (cm)	Profile Description
7-1	0-19	Grayish brown (10YR 5/2) dry; silt loam; no mottlings, no concretions; friable, weak sub-angular blocky structure; many fine to medium tubular pores, many fine to medium roots; diffused smooth horizon boundary.
7-2	19-44	Very dark grayish brown (10YR 3/2) dry; silty clay loam; few fine distinct yellowish brown (10YR 5/8) mottles; few soft to coarse block concretions; moderately strong angular blocky structure; slightly sticky, plastic when wet; common fine to medium tubular pores, common fine to medium roots; presence of broken streaks of clay cutans along pores lining and root channels; diffused wavy horizon boundary.
7-3	44-95	Brown (10YR 5/3) dry; fine sandy loam; common fine distinct yellowish brown (10YR 5/6) mottles; no concretions; weak subangular structure; friable when moist; sit very few fine roots; few fine interstitial pores; gradual irregular horizon boundary.
7-4	95-130	Light brownish gray (10YR 6/2) moist; loamy fine sand; granular structure; absence of plant roots; friable.

Described By: T.C. Anyaya Date: February 13, 1984

Table 3.1(8) PROFILE DESCRIPTION OF MASTER PIT IN THE PROPOSED EXTENSION AREA

A. General Information

Master Pit No.: 8
Project: Gumain Reservoir
Photo No.: 15
Location: San Nicolas, Floridablanca, Pampanga
Landform: alluvial terrace
Relief: slightly undulating
Land Use: sugarcane
Elevation: 30 m
Slope: 0 to 2%
Aspect: approximately 600 m west of Barangay San Nicolas

Surface Drainage: good
Internal Drainage: excessive
Soil Drainage Class: well drained
Soil Parent Material: alluvial deposit
Soil Series/Type: La Paze
Land Class: $\frac{1R}{Sc11BY}\left(\frac{2do}{12A}\right)$

B. Profile Description

Sample No.	Depth (cm)	Profile Description
8-1	0-31	Very dark gray (10YR 3/1) dry; sandy loam; no mottlings; weak very fine granular structure; slightly sticky, non-lastic when wet; few fine open interstitial pores, many fine roots observed; gradual wavy horizon boundary.
8-2	31-62	Very dark grayish brown (10YR 3/2) dry; sandy clay loam; common fine distinct yellowish red (5YR 5/8) mottles; moderately strong fine sub-angular blocky structure; slightly sticky, slightly plastic when wet; firm when moist; hard when dry; few fine open interstitial pores, few fine roots observed; clear irregular horizon boundary.
8-3	62-108	Dark brown (10YR 3/3) moist; sandy loam; common medium prominent yellowish red (5YR 5/8) mottles; weak fine granular structure; slightly sticky, slightly plastic when wet; friable to firm when moist; slightly hard when dry; few fine open tubular pores, few fine roots observed; few rounded and irregular shape gravels and stones; diffused smooth horizon boundary.
8-4	108-150	Light grayish brown (10YR 6/2) moist; loamy sand; no mottlings; single grains structure; non-sticky, non-plastic when wet; loose when dry; no pores observed, very few fine roots; few rounded gravels and stones.

Described By: B.B. Caprio Date: February 10, 1984

Table 3.1(9) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. General Information

Master Pit No.: 9
Project: Gumain Reservoir
Photo No.: 14
Location: Pandaraeg, Floridablanca, Pampanga
Landform: alluvial terrace
Relief: slightly undulating
Land Use: cultivated land
Elevation: 36 m
Slope: 1 to 2%
Aspect: approximately 700 m northeast of Barangay Pandaraeg

Surface Drainage: good
Internal Drainage: excessive
Soil Drainage Class: well drained
Soil Parent Material: recent alluvial deposit
Soil Series/Type: La Paz
Land Class: $\frac{2S}{L2I8X}$ - V

B. Profile Description

Sample No.	Depth (cm)	Profile Description
9-1	0-31	Pale brown (10YR 6/3) dry; sandy loam; friable; weak granular structure; common fine to very fine roots; clear irregular horizon boundary.
9-2	31-55	Light yellowish brown (10YR 6/4); loamy fine sand; no mottlings; friable, weak granular structure; common fine to very fine roots; clear irregular horizon boundary.
9-3	55-72	Light yellowish brown (10YR 6/4) dry; loamy sand; friable, granular structure; very few fine roots; clear irregular horizon boundary.
9-4	72-91	Pale brown (10YR 6/3) dry; sand; single grain structure; absence of plant roots; gradual broken horizon boundary.
9-5	91-150	Light yellowish brown (10YR 6/4); fine sand; loose, single structure.

Described By: T.C. Anyaya
R.A. Umagat

Date: February 14, 1984

Table 3.1(10) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. General Information

Master Pit No.: 10
Project: Gumain Reservoir
Photo No.: 10
Location: Del Carmen, Floridablanca, Pampanga
Landform: alluvial terrace
Relief: nearly level
Land Use: sugarcane
Elevation: 35 m
Slope: 0 to 1%
Aspect: approximately 900 m west of Barangay Carmen

Surface Drainage: good
Internal Drainage: excessive
Soil Drainage Class: well drained
Soil Parent Material: recent alluvial deposit
Soil Series/Type: La Paz
Land Class: $\frac{1R}{Sc11BY}$ $(\frac{2do}{12A})$

B. Profile Description

Sample No.	Depth (cm)	Profile Description
10-1	0-18	Very dark grayish brown (10YR 3/2) dry; sandy loam; no mottlings; moderately weak sub-angular blocky structure; friable when moist; moderately hard; compact when dry; few fine open tubular pores; common fine to medium roots; diffused wavy horizon boundary.
10-2	18-49	Dark brown (10YR 3/3) dry; sandy loam; no mottlings; granular structure, friable; few fine interstitial pores, many fine to very fine roots; diffused irregular horizon boundary.
10-3	49-63	Dark grayish brown (10YR 3/4) dry; loamy sand; no mottlings; structureless; friable when moist; loose when dry; very few fine roots; diffused ssooth horizon boundary.
10-4	63-82	Dark grayish brown (10YR 4/4) dry; coarse loamy sand; presence of few pebbles; absence of plant roots; granular structure; diffused irregular horizon boundary.
10-5	82-119	Yellowish brown (10YR 5/4) moist; loamy sand; granular structure; loose when dry; diffused irregular horizon boundary.
10-6	119-160	Yellowish brown (10YR 5/3) moist; sand; single grain structure; loose.

Described By: T.C. Anyaya
R.A. Umagat

Date: February 10, 1984

Table 3.2(1) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. General Information

Master Pit No.: 1
Project: Gumain Reservoir
Photo No.: 001 Fl. 118
Location: Rizal, Guagua, Pampanga
Land Form: alluvial terrace
Relief: nearly level
Land Use: paddy rice
Elevation:
Slope: 0 to 1%
Aspect: approximately 500 m north of Rizal Elementary School

Surface Drainage: fair
Internal Drainage: poor
Soil Drainage Class: poor
Soil Parent Material: alluvial deposit
Soil Series/Type: San Fernando
Land Class: 1R

B. Profile Description

Sample No.	Depth (cm)	Profile Description
1-1	0-10	Grayish brown (10YR 5/2) moist; clay loam, fine sub-angular blocky structure; slightly sticky, slightly plastic when wet; slightly friable when moist; few fine distinct dark brown mottles; many fine tubular pores; abrupt smooth horizon boundary.
1-2	10-22	Dark gray (10YR 4/1) moist; clay; fine sub-angulart blocky structure; sticky, plastic, compact; very few fine black concretion; few fine roots; clear wavy horizon boundary.
1-3	22-90	Light olive gray (2.5Y 6/2) moist; friable clay; weak fine granular structure; sticky and plastic when wet, friable when moist; few fine soft black manganese concretion; clear wavy horizon boundary.
1-4	90-150	Gray (10YR 5/1) wet; silty clay; weak fine granular structure; slightly sticky, slightly plastic, compact, hard when dry; few fine distinct greenish gray mottles.

Described By: H.G. Guias, R.A. Unagat
Date: February 16, 1983

Table 3.2(2) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. General Information

Master Pit No.: 2
Project: Gumain Reservoir
Photo No.: 004 Fl. 118
Location: San Juan, Lubao, Pampanga
Land Form: alluvial terrace
Relief: gently level
Land Use: water melon
Elevation:
Slope: 0 to 1%
Aspect: approximately 500 m northeast of Lubao

Surface Drainage: fair
Internal Drainage: poor
Soil Drainage Class: poor
Soil Parent Material: alluvial deposit
Soil Series/Type: San Fernando
Land Class: 2Rd-f

B. Profile Description

Sample No.	Depth (cm)	Profile Description
2-1	0-42	Dark grayish brown (10YR 4/2) moist; clay; fine weak sub-angular blocky structure; sticky when wet; hard when dry; many fine to medium roots penetration; abrupt smooth horizon boundary.
2-2	42-91	Grayish brown (10YR 5/2) moist; clay loam; weak medium sub-angular to angular blocky structure; sticky, slightly plastic when wet; hard when dry; common fine tubular pores, common fine to medium roots penetration; clear smooth horizon boundary.
2-3	91-108	Dark grayish brown (10YR 4/2) wet; silty clay; fine weak sub-angular blocky structure; sticky, slightly plastic when wet; hard when dry; few fine tubular pores, few fine roots.

Described By: T.C. Anyaya
R.A. Usagat

Date: February 22, 1983

Table 3.2(3) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. General Information

Master Pit No.: 3
Project: Gumain Reservoir
Photo No.: 038 Fl. 119
Location: Pulong Masli, Guagua, Pampanga
Land Form: alluvial terrace
Relief: nearly level
Land Use: paddy rice
Elevation:
Slope: 0 to 1%
Aspect: approximately 1.5 km east of Carmen

Surface Drainage: fair
Internal Drainage: fair
Soil Drainage Class: fair
Soil Parent Material: alluvial deposit
Soil Series/Type: San Manuel
Land Class: 2Rs (2s)

B. Profile Description

Sample No.	Depth (cm)	Profile Description
3-1	0-22	Brown (10YR 5/3) moist; loamy sand; single grain structure (although "grains" are, in fact, fine aggregate); few fine tubular pores, common fine roots penetration; abrupt irregular horizon boundary,
3-2	22-49	Very dark grayish brown (10YR 3/2) moist; fine sandy clay loam; fine weak sub-angular blocky structure; friable when moist; few fine faint reddish brown mottles; few fine open interstitial pores, common fine and few medium roots penetration; clear irregular horizon boundary.
3-3	49-66	Grayish brown (2.5Y 5/2) wet; fine sand; single grain structure; common fine roots penetration; gradual irregular horizon boundary.
3-4	66-100	Light brownish gray (2.5Y 4/2) wet; sand; single grain structure; few fine roots penetration.

Described By: T.C. Anyaya Date: February 16, 1983

Table 3.2(4) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. General Information

Master Pit No.: 4
Project: Gumain Reservoir
Photo No.: 036 Fl. 119
Location: Santo Domingo, Lubao, Pampanga
Land Form: alluvial terrace
Relief: gently level
Land Use: paddy rice
Elevation:
Slope: 0 to 1%
Aspect: approximately 1 km southeast of Santo Domingo, Lubao

Surface Drainage: fair
Internal Drainage: fair
Soil Drainage Class: fair
Soil Parent Material: alluvial deposit
Soil Series/Type: Quingua
Land Class: 1R (2 do)

B. Profile Description

Sample No.	Depth (cm)	Profile Description
4-1	0-23	Grayish brown (10YR 5/2) dry; sandy clay loam; moderately strong angular blocky structure; common fine distinct dark yellowish brown to yellowish brown mottles, few fine tubular pores, many fine to medium roots penetration; clear wavy horizon boundary.
4-2	23-47	Very dark grayish brown (10YR 3/2) moist; sandy clay loam; sub-angular blocky structure; friable when moist, slightly sticky when wet; hard when dry; common fine faint yellowish brown mottles; few fine to medium roots penetration; gradual smooth horizon boundary.
4-3	47-63	Gray (10YR 5/1) moist; sandy loam, weak sub-angular blocky structure; common distinct yellowish brown mottles; common fine tubular pores, few fine roots; clear smooth horizon boundary.
4-4	63-94	Dark Gray (10YR 4/1) moist; sandy loam, granular structure; friable; few fine faint to distinct yellowish brown mottles; few fine tubular pores.

Described By: T.C. Anyaya
R.A. Ueagat

Date: February 15, 1983

Table 3.2(5) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. General Information

Master Pit No.: 5
Project: Gumain Reservoir
Photo No.: 032 Fl 119
Location: Santa Cruz, Lubao, Pampanga
land Form: alluvial terrace
Relief: nearly level
Land Use: paddy rice
Elevation:
Slope: 0 to 1%
Aspect: approximately 500 m north of Santa Cruz, Lubao, Pampanga

Surface Drainage: fair
Internal Drainage: fair to good
Soil Drainage Class: fair to good
Soil Parent Material: alluvial deposit
Soil Series/Type: San Manuel
Land Class: 2Rsd (2s)

B. Profile Description

Sample No.	Depth (cm)	Profile Description
5-1	0-21	Very dark grayish brown (10YR 3/2) moist; fine sandy clay loam; fine weak sub-angular blocky structure; moderagely compact, moderately sticky; few fine faint yellowish brown mottles; common fine roots penetration, few fine tubular pores; abrupt smooth horizon boundary.
5-2	21-56	Dark grayish brown (10YR 4/2) moist; fine sand; single grain structure; few fine roots; clear smooth horizon boundary.
5-3	56-80	Grayish brown (10YR 5/2) wet; loamy fine sand; weak granular structure; common fine faint to distinct yellowish brown mottles; no roots.

Described By: T.C. Anyaya
R.A. Umagat

Date: February 22, 1983

Table 3.2(6) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. General Information

Master Pit No.: 6
Project: Gumain Reservoir
Photo No.: 034 Fl. 119
Location: San Miguel, Lubao, Pampanga
Land Form: alluvial terrace
Relief: gently level
Land Use: paddy rice
Elevation:
Slope: 0 to 1%
Aspect: approximately 800 m south of San Miguel, Lubao

Surface Drainage: fair
Internal Drainage: fair
Soil Drainage Class: fair
Soil Parent Material: alluvial deposit
Soil Series/Type: San Manuel
Land Class: 1R (2do)

B. Profile Description

Sample No.	Depth (cm)	Profile Description
6-1	0-10	Yellowish brown (10YR 5/4) dry; fine sandy loam; fine weak sub-angular blocky structure; friable; common fine and few medium roots penetration; gradual smooth horizon boundary.
6-2	10-29	Dark brown (10YR 3/3) moist; fine sandy clay loam; fine strong sub-angular blocky structure; friable when moist; slightly sticky when wet; few fine faint reddish brown mottles; few fine to medium interstitial pores, common fine roots penetration, clear smooth horizon boundary.
6-3	29-56	Brown (10YR 4/3) moist to wet; loamy fine sand; weak sub-angular blocky structure; common fine roots penetration; abrupt irregular horizon boundary.
6-4	56-92	Brown (10YR 4/3) wet; loamy sand; weak sub-angular to granular structure; loose when dry; few fine roots; clear smooth horizon boundary.
6-5	92-121	Pale brown (10YR 6/3) wet; fine sand; single grain structure; few fine roots; abrupt smooth horizon boundary.
6-6	121-150	Grayish brown (10YR 5/2) wet; fine sandy clay loam; sub-angular blocky structure; friable when moist; no roots, no tubular pores.

Described By: T.C. Anyaya Date: February 17, 1983

Table 3.2(7) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. General Information

Master Pit No.: 7
Project: Gumain Reservoir
Photo No.: 094 Fl. 121
Location: De La Paz, Lubao, Pampanga
Landform: alluvial terrace
Relief: gently level
Land Use: paddy rice
Elevation:
Slope: 0 to 2%
Aspect: approximately 600 m northeast of De La Paz

Surface Drainage: good
Internal Drainage: good
Soil Drainage Class: good
Soil Parent Material: alluvial terrace
Soil Series/Type: La Paz
Land Class: 2S-Y

B. Profile Description

Sample No.	Depth (cm)	Profile Description
7-1	0-31	Brown (10YR 5/2) moist; sandy loam, weak sub-angular to granular structure; few fine faint to distinct reddish brown mottles; few fine and few coarse interstitial pores, common fine roots penetration; presence of krotovinas and earth worm burrous; clear smooth horizon boundary.
7-2	31-49	Dark grayish brown (10YR 4/2) moist; fine sandy loam; weak sub-angular to granular structure; common fine distinct dark yellowish brown mottles; few fine soft concretion; few fine open tubular pores, few fine to medium roots penetration; clear smooth horizon boundary.
7-3	49-81	Grayish brown (10YR 5/2) moist; loamy fine sand, fine weak sub-angular blocky structure; few to common distinct yellowish brown mottles; common fine to medium open tubular pores, few fine roots; clear irregular horizon boundary.
7-4	81-109	Light Gray (10YR 6/1) moist; very fine sandy loam; moderately weak sub-angular blocky structure; friable when moist; common distinct to prominent dark yellowish brown to yellowish brown mottles; few fine to medium open tubular pores, no roots.

Described By: R.A. Unagat
T.C. Anyaya

Date: February 17, 1983

Table 3.2(8) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. General Information

Master Pit No.: 8
Project: Gumain Reservoir
Photo No.:
Location: San Pablo Segundo, Lubao, Pampanga
Landform: alluvial terrace
Relief: gently level
Land Use: paddy rice
Elevation:
Slope: 0 to 1%
Aspect:

Surface Drainage: fair
Internal Drainage: fair
Soil Drainage Class: fair to good
Soil Parent Material: alluvial deposit
Soil Series/Type: Quingua
Land Class: 1R (2do)

B. Profile Description

Sample No.	Depth (cm)	Profile Description
B-1	0-14	Very dark grayish brown (10YR 3/2) moist; fine sandy loam; fine sub-angular blocky structure; friable; few fine faint yellowish brown mottles; common fine open tubular pores, many medium and fine roots penetration; clear smooth horizon boundary.
B-2	14-47	Grayish brown (10YR 4/2) moist; sandy loam; granular structure; friable, non-sticky; common fine faint brownish yellow mottles; few fine open tubular pores, common fine to medium roots; gradual smooth horizon boundary.
B-3	47-73	Brown (10YR 4/3) moist; sand, single grain structure; loose; few fine roots; abrupt irregular horizon boundary.
B-4	73-92	Dark grayish brown (10YR 4/2) wet; loamy fines sand; granular structure; no roots penetration.

Described By: T.C. Aryaya
R.A. Umagat

Date: February 22, 1983

Table 3.2(9) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. General Information

Master Pit No.: 9
Project: Gumain Reservoir
Photo No.:
Location: San Nicolas, Floridablanca, Pampanga
Landform: alluvial terrace
Relief: nearly level
Land Use: paddy rice
Elevation:
Slope: 0 to 1%
Aspect: approximately 1.6 km southwest of Floridablanca town

Surface Drainage: fair
Internal Drainage: fair
Soil Drainage Class: fair
Soil Parent Material: alluvial deposit
Soil Series/Type: San Manuel
Land Class: 1R (2do)

B. Profile Description

Sample No.	Depth (cm)	Profile Description
9-1	0-30	Brown (10YR 4/3) dry; sandy loam; weak sub-angular blocky structure, common to many fine and medium roots penetration; abrupt smooth horizon boundary.
9-2	30-80	Brown (10YR 5/3) dry; loamy fine sand; granular structure; loose when dry; friable when moist; common fine to medium roots penetration; clear smooth horizon boundary.
9-3	80-110	Grayish brown (10YR 5/2) dry to moist; coarse sandy clay loam; sub-angular blocky structure; slightly sticky when wet; friable when moist; common fine roots; clear irregular horizon boundary.
9-4	110-130	Brown (10YR 5/3) wet; loamy sand; single grain; few fine roots.

Described By: T.C. Anyaya Date: February 16, 1983

Table 3.2(10) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. General Information

Master Pit No.: 10
Project: Gumain Reservoir
Photo No.: 096 Fl. 121
Location: Cabangcalan, Floridablanca, Pampanga
Landform: alluvial terrace
Relief: nearly level
Land Use: sugarcane
Elevation:
Slope: 0 to 2%
Aspect: approximately 1 km west of Cabangcalan, Floridablanca

Surface Drainage: fair to good
Internal Drainage: good
Soil Drainage Class: good
Soil Parent Material: alluvial deposit
Soil Series/Type: La Paz
Land Class: 2S-V

B. Profile Description

Sample No.	Depth (cm)	Profile Description
10-1	0-37	Brown (10YR 5/3) dry; fine sandy loam; fine weak sub-angular to granular structure; friable when moist, non-sticky; common fine and few coarse roots penetration; abrupt irregular horizon boundary.
10-2	37-74	Very pale brown (10YR 7/3) dry; fine sand; single grain structure; common fine roots; clear irregular horizon boundary.
10-3	74-100	Light yellowish brown (10YR 6/4) moist; loamy fine sand; fine sub-angular blocky structure; friable when moist; loose when dry; few fine faint brownish yellow mottles; few fine and coarse roots, common fine open tubular pores; gradual smooth horizon boundary.
10-4	100-140	Very pale brown (10YR 7/3) moist; fine sand; single grain; few fine roots.

Described By: T.C. Anyaya Date: February 15, 1983

Table 3.2(1)) PROFILE DESCRIPTION OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. General Information

Master Pit No.: 11
Project: Gumain Reservoir
Photo No.:
Location: Bodega, Dinalupihan, Bataan
Landform: alluvial terrace
Relief: gently level
Land Use: paddy rice
Elevation:
Slope: 0 to 1%
Aspect:

Surface Drainage: fair
Internal Drainage: fair
Soil Drainage Class: fair
Soil Parent Material: alluvial deposit
Soil Series/Type: Quingua
Land Class: 1R (2do)

B. Profile Description

Sample No.	Depth (cm)	Profile Description
11-1	0-10	Dark grayish brown (10YR 4/2) moist; fine sandy loam; granular structure; slightly compact, slightly sticky, friable when moist; few fine tubular pores, common fine roots penetration; abrupt smooth horizon boundary.
11-2	10-19	Very dark grayish brown (10YR 3/2) moist; fine sandy clay loam; fine sub-angular blocky structure; moderately sticky, compact, friable when moist; common fine open tubular pores, few fine to medium roots penetration; clear wavy horizon boundary.
11-3	19-39	Dark grayish brown (10YR 4/2) moist; clay loam; angular blocky structure; moderately compact, moderately sticky, few fine to medium open tubular pores, few fine roots; clear wavy horizon boundary;
11-4	39-64	Grayish brown (10YR 5/2) moist; fine sandy clay loam; fine sub-angular blocky structure; friable when moist; common fine distinct dark yellowish brown mottles; few fine to medium open tubular pores, no roots; abrupt smooth horizon boundary.
11-5	64-100	Dark grayish brown (10YR 4/2) moist; fine sandy clay loam; sub-angular blocky structure; moderately compact, moderately sticky; friable when moist; few fine to medium interstitial pores.

Described By: T.C. Anyaya
H.G. Guiao
R.A. Umagat

Date: March 2, 1983

Table 3.3(1) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. Master Pit: No. 1

B. Location: Barangay Saba, Hermosa, Bataan

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
1-1	9-19	7.3	0.11	45.0	0.91	1.57
1-2	19-37	8.0	0.15	22.5	0.78	1.34
1-3	37-95	8.1	0.21	56.5	0.68	1.17

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
1-1	20.71	1.81	0.69	10.50	4.74	3.02
1-2	24.47	3.40	0.79	13.08	5.19	2.01
1-3	26.32	3.66	0.91	13.84	5.90	2.01

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
1-1	0-19	47	39	14	L	16.93	8.87
1-2	19-37	50	39	11	L	18.12	8.41
1-3	37-95	52	39	9	L, SL	17.50	8.57

Remarks:
- pH: Soil-water ratio is 1:1
- EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm
- P_2O_5: Available phosphorus on Olsen method
- OC & OM: Organic carbon and organic matter, respectively
- CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil
- Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil
- Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.3(2) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. Master Pit: No. 2

B. Location: Barangay Balsic, Hermosa, Bataan

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
2-1	0- 25	6.0	0.05	28.0	1.10	1.89
2-2	25- 41	6.0	0.04	33.0	0.89	1.53
2-3	41- 61	6.3	0.02	33.0	0.83	1.43
2-4	61- 81	6.1	0.03	23.5	0.54	0.93
2-5	81-100	6.6	0.02	37.0	0.47	0.81
2-6	100-140	6.9	0.02	10.5	0.26	0.45

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
2-1	18.55	0.19	0.31	11.33	3.70	3.02
2-2	19.92	0.13	0.39	12.60	3.78	3.02
2-3	9.58	0.10	0.20	6.63	1.14	1.51
2-4	14.26	0.11	0.20	7.53	4.41	2.01
2-5	6.60	0.08	0.17	4.34	1.00	1.01
2-6	7.12	0.08	0.17	4.60	1.77	0.50

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
2-1	0- 25	50	39	11	L	16.56	7.52
2-2	25- 41	61	32	7	SL	15.40	8.13
2-3	41- 61	96	2	2	S	13.95	7.61
2-4	61- 81	90	7	3	S	11.25	5.63
2-5	81-100	98	1	1	S	8.92	3.54
2-6	100-140	98	1	1	S	11.35	4.38

Remarks:

pH: Soil-water ratio is 1:1

EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm

P_2O_5: Available phosphorus on Olsen method

OC & OM: Organic carbon and organic matter, respectively

CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil

Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil

Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.3(3) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. Master Pit: No. 3

B. Location: Barangay Bodega, Dinalupihan, Bataan

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
3-1	0- 29	4.9	0.08	20.0	1.33	2.28
3-2	29- 57	5.6	0.04	30.0	0.91	1.56
3-3	57- 96	5.8	0.04	47.0	0.91	1.56
3-4	96-150	5.9	0.03	38.0	0.65	1.12

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
3-1	16.43	0.23	0.26	6.49	2.92	6.53
3-2	23.32	0.17	0.40	12.77	3.45	6.53
3-3	25.06	0.16	0.45	12.92	5.00	6.53
3-4	15.49	0.09	0.31	8.36	3.21	3.52

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
3-1	0- 29	48	39	13	L	15.51	6.35
3-2	29- 57	49	39	12	L	20.51	8.75
3-3	57- 96	44	46	10	L	21.24	9.31
3-4	96-150	78	19	3	LS	16.50	6.30

Remarks:
- pH: Soil-water ratio is 1:1
- EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm
- P_2O_5: Available phosphorus on Olsen method
- OC & OM: Organic carbon and organic matter, respectively
- CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil
- Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil
- Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.3(4) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. Master Pit: No. 4

B. Location: Barangay Anon, Floridablanca, Pampanga

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
4-1	0- 27	5.3	0.07	31.0	1.68	2.89
4-2	27- 73	6.0	0.06	28.0	1.41	2.43
4-3	73- 95	6.0	0.04	36.0	0.81	1.39
4-4	95-150	6.2	0.03	29.0	0.76	1.31

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
4-1	23.96	0.47	0.31	10.61	4.53	8.04
4-2	31.94	0.32	0.45	17.66	6.98	6.53
4-3	29.94	0.27	0.45	16.50	6.69	6.03
4-4	30.17	0.27	0.46	16.29	7.12	6.03

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
4-1	0- 27	28	57	15	SiL	23.50	10.71
4-2	27- 73	28	55	17	SiL	24.50	11.75
4-3	73- 95	31	54	15	SiL	24.85	11.35
4-4	95-150	27	54	19	SiL	20.48	9.31

Remarks:

- pH: Soil-water ratio is 1:1
- EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm
- P_2O_5: Available phosphorus on Olsen method
- OC & OM: Organic carbon and organic matter, respectively
- CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil
- Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil
- Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.3(5) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. Master Pit: No. 5

B. Location: Barangay Gutad, Floridablanca, Pampanga

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
5-1	0- 26	4.8	0.09	35.0	1.46	2.51
5-2	26- 55	5.4	0.05	38.0	1.34	2.30
5-3	55- 90	5.9	0.07	36.0	1.25	2.15
5-4	90-112	6.1	0.04	50.0	0.89	1.53
5-5	112-140	5.9	0.04	43.0	0.73	1.26

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
5-1	23.16	0.36	0.31	8.97	3.97	9.55
5-2	27.86	0.28	0.45	15.78	6.32	5.03
5-3	29.16	0.25	0.45	16.02	5.91	6.53
5-4	29.08	0.20	0.45	16.40	6.00	6.03
5-5	31.02	0.17	0.45	16.70	7.17	6.53

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
5-1	9- 26	28	59	13	SiL	-	-
5-2	26- 55	37	48	15	L	22.42	11.75
5-3	55- 90	43	44	13	L	22.38	11.63
5-4	90-112	59	32	9	SL	22.35	11.75
5-5	112-140	51	40	9	L	19.82	8.21

Remarks:

pH: Soil-water ratio is 1:1

EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm

P_2O_5: Available phosphorus on Olsen method

OC & OM: Organic carbon and organic matter, respectively

CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil

Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil

Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.3(6) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. Master Pit: No. 6

B. Location: Barangay Dampe, Floridablanca, Pampanga

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
6-1	0- 19	5.2	0.07	44.0	1.54	2.65
6-2	19- 45	5.6	0.04	37.0	0.89	1.53
6-3	45- 84	6.0	0.02	30.0	0.89	1.53
6-4	84-147	6.2	0.04	27.0	0.39	0.67

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
6-1	29.28	0.31	0.32	13.44	5.66	9.55
6-2	28.39	0.12	0.32	14.54	5.87	7.54
6-3	17.78	0.09	0.26	10.28	3.13	4.02
6-4	28.12	0.12	0.40	16.92	6.66	4.02

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
6-1	9- 19	36	48	16	L	20.75	10.88
6-2	19- 45	45	42	13	L	21.98	9.21
6-3	45- 84	75	20	5	SL	14.70	7.88
6-4	84-147	33	57	10	SiL	22.87	10.50

Remarks:
- pH: Soil-water ratio is 1:1
- EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm
- P_2O_5: Available phosphorus on Olsen method
- OC & OM: Organic carbon and organic matter, respectively
- CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil
- Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil
- Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.3(7) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. Master Pit: No. 7

B. Location: Barangay Pabanlag, Floridablanca, Pampanga

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
7-1	0- 19	5.6	0.07	32.0	1.34	2.30
7-2	19- 44	5.7	0.04	23.0	1.23	2.12
7-3	44- 95	6.0	0.04	35.0	0.97	1.67
7-4	95-130	6.1	0.07	30.0	0.92	1.58

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
7-1	30.06	0.60	0.26	13.95	6.20	9.05
7-2	33.18	0.24	0.32	17.18	6.39	9.05
7-3	27.52	0.20	0.26	14.80	6.17	6.03
7-4	22.00	0.17	0.26	10.40	5.14	6.03

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
7-1	0- 19	35	51	14	SiL	30.62	15.25
7-2	19- 44	33	53	14	SiL	21.20	11.13
7-3	44- 95	37	42	21	L	18.80	9.38
7-4	95-130	59	24	17	SL	11.98	5.25

Remarks:
- pH: Soil-water ratio is 1:1
- EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm
- P_2O_5: Available phosphorus on Olsen method
- OC & OM: Organic carbon and organic matter, respectively
- CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil
- Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil
- Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.3(8) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. Master Pit: No. 8

B. Location: Barangay San Nicolas, Floridablanca, Pampanga

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
8-1	0- 31	5.8	0.06	90.0	1.20	2.06
8-2	31- 62	6.3	0.05	62.0	1.05	1.81
8-3	62-108	6.2	0.05	62.0	0.76	1.31
8-4	108-150	6.2	0.02	34.0	0.65	1.12

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
8-1	18.11	0.37	0.25	4.17	3.62	6.53
8-2	17.63	0.47	0.26	8.83	2.04	6.03
8-3	16.24	0.47	0.26	6.53	3.45	5.53
8-4	10.04	0.47	0.17	2.35	1.52	5.53

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
8-1	0- 31	59	24	17	SL	11.62	6.30
8-2	31- 62	50	27	23	SiL	10.08	5.75
8-3	62-108	58	22	20	SCL, SL	18.38	9.25
8-4	108-150	82	5	13	SL	8.92	4.75

Remarks:

pH: Soil-water ratio is 1:1

EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm

P_2O_5: Available phosphorus on Olsen method

OC & OM: Organic carbon and organic matter, respectively

CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil

Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil

Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.3(9) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. Master Pit: No. 9

B. Location: Barangay Pandaraeg, Floridablanca, Pampanga

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
9-1	0- 31	5.7	0.06	45.0	0.76	1.31
9-2	31- 55	6.4	0.02	34.0	0.70	1.20
9-3	55- 72	6.3	0.02	30.0	0.54	0.93
9-4	72- 91	6.6	0.01	28.0	0.49	0.84
9-5	91-150	6.6	0.02	33.0	0.33	0.57

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
9-1	15.01	0.28	0.26	6.04	3.91	4.52
9-2	17.59	0.08	0.26	9.30	4.43	3.52
9-3	11.70	0.06	0.17	5.69	3.27	2.51
9-4	11.75	0.08	0.17	5.31	3.68	2.51
9-5	12.53	0.01	0.17	5.85	3.99	2.51

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
9-1	0- 31	53	33	14	SL	13.10	7.35
9-2	31- 55	64	23	13	SL	13.02	6.21
9-3	55- 72	86	4	10	LS	8.53	3.25
9-4	72- 91	95	2	3	S	5.98	3.09
9-5	91-150	94	1	5	S	5.01	3.23

Remarks:
- pH: Soil-water ratio is 1:1
- EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm
- P_2O_5: Available phosphorus on Olsen method
- OC & OM: Organic carbon and organic matter, respectively
- CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil
- Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil
- Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.3(10) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE PROPOSED EXTENSION AREA

A. Master Pit: No. 10

B. Location: Barangay Del Carmen, Floridablanca, Pampanga

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
10-1	0- 18	5.1	0.05	44.0	0.83	1.43
10-2	18- 49	5.5	0.02	36.0	0.62	1.07
10-3	49- 63	5.7	0.02	29.0	0.57	0.98
10-4	63- 82	5.7	0.01	49.0	0.57	0.98
10-5	82-119	6.1	0.01	34.0	0.51	0.88
10-6	119-160	6.0	0.01	32.0	0.41	0.71

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
10-1	10.55	0.20	0.25	3.00	1.59	5.53
10-2	13.04	0.16	0.25	6.85	0.75	5.03
10-3	10.58	0.08	0.26	4.07	2.65	3.52
10-4	9.89	0.05	0.25	3.79	2.28	3.52
10-5	8.11	0.04	0.25	4.30	1.01	2.51
10-6	8.59	0.04	0.25	2.73	3.06	2.51

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
10-1	0- 18	58	23	19	SL	10.85	4.38
10-2	18- 49	60	23	17	SL	13.75	5.75
10-3	49- 63	74	13	13	SL	9.50	5.28
10-4	63- 82	84	6	10	LS	9.70	3.88
10-5	82-119	88	3	9	LS	8.07	3.53
10-6	119-160	89	5	6	S	9.25	3.13

Remarks:

pH: Soil-water ratio is 1:1

EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm

P_2O_5: Available phosphorus on Olsen method

OC & OM: Organic carbon and organic matter, respectively

CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil

Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil

Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.4(1) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. Master Pit: No. 1

B. Location: Barangay Rizal, Guagua, Pampanga

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
1-1	0- 10	6.8	0.47	11.5	3.22	5.54
1-2	10- 22	7.4	0.25	9.3	1.86	3.20
1-3	22- 90	7.2	0.14	8.0	0.98	1.69
1-4	90-150	7.8	0.22	7.0	0.89	1.53

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
1-1	23.99	0.07	0.08	11.38	5.54	6.92
1-2	20.84	0.05	0.38	10.45	4.69	4.94
1-3	27.12	0.07	0.33	13.20	9.07	4.45
1-4	25.04	0.08	0.34	11.92	9.74	3.46

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
1-1	0- 10	27	53	20	SiL	22.22	10.01
1-2	10- 22	23	49	28	CL	30.22	15.03
1-3	22- 90	11	47	42	SiL	30.79	13.43
1-4	90-150	20	54	26	SiL	32.76	15.83

Remarks:

pH: Soil-water ratio is 1:1

EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm

P_2O_5: Available phosphorus on Olsen method

OC & OM: Organic carbon and organic matter, respectively

CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil

Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil

Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.4(2) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. Master Pit: No. 2

B. Location: Barangay San Juan, Lubao, Pampanga

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
2-1	0- 42	6.6	1.75	18.0	2.65	4.56
2-2	42- 91	7.2	1.44	15.6	1.58	2.72
2-3	91-108	6.4	1.83	11.5	1.58	2.72

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
2-1	33.81	0.11	0.36	19.34	7.08	6.92
2-2	26.44	0.04	0.10	12.25	10.10	3.95
2-3	34.62	0.03	0.07	12.66	15.93	5.93

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
2-1	0- 42	18	49	33	SiCL	32.76	15.19
2-2	42- 91	12	56	32	SiCL	30.97	15.14
2-3	91-108	24	29	47	C	37.58	17.78

Remarks:

pH: Soil-water ratio is 1:1

EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm

P_2O_5: Available phosphorus on Olsen method

OC & OM: Organic carbon and organic matter, respectively

CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil

Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil

Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.4(3) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. Master Pit: No. 3

B. Location: Barangay Pulong Masli, Guagua, Pampanga

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
3-1	0- 22	5.0	0.24	22.5	3.36	5.76
3-2	22- 49	5.9	0.07	17.0	1.57	2.70
3-3	49- 66	6.5	0.05	14.5	0.81	1.39
3-4	66-100	6.9	0.03	12.5	0.64	1.10

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
3-1	14.82	0.04	0.14	4.11	2.63	7.90
3-2	16.89	0.03	0.11	6.99	3.34	6.42
3-3	11.74	0.03	0.06	4.85	2.35	4.45
3-4	8.56	0.03	0.06	3.09	1.43	3.95

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
3-1	0- 22	75	15	10	SL	15.03	6.33
3-2	22- 49	64	20	16	SL	20.12	10.20
3-3	49- 66	86	5	9	LS	10.35	5.44
3-4	66-100	94	1	5	S	6.35	2.89

Remarks:
- pH: Soil-water ratio is 1:1
- EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm
- P_2O_5: Available phosphorus on Olsen method
- OC & OM: Organic carbon and organic matter, respectively
- CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil
- Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil
- Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.4(4) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. Master Pit: No. 4

B. Location: Barangay Santo Domingo, Lubao, Pampanga

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
4-1	0- 23	4.7	0.24	27.5	1.35	2.32
4-2	23- 47	6.1	0.08	25.5	1.03	1.76
4-3	47- 63	6.5	0.08	24.5	0.92	1.58
4-4	63- 94	6.6	0.06	22.5	1.04	1.79
4-5	94-120	6.7	0.06	20.0	0.69	1.18
4-6	120-150	6.5	0.05	15.6	0.61	1.05

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
4-1	9.63	0.04	0.10	2.93	0.63	5.93
4-2	13.81	0.07	0.14	7.23	1.92	4.45
4-3	14.90	0.04	0.14	6.82	2.96	4.94
4-4	13.36	0.04	0.17	5.72	2.49	4.94
4-5	10.42	0.03	0.11	4.26	2.07	3.95
4-6	12.80	0.05	0.28	6.02	2.50	3.95

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
4-1	0- 23	62	27	11	SL	18.79	8.42
4-2	23- 47	62	24	14	SL	18.59	8.74
4-3	47- 63	60	24	16	SL	18.43	8.35
4-4	63- 94	72	14	14	SL	16.50	8.33
4-5	94-120	83	8	9	LS	9.81	5.34
4-6	120-150	71	16	13	SL	15.86	7.21

Remarks:
- pH: Soil-water ratio is 1:1
- EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm
- P_2O_5: Available phosphorus on Olsen method
- OC & OM: Organic carbon and organic matter, respectively
- CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil
- Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil
- Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.4(5) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. Master Pit: No. 5

B. Location: Barangay Santa Cruz, Lubao, Pampanga

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
5-1	0- 21	6.4	0.67	14.5	1.30	2.22
5-2	21- 56	7.1	0.32	13.0	0.58	0.99
5-3	56- 80	7.2	0.23	11.5	0.70	1.21
5-4	80-150	7.0	0.29	10.0	0.69	1.18

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
5-1	19.79	0.04	0.26	8.73	6.31	4.45
5-2	11.20	0.05	0.26	4.69	2.54	3.46
5-3	11.97	0.11	0.28	6.64	2.96	1.98
5-4	19.57	0.18	0.60	10.76	6.05	1.98

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
5-1	0- 21	55	28	17	SL	18.82	8.45
5-2	21- 56	95	1	4	S	9.71	3.76
5-3	56- 80	87	9	4	LS, S	8.91	4.25
5-4	80-150	49	31	20	L	26.15	12.39

Remarks:
- pH: Soil-water ratio is 1:1
- EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm
- P_2O_5: Available phosphorus on Olsen method
- OC & OM: Organic carbon and organic matter, respectively
- CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil
- Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil
- Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.4(6) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. Master Pit: No. 6

B. Location: Barangay San Miguel, Lubao, Pampanga

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
6-1	0- 10	5.0	0.23	15.6	1.43	2.48
6-2	10- 29	6.1	0.07	13.0	0.93	1.61
6-3	29- 56	6.8	0.08	12.5	0.84	1.45
6-4	56- 92	6.9	0.06	11.5	1.12	1.92
6-5	92-121	7.1	0.05	8.3	1.63	2.80
6-6	121-150	6.8	0.07	8.0	1.72	2.96

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
6-1	10.30	0.28	0.64	4.24	1.68	3.46
6-2	11.77	0.69	0.87	6.53	1.69	1.99
6-3	12.84	0.03	0.08	8.75	2.50	1.48
6-4	9.42	0.03	0.07	6.26	1.58	1.48
6-5	8.05	0.03	0.08	4.16	1.31	2.47
6-6	13.79	0.03	0.08	7.09	3.70	2.96

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
6-1	0- 10	59	31	10	SL	18.26	7.98
6-2	10- 29	61	29	10	SL	18.57	7.02
6-3	29- 56	46	47	7	L, SL	17.86	7.24
6-4	59- 92	66	29	5	SL	14.72	5.63
6-5	92-121	79	16	5	LS	9.59	4.44
6-6	121-150	52	35	13	L, SL	18.53	8.75

Remarks:

pH: Soil-water ratio is 1:1

EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm

P_2O_5: Available phosphorus on Olsen method

OC & OM: Organic carbon and organic matter, respectively

CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil

Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil

Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.4(7) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. Master Pit: No. 7

B. Location: Barangay De La Paz, Lubao, Pampanga

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
7-1	0- 31	5.1	0.20	17.0	2.12	3.65
7-2	31- 49	6.7	0.08	12.5	2.12	3.65
7-3	49- 81	6.9	0.08	11.5	1.37	2.35
7-4	81-109	7.2	0.06	10.0	2.20	3.79

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
7-1	17.45	0.03	0.08	6.67	1.69	8.98
7-2	17.80	0.04	0.06	11.10	4.71	1.89
7-3	18.28	0.07	0.08	11.70	4.45	1.98
7-4	18.44	0.10	0.06	11.96	5.33	0.99

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
7-1	0- 31	56	32	12	SL	17.10	8.04
7-2	31- 49	31	63	6	SiL	18.03	8.99
7-3	49- 81	35	60	5	SiL	18.80	8.61
7-4	81-109	25	70	5	SiL	18.50	8.78

Remarks:

pH: Soil-water ratio is 1:1

EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm

P_2O_5: Available phosphorus on Olsen method

OC & OM: Organic carbon and organic matter, respectively

CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil

Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil

Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.4(8) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. Master Pit: No. 8

B. Location: Barangay San Pablo Segundo, Lubao, Pampanga

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
8-1	0-14	5.8	0.15	19.0	1.88	3.23
8-2	14-47	6.8	0.06	13.0	1.03	1.76
8-3	47-73	7.2	0.06	11.5	0.66	1.13
8-4	73-92	7.2	0.06	10.0	1.35	2.32

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
8-1	14.18	0.08	0.06	7.52	3.06	3.46
8-2	9.41	0.03	0.12	5.11	2.17	1.98
8-3	5.27	0.03	0.19	3.07	0.99	0.99
8-4	19.28	0.03	0.19	14.29	3.88	0.99

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
8-1	0-14	65	24	11	SL	18.22	8.42
8-2	14-47	89	7	4	S	10.10	5.46
8-3	47-73	97	2	1	S	6.93	3.19
8-4	73-92	77	18	5	LS	13.88	5.99

Remarks:

pH: Soil-water ratio is 1:1

EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm

P_2O_5: Available phosphorus on Olsen method

OC & OM: Organic carbon and organic matter, respectively

CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil

Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil

Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.4(9) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. Master Pit: No. 9

B. Location: Barangay San Nicolas, Floridablanca, Pampanga

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
9-1	0- 30	5.7	0.14	15.6	1.34	2.30
9-2	30- 80	5.4	0.08	12.5	1.30	2.24
9-3	80-110	5.7	0.09	10.0	1.09	1.87
9-4	110-130	6.2	0.05	8.0	1.29	2.22

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
9-1	20.55	0.03	0.05	13.40	4.11	2.96
9-2	23.94	0.04	0.10	17.27	4.55	1.98
9-3	16.13	0.03	0.04	10.30	3.29	2.47
9-4	10.18	0.15	0.05	5.75	2.25	1.98

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
9-1	0- 30	65	26	9	SL	14.49	6.22
9-2	30- 80	66	26	8	SL	13.58	5.57
9-3	80-110	72	19	9	SL	14.60	5.67
9-4	110-130	72	19	9	SL	14.71	7.45

Remarks:

pH: Soil-water ratio is 1:1

EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm

P_2O_5: Available phosphorus on Olsen method

OC & OM: Organic carbon and organic matter, respectively

CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil

Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil

Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.4(10) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. Master Pit: No. 10

B. Location: Barangay Cabangcalan, Floridablanca, Pampanga

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
10-1	0- 37	5.6	0.09	18.0	1.26	2.16
10-2	37- 74	6.1	0.02	14.5	0.70	1.21
10-3	74-100	6.2	0.03	12.5	0.98	1.61
10-4	100-140	6.3	0.02	10.0	0.98	1.61

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
10-1	13.48	0.04	0.09	6.42	2.48	4.45
10-2	13.40	0.05	0.06	8.08	2.74	2.47
10-3	15.09	0.25	0.04	10.12	2.21	2.47
10-4	14.95	0.07	0.08	10.03	2.79	1.98

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
10-1	0- 37	59	33	8	SL	17.78	7.75
10-2	37- 74	93	4	3	S	5.99	2.23
10-3	74-100	52	44	4	SL	18.72	8.82
10-4	100-140	88	9	3	S	7.63	3.93

Remarks:
- pH: Soil-water ratio is 1:1
- EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm
- P_2O_5: Available phosphorus on Olsen method
- OC & OM: Organic carbon and organic matter, respectively
- CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil
- Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil
- Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil

Table 3.4(11) RESULTS OF LABORATORY TESTS ON SOIL SAMPLES OF MASTER PIT SURVEY IN THE EXISTING SERVICE AREAS OF IRRIGATION SYSTEM

A. Master Pit: No. 11

B. Location: Barangay Bodega, Dinalupihan, Bataan

C. Chemical Analysis

Sample No.	Depth (cm)	pH	EC (mmho/cm)	P_2O_5 (ppm)	OC (%)	OM (%)
11-1	0- 10	4.8	0.25	20.0	1.43	2.46
11-2	10- 19	6.4	0.09	18.0	1.32	2.27
11-3	19- 34	6.4	0.06	17.0	1.04	1.79
11-4	34- 64	6.6	0.06	15.6	1.34	2.30
11-5	64-100	6.5	0.05	12.5	1.24	2.14

Sample No.	CEC (me)	Exchangeable Cations (me)				Ex-Ac (me)
		K^+	Na^{++}	Ca^{++}	Mg^{++}	
11-1	10.00	0.08	0.14	2.95	1.50	5.43
11-2	21.94	0.08	0.13	13.50	3.29	4.94
11-3	12.57	0.05	0.11	4.49	2.98	4.94
11-4	15.06	0.03	0.12	7.09	2.88	4.94
11-5	13.40	0.03	0.12	5.94	1.88	5.43

D. Physical Analysis

Sample No.	Depth (cm)	Particle Size Distribution			Soil Texture	Percent Moisture Retention of Matric Tension in Bars of	
		Total Sand (%)	Silt (%)	Clay (%)		1/3	15
11-1	0- 10	44	43	13	L	25.54	10.78
11-2	10- 19	44	44	12	L	26.10	12.01
11-3	19- 34	32	53	15	SiL	25.71	11.28
11-4	34- 64	43	41	16	L	23.97	10.66
11-5	64-100	44	41	15	L	24.72	11.35

Remarks:

pH: Soil-water ratio is 1:1

EC: Electric conductivity, at 25°C for sample with soil-water ratio of 1:1, expressed by mmho/cm

P_2O_5: Available phosphorus on Olsen method

OC & OM: Organic carbon and organic matter, respectively

CEC: Cation exchange capacity on summation method, expressed by approximate milligram equivalent per 100 g dry soil

Exchangeable cations: Expressed by milligram equivalent per 100 g dry soil

Ex-Ac: Exchangeable acidity on $BaCl_2$-TEA method, expressed by milligram equivalent per 100 g dry soil