CHAPTER III GENERAL GEOLOGY AND SEISMOLOGY

3.1 General Geology

Bohol province consists of igneous rock on the eastern and western portion of the island with vast expanse of sedimentary rock on the center called the Ilihan Formation, a very extensive well bedded sequence of sandstone, shale, mudstone/siltstone. Common materials of these units are volcanic accumulation from the weathering of surrounding country rocks. Intrusive and extrusive igneous rocks represent about 30 percent of rock type in the province particularly in the northestern part of the Island. Uplifted reef limestone facies of considerable height later fringed the core of mainland Bohol. Sedimentary rocks occupy almost 70 percent of the Island. There are 10 sedimentary formation and 6 volcanic units. Sedimentary rocks are as follows:

Netasediments (Ks)-the slightly metomorphosed sandstone, shale and minor conglomerates constitute the Metasediments; observed on the northwestern flank of the island and usually interbedded and/or intercalated with the metavolcanics; deposited during Cretaceous to Early Tertiary.

Wahig Limestone (N_1L_s)-dated Lower Miocene; outcrops at the Anda Peninsula, Mabini, Abachanan and Trinidad; a thick, extensive, well compacted cystallized limestone with a very well developed karst landform; union formably overlie the volcanics; an abrupt upliftment of the island followed thus no chance for the sedimentation of younger formation.

Ilihan Formation (N_2)-extensive, a thick, well bedded, contorted and indurated sequence of shale, sandstone and siltstone; sedimented in a marine basin during Middle Miocene from the weathered materials of volcanic igneous from the volcanic flanks; lliha formation (N_2) overlain Sierra Bullones down to Ubay Municipality with patches in Abiliban, Condijay, Jagna and Alicia.

Tubigon Conglomerate (N_2Cg)-Outcropping on the western flank notably at Tubigon and Clarin are thick and slightly compacted conglomerates; made up of gravel to cobble sized, rounded to sub-rounded fragments of volcanic origin such as diorite, basalt and andesite; outcrops are usually weathered and very susceptible to erosion; formed during Middle Miocene.

Carmen Formation (N_2Ml)-occurred at the middle of the island; a thick, massive, beige to buff marl overlying sandstone and shale formation; soft, flat-lying and don't have clear stratification; calcareous debris and fine silty materials compose the marly matrix; Carmen and its vicinity were under marine environment during the Middle Miocene.

Sevilla Formation (N_2Cl)-thick, well bedded sandstone and shale sequence of calcareous clastics derived from surrounding limestone formation which gave origin to well developed domal hills; extensive on the central, western and southern portion of the island; can be accounted that these were former lagoons or canals where coral reefs cannot live because of unfavorable conditions.

Sierra Bullones Limestone (N_2Ls)-occupies an extensive area on the southern portion of the island; thick, well bedded, often soft and porous, slightly crystallized reef and fore-reef limestone; this reef is built up of limy skeletons of colonia algae, sponges, corals, animals and plants which abound on temperate and favorable shallow seas along the seaward margin; when these die, their skeletons become part of limy ridge; gradual but continuous emergence made way to a thick extensive limestone formation; probable age of this formation is Upper Miocene.

Candijay Clay (N_3)-slightly consolidated and poorly bedded mudstone, siltstone and sandstone containing shell fragments associated with coralline limestone; volcanic detritus and organic remains can also be found bedded in a non-uniform thickness; limited only at Candijay and coast of Guindulman.

Maribajoc Limestone (N_3Ls)- situated at the southern part of the island and along the coat of Loon and the islands of Calape and at the foot slopes of Anda Peninsula; young reef facies limestone of transgressive origin, including corals, shells and algae structure; it has poorly developed karst landform occurring on flat lying terrain mostly in lower elevation; light cream to dirty white, porous bushes of corals and algae are cemented together with its own dissolved minerals.

Alluvium (R)-usually consists of unsorted, heterogenous, unconsolidated, detrital fragments of clay, silt, sand gravel, cobbles in floodplains, stream beds, banks, and along the coastline.

Intrusive and extrusive igreous rock form the main core of the island. Bagement complex which is considered the oldest unit is situated on the eastern flank and is composed of metamorphosed basalt and andesite flows. Metavolcanics is displayed extensively on the western flank. Ultrabasic rocks were intruded caused by faulting which gave way to the intrusion of diorite on the western fank. The following units constitute the igneous rock;

La Victoria Volcanics (N_1V)-intermediate to basic composition that was solidified into thick and massive basalt, andesite and agglomarate; basalt are fine grained in texture, bluish black to dark grayish black with plagioclase and pyroxene at random orientation; andesitic aggromerate that outcrops near Buenavista, Carmen is fine to medium-graired in texture, gray to greenish gray on fresh surfaces; laths of plagioclase and amphibole is distinct; formed as an arcuate plateau at the middle of Bohol island probably extruded during the Lower to Middle Miocene.

Diorite (N_1)-consist mostly of quartz, feldspar and biotite, intruded into metasedimentary and metavolcanic country rocks causing hydrothermal alteration along its contacts; grayish white to light gray in color, coarse to medium grained, with distinct laths of plagioclage,

amphibole, quartz, biotite with iron oxides as accessory; the topography of these rock is expressed as a smooth rolling pattern, outcrops are mostly confined on the northern part of the island, dated Upper Cretaceous-Paleogene.

Ultrabasics (UC)-confined on the eastern flank composed of basic to ultrabasic dikes and laccolithis and predominantly consists of peridotite which is always almost serpentinized; massive, banded with serpentine, greenish to grayish black in color; commonly sheared and fractured indicating tectonic movements after its intrusions; susceptible to weathering giving formation to clayey materials; expressed gererally hilly to mountainous topography.

Malibalibod Valcanics (UV)-thick, extensive, basaltic to andesitic flows, mostly sheared, intercalated in places with clastic rocks; massive basalt flows and volcanic agglomerates are also abundant in some areas; appearing scattered on the eastern flank named after the towering mountain of this place; topography of this unit is hilly to maintainous.

Metavolcanics (Kv)-outcropping on the western portion of the island; thick, extensive, low grade metamorphosed volcanics made up of basaltic to andesitic dykes and flows intercalated in places with clastics; extruded during Cretaceous up to Paleocene; andesitic basalt is amygdaloidal and porphyritic; euhedral to subhedral laths of labradorite and andesine are roughly arranged in flow line and set in a basaltic groundmass.

Basement complex (BC)-slightly metamorphosed basalt and andesite flows and volcanic agglomerate constitute the bulk of this crushed basement complex; highly altered and sheared, metamorphosed sandstone and limestone sometimes found intercalating with this unit.

3.2 Geology of Project Area

Extensive sequence of sandstone, siltstone and shale made up the project area with alluvial deposits on river bed. The clastic materials that constitute the sequence are primarily volcanic in nature as

originating from igneous flanks of the surrounding volcanic rocks. The beddings of sedimentary rock on the project area are almost flat lying to sub-horizontally stratified. The project area was totally overlain by Ilihan Formation (N_2), an interbed of sedimentary clastics, cheifly sandstone, shale and siltstone, though conglomerate is distinctively noted on the reservoir area. It is assumed that these conglomerates are limited and confined only in few places. Sandstone bedding is medium grained and moderately indurated grayish to light gray in color and limited in exposures in the area. Shale beddings are grayish in color, fine-grained relatively friable and brittle when dry, very soft when wet and susceptible to weathering upon exposure to surface condition. Water enhances the slaking propensity ot these materials. Siltstone is gray to grayish in color with relatively same characteristics and property with the shale bedding.

Outcrops are well observed on river banks, however soil mantle blanket the whole area covering the underlying formation. Soil type is predominantly clay to silty clay with admixture of uncomplete weathered materials with an average thickness of 2 to 3 meters. Soil in the project area is a product ot in-situ wethering of the underlying formation prevalently.

The project area is moderately undulating to rolling with moderately high to low relief hills, as attributed to characteristic nature of the overlying formation which is soft and susceptible to weathering.

3.3 Seismology

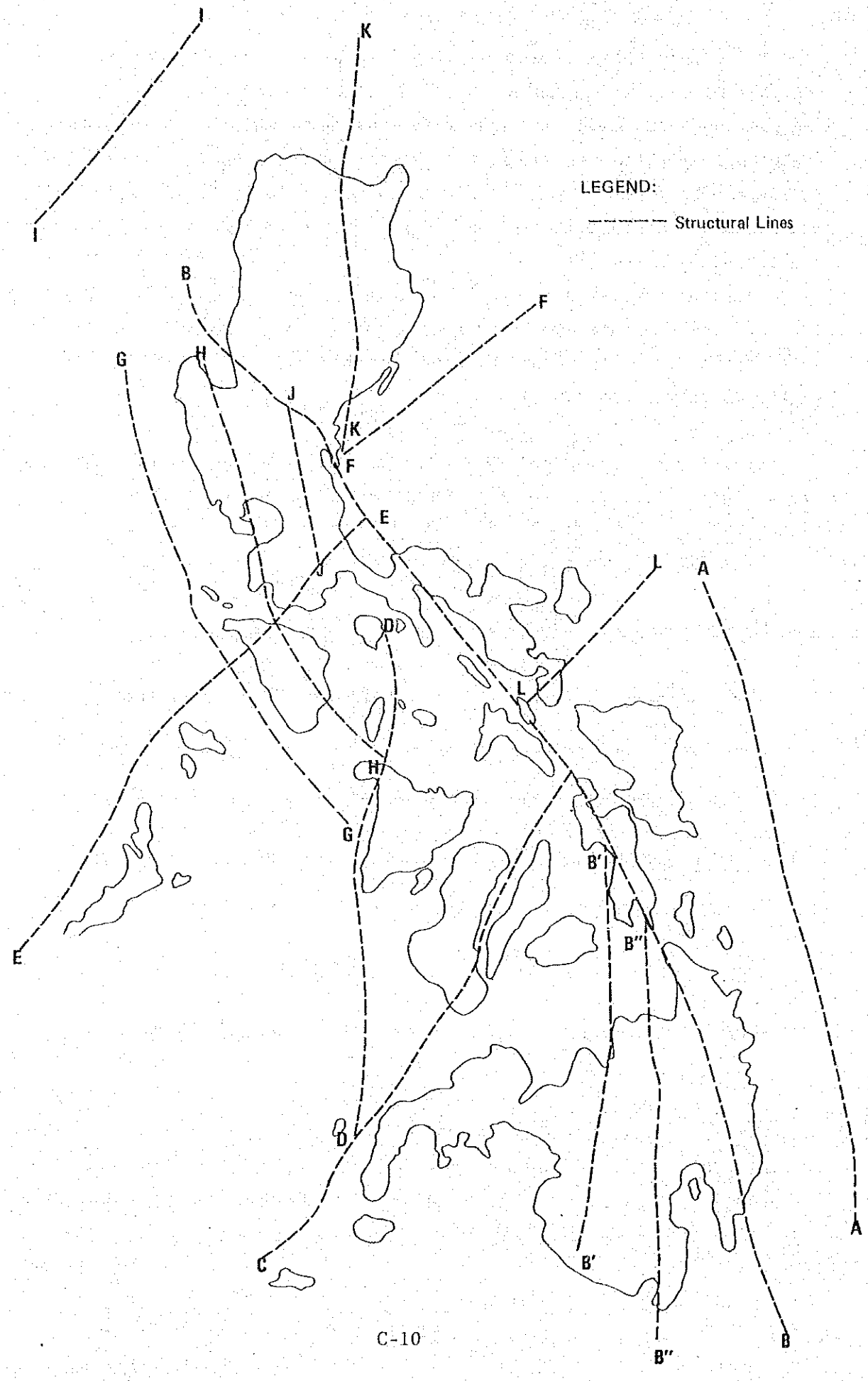
Since Bohol Island is located in a part of the Circum Pacific Earthquake Zone, it is naturally required to consider carefully an effect of earthquake. The earthquake around Bohol Island may almost occur by the tectonic movement along Visayas and Mindanao Block and the epicenters should be located on the above mentioned blocks. The major structure lines are line BB and CC according to the report of PAG-ASA (Philippine Atomospheric, Geophysical and Astronomical Services Administration) and shown in FIGURE C3-1.

Line BB-this line has been recognized by all as major fault zone of the Philippines. Beginning from the Lingayen Gulf, it follows the conspicous fault scarp across Central Luzon, Pollilo Island, Ragay Gulf, the elongated island of Ticao, Burias, and Masbate, northwestern Leyte. In Leyte, the "Master Fault" seems to have split into three legs. The westernmost leg started at a point west at Camotes Island and came down through Mindanao.

Evidences both seismic and geologic for the existence of this zone are very strong. Along this zone have originated some of destructive earthquakes.

Line CC-this line is inferred from the epicenters between Cebu and Negros Islands and those of the western coast of Zamboanga.

FIGURE C3-1 MAJOR STRUCTURAL LINES AT PHILIPPINES



CHAPTER IV GEOLOGICAL INVESTIGATION

4.1 Bayongan Dam

4.1.1 Topography

The proposed Bayongan dam site is located at about 6 km east of San Miguel poblacion in the northern part of Bohol Island. The dam site lies on the upstream of the Trinidad River called as the Bayongan River, which originates at Gov. Boyles in the flat plane with about EL 130 m more or less, and traverses the dam site toward northwest. The river changes its flow direction at about 3 km downstream from the damsite and joins the San Miguel River, a tributary of the Trinidad river. And then the river flows about 15 km at the downstream of this conjunction and flows into the Camotes Sea in the vicinity of Talibon. The river length is about 25 km. The river bed elevation at the damsite is about 25 m above MSL and its slope is about 1/350.

The catchment area of 11.2 sq.km is surrounded by hills with the elevation of top hills of about 100 m to 70 m. The damsite presents low and gentle hills which are 30 to 50 m in height from the river bed and can provide a large reservoir capacity.

The slope of abutment is approximately one to four. The cord-height rate of the damsite at about EL 50 m is about one to thirty.

4.1.2 Geology

The damsite belongs to Ilihan Formation (N_2), whose age is Middle Miocene geologically.

The base rock at the damsite consists mainly of siltstone with the alternating beds of siltstone, mudstone, sandstone and conglomerate. The base rock is almost horizontal (5 to 10 degrees of the dip). Two layers of conglomarate are observed, that thickness is about 10 to 15

meters in the reservoir site. Both conglomerates shall be used for embankment materials (the upstream of shell zone in dam).

The base rock forming the foundation is almost fresh and massive, even though its unconfined compression strength might be assumed less than 100 kg/cm^2.

The foundation rock mentioned above has no problem on the construction of fill type dam, it has a good bearing capacity and water tightness for dam height of about 30 m from an engineering and geological point of view.

The geological map and that explanation at the damsite and the reservoir are shown in FIGURE C4-1 and TABLE C4-1.

4.1.3 Boring Investigation

The boring investigation has been conducted at the proposed Bayongan damsite to confirm the geological foundation condition are listed up in TABLE C4-2. And the investigation location map at the damsite is shown in FIGURE C4-2 and the bore hole loggings are shown in FIGURE C4-3.

The brief description at each item of boring investigation is as follows;

a) Core-boring

Bore holes of 27 were totally drilled in 1981, and 1 hole was completed in 1985 for the Bayongan damsite. Boreholes having the name of BN, DA, SC, DC, BU, BD and RH had been proposed in Phase I Project (1981), and BDH have been proposed by this Study Team. According to the result of the boring investigation, the dam foundation is mainly composed of soft sedimentary rocks such as siltstone, mudstone, which has some thin interlayers of sandstone, and one layer of conglomerate. On the basis of core-boring results, it is summarized as follows;

The formation rock is overlain by thin overburden layer such as terrace and talus deposits. The thickness of overburden layer is less than two to three meters only, and the thickness of weathered rock layer is also two to three meters.

The base rock at the damsite has a good quality which shows 80 to 100 % core-recovery colored gray and 50 to 100 % Rock Quality Designation (R.Q.D), even though its unconfined compression strength might be assumed less than 100 kg/cm^2. In fact, that is massive, uniform and fresh bedrock. Unsuitable materials for dam construction such as overburden layer or weathered zone (specially, extremely weathered and moderately weathered zone) is lying 3 to 4 m in thickness below the existing ground surface.

In accordance with quality classification of bedrock (by Dr. Tanaka) (see TABLE C4-3) weathered rock corresponds to D to CL class and fresh rock to CM class. In short, there are very few problem concerning with the fill type dam construction which has a height of about 30 m from a geological point of view.

But, sheared and/or clayey potions are found at BD-2, DA-4, BU-3 and DC-1 bore hole. The line connecting these boreholes extends from northwest to southeast. This fact suggests that a fault and/or sheared zone is situated along this direction.

The geological profile along the dam axis is shown in FIGURE C4-4.

b) Water Pressure Test

The results of water pressure tests are shown in TABLE C4-4. Lugeon Values obtained at the damsite range from 0.4 to 40.8, and a relation between these values and depths is shown in FIGURE C4-5. As shown in FIGURE C4-5, it can be stated that the permeability of foundation rock is decreasing by the depth, and that at depths below 35 meters there is no Lugeon Value exceeding 5. Besides though the permeability of base rock is almost less than 10 Lugeon value and mainly

less than 5 Lugeon, some treatment of base rock shall be necessary as some high permeable parts - more than 10 Lugeon value - are found. And dam axis where there is more than 5 Lugeon value is less than almost 10 meters. As for the treatment of base rock the grouting at the core trench or the impervious blanket connected to the core zone is considered. The latter shall be more favourable than the former in point of both the construction and the cost, as the length of core trench is very long and impervious materials are easily obtained at the borrow area near the damsite. But as for bearing capacity for injection pressure, there is few problem because Lugeon test results indicate a pressure of more than 7.0 kg/cm^2 which is corresponding to more than twice head of reservoir water height.

Besides the results of water pressure test of DA-2 is judged that there is not so exact from P-Q curve. And as for BDH-1, the results might be suggested that water shall leak from the part of the packer and then from soil and weathered rock. Fresh rock shall indicate impervious layer less than 10 Lugeon value.

c) Penetration Test

Penetration tests have been performed in some bore holes. The penetration tests are using a split sampler which has 2.0 inches of inside diameter, 140 lbs of hammer in weight and 30 inches of height of drop.

Overburden layer shows less than 20 of value, extremely weathered rock and moderately weathered rock is less than 50 and sometimes less than 20, and slightly weathered and fresh rock indicates more than 50. So overburden layer, extremely weathered rock zone and moderately weathered rock zone have some question points concerning bearing capacity for dam foundation.

4.1.4 Test Pit Excavation

Test pits are excavated at the damsite and in the reservoir area. Those test pits are listed up in TABLE C4-5. The test pit loggings are

TABLE C4-1 EXPLANATION OF GEOLOGICAL MAP AT BAYONGAN DAMSITE (1/4)

No.of Outcrop	Rock Type	Explanation
(1)	SLT[1/]/SST[2/]	SST 20 cm thick, EW, 5°S, predominant SLT
(2)	SLT	Along creek bed, strike and dip; NS, 5°W
(3)	SLT-limy or Calcareous SST	SLT 1.00 m thick, thick soil covering, noted SST boulder among soil N70°W, 10°SW
(4)	SLT	No soil cover, extremely to slighty wethered from top to bottom, slaking every evident, yellowish to brownish gray, N80°E, 3°NW
(5)	SLT-SST	Predominant formation is SLT, SST about 30 cm thick, less than one meter thick of overling soil weathered rock, N10°W, 3°NE
(6)	SLT/SST	5 cm thick SST to 50 cm thick SLT ratio, SST is medium, hard to hard, SLT is hard but shows slaking, no soil cover, fault found
	Fault	20 cm displacement, actually two parrallel faults, right one about 20 cm thick, fault zone N 75°W, vertical.
(7)	SLT	Brownish gray SLT, N18°W, 10°NE, about 40 cm thick of top soil and about one meter thick of clay soil with some gravels (mostly pebble sizes)
(8)	SLT-SST	SST about 20 cm thick in-between predominant SLT. N10°W, 5°NE

Note: 1/: silstone
2/: sandstone

TABLE C4-1 EXPLANATION OF GEOLOGICAL MAP AT BAYONGAN DAMSITE (2/4)

No. of Outcrop	Rock Type	Explanation
(9)	SLT-SST	SST is yellowish brown, while SLT is brownish gray, moderately to slightly weathered, N10°W, 5°NE
(10)	Cong 1/	Presence of big boulders, but mostly 5 cm in diameter, consists mainly of volcanic rocks (basalt) and intrusive rocks, presence of sedimentaly rocks like SST and SLT is also noted, sandy matrix and sometimes silty
(11)	SLT/SST	Weathered SLT, soil cover less than 1 meter thick, SST about 50 cm thick, but thin beds about 3 to 5 cm thick also present, N70°E, 8°NW
(12)	SST	Thick bedded, well indurated, about 4 to 5 m thick, thin Cong beds or lens noted, NS, 10°W
(13)	SLT/SST	SST about 30 cm thick, apparently thins out downstream, essentially flat bedded
(14)	SLT	Moderately to slightly weathered, almost horizontal
(15)	SLT/SST	SST about 10 cm thick, SLT about 30 cm thick, NS, 8°W
(16)	SLT/SST	Same as (15), but more hardder and indurated, gray, fresh, N10°E, 5°NW
(17)	SST in-between SLT	Predominant bed is SLT, almost 5 m thick
(18)	SST in-between SLT	Same as (17)

Note: 1/: Conglomerate

TABLE C4-1 EXPLANATION OF GEOLOGICAL MAP AT BAYONGAN DAMSITE (3/4)

No.of Outcrop	Rock Type	Explanation
(19)	SST-SLT	Very hard, fine grained, gray, sandwiched between soft to slightly indurated SLT, overlain by 1 to 2 m thick of Terrace soil, N40°W, 5°SW
(20)	Td [1/] - SLT	Td with some boulders and pebbles overlying SLT, N75°E, 6°SE
(21)	SLT	Moderately wethered
(22)	SST/Cong-SLT	SST/Cong overlying SLT, almost horizontal
(23)	SLT	Moderately to slightly weathered
(24)	SLT-SST	Thin bedded SST in-between SLT beds, thickness of SST about 15 cm, N20°E, 5°SE
(25)	Cong-SLT-SST	Old test pit[2/], measuring 5 meters reveal and confirm presence of Cong which ranges about 5 to 10 m thick in the area, test pit consists of completely and imcompletely weathered Cong, one layer of SLT is very thin, about 10 to 15 cm in thickness, SST also noted but thins out and graded into Cong, Cong consists mostly of pebble size gravels and few small cobbles of volcanic and sedimentary rock in origin, average size 2 to 3 cm
(26)	Cong	Same as (25), only difference is presence of boulders about 30 to 40 cm size, about 4 m depth

Note: 1/: Terrace deposit

2/: CBM-7

TABLE C4-1 EXPLANATION OF GEOLOGICAL MAP AT BAYONGAN DAMSITE (4/4)

No.of Outcrop	Rock Type	Explanation
(27)	Cong-SLT	Cong overlied by SLT
(28)	SLT-Cong	SLT overlied by Cong
(29)	SLT	Test pit, mostly SLT with thin SST, about 2 m depth
(30)	SLT	
(31)	SLT	Test pit (CBM-5), about 1.5 m depth
(32)	SLT	Test pit (CBM-3)
(33)	SST/SLT	Flat bedded SST (1 meter thick) overlying SLT
(34)	SST	About 1 m thick, induration, medium to hard, massive, no fractures and joints, N60°E, 6°SE.
(35)	SLT	Almost flat bedded
(36)	Cong	Meinly 2 to 3 cm grain size
(37)	SLT-SST	
(38)	SLT	
(39)	Cong	Same as (36)
(40)	SLT	Same as (38)
(41)	SLT	With thin SST
(42)	SLT-SST	Test pit, about 2 m depth

TABLE C4-2 LIST OF BORE HOLES AT BAYONGAN DAM SITE

No. of DH	Date Started	Date Completed	Contractor	Purpose	Depth(m)	Location	Elev.(m)	Geology	Sampling	Test in Borehole No. SPT Setting	Test in Borehole No. WPT Setting
BN-1	Sept.2,'81	Sept.14,'81	EGI	Foundation Study on Dam-Axis	50	R.A.Downst	40.034	SH/SLT SST		8	13
BN-2	Sept.21,'81	Oct.1,'81	"	"	50	L.A.Downst	24.584	SH/SLT MST/SST CONG		9	9
BN-3	Oct.21,'81	Oct.26,'81	"	"	50	L.A.Downst	33.411	SH/MST/ SST/SLT		8	8
BN-4	Oct.2,'81	Oct.8,'81	"	"	50	R.A.Upst	28.334	"		5	9
BN-5	Oct.9,'81	Oct.15,'81	"	"	50	L.A.Upst	29.099	"		8	8
BN-6	Oct.16,'81	Oct.20,'81	"	"	50	L.A.Upst	32.887	"		9	9
DA-1	Dec.2,'81	Dec.9,'81	"	"	20	R.A.Downst	57.699	"	Sample Taken 6.8^m, 7.6^m	-	3
DA-2	Nov.25,'81	Nov.26,'81	"	"	20	R.A.Downst	48.273	"	Sample Taken 13.2^m	-	3
DA-3	Nov.22,'81	Nov.23,'81	"	"	20	R.A.Downst	34.830	"		-	3
DA-4	Nov.10,'81	Nov.12,'81	"	"	20	L.A.Downst	25.669	"		-	1
DA-5	-	-	"	"	20	L.A.Downst	52.806	"		-	3
DA-6	Dec.11,'81	Dec.11,'81	"	"	20	L.A.Downst	65.509	"		-	2
SC-1	Dec.22,'81	Dec.23,'81	"	Foundation on Spillway of Phase I	15	L.A.Downst	60.572	"		-	-
SC-2	Dec.14,'81	Dec.21,'81	"	"	15	L.A.Downst	61.252	"		-	-
SC-3	Dec.25,'81	Dec.26,'81	"	"	15	L.A.Downst	47.665	"		-	-
SC-4	Dec.27,'81	Dec.28,'81	"	"	15	L.A.Upst	36.105	"		-	-
DC-1	Dec.20,'81	Dec.21,'81	"	Diversion Conduit of Phase I	15	R.A.Upst	29.788	"		-	-
DC-2	Nov.24,'81	Nov.25,'81	"	"	15	R.A.Downst	25.596	"		-	-
DC-3	Nov.28,'81	Nov.29,'81	"	"	15	R.A.Downst	29.000	"		-	-
DC-4	Nov.27,'81	Nov.27,'81	"	"	15	R.A.Downst	33.310	"		-	-
BU-1	Nov.18,'81	Nov.19,'81	"	Foundation Investigation on Dam Base Upstream	10	L.A.Upst	25.713	"		13	-
BU-2	Nov.15,'81	Nov.15,'81	"	"	10	L.A.Upst	28.651	"		9	-
BU-3	Nov.16,'81	Nov.17,'81	"	"	10	R.A.Upst	25.549	"		5	-
BD-1	Nov.13,'81	Nov.14,'81	"	Downstream	10	L.A.Downst	35.908*	"		10	-
BD-2	Nov.8,'81	Nov.9,'81	"	"	10	L.A.Downst	31.938*	"		11	-
BD-3	Nov.6,'81	Nov.7,'81	"	"	10	L.A.Downst	26.516	"		6	-
RU-1	Nov.30,'81	Dec.1,'81	"	Foundation Stydy on R.A.	15	R.A.Downst	58.208	"	Sample Taken 6.8-7.1^m, 10.5^m	-	2
Total Borehole 27					Total Meter 595					Total 90	Settings 73
BDH-1	Mar.,'85	Mar.,'85	NIA	Foundation of Tunel Axis	40	R.A.	60.000	SH/MST/ SST/SLT		-	12
Total BH 28					Total Meter 635						85

* Survey of Phase I

Legend: *SH: Shale, SLT: Siltstone,* MST: Mudstone, SST: Sandstone, CONG: Conglomerate
R.A.: Right Abutment, L.A.: Left Abutment, Downst: Downstream, Upst: Upstream

TABLE C4-3 CLASSIFICATION OF DAM FOUNDATION ROCKS
(BY H. TANAKA)

Class	Geological Features
A	Rock forming minerals do not show weathering and alteration to be kept fresh. Cracks are well-compacted and weathering is not observed along the lines of cracks. Clear sound can be heard by the strike of hammer.
B	Rock forming minerals show partial weathering and alteration but rock is kept hard. Cracks are well-compacted. Clear sound can be heard by the strike of hammer.
CH	Rock forming minerals show weathering but rock is kept relatively hard and generally, colored by limonites and others. Blocks' cohesion gets weaker slightly. Blocks are fissured along the lines of cracks by the strong strike of hammer. Clay is often caught in cracks. A slight indistinct sound can be heard by the strike of hammer.
CM	Rock forming minerals are weathered and rock gets rather softer. Blocks are fissured along the lines of cracks by normal strike of hammer. Clay is often caught in cracks. A rather indistinct sound can be heard by the strike of hammer.
CL	Rock forming minerals are weathered and rock gets softer. Blocks are fissured along the lines of cracks by slight strike of hammer to leave clay in the cracks. Indistinct sound can be heard by the strike of hammer.
D	Rock forming minerals are weathered to be softened and rock is also soft remarkably to be broken by the slight strike of hammer. Blocks' cohesion is almost nothing. Clay is caught in cracks. Remarkable indistinct sound can be heard by the strike of hammer.

TABLE C4-4 RESULT OF WATER PRESSURE TESTS (1/3)

No	Interval (m)	Pressure (kg/km^2)	Lugeon Value	Geology 1/ 2/
BN-1	17.5 to 20.0	3.605	7.1	SLT/SST
	20.0 to 22.5	3.505	6.4	"
	22.5 to 25.0	3.56	4.9	"
	25.0 to 27.5	3.615	5.8	"
	27.5 to 30.0	3.395	4.7	"
	30.0 to 32.5	3.45	4.9	"
	32.5 to 35.0	3.505	4.1	"
	35.0 to 37.5	3.56	2.9	"
	37.5 to 40.0	3.625	3.5	"
	40.0 to 42.5	3.665	2.2	"
	42.5 to 45.0	3.44	1.9	"
	45.0 to 47.5	3.495	1.6	"
	47.5 to 50.0	3.605	0.7	"
BN-2	5.0 to 10.0	2.92	5.8	SLT/SST
	10.0 to 15.0	2.9	2.2	"
	15.0 to 20.0	2.97	4.4	"
	20.0 to 25.0	2.735	0.4	"
	25.0 to 30.0	2.69	1.9	"
	30.0 to 35.0	2.765	0.7	"
	35.0 to 40.0	2.71	1.9	"
	40.0 to 45.0	2.68	2.2	SLT/SST, Cong 3/
	45.0 to 50.0	2.8	1.1	Cong
BN-3	10.0 to 15.0	7.0	1.6	SLT/SST
	15.0 to 20.0	"	2.0	"
	20.0 to 25.0	"	1.7	"
	25.0 to 30.0	"	1.6	"
	30.0 to 35.0	"	2.2	"
BN-4	5.0 to 10.0	2.81	5.5	SLT/SST
	10.0 to 15.0	2.855	6.7	"
	15.0 to 20.0	2.965	4.7	"
	20.0 to 25.0	2.8	4.0	"

Note; 1/ Siltstone
2/ Sandstone
3/ Conglomerate

TABLE C4-4 RESULT OF WATER PRESSURE TESTS (2/3)

No	Interval (m)	Pressure (kg/km^2)	Lugeon Value	Geology
BN-4	25.0 to 30.0	2.96	1.9	SLT/SST
	30.0 to 35.0	3.02	0.8	"
	35.0 to 40.0	3.075	0.6	"
	40.0 to 45.0	2.995	1.1	"
	45.0 to 50.0	3.025	0.8	"
BN-5	10.0 to 15.0	2.75	4.0	SLT/SST
	15.0 to 20.0	2.77	2.5	"
	20.0 to 25.0	2.85	0.5	"
	25.0 to 30.0	2.77	1.4	"
	30.0 to 35.0	2.845	0.5	"
	35.0 to 40.0	2.79	1.3	"
	40.0 to 45.0	2.76	1.0	"
	45.0 to 50.0	2.79	0.8	"
BN-6	5.0 to 10.0	3.415	14.3	SLT/SST
	10.0 to 15.0	2.89	4.5	"
	15.0 to 20.0	2.98	2.9	"
	20.0 to 25.0	2.88	3.6	"
	25.0 to 30.0	3.045	1.6	"
	30.0 to 35.0	3.06	1.0	"
	35.p to 40.0	3.0	0.8	"
	40.0 to 45.0	2.955	0.7	"
	45.0 to 50.0	2.925	0.4	"
RH-1	5.0 to 10.0	2.76	9.5	SLT/SST
	10.0 to 15.0	2.76	2.6	"
DA-1	5.0 to 10.0	2.81	5.1	SLT/SST
	10.0 to 15.0	2.82	4.1	"
	15.0 to 20.0	2.98	2.0	"
DA-2	5.0 to 10.0	3.565	40.8	SLT/SST
	10.0 to 15.0	3.855	29.0	"
	15.0 to 20.0	4.06	10.9	"

TABLE C4-4 RESULT OF WATER PRESSURE TESTS (3/3)

No	Interval (m)	Pressure (kg/km²)	Lugeon Value	Geology
DA-3	5.0 to 10.0	2.95	6.1	SLT/SST
	10.0 to 15.0	3.32	1.7	"
	15.0 to 20.0	3.58	1.2	"
DA-4	10.0 to 15.0	2.93	4.0	SLT/SST
	15.0 to 20.0	3.02	1.7	"
DA-5	5.0 to 10.0	2.71	5.0	SLT/SST
	10.0 to 15.0	3.31	4.4	"
	15.0 to 20.0	3.38	3.1	"
DA-6	10.0 to 15.0	3.48	4.1	SLT/SST
	15.0 to 20.0	3.61	3.0	"
BDH-1	5.0 to 8.0	3.536	72.1	SLT/SST
	8.0 to 11.0	3.536	68.2	"
	11.0 to 14.0	3.536	54.3	"
	14.0 to 17.0	3.536	53.3	"
	17.0 to 20.0	3.536	50.7	"
	20.0 to 23.0	3.536	47.7	"
	23.0 to 26.0	3.536	42.7	"
	26.0 to 29.0	3.536	41.0	"
	29.0 to 31.0	3.536	61.1	"
	31.0 to 34.0	3.536	39.8	"
	34.0 to 37.0	3.536	37.4	"
	37.0 to 40.0	3.536	37.0	"

TABLE C4-5 LIST OF TEST PITS AT BAYONGAN DAM SITE

Test Pit Number	Date Started	Date Completed	Contractor	Purpose	Depth(m)	Location	Elev(m)	Geology	Sampling	Test on Soils
TP-CBM-3	Nov.,'81	Nov.,'81	EGI	Borrow Materials	2.10	Reservoir Area	-	CLAY SH/MST/SST SLT	-	-
TP-CBM-4	Nov.,'81	Nov.,'81	"	"	5.10	"	-	"	-	-
TP-CBM-5	Nov.,'81	Nov.,'81	"	"	4.75	"	-	"	-	-
TP-CBM-6	Nov.,'81	Nov.,'81	"	"	6.64	"	-	"	-	-
TP-CBM-7	Nov.,'81	Nov.,'81	"	"	5.48	"	-	"	-	-
TP-1	-	-	"	"	3.4	"	-	"	-	-
TP-2	-	-	"	"	4.3	"	-	"	-	-
TP-3	-	-	"	"	4.8	"	-	"	-	-
TP-4	-	-	"	"	4.8	"	-	"	-	-
TP-5	-	-	"	"	4.65	"	-	"	-	-
TP-BN-1	Sept.,'81	Sept.,'81	"	Foundation Investigation	3.5	Along Dam AXIS	46.108*	"	Undisturbed Soil Samples	Laboratory Test
TP-BN-2	Sept.,'81	Sept.,'81	"	"	4.10	"	25.678*	"	"	"
TP-BN-3	Sept.,'81	Sept.,'81	"	"	-	"	-	"	"	"
TP-BN-4	Sept.,'81	Sept.,'81	"	"	5.05	"	-	"	"	"
BTP-1	Feb.2,'85	Feb.5,'85	NIA	Borrow Materials	3.50	Right Abutment	63.507	SILTY CLAY SST/SH/MST	Disturbed Soil Samples	"
BTP-2	Feb.2,'85	Feb.5.'85	"	"	3.10	"	63.967	SILTY CLAY SH/SLT/SST	"	"
BTP-3	Feb.2,'85	Feb.3,'85	"	"	3.50	"	57.442	"	"	"
BTP-4	Feb.2,'85	Feb.2,'85	"	"	3.70	Left Abutment	34.935	SILTY CLAY SST/SH/SLT	"	"
BTP-5	Feb.1,'85	Feb.3,'85	"	"	3.60	"	40.202	SILTY CLAY SST/SH/SLT/MST	-	-
BTP-6	Feb.1,'85	Feb.3,'85	"	"	3.20	"	46.569	"	Disturbed Samples	Laboratory Test
BTP-7	Feb.1,'85	Feb.3,'85	"	"	3.20	"	53.343	SILTY CLAY SLT/SST/SH	"	"
BTP-8	Feb.1,'85	Feb.3,'85	"	"	2.75	"	49.039	CLAY SST/SH/SLT/MST	-	-
BTP-9	Feb.9,'85	Feb.10,'85	"	"	3.10	Reservoir Area	44.864	"	Disturbed Samples	Laboratory Test
BTP-10	Feb.9,'85	Feb.10,'85	"	"	3.65	"	44.530	"	"	"
BTP-11	Feb.9,'85	Feb.10,'85	"	"	3.92	"	38.833	SILTY CLAY SLT/SST/SH	—	—

Note: * SURVEY OF PHASE I PROJECT

FIGURE C4–1 GEOLOGICAL MAP AT BAYONGAN DAMSITE AND RESERVOIR AREA (S = 1 : 10,000)

LEGEND:

m (1)	Number of Outcrop
20/10	Strike and Dip of Strata
- - -	Geological Contact Line
Td	Terrace Deposit
Al	Alternation of Siltstone and Sandstone
Cong	Conglomerate

FIGURE C4-2 INVESTIGATION LOCATION MAP
AT BAYONGAN DAM SITE

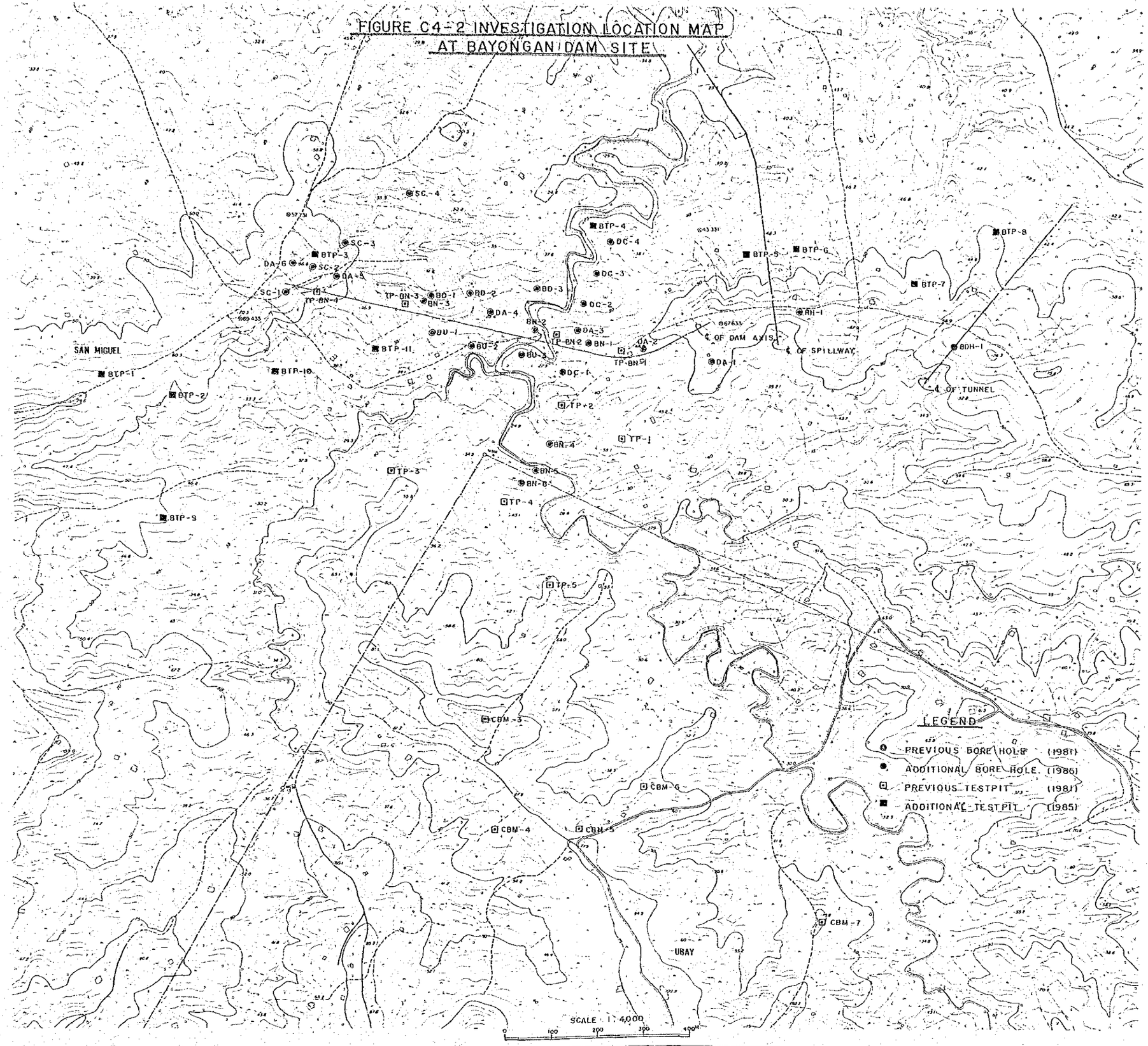
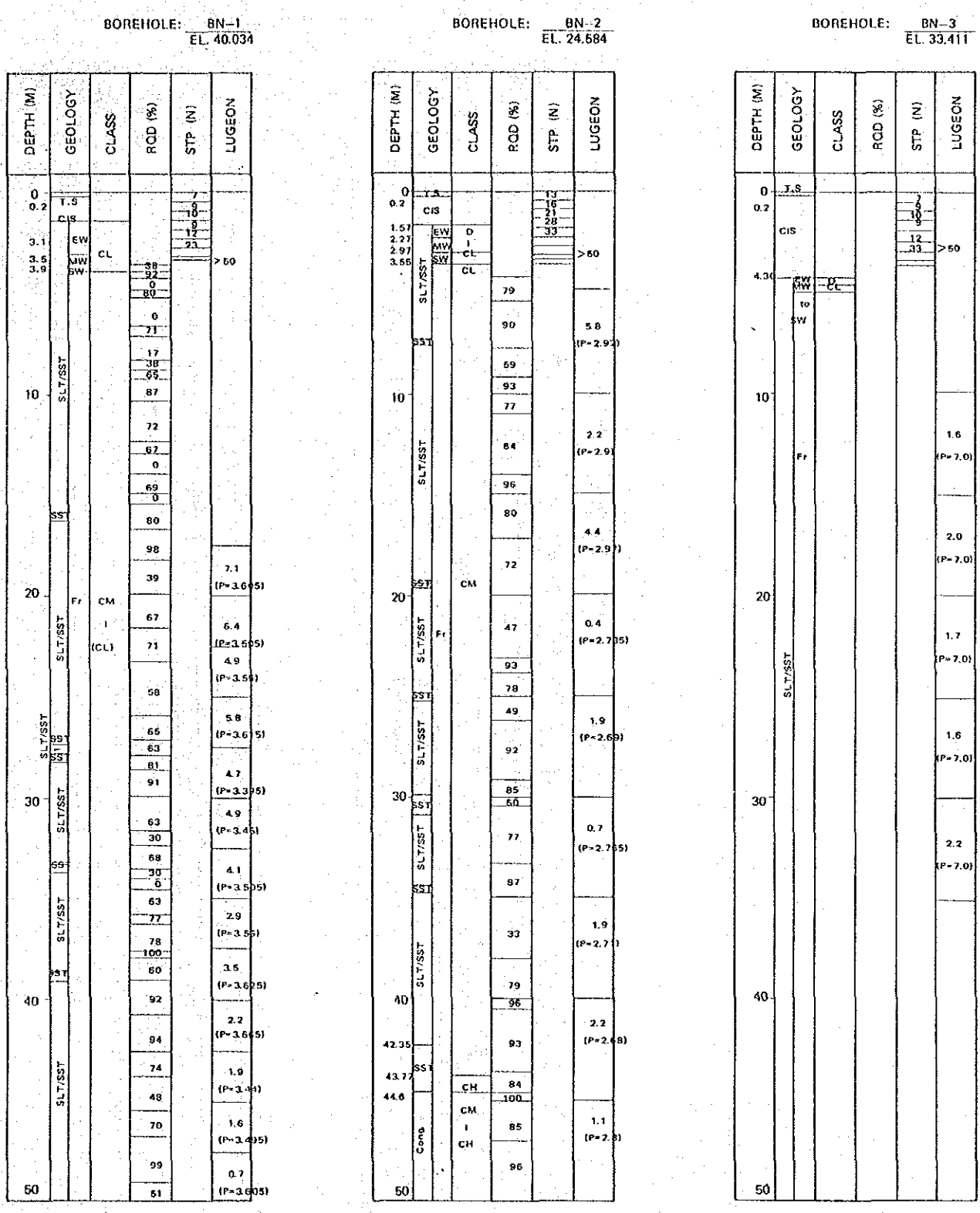


FIGURE C4-3 BOREHOLE LOGGINGS AT BAYONGAN DAMSITE (1/6)



LEGEND:

T.S	–	Top soil	SLT	–	Siltstone	EW	– Extremely weathered
CIS	–	Clay materials	SST	–	Sandstone	MW	– Moderately weathered
CIC	–	Gravelly Clay	Cong.	–	Conglomerate	SW	– Slightly weathered
SdyC	–	Sandy clay				Fr	– Fresh rock
SlyC	–	Silty clay					
	–	Sheared zone					

FIGURE C4-3 BORE HOLE LOGGINGS AT BAYONGAN DAMSITE (2/6)

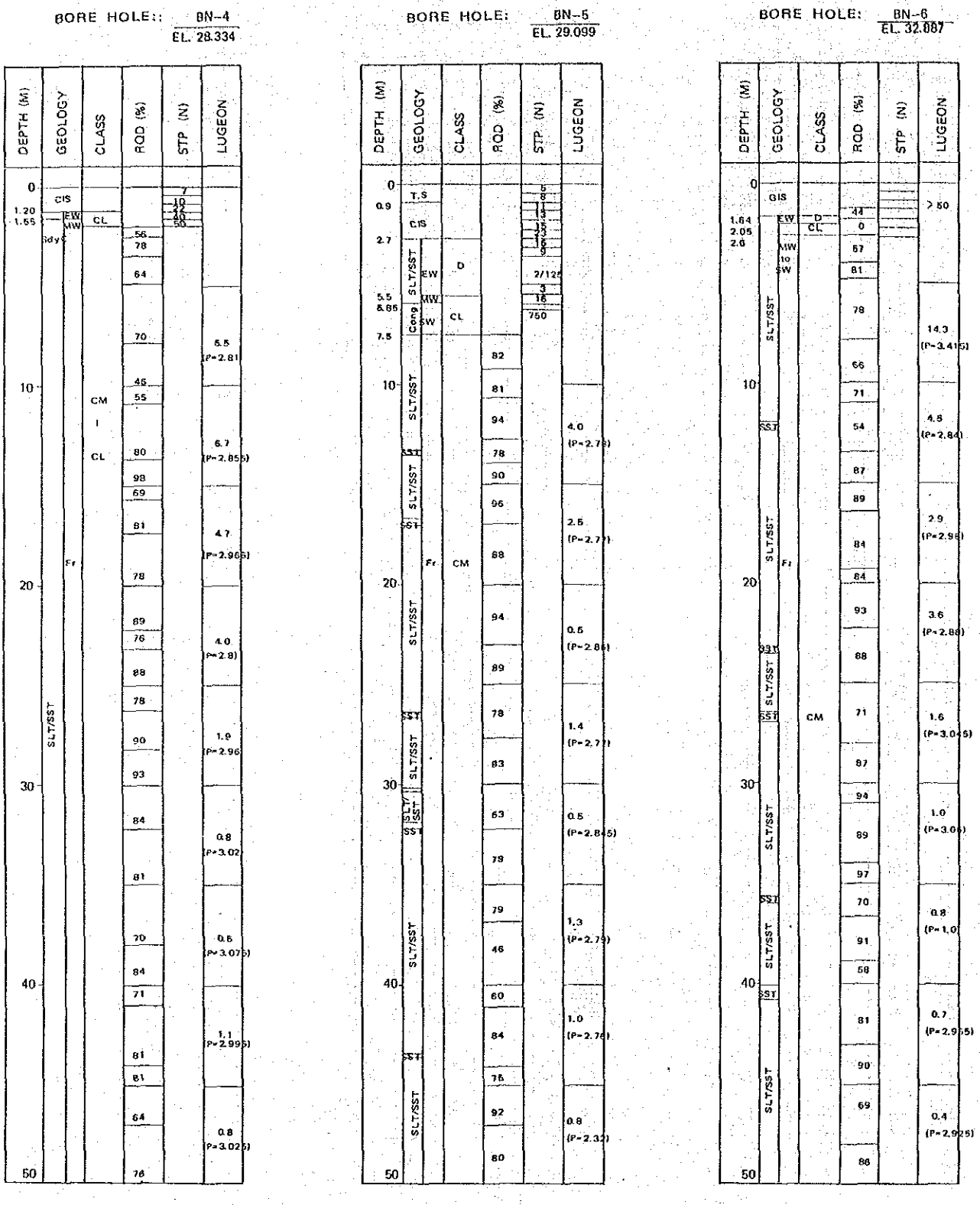
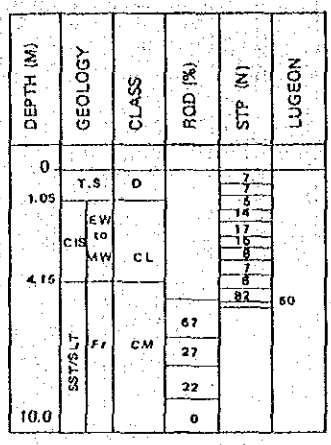
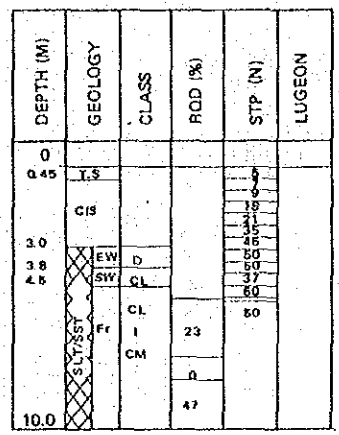


FIGURE C4-3 BORE HOLE LOGGINGS AT BAYONGAN DAMSITE (3/6)

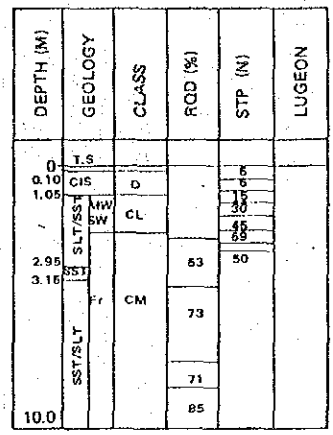
BORE HOLE: BD-1
EL.



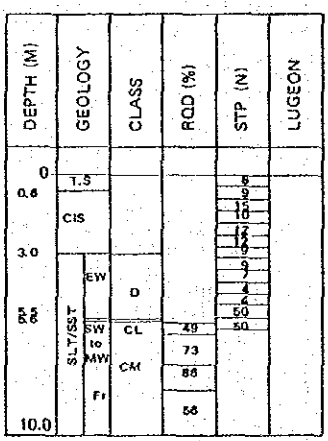
BORE HOLE: BD-2
EL.



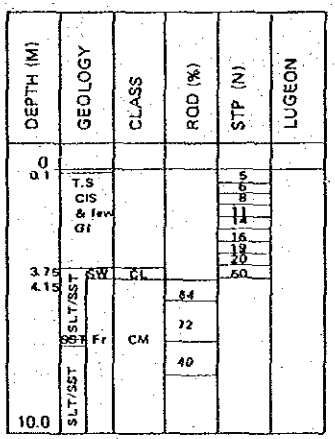
BORE HOLE: BD-3
EL. 26.516



BORE HOLE: BU-1
EL. 26.713



BORE HOLE: BU-2
EL. 28.651



BORE HOLE: BU-3
EL. 25.549

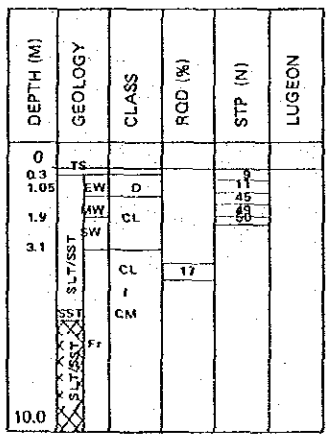
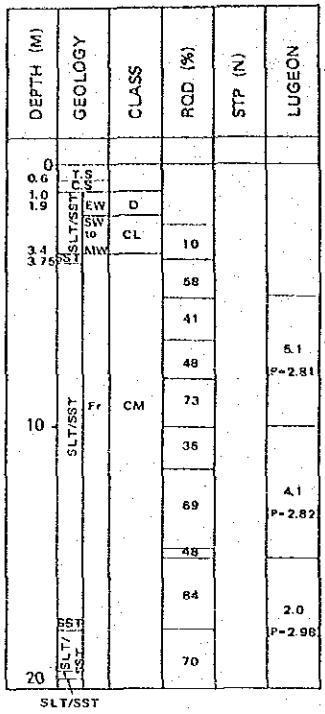
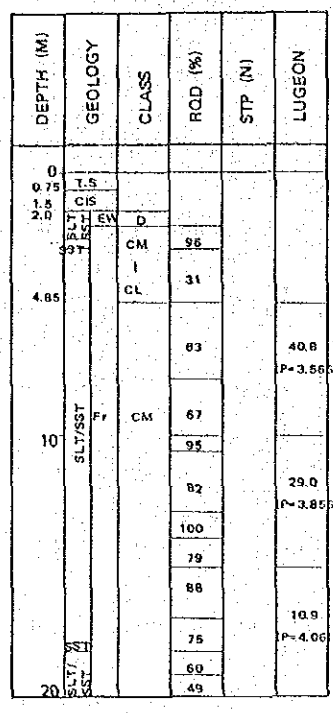


FIGURE C4-3 BORE HOLE LOGGINGS AT BAYONGAN DAMSITE (4/6)

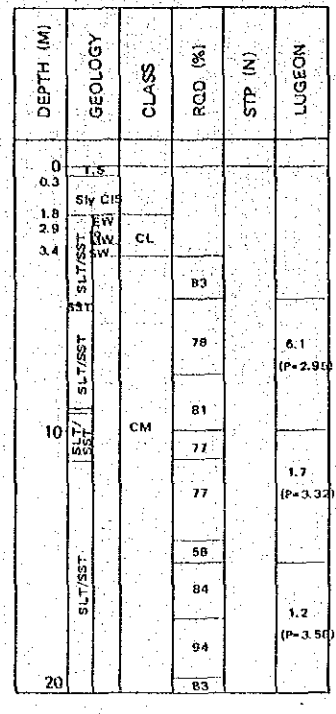
BORE HOLE: DA-1
EL. 67.699



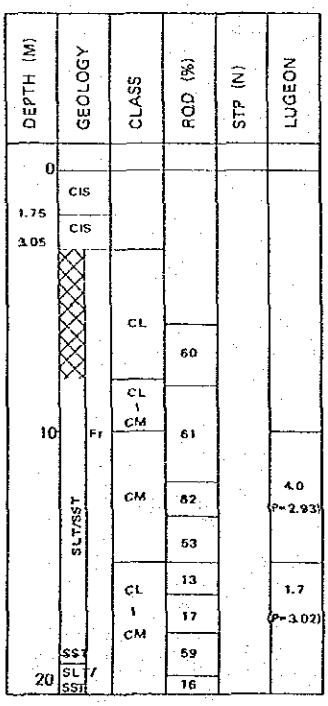
BORE HOLE: DA-2
EL. 48.273



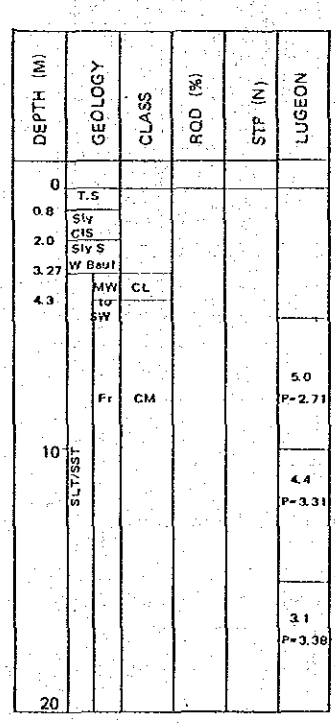
BORE HOLE: DA-3
EL. 34.830



BORE HOLE: DA-4
EL. 25.669



BORE HOLE: DA-5
EL. 52.806



BORE HOLE: DA-6
EL. 65.509

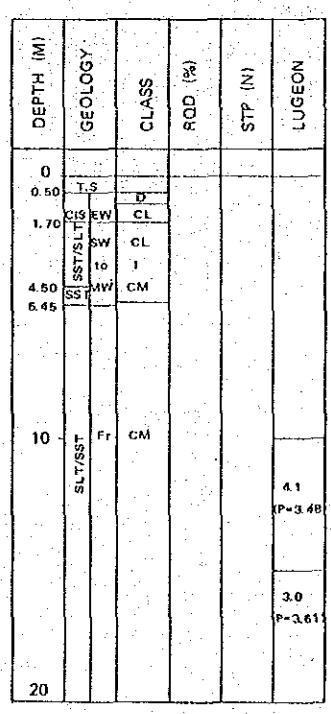


FIGURE C4-3 BORE HOLE LOGGINGS AT BAYONGAN DAMSITE (5/6)

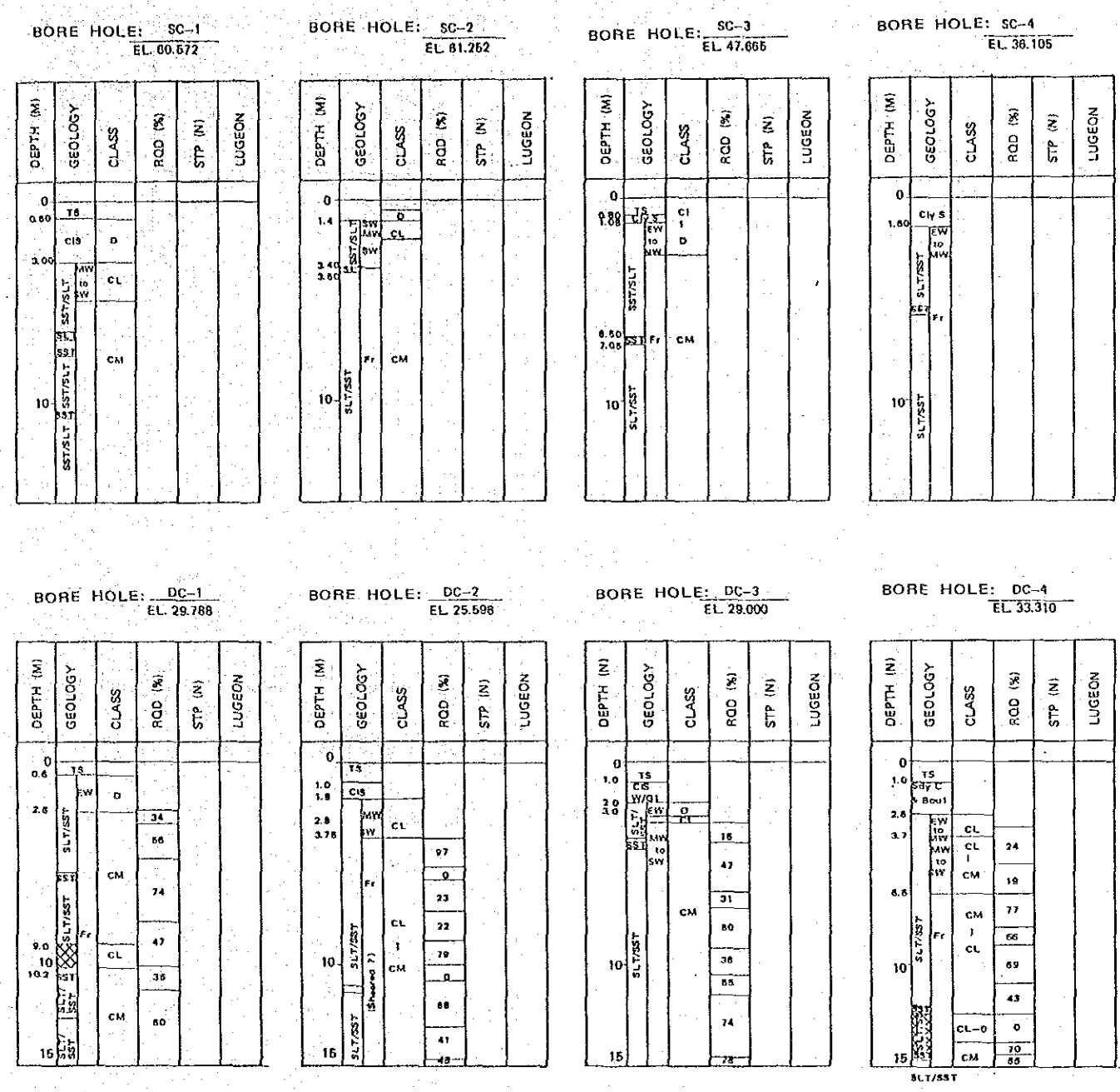
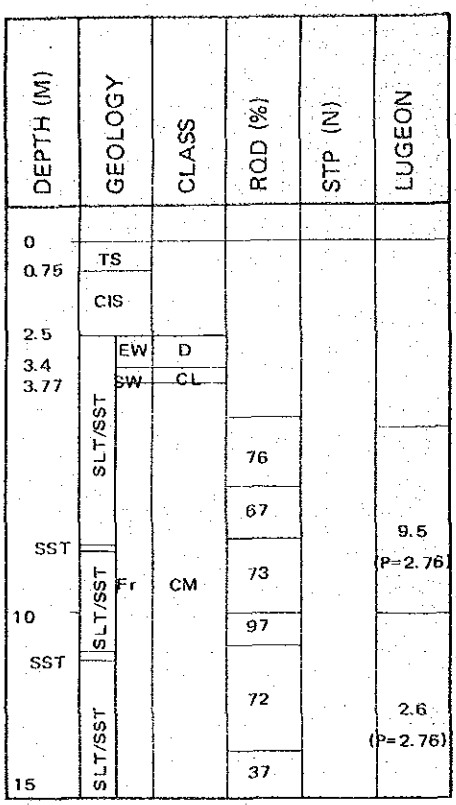
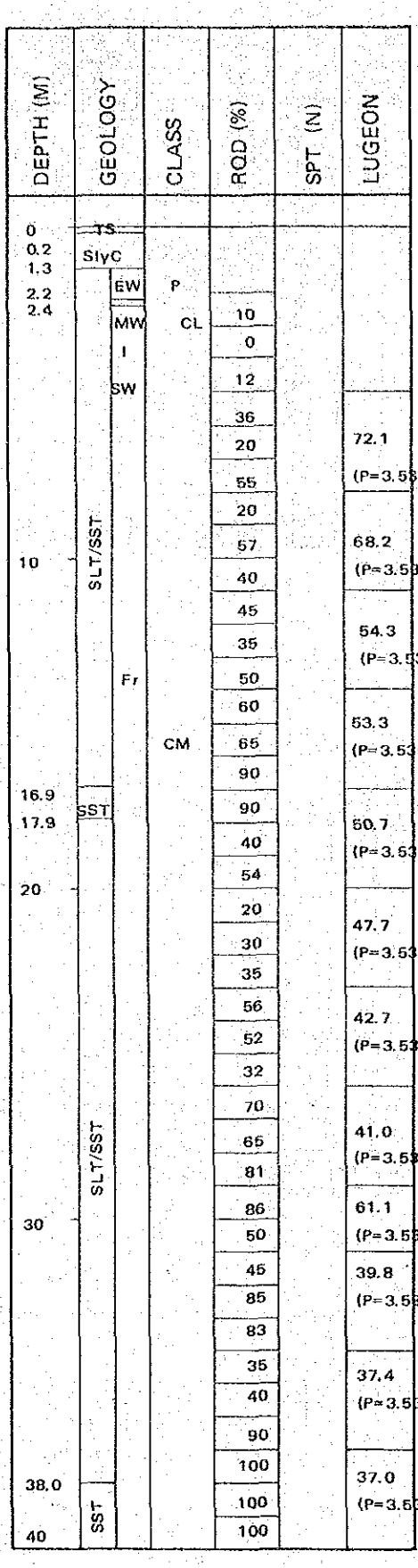


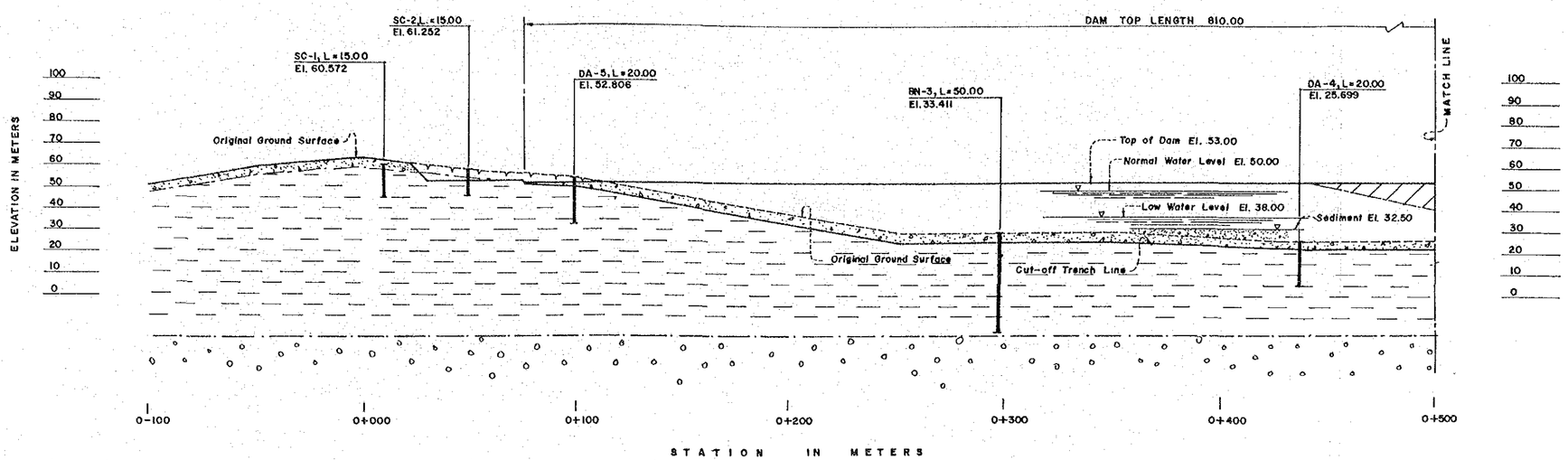
FIGURE C4-3 BOREHOLE LOGGINGS AT BAYONGAN DAMSITE (6/6)

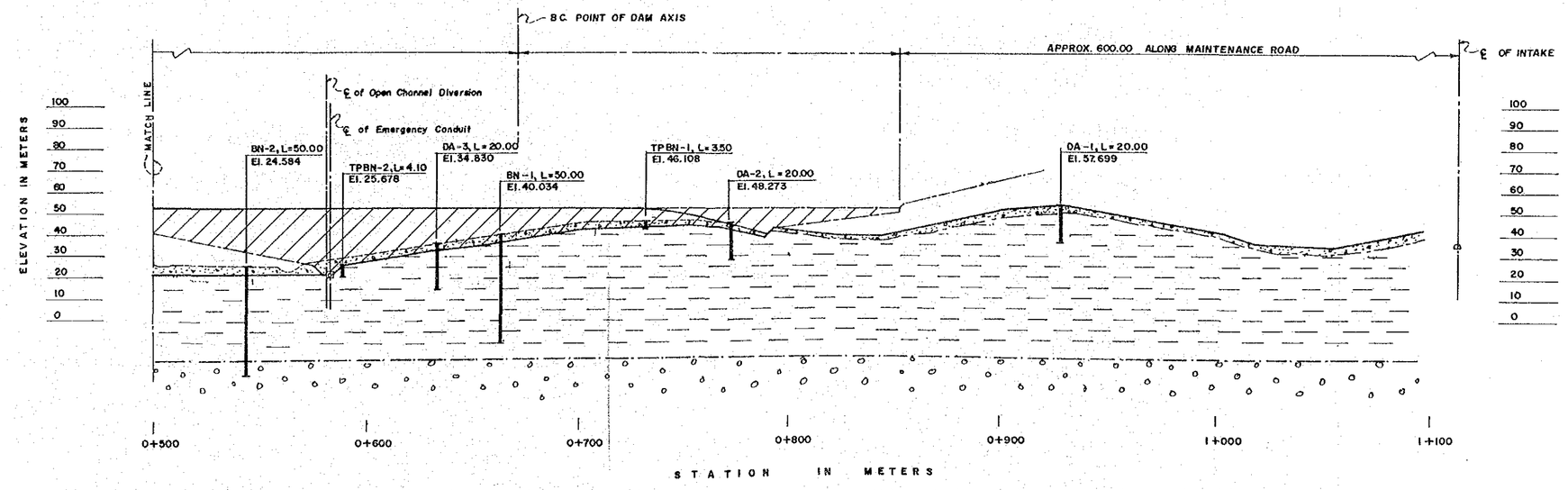
BORE HOLE: BH-1
EL. 58.208



BORE HOLE: BDH-1
EL. 60.000







LEGEND

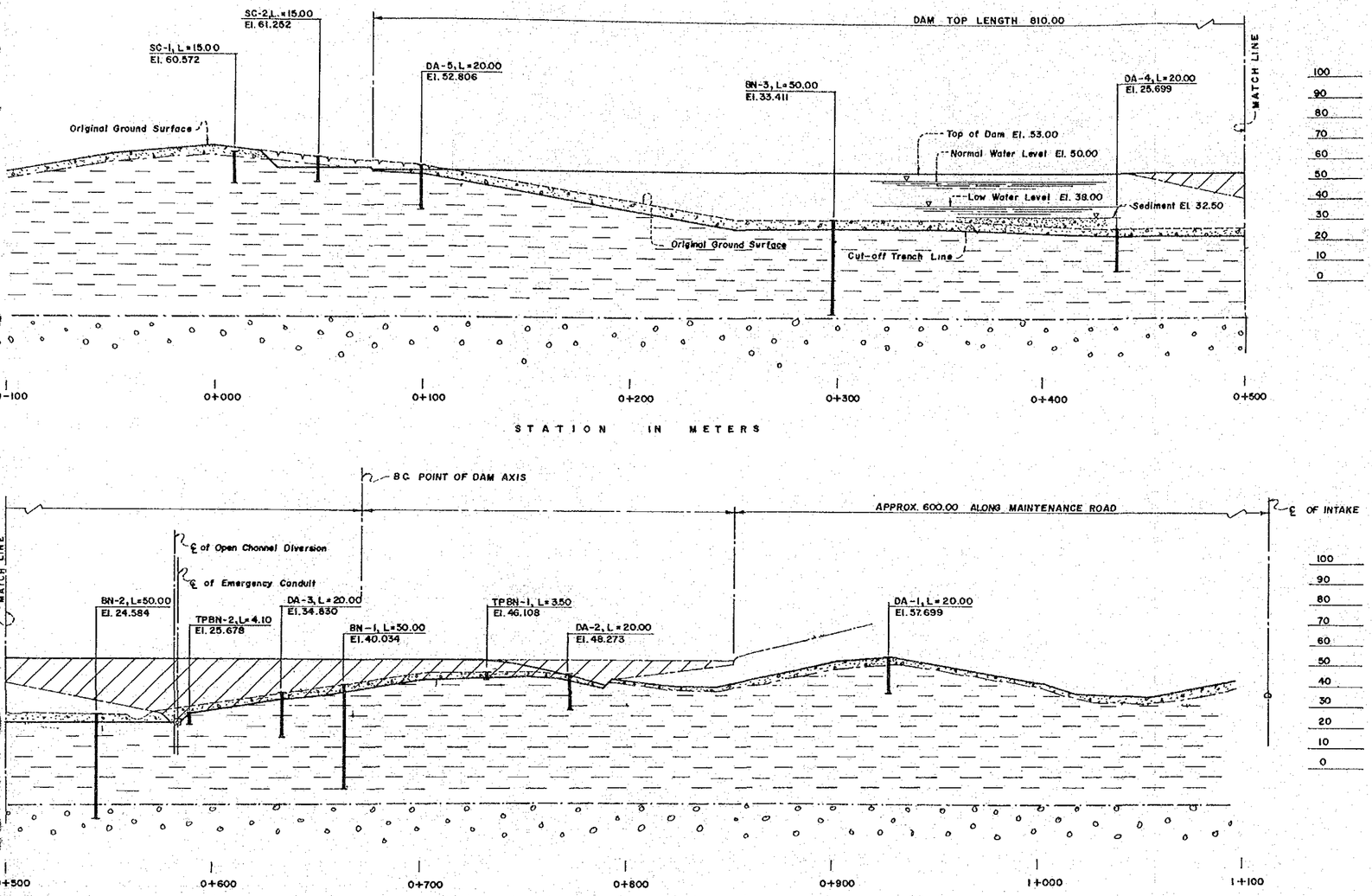
- Soil and weathered rock
- Alternation of siltstone and sand stone
- Conglomerate
- Geological contact line
- Drill holes

0 20 40 60 80 100 m

Scale 1: 2,000

BAYONGAN DAM

FIGURE C4-4 GEOLOGICAL PROFILE
(FROM STA. 0-100 TO STA. 1+100)



LEGEND

- Soil and weathered rock
- Alternation of siltstone and sand stone
- Conglomerate
- Geological contact line
- Drill holes

0 20 40 60 80 100 m

Scale 1: 2,000

BAYONGAN DAM

FIGURE C4-4 GEOLOGICAL PROFILE
(FROM STA. 0-100 TO STA. 1+100)

FIGURE C4-5 RELATION BETWEEN LUGEON VALUE AND DEPTH

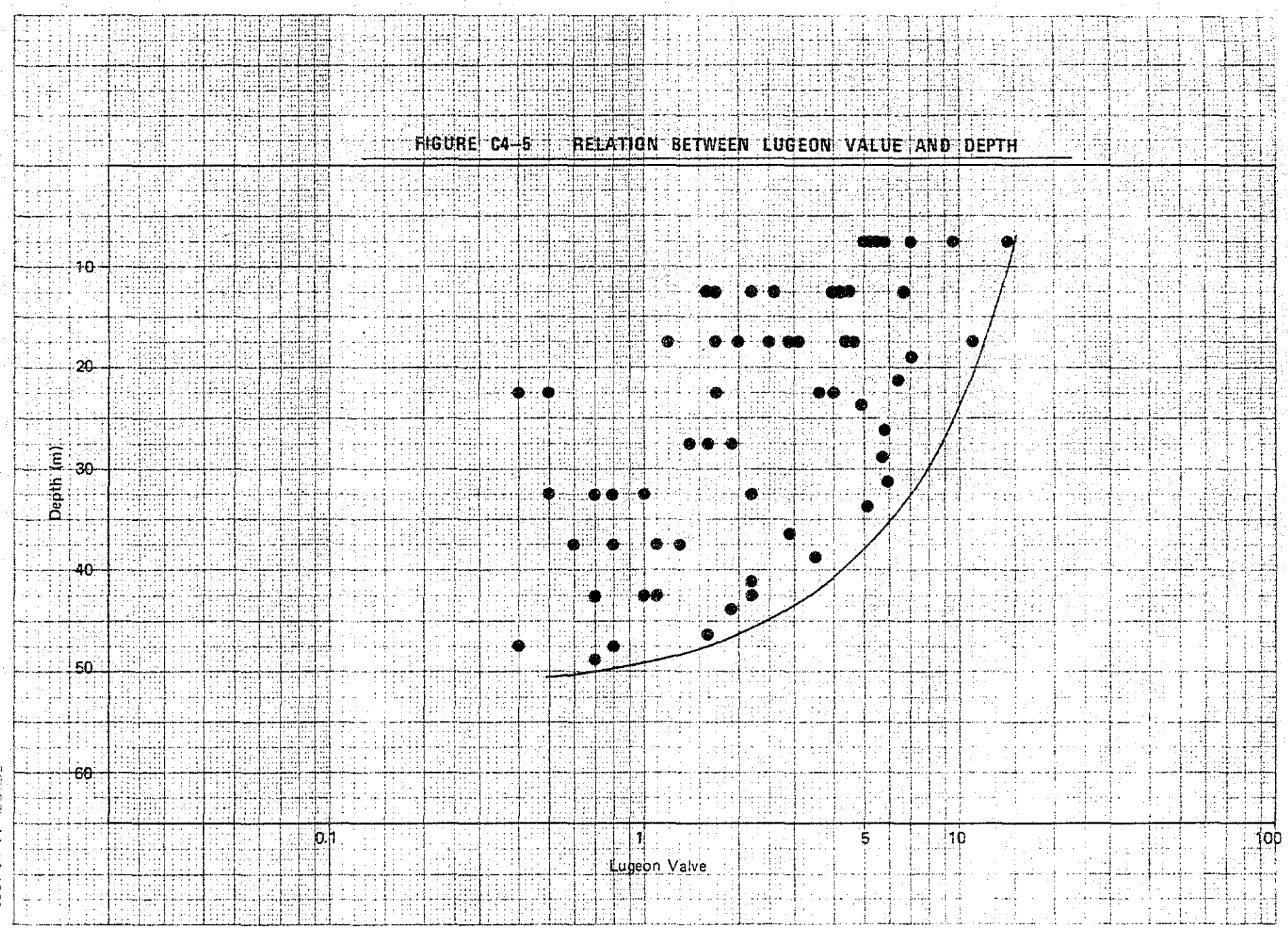


FIGURE C4-6 TEST PIT LOGGINGS AT BAYONGAN DAMSITE (1/4)

TEST PIT NO. TP-BN-1
ELEVATION 46.108

DEPTH (M)	GEOLOGY	WEATHERING	SOIL CLASSIFICATION	SAMPLING	REMARKS
0.35	TS		CL	UNDISTURBED SAMPLE	FOUNDATION INVESTIGATION ON DAM AXIS DIP AND STRIKE OF STRATA N35° – 45°W, S – 10° SW
0.65	Sly Cl		CL		
1	SLT/SST	EW to MW	BEDROCK		
2.1		SW			
3		Fr			
3.5					

TEST PIT NO. TP-BN-2
ELEVATION 26.678

DEPTH (M)	GEOLOGY	WEATHERING	SOIL CLASSIFICATION	SAMPLING	REMARKS
0.2	TS		CL	UNDISTURBED SAMPLE	FOUNDATION INVESTIGATION ON DAM AXIS DIP AND STRIKE OF STRATA N35° – 45° W, S – 10° SW
1	Sly Cl		CL		
1.2	SLT/SST	EW to MW	BEDROCK		
3.8		Fr			
4					
4.1					

TEST PIT NO. TP-BN-4
ELEVATION

DEPTH (M)	GEOLOGY	WEATHERING	SOIL CLASSIFICATION	SAMPLING	REMARKS
0.3	TS		CL	UNDISTURBED SAMPLE	FOUNDATION INVESTIGATION ON DAM AXIS N35° – 30°E, 10° NW
1	Sly Cl		CL		
1.15	SLT/SST	EW to MW	BEDROCK		
3.25	GST				
4	SLT/SST	Fr			
5					
5.05					

TEST PIT NO. CBM-3
ELEVATION

DEPTH (M)	GEOLOGY	WEATHERING	SOIL CLASSIFICATION	SAMPLING	REMARKS
0.20	TS		CL	NO SAMPLE	MATERIAL INVESTIGATION
1	SST/SLT	MW – EW	BEDROCK		
2					
2.10					

TEST PIT NO. CBM-4
ELEVATION

DEPTH (M)	GEOLOGY	WEATHERING	SOIL CLASSIFICATION	SAMPLING	REMARKS
0.40	TS		CL	NO SAMPLE	MATERIAL INVESTIGATION
1	CIS				
1.35	SST/SLT	MW	BEDROCK		
3.90					
4	SST				
5					
5.10					

TEST PIT NO. CBM-5
ELEVATION

DEPTH (M)	GEOLOGY	WEATHERING	SOIL CLASSIFICATION	SAMPLING	REMARKS
0.40	TS		CL	NO SAMPLE	PURPOSE: MATERIAL INVESTIGATION
1	CIS	EW	CL		
1.10	SST/SLT	MW	BEDROCK		
2					
3					
4					
4.75					

TEST PIT NO. CBM-6
ELEVATION

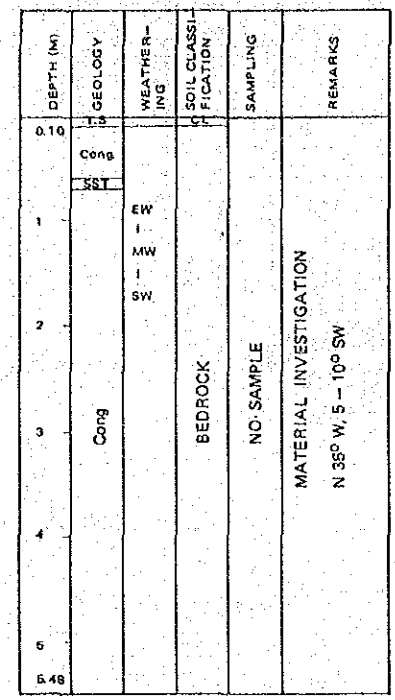
DEPTH (M)	GEOLOGY	WEATHERING	SOIL CLASSIFICATION	SAMPLING	REMARKS
0.20	TS		CL	NO SAMPLE	PURPOSE: MATERIAL INVESTIGATION
1	CIS		CL		
1.10	SLT/SST	MW	BEDROCK		
2					
3					
4					
5					
6					
6.61					

LEGEND:

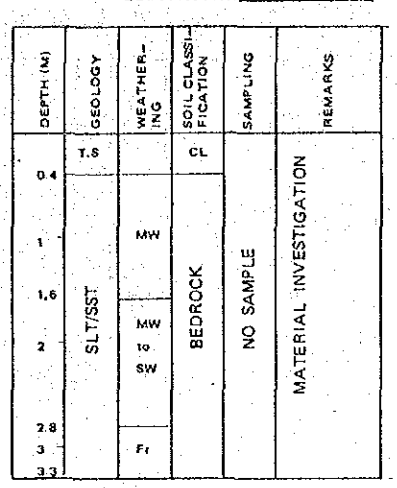
TS	–	Top Soil	EW	–	Extremely Weathered
CIS	–	Clay Materials	MW	–	Moderately Weathered
GIC	–	Glavery Clay	SW	–	Slightly Weathered
SdyC	–	Sandy Clay	Fr	–	Fresh Rock
SlyC	–	Silty Clay			
SLT	–	Siltstone			
SST	–	Sandstone			
Cong	–	Conglomerate			

FIGURE C4-6 TEST PIT LOGGINGS AT BAYONGAN DAMSITE (2/4)

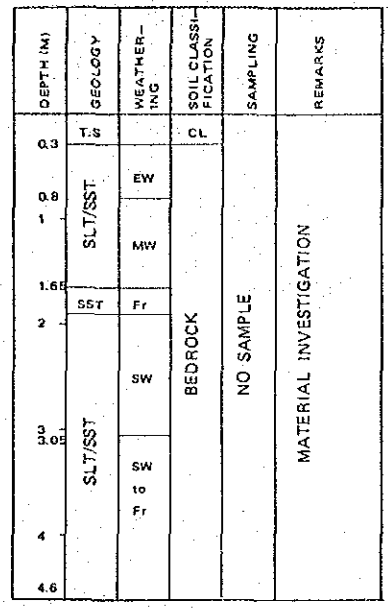
TEST PIT NO. CBM-7
ELEVATION:



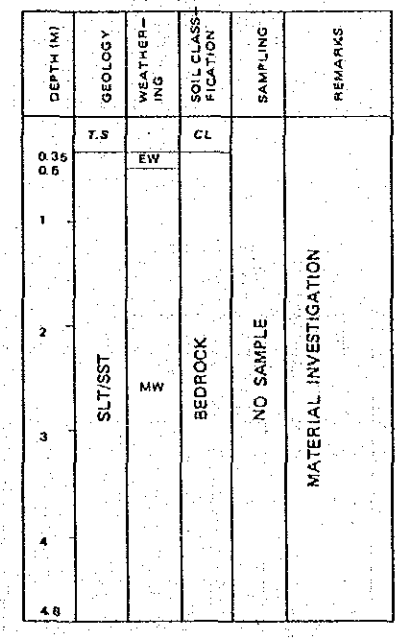
TEST PIT NO. TP-1
ELEVATION:



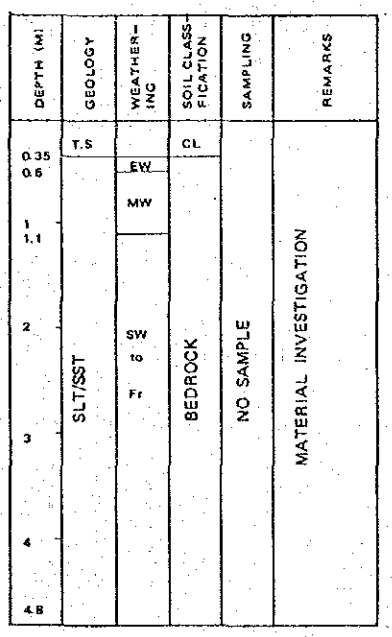
TEST PIT NO. TP-2
ELEVATION:



TEST PIT NO. TP-3
ELEVATION:



TEST PIT NO. TP-4
ELEVATION:



TEST PIT NO. TP-5
ELEVATION:

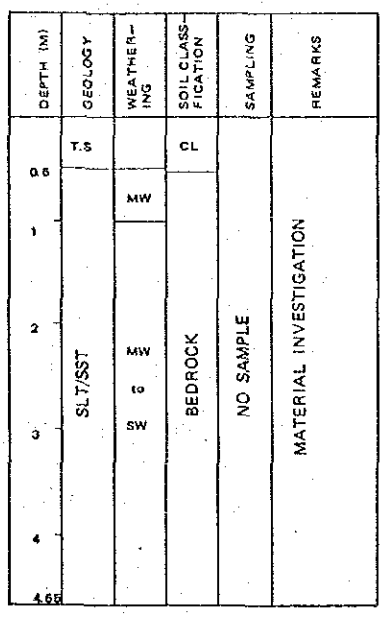
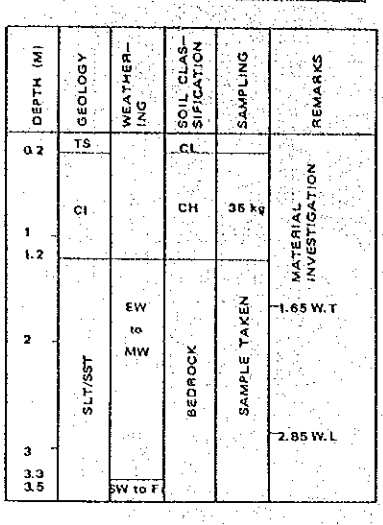
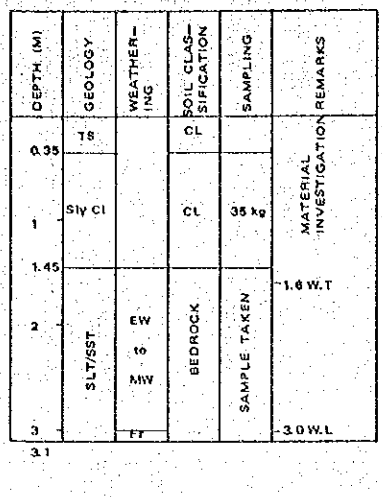


FIGURE C4-6 TEST PIT LOGGINGS AT BAYONGAN DAMSITE (3/4)

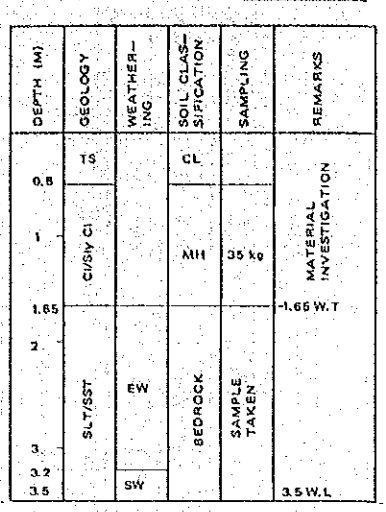
TEST PIT NO. BTP-1
ELEVATION 63.507



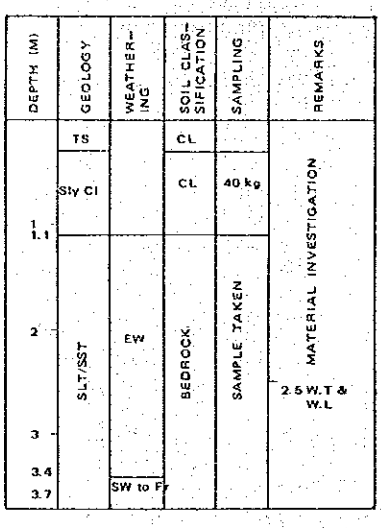
TEST PIT NO. BTP-2
ELEVATION 63.967



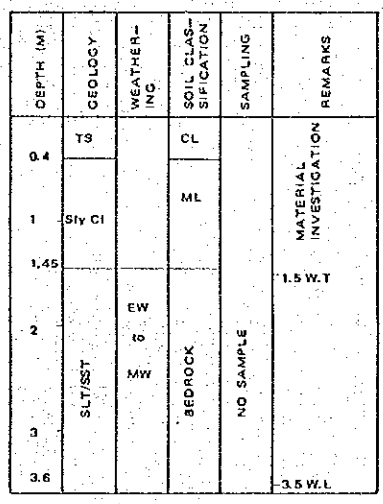
TEST PIT NO. BTP-3
ELEVATION 57.442



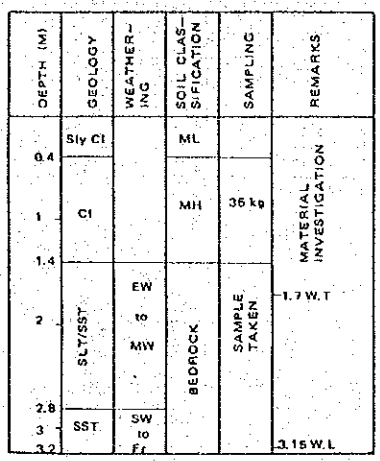
TEST PIT NO. BTP-4
ELEVATION 34.935



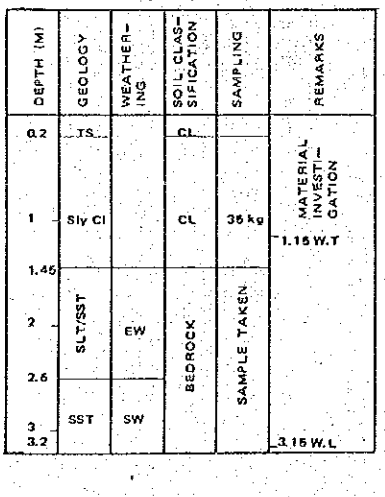
TEST PIT NO. BTP-5
ELEVATION 40.202



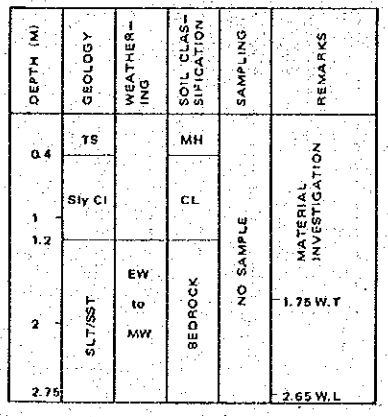
TEST PIT NO. BTP-6
ELEVATION 46.569



TEST PIT NO. BTP-7
ELEVATION 53.343



TEST PIT NO. BTP-8
ELEVATION 49.039



TEST PIT NO. BTP-9
ELEVATION 44.864

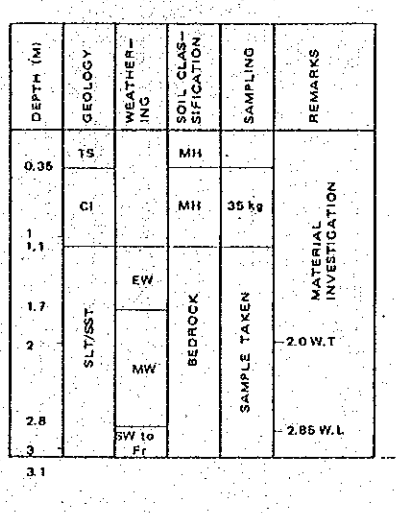


FIGURE C4-6 TEST PIT LOGGINGS AT BAYONGAN DAMSITE (4/4)

TEST PIT NO. BTP-10
ELEVATION 44.530

DEPTH (M)	GEOLOGY	WEATHERING	SOIL CLASSIF.	SAMPLING	REMARKS
0.3	T.S		MH		MATERIAL INVESTIGATION
1	Slv Cl		CL	35 x 8	
1.45					
2	SLT/SST	EW	BED ROCK	SAMPLE TAKEN	
2.4		MW			
2.9					
3	SLT	SW to Fr			
3.65					3.65 W.T W.L

TEST PIT NO. BTP-11
ELEVATION 38.833

DEPTH (M)	GEOLOGY	WEATHERING	SOIL CLASSIF.	SAMPLING	REMARKS
0.1	T.S		MH	NO SAMPLE	MATERIAL INVESTIGATION
1	Slv Cl		CL		
1.2					1.4 W.T
2	SLT/SST	EW	BED ROCK		
3		MW			
3.9					3.7 W.L

FIGURE C4-7 TEST PIT LOGGING OF BTP-1

Feature: Materials Investigation Project: Bohol Irrigation Project Hole No.: BTP-1
Area Designation: Bayongan Damsite Location: Right Abutment Ground El.: 63.507
Depth to Ground Water Level: 1.65 m Method of Excavation: Hand Dug Logged by: R. M. Puse
Approximate Dimension of Hole: 2m x 2m Date Excavated: Feb. 2-5, 1985

Size / Type of Sample Taken	Depth (Meter)	Legend	Visual Classification and Description of Material
	0		0.0 - 0.20 m: Silty Clay (OL) Top Soil Light brown in color with pebble sized fragments and organic matters, low to medium plasticity, firm
35 kg Feb. 8, 1985	1		0.20 - 1.20 m: Clay (CH) Yellowish brown in color with traces of grayish colored fragments, medium to high plasticity, silt and pebble sized materials noted, slightly wet in place
	2		1.20 - 3.30 m: Sandstone-Shale-Siltstone Interbeds Extensively to moderately weathered formation breaks at slight finger pressure, fissile when dry
	3		
	4		3.30 - 3.50 m: Fresh Bedrock to Slightly Weathered Formation
	5		
	6		Water Table --1.65 m Water Level --2.85 m Bottom Level--3.50 m
	7		Date Investigated: Feb. 8, 1985
	8		
	9		

FIGURE C4-8 TEST PIT LOGGING OF BTP-2

Feature: Materials Investigation Project: Bohol Irrigation Project Hole No.: BTP-2
Area Designation: Bayongan Damsite Location: Right Abutment Ground El.: 63.967
Depth to Ground Water Level: 1.60 m Method of Excavation: Hand Dug Logged by: R. M. Puse
Approximate Dimension of Hole: 2m x 2m Date Excavated: Feb. 2-5, 1985

Size / Type of Sample Taken	Depth (Meter)	Legend	Visual Classification and Description of Material
	0		0.0 - 0.35 m: Silty Clay (CL) Top Soil Slightly plastic, grayish to dark gray in color, organic materials presnet, gritty at feel due to pebble sized to sand sized fragments
Sample Taken 35 kg Feb. 8, 1985	1		
	2		0.35 - 1.45 m: Silty Clay (CL) Light brown to yellowish brown in color, slight to medium in plasticity with traces of weathered fragments of bedrock, slightly wet; below water table
	3		1.45 - 3.00 m: Weathered Sandstone-shale-siltstone Interbed Brownish in color to yellowish gray, layers still distinct, breaks at slight finger pressure, brittle when dry, moderately to extremely weathered interbeds
	4		
	5		3.00 - 3.10 m: Fresh Bedrock Fresh bedrock dark gray in color hard when dry
	6		
	7		Water Table --1.60 m Water Level --3.00 m Bottom Level--3.10 m Date Investigated: Feb. 8, 1985
	8		
	9		

FIGURE C4-9 TEST PIT LOGGING OF BTP-3

Feature: Materials Investigation Project: Bohol Irrigation Project Hole No.: BTP-3
Area Designation: Bayongan Damsite Location: Right Abutment Ground El.: 57.442
Depth of Ground Water Level: 1.65 m Method of Excavation: Hand Dug Logged by: R. M. Pus
Approximate Dimension of Hole: 2m x 2m Date Excavated: Feb. 2-5, 198

Size / Type of Sample Taken	Depth (Meter)	Legend	Visual Classification and Description of Material
	0		0.0 - 0.50 m: Silty Clay(CL) Top Soil Light brown to grayish in color with pebble sized materials and organic remnants present
35 kg	1		0.50 - 1.65 m: Clay/Silty Clay (CL) Light brown to yellowish in color, inclusions of cobble to angular sized fragments of shale, medium to high plasticity wet in place
	2		1.65 - 3.20 m: Extremely Weathered Formation Grayish in color, soft in place very wet, Brittle and easily breaks when dry, sandstone shale-siltstone interbeds
	3		
	4		3.20 - 3.50 m: Slightly Weathered Formation Grayish in color, moderately hard, fissility noted on excavated stockpile especially when dry
	5		
	6		Water Table --1.65 m Water Level --3.50 m Bottom Level--3.50 m
	7		Date Investigated: Feb. 8 1985
	8		
	9		

FIGURE C4-10 TEST PIT LOGGING OF BTP-4

Feature: Materials Investigation Project: Bohol Irrigation Project Hole No.: BTP-4
Area Designation: Bayongan Damsite Location: Left Abutment Ground El: 34.935
Depth to Ground Water Level: 2.50 m Method of Excavation: Hand Dug Logged by: R. M. Puse
Approximate Dimension of Hole: 2m x 2m Date Excavated: Feb. 2-5, 1985

Size / Type of Sample Taken	Depth (Meter)	Legend	Visual Classification and Description of Material
	0		0.0 - 0.30 m: Silty Clay (OL) Top Soil Light brown to brown in color, moderate plasticity pea sized materials and organic plant remnants notable.
40 kg Feb. 8, 1985	1		0.30 - 1.10 m: Silty Clay (CL) Yellowish brown in color, relics of former bedrock beddings still distinct as evidence of in situ weathering, slight to medium plasticity organic plant remains and roots present on section
	2		
	3		1.10 - 3.40 m: Extremely Weathered Interbeds Interbedded sandstone-shale-siltstone similating section of bedrock becomes moderately weathered on lower section, light brown in color, slightly plastic soft, breaks at slight pressure of band, brittle when dry
	4		
	5		3.40 - 3.70 m: Slightly weathered to Fresh Bedrock Dark gray in color, fissile when dry, very brittle
	6		
	7		Water Table--2.50 m Water Level--2.50 m
	8		Date Investigated: Feb. 8, 1985
	9		

FIGURE C4-11 TEST PIT LOGGING OF BTP-5

Feature: Materials Investigation Project: Bohol Irrigation Project Hole No.: BTP-5
Area Designation: Bayongan Damsite Location: Left Abutment Ground El.: 40.202
Depth to Ground Water Level: 1.50 m Method of Excavation: Hand Dug Logged by: R. M. Puse
Approximate Dimension of Hole: 2m x 2m Date Excavated: Feb. 1-3, 1985

Size / Type of Sample Taken	Depth (Meter)	Legend	Visual Classification and Description of Material
	0		0.0 - 0.40 m: Silty Clay(CL) Top Soil Silty in character with rough pebble sized materials, brown to dark brown in color, slightly plastic, plant remnants present
	1		0.40 - 1.45 m: Silty Clay (ML) Yellowish in color with grayish traces of former bedrock, inclusions of angular fragments of sedimentaries, slight to medium plasticity, sticky
	2		
	3		1.45 - 3.60 m: Extremely to Moderately Weathered Interbeds Sequence of sandstone, shale, siltstone, feels soft at hand pressure, brittle when dry, grayish in color, weathered materials sticky
	4		
	5		
	6		Water Table --1.50 m Water Level --3.50 m Bottom Level--3.60 m
	7		
	8		Date Investigated: Feb. 8, 1985
	9		

FIGURE C4-12 TEST PIT LOGGING OF BTP-6

Feature: Materials Investigations Project: Bohol Irrigation Project Hole No.: BTP-6
Area Designation: Bayongan Damsite Location: Left Abutment Ground El.: 46.569
Depth to Ground Water Level: 1.70 m Method at Excavation: Hand Dug Logged by: R. M. Puse
Approximate Dimension of Hole: 2m x 2m Date Excavated: Feb. 1-3, 1985

Size / Type of Sample Taken	Depth (Meter)	Legend	Visual Classification and Description of Material
	0		0.0 - 0.40 m: Silty Clay (ML) Dark brown in color, slight to medium plasticity, very sticky when wet, firm and dry in place
35 kg	1		
			0.40 - 1.40 m: Clay (MH) Yellowish in color, medium plasticity, sticky when wet, coverings of former bedrock noted
	2		
	3		
			1.40 - 2.80 m: Extremely to Moderately Weathered Interbed Grayish in color, soft when wet, brittle when dry
	4		
	5		2.80 - 3.20 m: Slightly Weathered to Fresh Bedrock Notably sandstone, hard, gray in color
	6		Water Table --1.70 m Water Level --3.15 m Bottom Level--3.20 m
	7		
	8		Date Investigated: Feb. 8, 1985
	9		

FIGURE C4-13 TEST PIT LOGGING OF BTP-7

Feature: Materials Investigation
Area Designation: Bayongan Damsite
Depth to Ground Water Level: 1.15 m
Approximate Dimension of Hole: 2m x 2m

Project: Bohol Irrigation Project
Location: Left Abutment
Method of Excavation: Hand Dug

Hole No.: BTP-7
Ground El.: 53.343
Logged by: R. M. Pus
Date Excavated: Feb. 1-3, 1985

Size / Type of Sample Taken	Depth (Meter)	Legend	Visual Classification and Description of Material
35 kg Feb. 2, 1985	0 – 1		0.0 - 0.20 m: Silty Clay (CL) Dark brown in color, thin top soil pea-sized materials and smaller fragments noted, firm and hard in place, sticky and slight to medium plasticity
	1 – 2		0.20 - 1.45 m: Silty Clay (CL) Product of in situ weathering of bedrock sedimentaries, light brown to yellowish brown in color, medium plasticity, very sticky when wet
	2 – 3		
	3 – 4		1.45 - 2.50 m: Extremely Weathered Interbeds Distinctive is extremely weathered siltstone, yellowish brown in color with angular sizes of fragments, soft when wet with slight plasticity
	4 – 5		2.50 - 3.20 m: Sandstone Slightly Weathered Slightly weathered, grayish to light gray in color, medium grained, easily breaks at hammer blow, medium hard when dry
	5 – 6		
	6 – 7		Water Table --1.15 m Water Level --3.15 m Bottom Level--3.20 m
	7 – 8		Date Investigated: Feb. 8, 1985
	8 – 9		

FIGURE C4-14 TEST PIT LOGGING OF BTP-8

Feature: Material Investigation Project: Bohol Irrigation Project Hole No.: BTP-8
Area Designation: Bayongan Damsite Location: Left Abutment Ground El.: 49.039
Depth to Ground Water Level: 1.75 m Method of Excavation: Hand Dug Logged by: R. M. Puse
Approximate Dimension: 2m x 2m Date Excavated: Feb. 1-3, 1985

Size / Type of Sample Taken	Depth (Meter)	Legend	Visual Classification and Description of Material
	0		0.0 - 0.40 m: Clay (MH) Dark brown in color slight to medium plasticity, organic roots of plants notable, firm and hard when dry, very sticky when wet, silt and larger fragments present
	1		
	2		0.40 - 1.20 m: Silty Clay (CL) Yellowish brown in color, remnants of former bedrock angular in shape, soft at finger pressure, slight to medium plasticity
	3		
	4		1.20 - 2.75 m: Moderately to Extremely Weathered Formation Interbed of sandstone-shale-siltstone, soft and sticky when wet
	5		
	6		Water Table --1.75 m Water Level --2.65 m Bottom Level--2.75 m
	7		
	8		Date Investigated: Feb. 8, 1985
	9		

FIGURE C4-15 TEST PIT LOGGING OF BTP-9

Feature: Material Investigation Project: Bohol Irrigation Project Hole No.: BTP-9
Area Designation: Bayongan Damsite Location: Right Abutment Ground El.: 44.864
Depth of Ground Water Level: 2.00 m Method of Excavation: Hand Dug Logged by: R. M. Puse
Approximate Dimension of Hole: 2m x 2m Date Excavated: Feb. 9-10, 1985

Size / Type of Sample Taken	Depth (Meter)	Legend	Visual Classification and Description of Material
	0		0.0 - 0.35 m: Clay (MH) Top Soil Light brown in color, silty and pebbly in character, medium plasticity, very sticky when wet, firm and hard in place when dry
35 kg Feb. 11, 1985	1		
	2		0.35 - 1.10 m: Clay (MH) Yellowish brown in color, angular materials notable, very soft, medium plasticity, coverings of former bedrock noted
	3		1.10 - 1.70 m: Extremely Weathered Formation Similating interbed, slightly plastic very soft, distinctively shall almost flat lying
	4		
	5		1.70 - 2.80 m: Moderately Weathered Formation Soft to slightly hard, fragments when very dry becomes brittle at hand pressure, light gray in color--notably sandstone/siltstone
	6		2.80 - 3.10 m: Slightly Weathered to Fresh Bedrock
	7		Water Table --2.00 m Water Level --2.85 m Bottom Level--3.10 m
	8		Date Investigated: Feb. 11, 1985
	9		

FIGURE C4-16 TEST PIT LOGGING OF BTP-10

Feature: Material Investigation Project: Bohol Irrigation Project Hole No.: BTP-10
Area Designation: Bayongan Damsite Location: Right Abutment Ground El.: 44.530
Depth to Ground Water Level: 3.65 m Method of Excavation: Hand Dug Logged by: R. M. Puse
Approximate Dimension of Hole: 2m x 2m Date Excavated: Feb. 9-10, 1985

Size / Type of Sample Taken	Depth (Meter)	Legend	Visual Classification and Description of Material
	0		0.0 - 0.30 m: Clay (MH) Top Soil Light brown in color, moderate to high plasticity, very sticky when wet, slight to medium crushing strength when dry, organic remnants present
35 kg Feb. 11, 1985	1		0.30 - 1.45 m: Silty Clay (CL) Moderate to high plasticity noted yellowish brown in color, less fragments noted, traces of former beddings distingwishable
	2		
	3		1.45 - 2.40 m: Extremely Weathered Interbeds Soft, brittle and breaks at slight finger pressure, yellowish to grayish in color, slightly plastic and sticky
	4		
	5		2.40 - 2.90 m: Moderately Weathered Formation Yellowish to gray in color, bedding distinctive
	6		2.90 - 3.65 m: Slightly Weathered to Fresh Bedrock Gray in color, hard, distinctively siltone
	7		
	8		Water Table--3.65 m Water Level--3.65 m Date Investigated: Feb. 11, 1985
	9		

FIGURE C4-17 TEST PIT LOGGING OF BTP-11

Feature: Material Investigation Project: Bohol Irrigation Project Hole No.: BTP-11
Area Designation: Bayongan Damsite Location: Right Abutment Ground El.: 38.833
Depth to Ground Water Level: 2.25 m Method of Excavation: Hand Dug Logged by: R. M. Puse
Approximate Dimension of Hole: 2m x 2m Date Excavated: Feb. 9-10, 1985

Size / Type of Sample Taken	Depth (Meter)	Legend	Visual Classification and Description of Material
	0		0.0 - 0.10 m: Clay (MH) Top Soil Light brown in color, high plasticity when wet, very sticky at hand, pebble sized fragments mixed in section
	1		0.10 - 1.20 m: Silty Clay (CL) Moderately plastic, yellowish brown in color, inclusions of angular fragments noted from uncomplete weathering of beddings, slight to medium plasticity
	2		
	3		1.20 - 2.55 m: Extremely weathered Siltstone/Sandstone Beddings similating to soil, soft, slightly plastic when wet, sticky, almost flat lying
	4		2.55 - 3.90 m: Moderately Weathered Siltstone/ Sandstone Bedding distinct, soft, grayish in color, brittle when dry, slightly hard
	5		
	6		
	7		Water Table --1.40 m Water Level --3.70 m Bottom Level--3.90 m Date Investigated: Feb. 11, 1985
	8		
	9		

shown in FIGURE C4-6 to 17. 14 test pits have been carried out in Phase I Project, and 11 test pits have been completed by this Study Team. The test pit excavations result in the encounter of fresh or slightly weathered base rock at 2 to 4 meters below the ground surface.

4.1.5 Foundation of Facilities

a) Spillway

The spillway is proposed to be founded on the right abutment of the dam axis. According to the result of the existing test pits conducted and drill hole data, the average thickness of soil including the weathered portion of the bedrock is approximately 3 to 4 meters. These figures are assumed to be deeper on the downslope of the spillway line since weathering extends deeper on more gradual slopes. Though these overburden layer and weathered rock zone have some question points concerning bearing capacity, but fresh rock of the alternating beds of siltstone and sandstone has a good quality for the foundation of spillway.

b) Intake Facility

Drilling exploration (BDH-1) on the proposed the intake facility has been conducted to determine the extent of weathering and the engineering properties of the foundation at greater depths.

According to the result of BDH-1, the foundation of the intake facility at the elevation of about 35 m is fresh rock of the alternating bed of siltstone and sandstone and is formed with a consolidated rock.

4.2 Capayas Dam

4.2.1 Topography

The proposed Capayas damsite is located at about 6 km southwest of Ubay Poblacion in the northern part of Bohol Island. The damsite is situated at the upstream of the Bayang river, a tributary of the Soon river.

The river has water resources in the vicinity of southeastern part of dam site, which is one mountain of EL 425 m. The river traverses the dam site toward northwest and joins the Soon river at about 5.5 km downstream from the dam site in the vicinity of Tubog and then after the river flows about 7.5 km, it flows into the Camotes Sea in the vicinity of Mandawa. The river length is about 18 km. The river bed elevation is about 21 m above MSL at the dam site and its gradient is about 1/150.

The Capayas reservoir area is surrounded by hills with elevation of tophills of about less than 100 m, but the catchment area of 13.1 sq.km is surrounded by mountain area with the elevation more than 100 m and up to 425 m. The feature of the abutment at the dam site shows low and gentle hills which are 10 to 20 meters in height from the river bed. The topography of the damsite is formed with the river section having the narrow width of about 20 m at the elevation of 21 m and with both banks having a long distance of about 600 m respectively.

The slope of abutment is approximately one to twenty. The cord-height rate of the dam site at EL 35 m is about one to fourty.

4.2.2 Geology

The foundation at the Capayas dam site is composed of sedimentary rock of Ilihan formation and the reservoir area consists of Malibalibod Volcanic Andesite and Aglomerate in the geological stratigraphy. The volcanic rock of Malibalibod Volcanics unconformably overlies the Ilihan formation and predominates in the high land. The sedimentary rock forms hills less than about EL 40 m, but on the other hand the volcanic rocks makes hills more than about EL 60 m.

The contact of these rocks is located in about 600 m on the upstream of the dam site, where the dip and strike of sedimentary rock shows almost N 10°E, 20°NW.

The base rock is mainly composed of siltstone with the alternating beds of siltstone, mudstone, sandstone and conglomerate. But there is

a predominant conglomerate zone at about 300 m on the upstream of the dam site up to the contact of volcanic rocks.

The base rock forming the foundation of dam body is almost fresh and massive, even if it is called one of soft rocks with assumed unconfined compression strength of less than 100 km/cm^2.

The foundation rock mentioned above has no problem on the construction of fill type dam. It has a good bearing capacity and water tightness for less than 20 m dam in height from an engineering and geological point of view.

The geological map and the location map at the dam site and the reservoir is shown in FIGURE C4-18 and that explanation is shown in TABLE C4-6.

4.2.3 Boring Investigation

The boring investigation has been conducted at the proposed Capayas dam site to confirm the geological foundation condition as listed up in TABLE C4-7. And the bore hold loggings are shown in FIGURE C4-19.

The brief description at each item of boring investigation is as follows;

a) Core-boring

The boring of 3 holes have been completed by this Study Team. According to the result of boring investigation along the dam axis, the dam foundation is mainly composed of soft sedimentaly rocks consisting of alternation of siltstone, mudstone, sandstone and conglomerate. From the dip and strike of the base rock at the damsite, the base rock along the dam axis is considered to incline toward left abutment very gently and that conglomerate of CDH-2 and CDH-3 is the same layer. On the basis of core-boring results, it is summarized as follows;

The foundation at the dam site is formed with a consolidated rock formation which presents 80 to 100 % core-recovery and 30 to 90 % R.Q.D. The overburden or weathered layer to be removed in dam construction is lying with thin layer of 3 to 5 m below ground surface. Weathered rock layer is corresponding with D to CL class but fresh rock belongs to CM class.
The geological profile along dam axis is shown in FIGURE C4-20.

b) Water Pressure Test

The results of water pressure tests are shown in TABLE C4-8. According to the results of CDH-2, depth of more than 9 meters is less than 10 Lugeon value, and mainly less than 5 Lugeon value. But another bore holes (CDH-1, CDH-3) indicate more than 10 Lugeon value. This results might be suggested that water shall leak from the part of the packer and then from gravely clay and weathered rock. Fresh rock shall indicate impervious layer the same as results of CDH-2. But as the surface of base rock shall indicate semipervious to pervious, the foundation treatment shall be necessary.

In the case of the foundation treatment, it shall be able to prolong the seepage length by setting up the spoiled blanket burying to some degree the river bank at the upstream of dam body instead of grouting works. Because grouting works will become high cost, as the core trench has a long distance.

4.2.4 Test Pit Excavation

Test pits are excavated at the dam site. That test pits are listed up in TABLE C4-9 and the test pit loggings are shown in FIGURE C4-21 to 27. The test pit excavations result in the encounter of fresh rock or slightly weathered base rock at 2 to more than 3 meters below the ground surface.

4.2.5 Foundation of Facilities

a) Spillway

The spillway is provided at the left bank. The base rock is mainly composed of soft sedimentary rocks and the overburden or weathered layer shall be lying with thin layer of 3 to 5 m below ground surface as same as dam axis.

b) Intake Facility

The intake facility is provided at the right bank of the Bayang river.

According to the result of CDH-2, the foundation of the intake facility is composed of fresh rock consisting of alteration of siltstone and sandstone.

TABLE C4-6 EXPLANATION OF GEOLOGICAL MAP AT CAPAYAS DAMSITE (1/5)

No.of Outcrop	Rock Type	Explanation
(1)	Cong [1/] overlying An [2/]	Cong is flat fedded, consists of pebble to cobble clasts cemented by lime, sub-rounded to sub-angular to rounded, medium hard to hard, massive, An is closely fractured and jointed but hard and fresh
(2)	Cong	Strike and dip; N45°E, 10°NW, same as (1)
(3)	Ag [3/]	Angular clasts, all An, size ranges from cobbles to Pebbles in a voecanic matrix, massive, contact between Ag and Cong may be an unconformity.
(4)	An	30 meters upstream is a heavily fractured An, About 5 meters more upstream, rock changes to Ag with andesitic matrix, fragments are small (1 to 10cm across), angular and fractured
(5)	Cong-Ag contact	At the river bend big limestone is inclused into Cong which overlies Ag, contact is clear, Cong is lighter in color because of the cementing material is lime, it has a more rounded and varied clasts as

Note: 1/: Conglomerate
2/: Andesite
3/: Agglomerate

TABLE C4-6 EXPLANATION OF GEOLOGICAL MAP AT CAPAYAS DAMSITE (2/5)

No. of Outcrop	Rock Type	Explanation
		compared with Ag which has angular An fragments cemented by the same andesitic matrix, Cong has also bigger size of clasts
(6)	An	Tight fractures, grayish in color, fresh
(7)	SST[1/]-Cong	SST overlying Cong, about one meter thick, N45°E, 18°NW, Terrace deposit of one meter thick is present on both abutment, limy matri
(8)	Sandy Cong-SLT [2/]	N45°E, 30°NW, downstream near the water on the left abutment is SLT.
(9)	SLT	About 1.5m thick, with some thin SST layers overlain by extremely weathered SLT and SST about 2m thick, N60°E, 20°NW
(10)	An	Closely fractured, fracturing no definite direction
(11)	Cong	Located at the intersection of creek/ gully
(12)	SLT/SST	N45°E, 25°NW
(13)	SLT/SST/Cong	Thickness approximately one meter, N25°E, 30°NW
(14)	SLT/SST/Cong	Thin SST layer in 1.5 m thick SLT, N16°E, 15°NW
(15)	SLT/SST	Founded near the road, SLT on top then SST, both overlain by a soil layer about 1.5 m thick, SLT two meter thick, SST 50 cm thick, N10°E, 18°NW

Note: 1/ : Sandstone
2/ : Siltstone

TABLE C4-6 EXPLANATION OF GEOLOGICAL MAP AT CAPAYAS DAMSITE (3/5)

No. of Outcrop	Rock Type	Explanation
(16)	SLT	Same as (15), SLT becoming predominant, N10°E, 15°NW
(17)	SST-Cong-SLT	SST underlain by Cong and overlain by SLT, NS, 10°NW
(18)	SLT/SST	Predominance of SLT and SST, former overlain by gravely soil (Terrace deposit), N30°E, 18°NW.
(19)	SLT/SST	Predominance of SLT, thickness of SST 10 to 20 cm, same attitude as (18)
(20)	SST-SLT	SST on creek bed overlain by SLT
(21)	SLT/SST	About 3 m thick, interbed on the left abutment, thickness of SST about 5 to 10 cm, while SLT is about 10 to 20 cm, SST is generally medium hard while SLT is slightly hard to soft, general strike and dip; NS, 25°W
	River deposit	Consists of varied sizes of different rock types, boulders as big as 1 m across is present, silty matrix
(22)	Cong/SLT/SST	Matrix of Cong is lime, Cong 5 m thick, SST 3.0 m, Limestone and Cong 50 cm, N10°E, 25°NW, joints; N40°W, vertical, parallel to one another, interval about 1 m, 10 joints all in all
(23)	Cong/SLT/SST	Cong has silty and sandy matrix, includes big boulders of SST-about 50 cm across, N5°E, 45°NW, Steep dip may be due to volcanic influence, no appreciable joints
(24)	Cong	

TABLE C4-6 EXPLANATION OC GEOLOGICAL MAP AT CAPAYAS DAMSITE (4/5)

No.of Outcrop	Rock Type	Explanation
(25)	Cong-SST	Overlying Cong is SST of about 1 m thick, N10°E, 20°NW
(26)	Cong-SST-SLT	
(27)	SLT/SST	NS, 20 to 25 NW, thicker SST beds about 1 m, SLT still more predominant, noted also one thin bed of Cong on left abutment, about 30 cm thick
(28)	Cong-SLT/SST	Cong 1 m thick, SLT-SST 15 m, SST about 25 % only, maximum thickness 25 cm, maximum thickness of SLT 30 cm, rocks overlain by terrace gravel of about 1.5 m thick, N10°E, 22°NW
(29)	SLT/SST	
(30)	Cong	3 m thick
(31)	SLT/SST	N10°E, 22°NW
(32)	SLT	
(33)	Cong/SLT/SST	N5°E, 20°NW
(34)	Cong/SLT/SST	Cong is 2 m thick, SLT is predomimant
(35)	SLT/SST	N20°E, 20°NW
(36)	Cong/SST	Cong 2 m thick, SST about 1.5 m overlies Cong, terrace deposit about 3 m, N20°E, 18°NW
(37)	Limestone Cong boulders	Boulders about 3 m across, indicates near by contact, may be a little upstream of volcanic rock and sedimentary rock, also noted on left bank not far from hear (about 10 m), preponderance of limestone Cong rocks about 5 m across

TABLE C4-6 EXPLANATION OF GEOLOGICAL MAP AT CAPAYAS DAMSITE (5/5)

No. of Outcrop	Rock Type	Explanation
(38)	An	
(39)	Contact of Cong-SST and An	Near contact of sedimentary rocks and volcanic rocks
(40)	Cong	Pebbles and small gravel size
(41)	SLT/SST	
(42)	Cong	with some SST and SLT

TABLE C4-7 LIST OF BORE HOLES AT CAPAYAS DAM SITE

Borehole Number	Date Started	Date Completed	Contractor	Purpose	Depth (m)	Location	Elev. (m)	Geology	Test in Borehole WPT
CDH-1	Feb. 28, 1985	Feb. 29, 1985	NIA	Foundation Study on Dam Axis	18.0	Dam Axis, L.A. 1/	33.07	SLT/SST	5
CDH-2	Mar. 7, 1985	Mar. 9, 1985	"	"	30.0	Dam Axis; Intake	28.00	SLT/SST /Cong	8
CDH-3	Mar. 3, 1985	Mar. 4, 1985	"	"	15.0	Dam Axis, R.A. 2/	34.98	SLT/SST /Cong	4
Total BH 3					63.0				17

Note; 1/ Left Abutment
2/ Right Abutment

TABLE C4-8 RESULT OF WATER PRESSURE TESTS

No	Interval (m)	Pressure (kg/km^2)	Lugeon Value	Geology
CDH-1	3.0 to 6.0			SLT/SST
	6.0 to 9.0			"
	9.0 to 12.0			"
	12.0 to 15.0			"
	15.0 to 18.0			"
CDH-2	6.0 to 9.0	1.53	42.3	SLT/SST
	9.0 to 12.0	1.53	7.2	"
	12.0 to 15.0	1.53	2.7	"
	15.0 to 18.0	1.53	1.2	SST, Cong
	18.0 to 21.0	1.53	1.0	Cong
	21.0 to 24.0	1.53	1.1	SLT/SST/Cong
	24.0 to 27.0	1.53	0.3	"
	27.0 to 30.0	1.53	1.5	"
CDH-3	3.0 to 6.0	1.51	76.1	SLT/SST/Cong
	6.0 to 9.0	1.51	70.2	"
	9.0 to 12.0	1.51	49.6	"
	12.0 to 15.0	1.51	12.8	"

TABLE C4-9 LIST OF TEST PITS AT CAPAYAS DAM SITE

Test Pit Number	Date Started	Date Completed	Contractor	Purpose	Depth (m)	Location	Elev. (m)	Geology	Sampling	Test on Soils Samples
CTP-1	Feb.1,1985	Feb.3,1985	NIA	Foundation and Material Investigation	2.45	Left Abutment		Gravelly Clay,SLT/ SST	-	-
CTP-2	Feb.1,1985	Feb.3,1985	"	"	2.40	"		Siltyclay/ Clay,SLT	Disturbed Samples	Laboratory Test
CTP-3	Feb.1,1985	Feb.3,1985	"	"	1.20	"		Clay/ Siltyclay, SST	"	"
CTP-4	Feb.1,1985	Feb.3,1985	"	"	3.70	Right Abutment		Clay/ Siltyclay, SST/SLT	"	"
CTP-5	Feb.1,1985	Feb.3,1985	"	"	2.90	"		Clay/ Gravelly Clay, SLT	"	"
CTP-6	Feb.1,1985	Feb.3,1985	"	"	3.30	"		Clay/ Siltyclay, SLT	-	-

FIGURE C4-18 GEOLOGY AND INVESTIGATION LOCATION MAP AT CAPAYAS DAMSITE AND RESERVOIR AREA

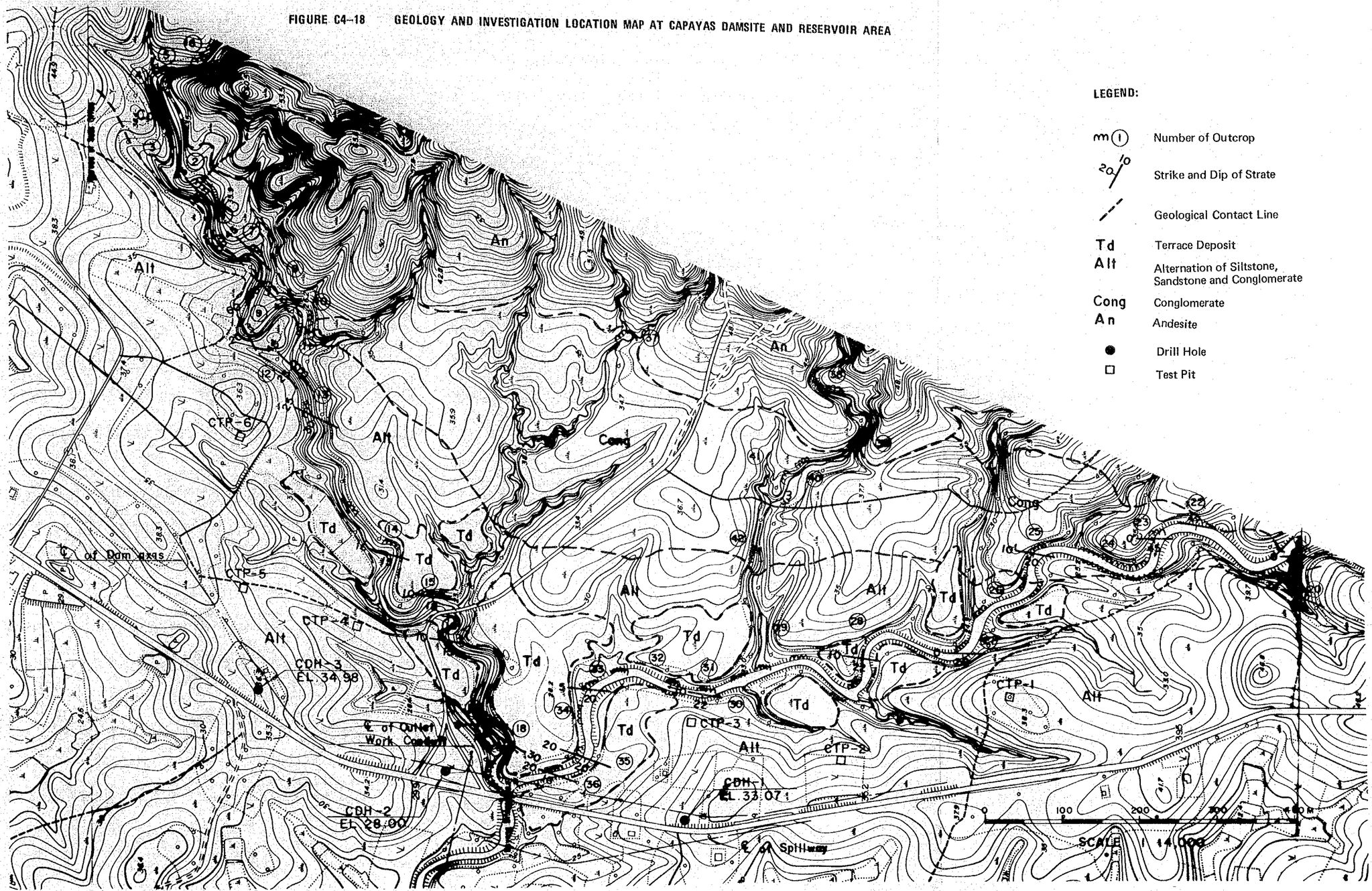


FIGURE C4–18 GEOLOGY AND INVESTIGATION LOCATION MAP AT CAPAYAS DAMSITE AND RESERVOIR AREA

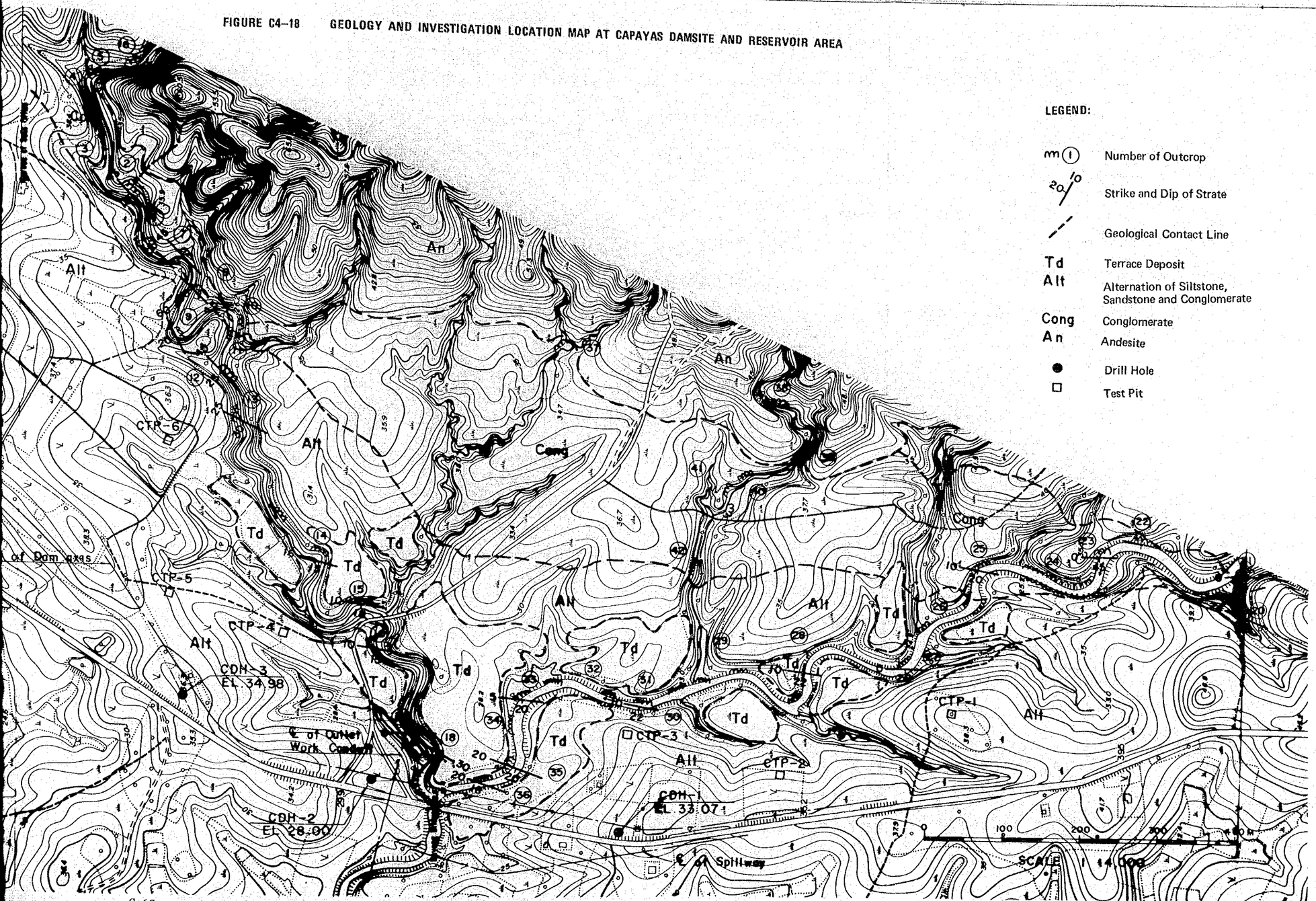


FIGURE C4–19 BOREHOLE LOGGINGS AT CAPAYAS DAMSITE