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REPORT

RESULTS OF GEOLOGIC, GEOTECHNICAL, AND
HYDROLOGIC INVESTIGATIONS OF A PORTION
OF THE PROPOSED EXPLORATION RAMP,
CRANDON MINE

FOR EXXON COMPANY, U.S.A.

Dames & Moore
August 10, 1977
Job No. 8837-058-07

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RESULTS OF GEOLOGIC, GEOTECHNICAL, AND
HYDROLOGIC INVESTIGATIONS OF A PORTION
OF THE PROPOSED EXPLORATION RAMP, CRANDON MINE

INTRODUCTION

This report presents the results of Dames & Moore's investigation along the axis of the exploration ramp as requested by Mr. Robert Russell, Exxon Company, U.S.A. The scope of work is in accordance with our proposal dated May 13, 1977 and as modified by Mr. Mel Lawson and Mr. Frank Sonderman, Exxon Company, U.S.A. The modifications are described in our revised proposals dated June 22 and July 11, 1977.

PURPOSE

The specific purposes of this investigation were as follows:

1. Perform a general geologic investigation in the glacial drift and the bedrock along the planned axis of the exploration ramp. Major emphasis was placed on the surficial glacial drift with minor emphasis on identification of fracture and fault zones, and delineation of the top of unweathered bedrock. Exxon Company, USA assumed the lead in the evaluation of the bedrock geology and therefore, this report does not address that aspect in great detail;
2. Provide a conceptual design and cost appraisal of a system to dewater the glacial drift for the construction of the exploration ramp; and
3. Provide a general recommendation for the configuration of the excavation slope.

SCOPE OF WORK

The results of this investigation were achieved through field, office, and laboratory investigations described below:

1. Field Investigation - Borings were drilled at nine locations (Figure 1). All the borings (DMI-1, 2, 3, 4, 5, 7, 8, 9, and 11) were drilled into bedrock at varying depths. Soil samples were taken in the glacial overburden materials for geologic classification and laboratory testing. Upon penetrating the bedrock, rock coring techniques were employed to obtain a continuous sample of the bedrock. The depths of the soil samples and rock cores, geologic descriptions, and pertinent engineering data are presented on the boring logs in Appendix A. In addition, piezometers were installed at three locations in two borings (DMI-1 and DMI-2). The locations and design of the piezometers are shown in Table A-1 and on Figure A-1 in Appendix A, respectively.
2. Laboratory Investigation - The laboratory investigation consisted of performing sieve and hydrometer analyses on selected samples to determine the grain-size distribution of the glacial overburden materials to aid in geologic classification and to allow an approximation of soil permeability. The results of the grain-size analyses are presented in Appendix B. The calculated permeabilities are tabulated in Table 1. Direct shear tests were performed on selected samples as part of the slope stability appraisal. The results of the direct shear tests are presented on the boring logs in Appendix A (Borings DMI-1 and 9).
3. Office Engineering - The office investigation consisted of preparing the conceptual dewatering design, performing the stable slope analysis, summarizing the geologic data collected during the field drilling investigation, and report preparation.

SITE CONDITIONS

TOPOGRAPHY

The topography in the Crandon area is typical of glaciated areas consisting of elongated ridges and knobby hills separated by relatively broad stream valleys which are generally occupied by wetland areas. Maximum relief in the general vicinity of the proposed exploration ramp is approximately 100 feet. Along the axis of the proposed excavation

through the glacial materials, the topography varies from approximately 1610 feet (MSL) to elevations greater than 1645 feet (MSL). The area west of the exploration ramp is an upland area while the area east of the ramp is a wetland area associated with the drainage system from Skunk Lake to Little Sand Lake.

GEOLOGY

The unconsolidated deposits that overlie the volcanic bedrock in the ramp vicinity consist of glacial materials ranging in thickness from about 54 to 99 feet. Generally, the overburden can be classified as glacial outwash deposits consisting of sand and gravel with local concentrations of silt, cobbles, and boulders. The geologic materials underlying the glacial deposits in the ramp vicinity consist of Precambrian volcanic tuff which has been subjected to strong chemical weathering and has been altered in-situ to a saprolite consisting of red silty clay. The degree of weathering decreases with depth and the saprolite grades rapidly to strongly weathered volcanic tuff bedrock.

The locations of Geohydrologic Cross-sections presented in this report are shown on Figures 1 and 2. Geohydrologic Cross-sections A-A' (Figure 3) and C-C' (Figure 5) were constructed as part of previous studies by Dames & Moore (Reference 1, Bibliography).

The geologic data obtained from the borings drilled during this investigation were used in conjunction with the laboratory permeability data to construct Geohydrologic Cross-section B-B' which is shown on Figure 4. The lithologies of the glacial materials on the Geohydrologic Cross-section B-B' were simplified for clarity of presentation, and the units presented are distinguished according to geohydrologic criteria to delineate the major

units of interest in the glacial overburden. Geohydrologic Zone I was delineated as two deposits consisting primarily of silty sand with local concentrations of gravel, cobbles, and boulders. The upper zone constitutes the major surficial deposit along the ramp axis. The zone is continuous along the entire ramp axis and ranges in thickness from 3 to 12 feet. The lower zone is present in borings DMI-2, 4, 5, 7, and 8. This zone occurs as the basal deposit of the glacial drift in these borings and immediately overlies the Precambrian bedrock system. The permeability of this lower zone is low relative to other zones present in the ramp area, with values ranging from 10^{-3} to 10^{-5} cm/sec. The permeability of this zone was based on visual inspection of the soil material and comparison with other materials present in the subsurface along the ramp axis. It should be noted that permeabilities were not calculated for the upper unit of Geohydrologic Zone I.

Geohydrologic Zone II underlies the upper unit of Geohydrologic Zone I and consists primarily of outwash deposits of interbedded clean fine to coarse and fine to medium sand with zones of gravel and cobbles occurring locally. This zone is continuous along the entire ramp axis and ranges in thickness from about 8 to 42 feet. The permeability of this zone generally ranges from 10^{-2} to 10^{-3} cm/sec.

The major zone of interest from a geohydrologic standpoint is Geohydrologic Zone III. The ground water table is present in this zone approximately 50 feet below ground surface; therefore, this zone will require dewatering to allow construction of the exploration ramp. This zone consists primarily of fine to coarse sand and fine to coarse gravel with numerous cobbles and boulders. Geohydrologic Zone III is continuous along the entire ramp axis and ranges in thickness from about 14 to 65 feet. Permeabilities around boring DMI-8, where the zone is silty, generally average

about 10^{-3} cm/sec. The permeability of Geohydrologic Zone III generally averages 10^{-2} cm/sec along the ramp axis from boring DMI-7 to DMI-9.

As previously mentioned, the bedrock along the ramp axis consists primarily of Precambrian volcanic tuff. The bedrock surface along the ramp axis is shown on Geohydrologic Cross-section B-B' (Figure 4). The bedrock surface was generally defined during the field investigation as the point where the Dames & Moore soil sampler (diagram in Appendix A, Figure A-3) could not be driven and rock coring techniques were required to obtain samples of the geologic material. The bedrock surface along the ramp axis may control the topographic high extending from boring DMI-4 to DMI-9. As per the bedrock contour maps provided by Exxon Company, USA, the center of the bedrock high is several hundred feet northwest of the leg of the ramp defined by borings DMI-9 through DMI-4.

The structural features present in the volcanic bedrock along the ramp axis were delineated and described primarily by Exxon Company, USA. The major fault and fracture zones as identified by Exxon are shown on the Geohydrologic Cross-section B-B' (Figure 4). Complete detailed logs of the borings in the bedrock are presented in Appendix A. The information presented on these logs represents a compilation of the boring logs of the bedrock prepared by Exxon, and the logs of the overburden prepared in the field by the Dames & Moore engineer who supervised the boring program. In addition, the bedrock log compiled by Exxon, as well as brief discussions of each boring, are presented in Appendix C.

GROUND WATER HYDROLOGY

The geohydrologic setting in the vicinity of the exploration ramp consists of an unconfined sand and gravel aquifer. The ground water table

occurs in Geohydrologic Zone III at approximately elevation 1588 feet (MSL) or about 49 feet below ground surface (based on July 12, 1977 water level measurements in piezometers installed in boring DMI-2). Therefore, the saturated thickness of the glacial drift along the ramp axis ranges from about 10 feet at boring DMI-9 to approximately 36 feet at boring DMI-8. Water level measurements made in April 1977 (Reference 1) in boring DW-2U (Figure 2) showed the elevation slightly higher at about 1590 feet (MSL). Therefore, the saturated thickness of the glacial drift in April was about 12 feet at boring DMI-9 to about 38 feet at boring DMI-8. The saturated thickness of the glacial drift in the area to be excavated is shown on Figure 6. The saturated thickness shown was derived by contouring the difference in elevation between the top of the Precambrian system and the ground water table elevation of 1588 ft (MSL). As shown, approximately 10 feet of saturated glacial drift will require dewatering to provide a reasonably dry excavation.

During previous studies by Dames & Moore (Reference 1) in the general vicinity of the exploration ramp, Geohydrologic Zones II and III were mapped as a single aquifer Upper Aquifer (Figures 3 and 5). These studies showed that this aquifer is apparently artesian east of the exploration ramp. Figures 3 and 5 also show that the aquifer is not saturated west of the exploration ramp; therefore, no ground water flow occurs in this area.

Geohydrologic Cross-section C-C' (Figure 5) shows the aquifer pinching out north of the exploration ramp between borings DMA-12 and DMA-31. Therefore, the aquifer is apparently bordered on the west by a no-flow boundary and on the north by a barrier boundary. As also shown on Figure 5, the aquifer is continuous and saturated generally south of the exploration ramp in the direction of Little Sand Lake.

AQUIFER PARAMETERS

As discussed in the preceding section, the sand and gravel aquifer system in the general vicinity of the exploration ramp is under both water table and artesian conditions. As part of the previous study (Reference 1), pumping tests were conducted in Test Well 1 (TW-1) east of the exploration ramp (Figure 2). The aquifer in this area is artesian. The pumping test indicated that the aquifer transmissivity averages about 50,000 gallons per day per foot of aquifer (gpd/ft). The thickness of the aquifer around TW-1 is about 50 feet, indicating a permeability of about 1,000 gallons per day per square foot of aquifer. The coefficient of storage was calculated to be about 2×10^{-4} .

In the immediate vicinity of boring DMI-9 where the bedrock is topographically high, the aquifer is under water table conditions and the saturated thickness of the aquifer is about 10 feet. The transmissivity is calculated to be about 10,000 gpd/ft, using the permeability of 1,000 gpd/ft² determined from the pumping test on TW-1. As the saturated portion of the aquifer increases in thickness away from DMI-9 (and away from the bedrock high), the transmissivity would increase in direct proportion to the saturated thickness, assuming a constant permeability of 1,000 gpd/ft². Consequently, the maximum transmissivity within the boundaries of the exploration ramp is approximately 28,000 gpd/ft. The coefficient of storage under water table conditions is higher than that for artesian conditions and is roughly equivalent to the effective porosity of the aquifer material. Therefore, the coefficient of storage is estimated to be about 0.20 in the immediate vicinity of the exploration ramp.

As mentioned previously, particle size analyses (sieve and hydrometer analyses) were conducted on selected samples (Appendix B). Using the results

of the particle size analyses, coefficients of permeability were calculated using the Hazen Approximation (Table 1). The calculated permeabilities in Geohydrologic Zone II and III range from 120 gpd/ft² to 1900 gpd/ft², and are considered to compare favorably with the permeability of 1000 gpd/ft as determined from the pumping test on TW-1.

SURFACE WATER - GROUND WATER RELATIONSHIPS

The main surface water bodies in the exploration ramp area (Figure 2) are Little Sand Lake and Skunk Lake. Little Sand Lake is located immediately south of the site and at its northern-most point is about 2,000 feet from the ramp excavation. Skunk Lake is 1,200 feet northeast of the exploration ramp.

Surface water-ground water relationships in the site vicinity are somewhat complex and variable. The lakes in the site vicinity appear to be related to the overall ground-surface water regime to some degree. The water surface elevation of Little Sand Lake was about 1,591 feet above sea level (MSL) during May 1977. Ground water elevations northeast and north of the lake were (April 1977) between 1,588 and 1,590 feet MSL at piezometers DMA-10 and DW-2U, respectively. The water level in piezometer DMA-10, located south of Little Sand Lake, was about 10 or more feet^t below lake level. These data indicated that Little Sand Lake may slowly feed^d the ground water regime. Ground water elevations near Skunk Lake were lower than the lake level, indicating that these lakes are not directly connected to the underlying aquifers.

It is likely that the materials underlying the lakes near the site are low permeability deposits of silt, fine sand, and till, and the interconnection between these lakes and the ground water regime is mostly by

slow movement through these confining beds.

CONCEPTUAL DEWATERING SYSTEM

The purpose of the dewatering system described herein is to provide a reasonably dry excavation to allow construction of the exploration ramp down to the bedrock. The preliminary configuration of the planned excavation is shown on Figure 7. The configuration considers the general exploration ramp design provided Dames & Moore by Exxon Company, USA, the area required for installation of an effective dewatering system, and the slope stability requirements which will be discussed later in this report. With respect to these factors, the resulting excavation will be about 625 feet long and have a maximum width of 339 feet. The pit is expected to range from about 55 feet to 60 feet in depth, depending upon the thickness of the glacial drift overburden.

DEWATERING SYSTEM DESIGN

In order to construct the exploration ramp, it will be necessary to dewater the saturated glacial drift in the ramp area. The quantities of ground water which will have to be pumped from the excavation were determined by using standard techniques of ground water analysis, as follows:

- (1) Theis non-equilibrium well formula;
- (2) Theim equation of steady flow to a well;
- (3) Direct application of Darcy's Law; and
- (4) Determination of specific capacity of the excavation using the Theis non-equilibrium well formula.

In all four methods, the excavation was assumed to be a fully penetrating, circular well with a diameter of 300 feet. Aquifer coefficients

were based on the data presented in Table 2 and were as follows:

Permeability (gpd/ft ²)	1,000
Transmissivity (gpd/ft)	20,000 (average)
Storage Coefficient	0.05 (average)
Saturated Thickness of Aquifer (feet)	20

The optimum pumping rates calculated^d using the four listed methods were 300, 350, 450, and 425 gpm (gallons per minute), respectively; or 432,000, 504,000, 648,000 and 612,000 gpd (gallons per day), respectively. Therefore, the required pumping rate to maintain a dry excavation is expected to range between 300 and 450 gpm. These pumping rates will result in a ground water flow rate to the line of well points ranging from 0.30 to 0.46 gpm/linear feet of perimeter. These values compare favorably with published average values (Corps of Engineers, 1971) of about 0.1 to 1 gpm/linear foot of perimeter for ground water flow to a line of well points for similar soil materials and equivalent lowering of the ground-water table. Based on the Theis non-equilibrium equation, the optimum pumping schedule appears to be 400 gpm for the first 10 days of pumping and 300 gpm thereafter.

RECOMMENDED CONCEPTUAL DEWATERING SYSTEM

It is our opinion that the most cost effective and efficient system for dewatering the ramp excavation consists of peripheral vertical well points used in conjunction with ditches and sumps. The recommended system is shown on Figures 7 and 8.

The recommended system will require that a bench be constructed along the excavation slope to allow installation of the well points. It is recommended that the bench be constructed at a level about 2 feet above

the ground water level existing at the time of excavation. This will keep to a minimum the suction head imposed on the dewatering system and, consequently, will provide a more efficient dewatering system. It is recommended that a system of approximately 150 well points (Figure 7), 1½ inches in diameter, be installed along the bench at intervals of about 6 feet pumping 2-3 gpm. The well points should be connected to a common header pipe (6-8 in. diameter) which is in turn connected to a pumping station which will deliver the water to a pipeline which will transport the water to a point of disposal. The recommended design of the well points is shown on Figure 8.

As shown on Figure 8, it is recommended that the well points be installed by jetting and washing a temporary casing down to the clay material overlying the bedrock. It is possible, however, that the success of this method may be limited in the exploration pit area due to the large number of cobbles and boulders present in the glacial drift. Due to their large sizes, it may be difficult or impossible to wash the cobbles and boulders from the bottom of the hole to the surface. In this event, one alternative would be to offset the well point a few feet from the original location in order to bypass the cobbles and boulders. Should the cobbles and boulders continue to prevent relatively easy installation, it may be necessary to drill the holes for the well points with a rotary wash drilling rig.

As shown on Figure 6, the thickness of the saturated glacial drift in the vicinity of boring DMI-9 ranges from 10 to 18 feet. The well point system recommended above are suction lift well points and will not lower the water table much in excess of 15 feet (approximately elevation 1573 ft, MSL). Therefore, it may be necessary to install several well points or a small sump system in the excavation beside the exploration ramp in the vicinity of

DMI-9 to dewater this small area.

In addition to the well points, it is recommended that upon excavating down to the clay overlying the bedrock that a bench 20 feet wide be constructed to allow the excavation of a sump trench (Figures 7 and 8) a few feet into the clay. The purpose of the sump trench will be to collect the ground water seeping between the well points. The sump trench should be sloped toward the northern end of the bench where a pumping station should be located (Figure 7) for transporting the water out of the excavation and to a point of disposal.

It is possible that the surface elevation of the clay unit is somewhat variable and the clay may be thin in certain areas. Consequently, proper sloping of the sump trench may be difficult. In this case, clay dikes can be utilized to form a sump trench to allow collection of seepage flowing between the well points (Figure 8).

The estimated costs for dewatering the exploration ramp excavation are presented in Table 3. The costs are based on a construction schedule of approximately 12 weeks with 10 weeks of active pumping. Based on conversations with the Wisconsin Department of Natural Resources, it is highly probable that a permit will be required to operate the dewatering system.

DISPOSAL OF DISCHARGE

This section presents various methods of disposing of the ground water pumped from the exploration ramp excavation. Each of the methods could be employed to dispose of all the discharge, or two or more of the methods could be used in combination with each method being employed to dispose of some percentage of the total discharge. The methods of disposal

presented and discussed are as follows:

- (1) Spray discharge into the wetlands south of Skunk Lake;
- (2) Direct discharge into Skunk Lake;
- (3) Inject the water back into the glacial aquifer via the wells existing in the area, such as TW-1, WW-1, and WW-2; and
- (4) Inject the water into the unsaturated zone of the glacial drift (recharge area, Figure 2).

It is highly probable that all of the methods listed would require a permit from the Wisconsin Department of Natural Resources. As a prerequisite to obtaining the permit, it is likely that an environmental assessment of the impacted area will have to be performed.

Spray Discharge - This method would consist of utilizing a sprinkler system to dissipate the discharged water over a relatively large area. Assuming a constant discharge of 300 gpm, approximately 16 acres would be covered to a depth of 1 inch in a 24-hour pumping period. However, this does not take into account water losses due to direct evaporation and some degree of transpiration. It is estimated, based on average annual evapotranspiration rates given in Reference 1, that approximately 60 percent of the discharged water would be lost to evaporation and transpiration, leaving ground water infiltration and surface water runoff of about 180 gpm (0.4 cubic feet per second). The total evapotranspiration rate will probably be higher during the excavation dewatering because this disposal method would be restricted to the summer months consequently reducing the total infiltration and runoff even further. Although not analyzed quantitatively, it is believed that the drainage system in the area could easily assimilate the discharge quantities expected.

The primary disadvantage of this system is that it would not be

possible to spray in the winter months due to freezing temperatures, thus the exploration ramp construction would be restricted to the summer months if this discharge system were employed.

The estimated cost of this disposal method is given in Table

3.

Discharge into Skunk Lake - Skunk Lake is located northeast of the exploration ramp at a distance of approximately 1200 feet. Direct discharge of 300 gpm into Skunk Lake, which has a surface area of approximately 12 acres, would result in a water level rise of about 1.3 inches per day, not accounting for losses due to outflow from the lake and evaporation. Although not analyzed in detail, it is believed Skunk Lake could assimilate this quantity of water.

The estimated cost of this disposal method is given in Table 3.

Injection Through Existing Ground Water Wells - The wells considered for this method of disposal were WW-1, WW-2, and TW-1 (Figure 2). All three wells extend into the saturated portion of the glacial aquifer at their respective locations. WW-1 and TW-1 are finished in the upper glacial aquifer. TW-1 is under artesian pressure and WW-1 is under water table conditions. WW-2 is finished in a lower aquifer which is under artesian pressure (Figure 3). It is estimated, based on the specific capacity of TW-1 and WW-2 that approximately 50 and 150 to 175 gpm could be injected into these wells, respectively. Based on the specific capacity of WW-2, it is estimated that approximately 70 gpm could be injected into this well. However, before this disposal method is employed, it is recommended that injection tests be made in each of the wells to determine their capacity for accepting injected water.

The estimated cost of this disposal method is given in Table 3.

Injection Wells in the Unsaturated Zone - This method would consist of drilling 2 to 3 wells for injection in the recharge area designated on Figure 2. The glacial aquifer is unsaturated in this area and would probably readily accept injected water. Based on the specific capacities of wells WW-2 and TW-1, each of the wells tapping the unsaturated glacial materials would probably accept 150-175 gpm, assuming the permeability of the unsaturated glacial materials is similar to materials tapped by TW-1 and WW-2.

It is recommended, however, that injection tests be conducted on an existing well in the vicinity of the recommended recharge area, preferably WW-2, before employing this method for the disposal of discharge.

The primary advantage of this method is that the wells would probably accept a higher injection rate than the wells in the saturated portion of the aquifer, thereby, possibly reducing the number of wells required to dispose of the discharge from the excavation. In addition, injecting through these wells would not interrupt the use of the existing wells for water supply purposes.

The estimated cost of this method is presented in Table 3.

ENVIRONMENTAL CONSIDERATIONS

OF DEWATERING

EFFECTS ON USERS

The Theis non-equilibrium well formula was used to develop relationships between drawdown and distance from the ramp excavation, and between drawdown and time (duration of pumping). Figure 9 presents contours

of equal drawdown after 100 days of continuous pumping at various distances from the ramp excavation. As shown, the boundary conditions discussed previously were introduced to simulate the unsaturated portion of the aquifer west of the exploration ramp as well as to account for the pinching out of the aquifer to the north. It is noted that the boundary is the same as used in Reference 1.

As shown on Figure 9, the one-foot drawdown contour crosses the northern end of Little Sand Lake. Consequently, those wells tapping the glacial aquifer in this area may experience approximately 1-1.5 feet of drawdown. It is noted, however, that the situation depicted is conservative and actual drawdowns in the wells along the lake may be somewhat less than depicted.

EFFECTS ON SURFACE WATER BODIES

Although not analyzed in detail, it is believed that the near-by surface water bodies will be affected only slightly by the exploration ramp dewatering. The drawdown contours shown on Figure 9 show the water level in the aquifer declining about 2 feet in the vicinity of Skunk Lake.

Previous studies (Reference 1) indicated that Skunk Lake is not hydrologically connected to the glacial aquifer. The wetlands south of Skunk Lake are underlain by lacustrine silts and clays (Figure 3) and are also probably not hydrologically connected to the aquifer system. Consequently, dewatering of the exploration ramp should not have any apparent effect on the Skunk Lake and wetlands area.

Previous studies (Reference 1) indicated that Little Sand Lake was connected hydrologically to the glacial aquifer system. However, the connection was considered poor due to the lake bottom acting as a confining

unit (Figure 5). When the ground water levels decline at the northern end of Little Sand Lake, infiltration through the lake bottom will be induced by the increasing head difference between the lake water surface and the ground water potentiometric surface.

Induced infiltration was calculated to be about 330,000 gpd (Reference 1) for the dewatering system discussed in that report. However, the head decline expected with dewatering the exploration ramp will not be as great and the area of influence will not extend as far south under Little Sand Lake. Therefore, induced infiltration should be much less than the 330,000 gpd previously mentioned.

EFFECTS OF DISCHARGE ON DISCHARGE DISPOSAL AREAS

This section pertains to the degree of environmental impact upon disposal areas induced by the disposal of ground water pumped from the exploration ramp excavation. This topic was not specifically addressed during this study. Therefore, only a very general evaluation of the possible environmental impact is presented. In addition, the evaluation is limited to a general statement about the possible impact on the water quality of the receiving bodies. It is highly probable that a detailed evaluation of the possible environmental impact upon the receiving bodies will be required to obtain the permits for disposal. The specific areas of concern would be the areas receiving the discharged ground water and consist of the following: (1) Skunk Lake, (2) the wetlands south of Skunk Lake, and (3) the glacial aquifer system in the vicinity of inspection wells.

The quality of the ground water in the glacial aquifer system is of high quality in the vicinity of the exploration ramp with total dissolved solids in the ground water generally averaging about 100 PPM (parts per

million). The ground water satisfies drinking water quality criteria since the aquifer also serves as the primary source of domestic supplies in the areas around Little Sand Lake. Therefore, since the quality of the ground water is high, the ground water pumped from the excavation is not expected to significantly affect the water quality of any of the receiving water bodies mentioned previously in this section. However, further work will have to be performed to evaluate in detail the possible environmental impact upon the disposal areas.

SLOPE STABILITY

The subsurface conditions at the proposed location of the exploration ramp were investigated by drilling nine borings. The borings show that the subsurface soil and rock profile consists of a 3 to 12-foot thick layer of medium to dense silty sand and sandy soil overlying approximately 40 to 80 feet of very dense granular material which ranges in composition from poorly-graded sand to well-graded gravels. The granular deposit is underlain by approximately 3 to 10 feet of highly plastic clay (residual soil) and highly weathered bedrock (saprolite). The clay and saprolite is underlain by volcanic tuff, containing numerous fractured and broken zones.

Our recommendations regarding the cut slopes for the ramp have been developed based on a slope stability analysis. Parameters used in the slope stability analysis were obtained from direct shear tests on the sand overburden soils and from direct shear tests on the highly weathered rock (saprolite) immediately below the overburden soils. The direct shear tests on the highly weathered rock were performed to determine its residual

strength (residual strength was considered to be representative of the material in highly fractured and broken zones). The results of the strength tests have also been correlated with the properties of similar material of comparable density. The stability of the cut slopes for the exploration ramp has been investigated using both conventional slope stability analysis for cohesionless material and wedge analysis. The stability of the cut slopes for the granular material was evaluated for the portions of the slopes both above and below the water table.

Based on our analysis, we recommend that the slopes in the excavation for the exploration ramp be cut as shown on Figure 7. The clay immediately above bedrock should be cut at a slope of 1 vertical to 1 horizontal. At the top of the clay layer, a 20-foot bench should be provided. This bench would serve to collect debris from possible erosion of the cut slope above. From the top surface of the clay to 14 feet above the clay, the slope should be cut at an inclination of 1 vertical to 2 horizontal. At the top of this slope, a 20-foot horizontal bench should be provided for the installation of dewatering equipment. From this bench to the surface, the slope should be cut at 1 vertical to 1.5 horizontal, and provided with a 10-foot wide bench at 20-foot depth intervals for erosion control.

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TABLE 1

RESULTS OF LABORATORY PERMEABILITY TESTS

Boring Designation	Depth (feet)	Type ¹ Test	Permeability ²		Moisture Content (percent)	Soil ³ Type
			cm/sec	Gallons per day per square feet		
DMI-1	14.0	PS	4.9×10^{-3}	105	15.8	SP/SM
DMI-1	33.5	PS	2.25×10^{-2}	475	9.7	SW
DMI-1	43.5	PS	3.24×10^{-2}	685	6.4	SW/GW
DMI-1	54.0	PS	4.9×10^{-3}	105	11.0	SW/GW
DMI-2	42.0	PS	7.8×10^{-2}	1650	6.8	SW
DMI-4	34.0	PS	4.9×10^{-3}	105	6.9	SW
DMI-4	48.5	PS	3.6×10^{-2}	760	7.6	SW
DMI-4	58.5	PS	9.0×10^{-2}	1900	8.4	SW/GW
DMI-4	68.5	PS	4.9×10^{-5}	1.0	8.9	SM
DMI-7	64.5	PS	3.6×10^{-2}	760	8.1	SW
DMI-7	83.5	PS	8.1×10^{-3}	170	6.9	SM/SW
DMI-8	29.0	PS	2.89×10^{-2}	610	4.8	SP
DMI-8	58.5	PS	5.6×10^{-3}	120	11.2	SW
DMI-9	43.5	PS	6.7×10^{-2}	1420	7.5	SW/GW

¹PS - Particle Size Analysis (See Appendix B).

²Permeability calculated with Hazen's approximation.

³See Boring Logs (Appendix A) for detail soil description.

TABLE 2
GEOHYDROLOGIC DATA
IN VICINITY OF EXPLORATION RAMP

Ground water table elevation, feet (MSL)	1588-1590 ¹
Saturated thickness of glacial drift, feet	10-28 ^{2A} 12-30 ^{2B}
Average Permeability (gpd/ft ²)	1000 ³
Transmissivity (gpd/ft)	10,000 - 28,000 ^{4A} 12,000 - 30,000 ^{4B}
Storage Coefficient	0.2 - 0.0002

Notes:

- (1) Based on ground-water levels measured in DMI-2 piezometer on 7-12-77, and in piezometer DW-2U in April, 1977 (Reference 1).
- (2) Based on difference between bedrock elevation and water table elevations listed above.
- (3) Determined from pumping test on TW-1 (Reference 1).
- (4) Based on permeability above and saturated thickness.
- (5) Estimated.

TABLE 3

DEWATERING SYSTEM COSTS

1. Rental costs for following:

- (a) 150 well points
- (b) 1 - 8-inch pump and associated equipment
1 - 6-inch pump and associated equipment
3 - 3-inch pumps and associated equipment
- (c) 1060 feet of 6 - 8-inch header pipe

NOTE: Based on 3-month rental

Subtotal (a-c) \$28,000

- (d) Jet-pump and hole puncher (1 month) 3,000
- (e) Temporary casing 720
- (f) Mobilization (a-e) 2,000

2. Material:

- (a) Gravel packing 900
- (b) Miscellaneous materials 300

3. Labor:

- (a) Install and remove well points \$18,000
- (b) Setting discharge lines, mount pumps, trucking 2,000

4. Pumping:

24-hrs/day, 7 days per week for 10 weeks 35,000

- 5. Excavating sump trench on constructing clay dike 4,000

TOTAL COSTS DEWATERING \$93,920

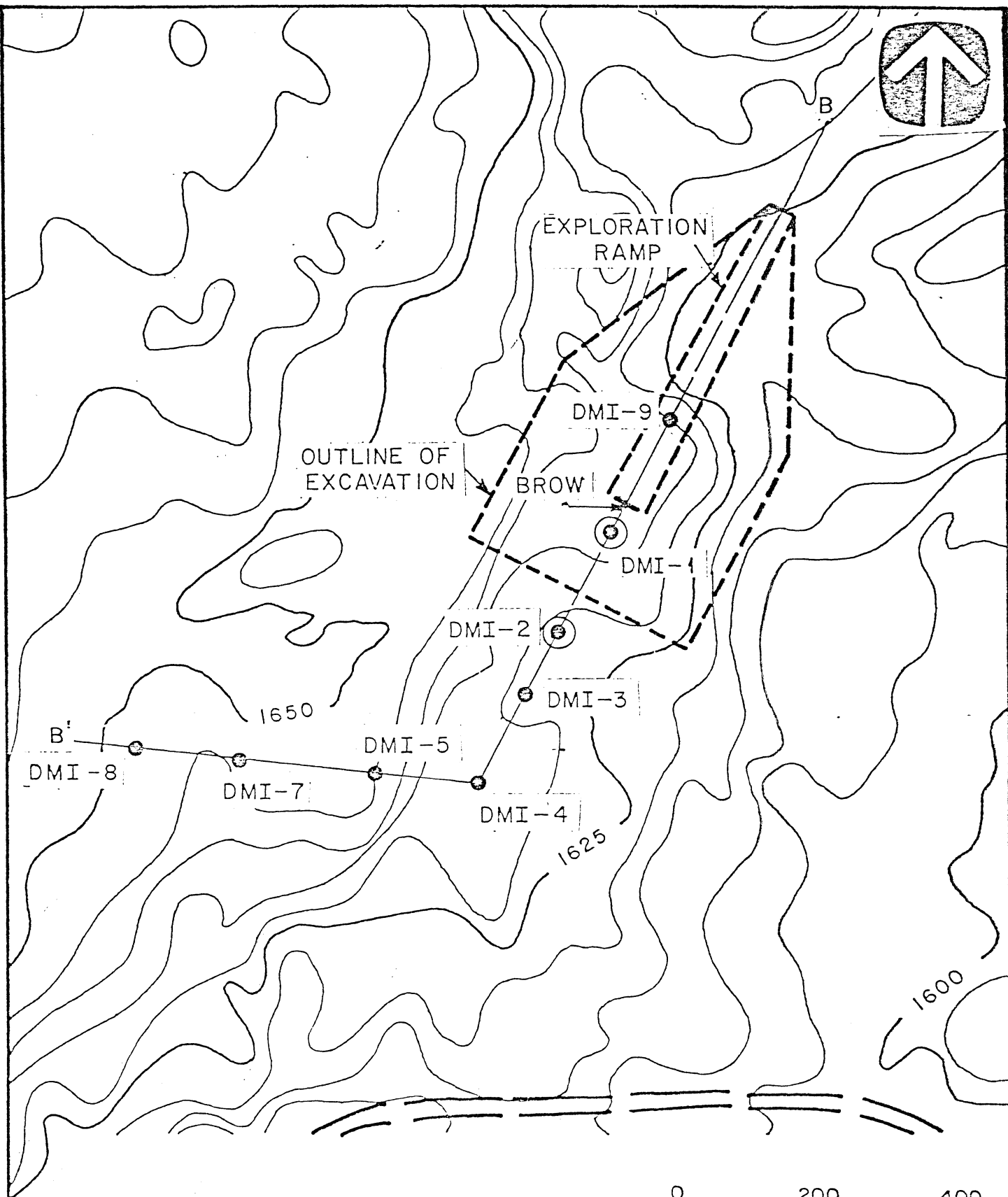
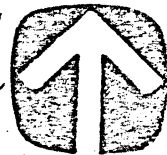
NOTE: The above do not include costs for the possible necessity of drilling the holes for the installation of well points.

ESTIMATED DRILLING COSTS \$20,000

Disposal Costs

- Option No. 1 - Spray disposal to wetlands \$ 2,700
- Option No. 2 - Disposal directly to Skunk Lake \$ 2,000
- Option No. 3 - Injection in existing wells \$ 3,500
- Option No. 4 - Injection in near wells (3-total) \$ 9,000

NOTES: Dewatering costs, not including drilling costs and disposal costs can be adjusted at a rate of \$6000 per week if the actual ramp construction schedule differs from 10-weeks.

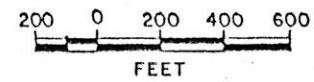
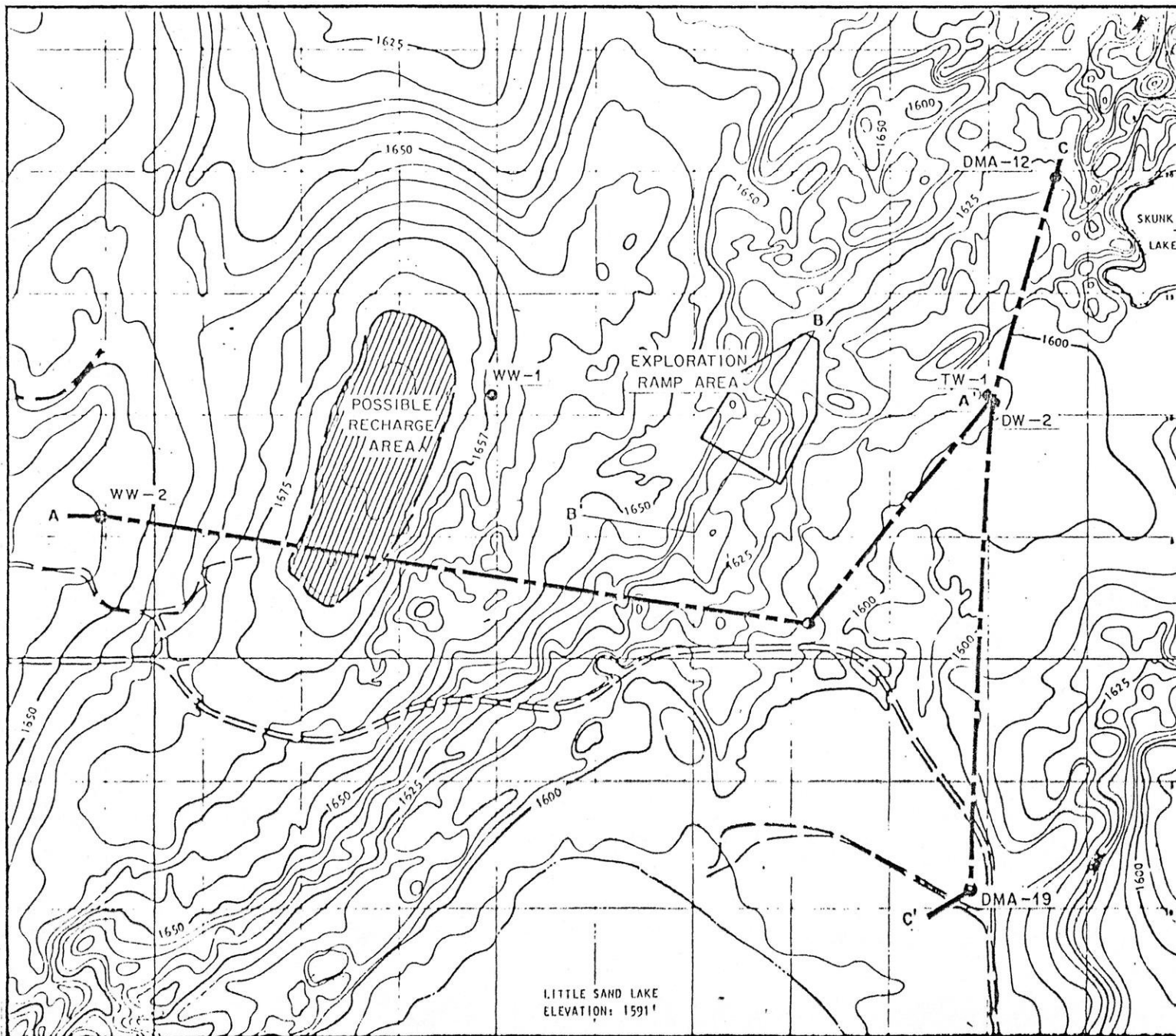


LEGEND:

- BORING LOCATIONS
- ⊙ PIEZOMETER LOCATIONS

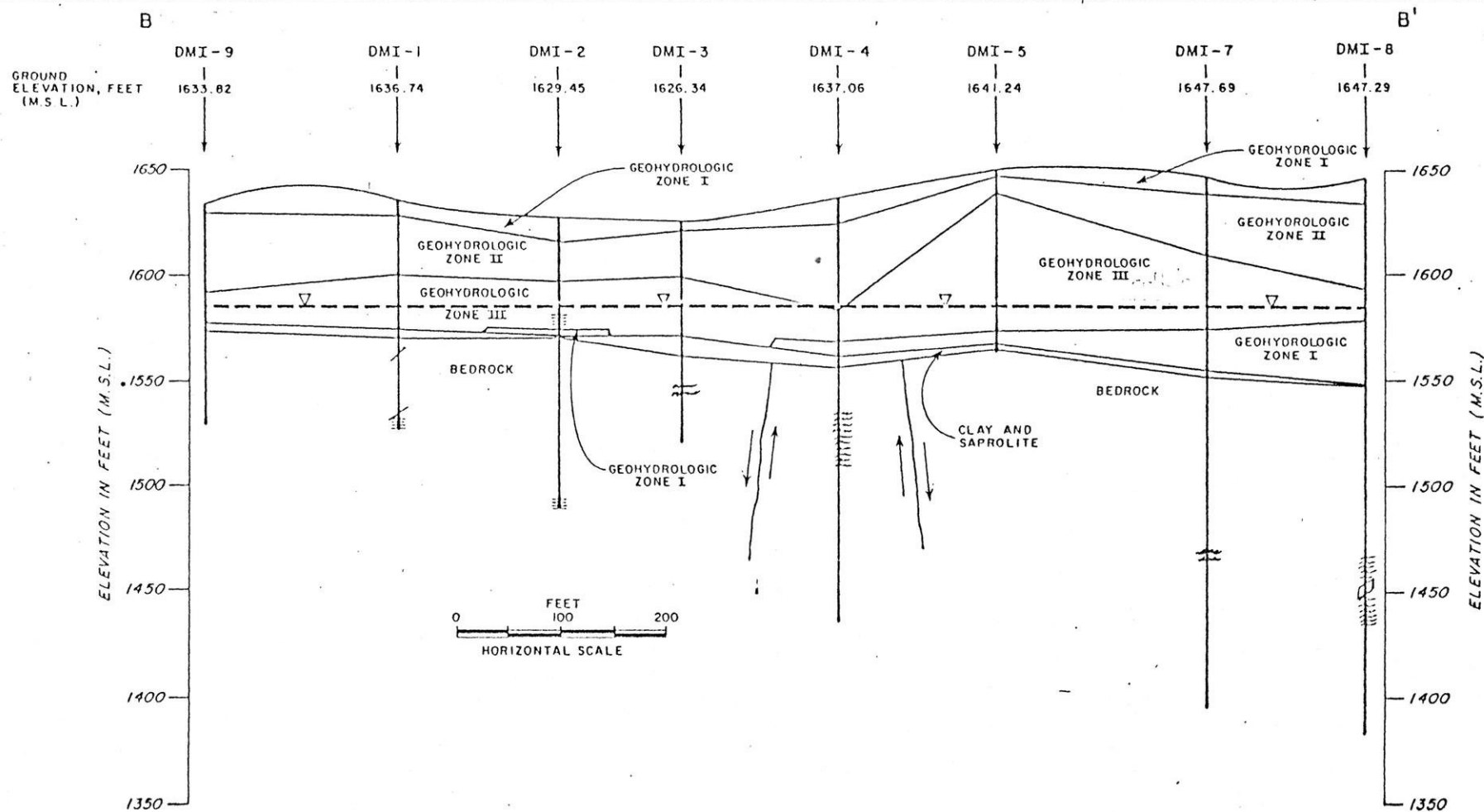
PLOT PLAN SHOWING BORING
AND PIEZOMETER LOCATIONS,
AND EXPLORATION
RAMP EXCAVATION

DAMES & MOORE



MAP SHOWING LOCATIONS OF
GEOHYDROLOGIC CROSS-SECTIONS
AND POSSIBLE RECHARGE AREA

DAMES & MOORE



GEOHYDROLOGIC SECTION B-B'

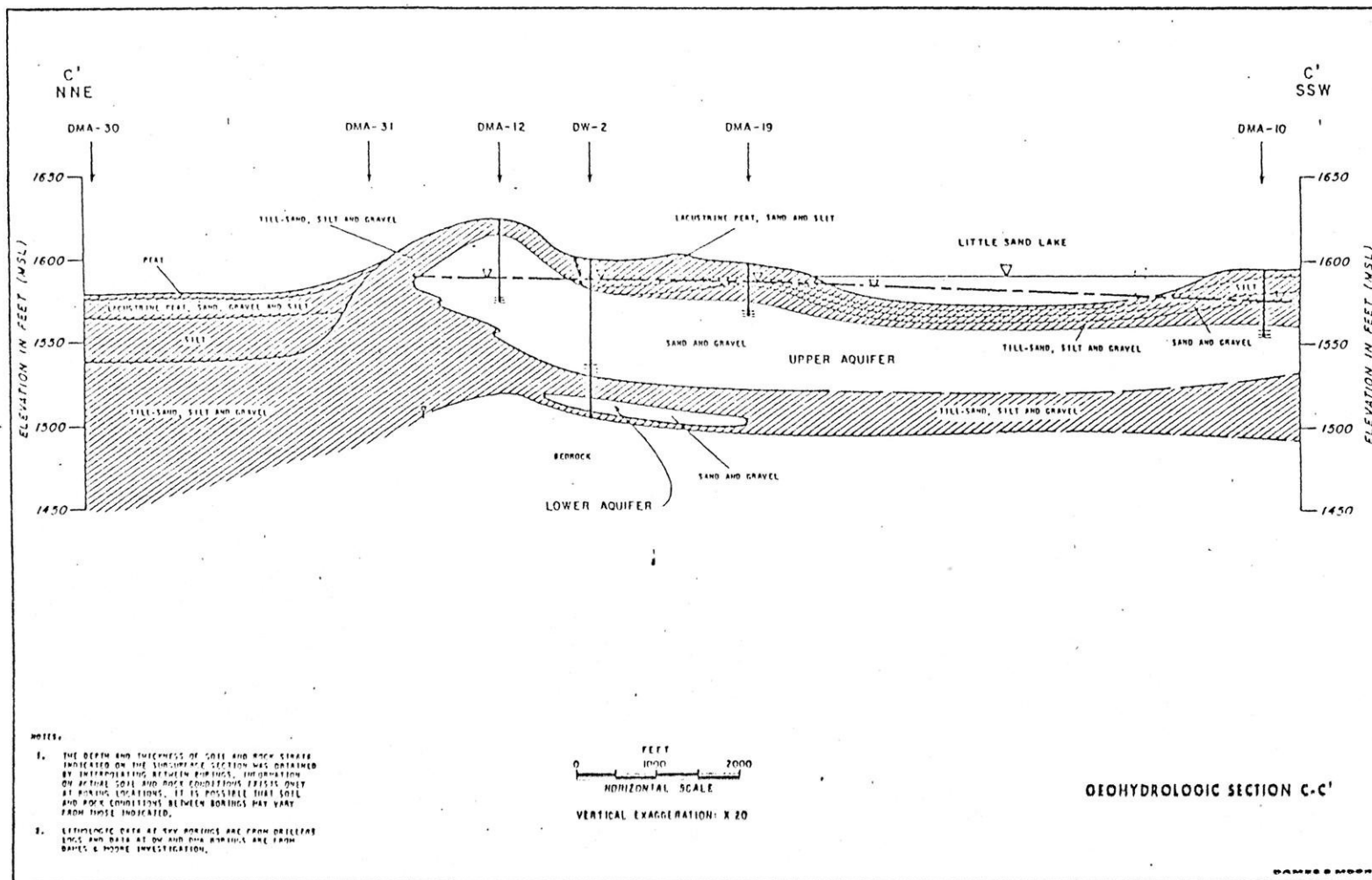
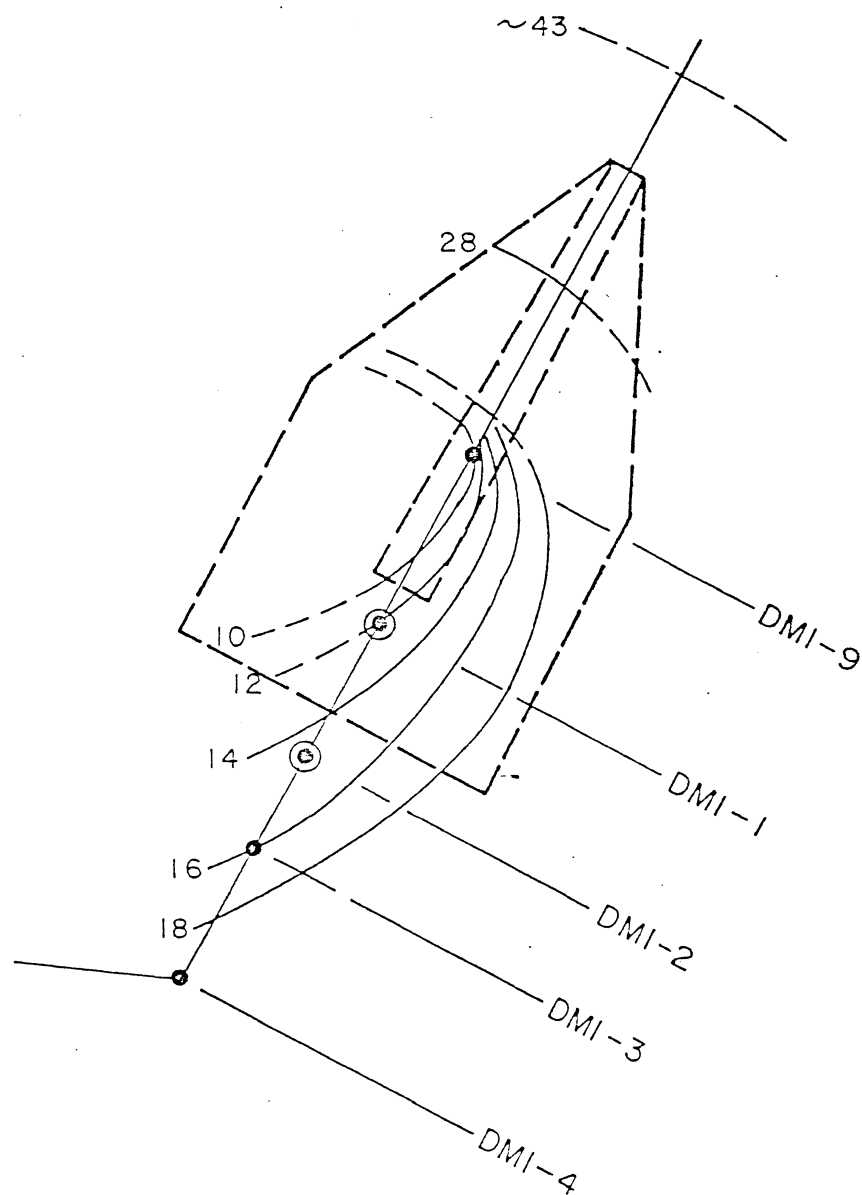


FIGURE 5



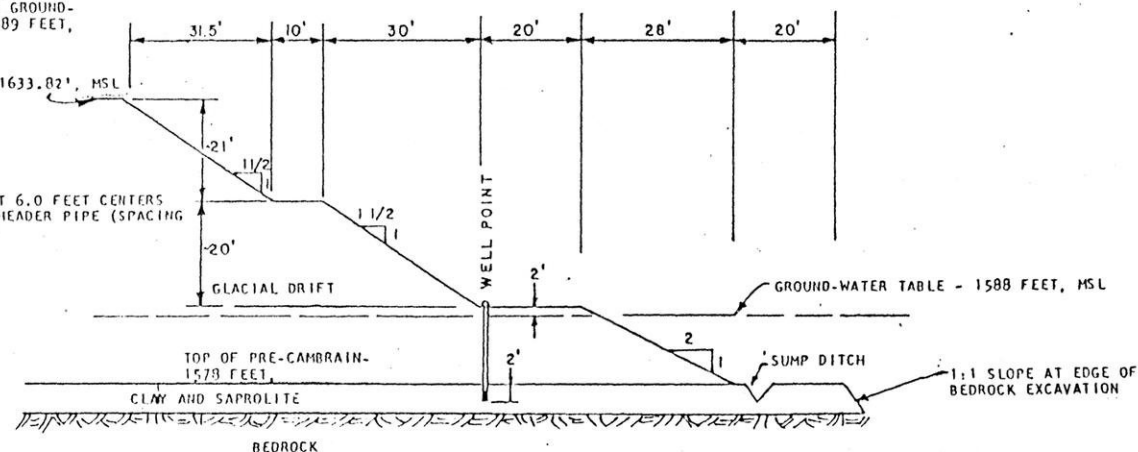
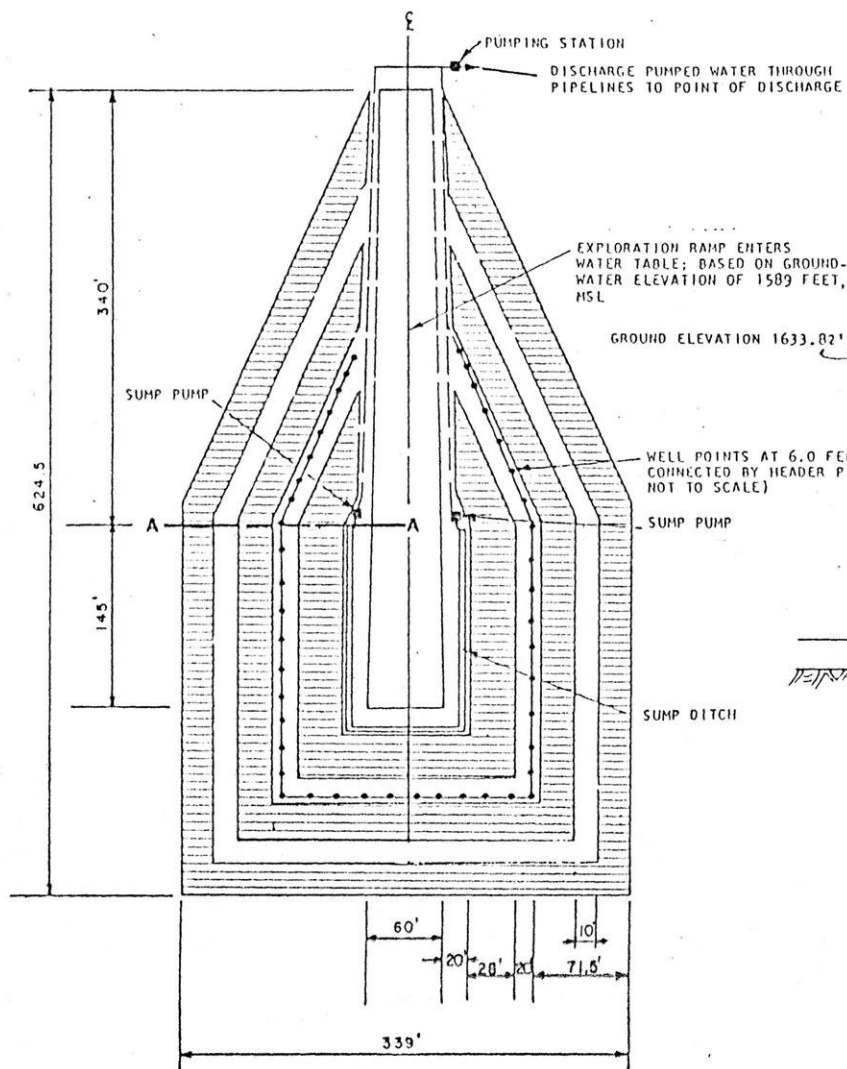
LEGEND:

- 16 — SATURATED THICKNESS,
FEET
- BORING LOCATIONS
- ⊙ PIEZOMETER LOCATIONS

NOTE: BASED ON DIFFERENCE
BETWEEN ELEVATION OF
BEDROCK AND WATER TABLE
ELEVATION OF 1588' (MSL)

SATURATED THICKNESS
OF GLACIAL DRIFT IN
EXPORATION RAMP VICINITY

DAMES & MOORE



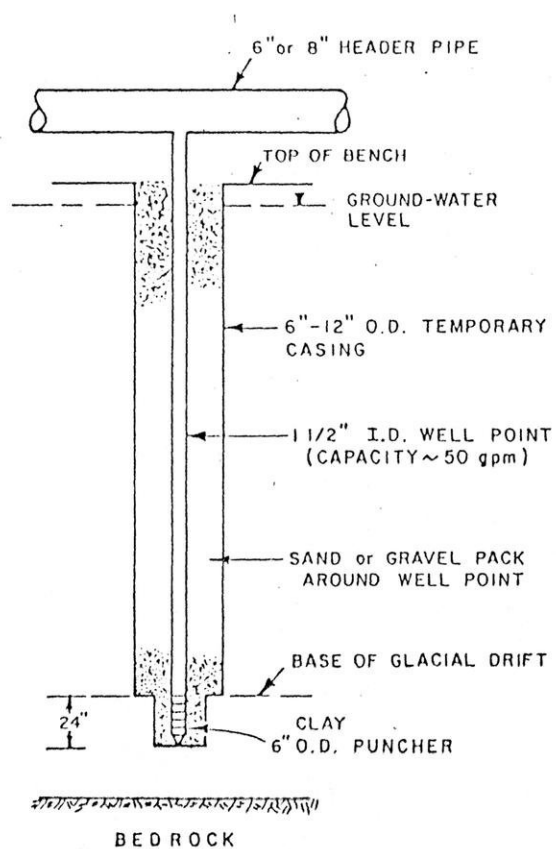
NOTE:

1. CONFIGURATION OF THE EXPLORATION RAMP IS BASED UPON THE FOLLOWING:
 - 1) GLACIAL DRIFT THICKNESS OF 55 FEET FOUND AT BORING DHI-9, AND,
 - 2) GROUND WATER ELEVATION MEASUREMENTS MADE AT BORING DHI-2, WHICH HAS A PIEZOMETER AT THE BASE OF THE GLACIAL DRIFT.

CONCEPTUAL CONFIGURATION
OF EXPLORATION
RAMP EXCAVATION, DEWATERING
SYSTEM AND RECOMMENDED
STABLE SLOPE CONFIGURATION

DAMES & MOORE

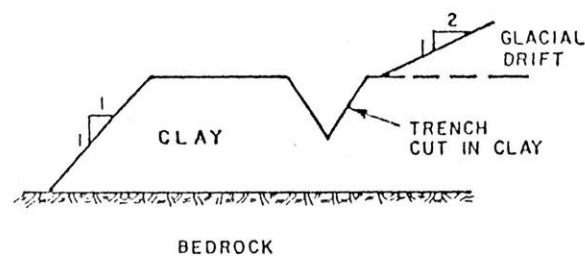
A. WELL POINT INSTALLATION



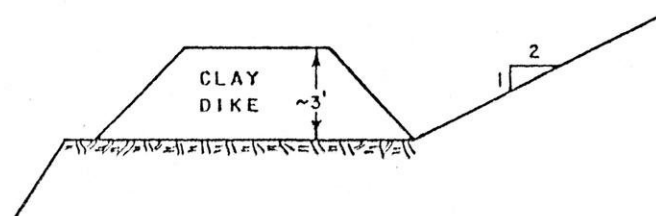
INSTALLATION PROCEDURE:

- (1) TEMPORARY CASING (6"-12" O.D.) WITH A TIP PUNCHER (6" O.D.) IS JETTED AND DRIVEN 2 FEET INTO THE CLAY.
- (2) AFTER CLEANING OUT THE HOLE, THE 1 1/2" WELL POINT WITH A 24" SCREEN IS INSERTED; SAND IS INSERTED AND TEMPORARY CASING IS PULLED.

B. SUMP SYSTEM

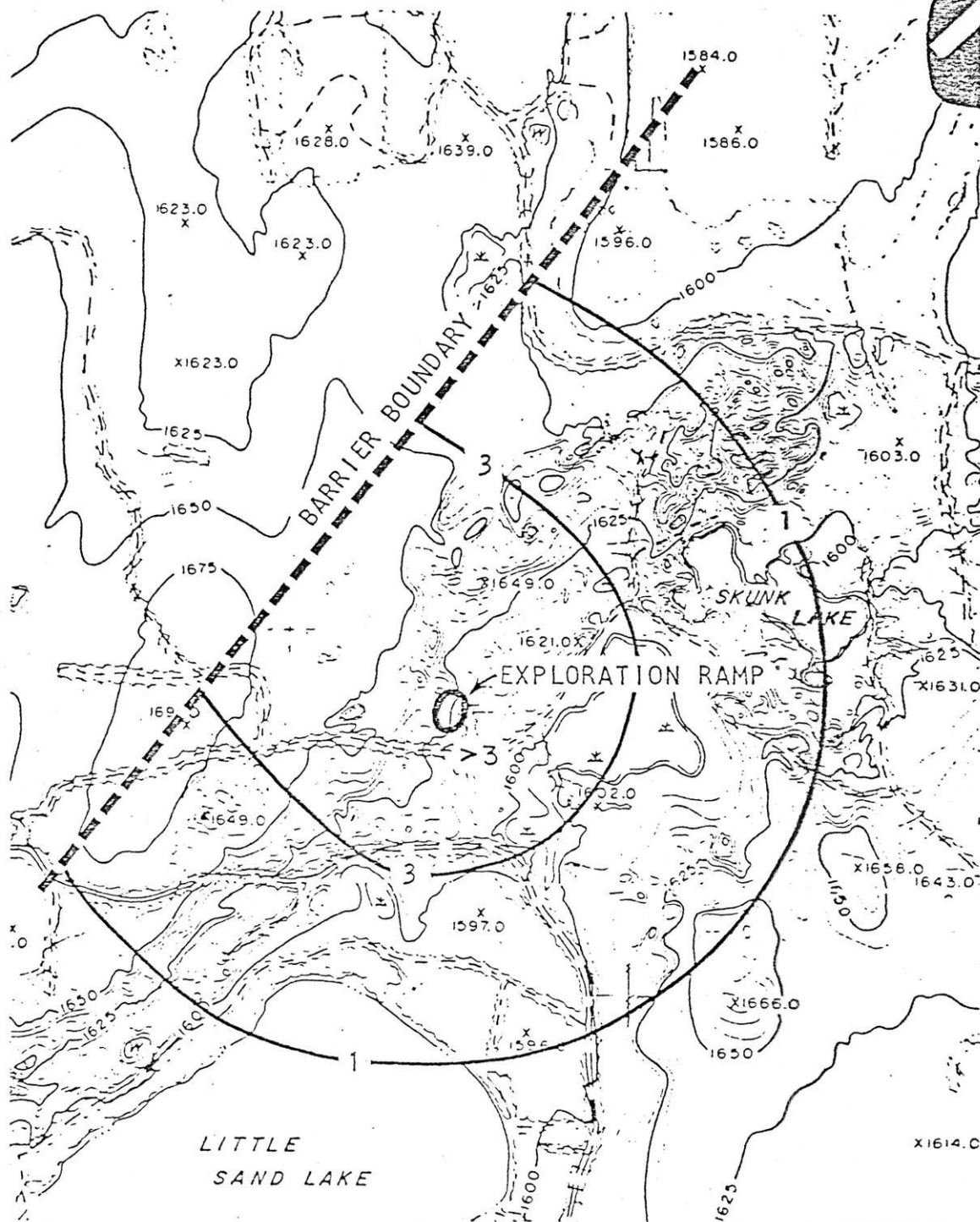


C. ALTERNATE SUMP SYSTEM



NOTE: IF CLAY HAS TO BE EXCAVATED, CLAY DIKE CAN BE BUILT TO FORM SUMP.

DETAILS OF
DEWATERING SYSTEM



— 3 — INDICATES DRAWDOWN IN FEET

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APPENDIX A - BORING LOGS

TABLE A-1

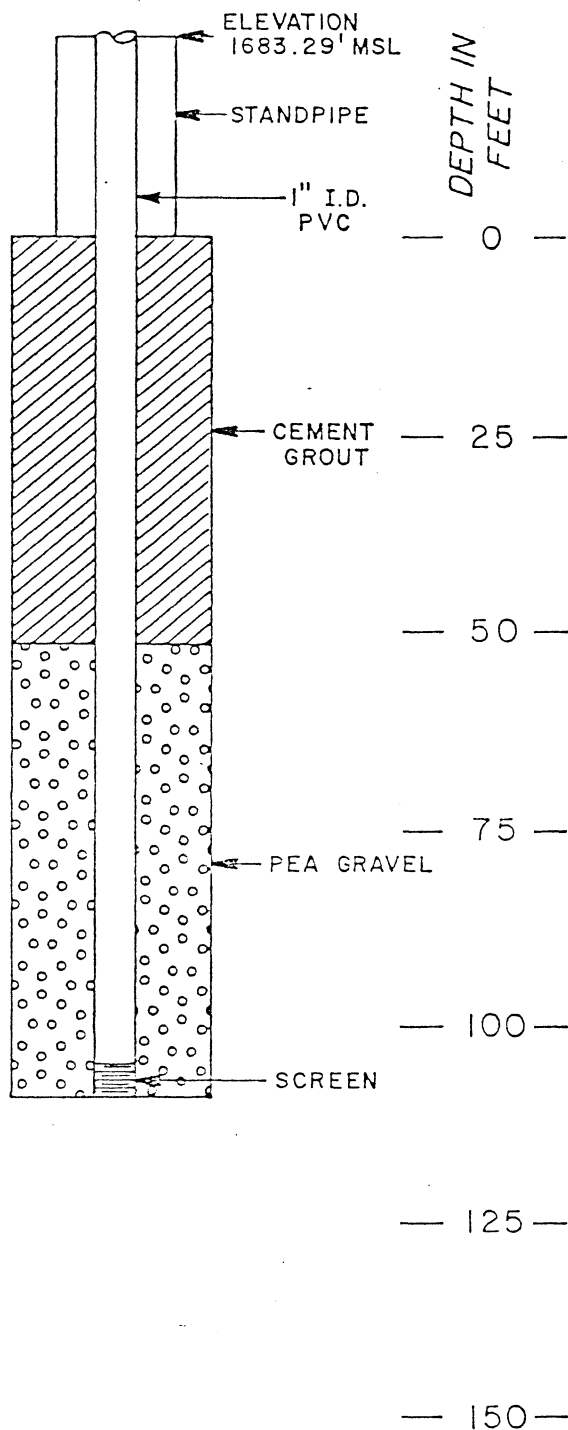
HORIZONTAL AND VERTICAL CONTROL OF BORINGS

Boring Designation	Ground Elevation feet (MSL)	Standpipe Elevation ¹ feet (MSL)	Horizontal Coordinates ²	
			North	East
DMI-1	1636.74	1638.29	116,746.693	2,278,815.316
DMI-2	1629.43	1630.77	116,608.916	2,278,750.054
DMI-3	1626.34	--	116,504.436	2,278,692.158
DMI-4	1637.06	--	116,374.694	2,278,621.737
DMI-5	1641.24	--	116,392.018	2,278,473.556
DMI-7	1647.69	--	116,412.929	2,278,275.264
DMI-8	1647.29	--	116,430.248	2,278,125.170
DMI-9	1633.82	--	116,908.854	2,278,902.931
DMI-11	1634.82	--	116,544.035	2,278,599.478

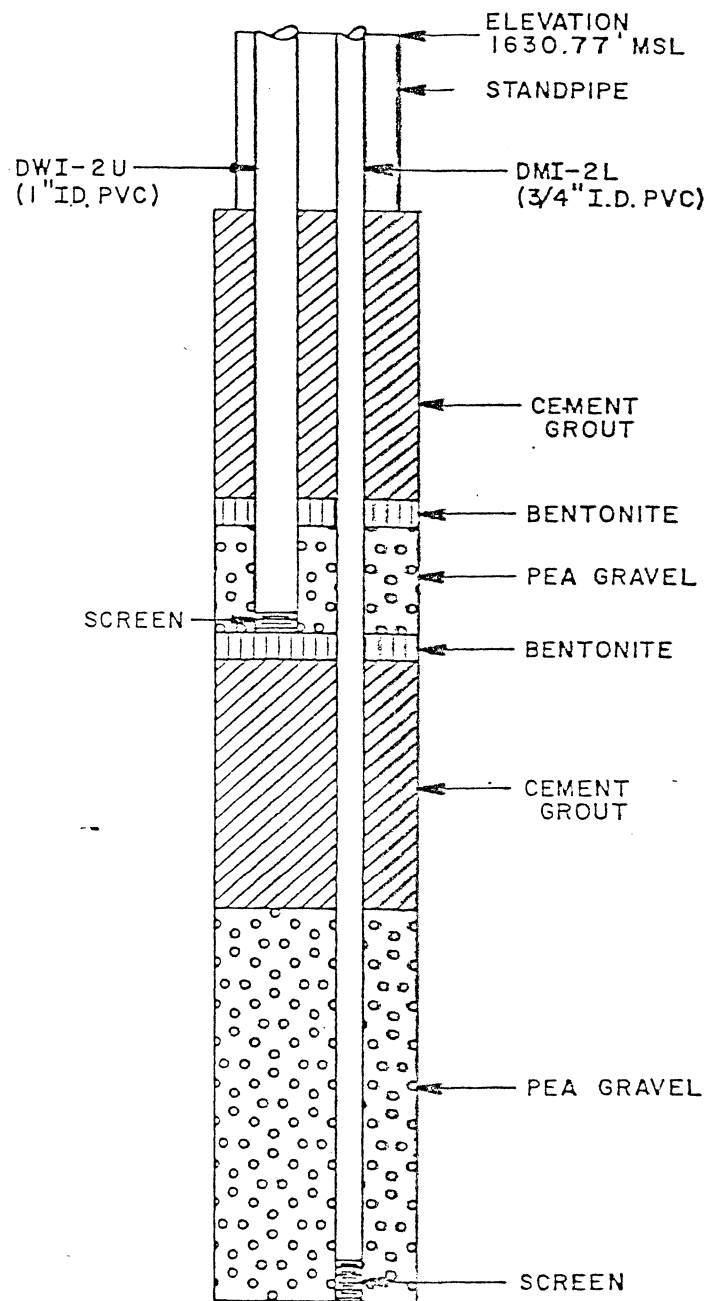
Notes:

- (1) Piezometers installed in only DMI-1 and DMI-2.
- (2) Wisconsin Grid System.

DMI-1

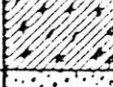
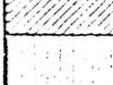
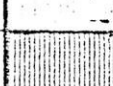
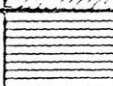


DMI-2



DETAILS OF
PIEZOMETER
INSTALLATION

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MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS	CLEAN SAND (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS.

SOIL CLASSIFICATION CHART

UNIFIED SOIL CLASSIFICATION SYSTEM

DRIVING OR PUSHING
MECHANISM

COUPLING
WATER OUTLETS

NOTCHES FOR
ENGAGING
FISHING TOOL

NEOPRENE GASKET

HEAD

CHECK VALVES

VALVE CAGE

SPACE TO RECEIVE
DISTURBED SOIL

NOTE:
"HEAD EXTENSION" CAN
BE INTRODUCED BETWEEN
"HEAD" AND "SPLIT BARREL"

SPLIT BARREL
(TO FACILITATE REMOVAL
OF CORE SAMPLE)

CORE-RETAINER
RINGS
(2-1/2" O.D. BY 1" LONG)

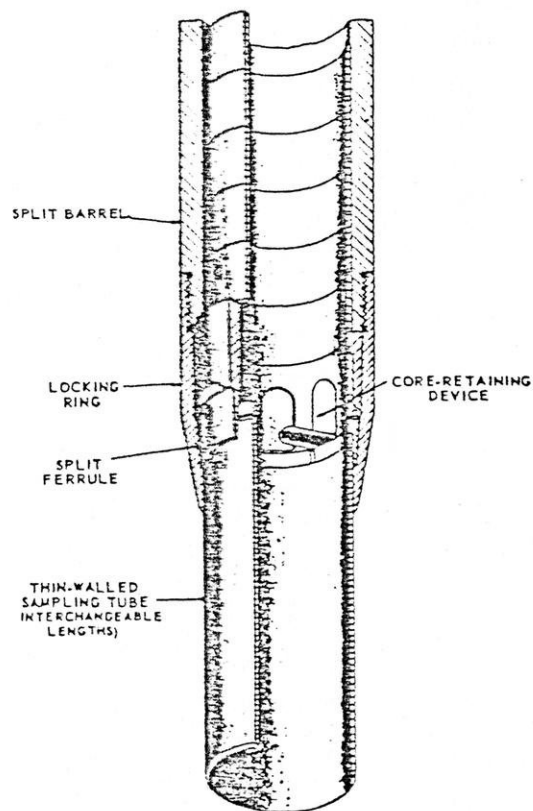
BIT

CORE-RETAINING
DEVICE
RETAINER PLATES
(INTERCHANGEABLE WITH
OTHER TYPES)

SOIL SAMPLER TYPE U

FOR SOILS DIFFICULT TO RETAIN IN SAMPLER
U. S. PATENT NO. 2,318,062

ALTERNATE ATTACHMENTS



DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH T/N PSF	ATTERBERG LIMITS			FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	MO
			LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %				
0									
5									
10									
15						15.8			
20									
25									
30									
35		1600/1000 2850/1750 5250/3000				9.7			
40									
45						6.4			
50									
55						11.0			
60		1650/2000 2250/4000 3750/6000				13.7	112		
65								100	100
70		1660/2000 2550/4000 3730/6000				16.4	116		
75								100	80

NOTES:

ELEVATIONS PRESENTED REFER TO MEAN SEA LEVEL DATUM.

INDICATES NUMBER OF BLOWS REQUIRED TO DRIVE A DAMES & MOORE SAMPLER ONE FOOT WITH A 340 POUND WEIGHT FALLING 24 INCHES.

29 ■ INDICATES DEPTH AND RECOVERY OF DAMES & MOORE (TYPE U) SAMPLE.

■ INDICATES DISTURBED DAMES & MOORE SAMPLE RECOVERY.

T = SHEAR STRENGTH

N = NORMAL STRESS

BORING DMI-1

SURFACE ELEVATION 1636.74

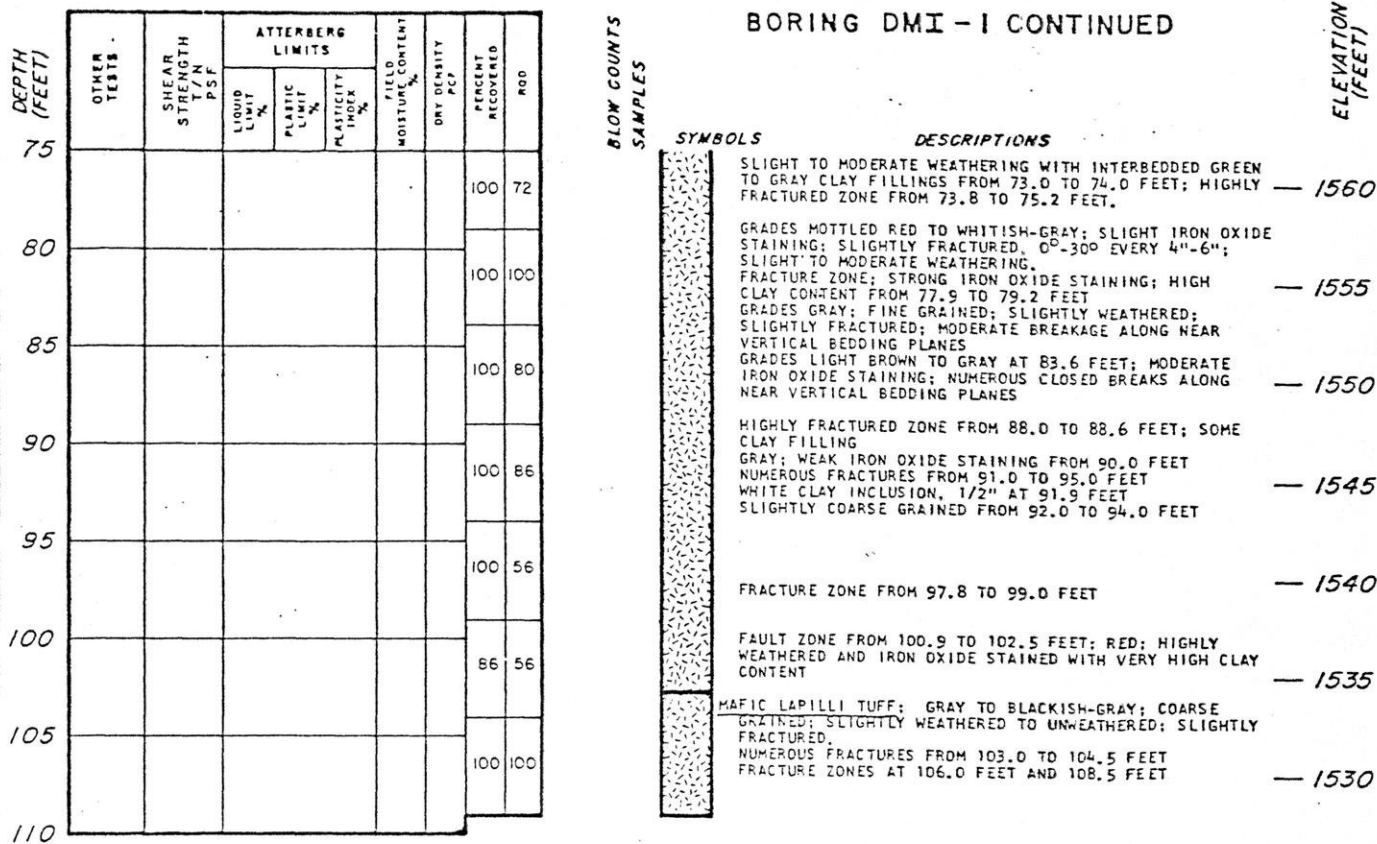
BLOW COUNTS
SAMPLESELEVATION
(FEET)

BLOW COUNTS SAMPLES	SYMBOLS	DESCRIPTIONS	ELEVATION (FEET)
	ML	BROWN SANDY SILT; TRACE ORGANICS AND ROOT FRAGMENTS; MEDIUM STIFF	— 1635
25 ■	GM	LIGHT BROWN FINE SILTY SAND; TRACE MEDIUM TO COARSE SAND; LITTLE GRAVEL AND CLAY; LOOSE	
		GRAVEL GRADES OUT AT 7.0 FEET	— 1630
20 ■		LIGHT BROWN FINE TO VERY FINE SILTY SAND, LITTLE FINE GRAINED MICA, LOOSE; INTERBEDDED WITH TAN MEDIUM TO COARSE SAND, TRACE FINE GRAINED MICA, SOME BLACK SHALE FRAGMENTS, MEDIUM DENSE	— 1625
47 ■	SP	SILTY LAYER AT 14.0 FEET	
	SM		— 1620
68 ■		GRADING TO VERY DENSE	
		LOCALLY SOME COARSE GRAVEL BELOW 19.0 FEET	— 1615
70 ■			
80/4" ■	SW	TAN MEDIUM TO COARSE SAND; SOME FINE GRAVEL AND BLACK SHALE FRAGMENTS; TRACE MICA; TRACE SILT; VERY DENSE	— 1610
60 ■			— 1605
250 ■		TAN TO REDDISH-BROWN FINE TO COARSE SAND WITH FINE TO COARSE GRAVEL; OCCASIONAL COBBLE; LOCALLY SILTY; VERY DENSE	— 1600
		SOME COBBLES FROM 40.0 TO 41.0 FEET	— 1595
200 ■	SW	LOCALLY COARSE GRAVEL WITH 3"-4" COBBLES	— 1590
	GW		
		SOME COBBLES AT 53.0 FEET	— 1585
220 ■			— 1580
150 ■	CH	PRECAMERIAN SYSTEM GREEN TO GRAY CLAY; SOME SILT AND FINE TO COARSE GRAVEL; VERY STIFF; HIGHLY WEATHERED SAPROLITE WITH POCKETS OF RED CLAY AT 63.0 FEET	— 1575
		MAFIC LAPILLI TUFF; GREEN TO GRAY; FINE GRAINED; MODERATELY WEATHERED WITH OCCASIONAL RED CLAY FILLED FRACTURES	
		GRADES GREEN TO BLACKISH-GREEN FROM 65.5 FEET; COARSE GRAINED; SLIGHTLY WEATHERED; SLIGHTLY FRACTURED (FRACTURES 30°-65° EVERY 8"-12" WITH OCCASIONAL CLAY FILLING FROM 67.5 TO 72.6 FEET)	— 1570
		FAULT ZONE, CLAY GOUGE FROM 72.6 TO 73.8 FEET	— 1565
		INTERMEDIATE ASH TUFF; GRAY TO BROWN; FINE GRAINED;	

BORING CONTINUED

LOG OF BORINGS

DAMES & MOORE



LOG OF BORINGS

DAMES & MOORE

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH T/N PSF	ATTERBERG LIMITS			FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	ROD
			LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %				
0									
5									
10									
15									
20									
25									
30									
35									
40						6.2	128		
45									
50									
55									
60								100	10
65								100	91
70								100	100
75									

BORING DMI-2

SURFACE ELEVATION 1629.43

ELEVATION
(FEET)

BLOW COUNTS SAMPLES	SYMBOLS	DESCRIPTIONS	ELEVATION (FEET)
	OL	BLACK FIBROUS SILT WITH ORGANICS; WITH LEAVES AND ROOTS; WITH 6" - 12" COBBLES (TOPSOIL - 12")	
23	ML	MOTTLED LIGHT BROWN AND DRANGISH-BROWN CLAYEY SILT; MEDIUM STIFF	— 1625
19	SM	BROWN FINE TO MEDIUM SILTY SAND; SOME COARSE SAND AND FINE TO COARSE GRAVEL; MEDIUM DENSE	— 1620
58		BROWN TO TAN FINE SAND; TRACE SAND SIZE BLACK SHALE FRAGMENTS; INTERBEDDED WITH MEDIUM TO COARSE SAND, LITTLE BLACK SHALE FRAGMENTS; MEDIUM DENSE	— 1615
100/3"	SP	TRACE FINE TO COARSE GRAVEL FROM 19.5 TO 20.5 FEET	— 1610
40			— 1605
90		GRADES VERY DENSE	— 1600
200		BROWN FINE TO COARSE SAND AND FINE TO COARSE GRAVEL; LOCALLY TRACE SILT; VERY DENSE	— 1595
		GRADES TO SOME COBBLES (6" - 12") AT 34.0 FEET	— 1590
80	SW GW		— 1585
120		GRADES TO TRACE GREENISH-GRAY SILTY RESIDUAL INCLUSIONS	— 1580
		24" BOULDER AT 51.0 FEET	
65/3"	SM	DRANGISH-BROWN SILTY FINE SAND; LITTLE CLAY; SOME FINE TO COARSE GRAVEL	— 1575
	CH	PERCAMBRIAN SYSTEM RED CLAY AND HIGHLY WEATHERED SAPROLITE FRAGMENTS; SOME SILT; VERY HARD	
		FELSIC - INTERMEDIATE LAPILLI TUFF; GRAY; LOCALLY SOME IRON OXIDE STAINING; MEDIUM GRAINED; SLIGHT TO MODERATE SURFACE WEATHERING; MODERATELY FRACTURED; 2" - 3" FRACTURE ZONE EVERY 8" - 12"	— 1570
		STRONG BREAKAGE EVERY .5 TO 1 INCH ALONG BEDDING PLANES FROM 58.2 TO 59.0 FEET	
		RED CLAY FILLED FRACTURES (1/16") FROM 60.0 TO 60.2 FEET	
		STRONG BREAKAGE EVERY 1/4" ALONG BEDDING PLANES FROM 62.5 TO 63.0 FEET	— 1565
		IRON OXIDE STAINED, TIGHT, VERTICAL FRACTURE FROM 63.2 TO 65.5 FEET	
		MODERATE IRON OXIDE STAINING FROM 67.3 TO 68.5 FEET; TRACE CLAY IN FRACTURE ZONE FROM 67.3 TO 67.7 FEET	
		GRADES GRAY; SLIGHTLY WEATHERED; SLIGHTLY FRACTURED FROM 68.6 FEET; 0° - 20° FRACTURES EVERY 4" - 8"	— 1560
			— 1555

BORING CONTINUED

LOG OF BORINGS

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH T/N PSF	ATTERBERG LIMITS			FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	ROD
			LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %				
75									
80								100	80
85								100	73
90								100	89
95								100	77
100								100	100
105								100	100
110								100	100
115								100	18
120								100	95
125								100	96
130								100	79
135								100	79
140									

BLOW COUNTS
SAMPLES

BORING DMI - 2 CONTINUED

ELEVATION
(FEET)

SYMBOLS

DESCRIPTIONS

LOCALLY WEAK IRON OXIDE STAINING FROM 75.0 FEET;
MODERATELY WEATHERED; SOME BREAKAGE ALONG NEAR
VERTICAL BEDDING PLANES

— 1550

TRACE BRIGHT GREEN MINERAL INCLUSIONS FROM 83.0
FEET

INTERMITTENT MODERATE TO STRONG IRON OXIDE STAINING
FROM 84.0 FEET; MOTTLED RED, GREEN, AND WHITISH-GRAY;
MODERATELY WEATHERED; MODERATELY FRACTURED

— 1545

STRONG BREAKAGE EVERY .5 TO 1 INCH ALONG BEDDING
PLANES FROM 87.0 TO 88.4 FEET

— 1540

NUMEROUS MICROFRACTURES FROM 92.0 TO 96.0 FEET

— 1535

GRADES WHITISH-GRAY TO GRAY AT 96.0 FEET; VERY FINE
GRAINED; MODERATELY WEATHERED; SLIGHTLY FRACTURED;
OCCASIONAL BRIGHT GREEN MINERAL INCLUSION;
WEAK FRACTURE ZONE FROM 97.5 TO 98.5 FEET; SOME
CLAY LINED FRACTURES

— 1530

1" CLAY FILLED FRACTURE AT 100.6 FEET
GRADES GRAY; LOCALLY WEAK IRON OXIDE STAINING FROM
101.0 FEET; SLIGHTLY WEATHERED; SLIGHTLY FRACTURED;
OCCASIONAL IRON OXIDE STAINED, TIGHT FRACTURE

— 1525

— 1520

GRADES WHITISH-GRAY WITH LOCALLY WEAK IRON OXIDE
STAINING FROM 114.0 TO 118.5 FEET; MODERATELY
WEATHERED; MODERATELY TO HIGHLY FRACTURED; 1 - 2"
CLAY LINED FRACTURE ZONES AT 117.0, 117.5, AND
118.1 FEET

— 1515

GRADES GRAY; MEDIUM GRAINED; SLIGHTLY WEATHERED;
SLIGHTLY FRACTURED; OCCASIONAL GREEN MINERAL
INCLUSIONS

— 1510

60° OPEN FRACTURE AT 122.2 FEET
80° OPEN, IRON OXIDE STAINED FRACTURE AT 123.7 FEET
70° OPEN FRACTURE FROM 124.7 FEET

— 1505

MODERATE IRON OXIDE STAINING FROM 129.2 TO 130.7 FEET
4" WEAK CLAY LINED FRACTURE ZONE AT 129.7 FEET

— 1500

SOME FRACTURES ALONG NEAR VERTICAL BEDDING PLANES

— 1495

FRACTURING ALONG BEDDING PLANE EVERY .5 TO 1 INCH

— 1490

BORING COMPLETED AT 139.0 FEET ON 6-21-77.
CASING USED TO A DEPTH OF 58.0 FEET.

LOG OF BORINGS

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH T/N PSF	ATTERBERG LIMITS			FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	ROD
			LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %				
0									
5									
10									
15									
20									
25									
30									
35									
40									
45									
50									
55									
60									
65									
70								100	100
75								100	70

BORING DMI-3

SURFACE ELEVATION 1626.34

ELEVATION
(FEET)BLOW COUNTS
SAMPLES

SYMBOLS

DESCRIPTIONS

8	SP	BROWN FINE SAND; TRACE FINE TO COARSE GRAVEL; LOOSE (ROAD FILL - 10")	— 1625
	ML	DARK BROWN CLAYEY SILT; SOME ORGANICS AND ROOTS (TOPSOIL - 12")	
17	SW	BROWN FINE TO COARSE SAND WITH FINE TO COARSE SAND AND FINE TO COARSE GRAVEL; LOCALLY SOME SILT; MEDIUM DENSE WITH SOME 3" - 4" COBBLES FROM 4.5 TO 6.0 FEET	— 1620
12	GW		
28	SP	BROWN FINE SAND; TRACE SILT; MEDIUM DENSE	— 1615
		GRADES WITH OCCASIONAL LAYERS OF TAN COARSE SAND	
43	SP	BROWN FINE TO MEDIUM SAND WITH INTERBEDDED FINE TO COARSE SAND WITH LOCAL ZONES OF FINE TO COARSE GRAVEL; DENSE TO VERY DENSE	— 1610
	SW		
65			— 1605
160		FINE TO COARSE GRAVEL WITH INTERBEDDED FINE TO COARSE SAND; VERY DENSE	— 1600
		3"-4" COBBLES	
100/0"			— 1595
			— 1590
250	GW		— 1585
	SW	COBBLES UP TO 6"	
100/5"			— 1580
			— 1575
175/6"		18" BOULDER FROM 49.5 FEET	
			— 1570
200/3"		14" BOULDER FROM 52.5 FEET	
		PRECAMBRIAN SYSTEM	
150/3"	CH	MOTTLED RED; OLIVE-GREEN AND GRAY RESIDUAL CLAY; SOME SILT; SOME COARSE SAND AND FINE GRAVEL; VERY HARD; SOME FRAGMENTS OF HIGHLY WEATHERED SAPROLITE	— 1570
		GRADES SOME WHITE MOTTLING	— 1565
		FELSIC - INTERMEDIATE LAPILLI TUFF; MAFIC CHLORITIC FRAGMENTS; SUBANGULAR; FELSIC FRAGMENTS; COARSE TUFF - MEDIUM LAPILLI, GENERALLY SUBROUNDED	— 1560
		HEAVILY IRON OXIDE STAINED FROM 67.3 TO 69.7 FEET; MAFIC FRAGMENTS ALTERED TO CHLORITE AND WEAK CLAYS	
		FRACTURE ZONE FROM 69.0 TO 70.6 FEET	
		FRACTURE ZONE FROM 71.5 TO 72.3 FEET	— 1555

BORING CONTINUED

LOG OF BORINGS

8837-058-07

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH T/N PSF	ATTERBERG LIMITS			FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	RQD
			LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %				
75								100	57
80								100	90
85								100	70
90								100	100
95									
100								100	90
105									

BLOW COUNTS
SAMPLES

BORING DMI - 3 CONTINUED

ELEVATION
(FEET)

SYMBOLS

DESCRIPTIONS

FRACTURE ZONE FROM 76.3 TO 76.7 FEET

— 1650

FRACTURE ZONE FROM 79.3 TO 82.3 FEET

— 1645

FRACTURE ZONE FROM 86.5 TO 86.8 FEET

— 1640

FRACTURE ZONE FROM 89.3 TO 89.7 FEET

— 1635

FRACTURE ZONE FROM 97.7 TO 98.0 FEET

— 1630

WEAK IRON OXIDE STAINED CHLORITE ALTERED MAFIC
FRAGMENTS (ORE PIECES 10 - 14" IN LENGTH) FROM
89.7 TO 105.0 FEET

— 1625

BORING COMPLETED AT 105.0 FEET ON 5-24-77.
NO GROUNDWATER LEVEL RECORDED.

LOG OF BORINGS

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH T/N PSF	ATTERBERG LIMITS			FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	ROD
			LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %				
0									
5									
10									
15									
20									
25									
30									
35						6.9	122		
40									
45									
50						7.6	126		
55									
60						8.4	131		
65									
70						8.9	131		
75									

BORING DMI - 4

SURFACE ELEVATION 1637.06

ELEVATION
(FEET)BLOW COUNTS
SAMPLES

SYMBOLS

DESCRIPTIONS

		ORANGISH-BROWN AND BROWN FINE TO MEDIUM SAND; LOCALLY WITH COARSE SAND AND FINE TO COARSE GRAVEL; OCCASIONAL COBBLE; TRACE SAND SIZE BLACK SHALE FRAGMENTS; MEDIUM DENSE	— 1635
34	SM	GRADES DARK BROWN SILT SEAM	
		GRADES TAN TO LIGHT BROWN FINE SILTY SAND; TRACE FINE TO COARSE GRAVEL; TRACE SAND SIZE BLACK SHALE FRAGMENTS; DENSE	— 1630
40			
41		TAN TO BROWN VERY FINE TO FINE SAND; TRACE SAND SIZE BLACK SHALE FRAGMENTS; TRACE SILT; TRACE MICA	— 1625
			— 1620
75		GRADES VERY DENSE	
			— 1615
108	SP		— 1610
60		18" BROWN SILTY LAYER FROM 32.0 FEET GRADING COASER	— 1605
56		GRADES TO TRACE FINE GRAVEL	
		TAN FINE TO COARSE SAND INTERBEDDED WITH BROWN FINE SAND; LOCALLY SOME FINE TO COARSE GRAVEL; TRACE SILT; VERY DENSE	— 1600
68			
			— 1595
108	SW		— 1590
70		GRADES TO OCCASIONAL COBBLE	
			— 1585
70 1/4"		TAN TO ORANGE FINE TO COARSE SAND AND FINE TO COARSE GRAVEL; TRACE SILT; 4"-6" COBBLES; VERY DENSE	
			— 1580
90	SW GW	GRADES GRAY 12" COBBLE FROM 60.0 FEET	
		GRADES NUMEROUS 4"-6" COBBLES	— 1575
		6" COBBLE FROM 67.0 FEET	
110 1/2"	SM	REDDISH-BROWN SILTY FINE SAND; TRACE COARSE SAND AND FINE GRAVEL; VERY DENSE	— 1570
		6" COBBLE AT 74.5 FEET	— 1565

BORING CONTINUED

LOG OF BORINGS

8837-058-07

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH T/N PSF	ATTERBERG LIMITS			FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	NO.
			LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %				
75									
80								81	50
85								70	38
90								16	0
95								32	20
100								100	80
105								91	77
110								100	87
115								100	77
120								100	54
125								100	75
130								100	84
135									
140								100	64
145								100	76
150									

BLOW COUNTS
SAMPLES

BORING DMI - 4 CONTINUED

ELEVATION
(FEET)

SYMBOLS

DESCRIPTIONS

100/3"	CH	PRECAMBRIAN SYSTEM RED CLAY; SOME SILT AND FINE TO COARSE SAND; HARD	— 1560
		GRADES WITH HIGHLY WEATHERED SAPROLITE FRAGMENTS AT 79.5 FEET	
		INTERMEDIATE ASH TUFF; RED; STRONG IRON OXIDE STAINING; HIGHLY WEATHERED - LOCALLY CLAYEY FRACTURE ZONES EVERY EVERY 6"-12"	— 1555
		VERY HIGH CLAY CONTENT - ROCK BADLY BROKEN AND WASHED AWAY	— 1550
			— 1545
			— 1540
		BASE OF HIGHLY OR INTENSE WEATHERING AT 98.0 FEET	
		YELLOWISH-GRAY; FINE GRAINED; MODERATE SURFACE WEATHERING; SLIGHTLY FRACTURED EVERY 12"-18"	— 1535
		HIGHLY WEATHERED FRACTURE CLAY LINED ZONE FROM 102.5 TO 103.5 FEET; STRONG IRON OXIDE STAINING	
			— 1530
		5° CLAY LINED FRACTURE AT 107.5 FEET	
		WEATHERED AND FRACTURED IRON OXIDE STAINED ZONE FROM 108.1 TO 108.4 FEET	
		YELLOW CLAY FILLED FRACTURE ZONE FROM 110.4 TO 110.0 FEET	— 1525
		SOME NEAR VERTICAL FRACTURES FROM 111.0 TO 112.5 FEET	
		HIGHLY WEATHERED, FRACTURED AND IRON OXIDE STAINED 112.2 TO 113.0 FEET	— 1520
		SLIGHTLY FRACTURED FROM 115.0 TO 116.0 FEET NEAR HORIZONTAL EVERY 6"-10"	
		IRON OXIDE STAINED FRACTURE ZONE FROM 117.6 TO 118.3 FEET	
		GRADES GRAY; MEDIUM TO COARSE GRAINED FROM 118.3 FEET; SLIGHT TO MODERATE SURFACE WEATHERING	— 1515
		OCCASIONAL IRON OXIDE STAINED VUG FROM 119.0 TO 120.0 FEET	
		HIGHLY FRACTURED ZONES FROM 120.3 TO 121.3 FEET AND 122.0 TO 122.5 FEET; WITH IRON OXIDE STAINING	— 1510
		NEAR VERTICAL FRACTURES FROM 124.0 TO 125.0 FEET SLIGHTLY OPEN FRACTURE FROM 125.0 TO 131.0 FEET	
		SOME CLOSED FRACTURES; MODERATE IRON OXIDE STAINING FROM 126.4 TO 126.8 FEET; 127.2 TO 127.4 FEET AND 131.5 TO 131.7 FEET	
		VERTICAL FRACTURE FROM 130.8 TO 131.3 FEET YELLOW, CLAY LINED FRACTURE ZONE FROM 131.8 TO 132.1 FEET	— 1505
		MODERATELY FRACTURED EVERY 2"-4"; MODERATE IRON OXIDE STAIN FROM 134.4 TO 136.0 FEET	
		CLAY AND SILT LINED FRACTURE ZONE FROM 138.2 TO 138.5 FEET	— 1500
		VERTICAL FRACTURE FROM 139.0 TO 140.0 FEET	
			— 1495
		MODERATELY WEATHERED AND FRACTURED ZONE FROM 146.3 TO 147.5 FEET; MODERATE IRON OXIDE STAIN; SOME CLAY FILLING	— 1490
		FINE TO MEDIUM GRAINED FROM 148.0 FEET; SLIGHTLY FRACTURED WITH 45° - 60° FRACTURE EVERY 8"-12"; LOCALLY MODERATE IRON OXIDE STAINING; OCCASIONAL VUGS, PINPOINT TO 1/2"	

BORING CONTINUED

LOG OF BORINGS

DAMES & MOORE

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH T/N PSF	ATTERBERG LIMITS			FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	NO.
			LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %				
150								100	100
155									
160								100	92
165									
170								100	97
175									
180								100	100
185									
190								100	92
195									
200								100	92
205									

BLOW COUNTS
SAMPLES

BORING DMI - 4

ELEVATION
(FEET)

SYMBOLS

DESCRIPTIONS

IRON OXIDE STAINING GRADES OUT

— 1485

GRADES OCCASIONAL QUARTZ FILLED FRACTURE 1/8"

— 1480

MODERATELY WEATHFRED; SLIGHTLY TO MODERATELY
FRACTURE WITH 200-750 FRACTURES EVERY 4"-8" WITH
IRON OXIDE STAINING

— 1475

3" WEAK FRACTURE ZONE AT 169.0 FEET
UNFRACTURED, HIGHLY COMPETENT AT 169.3 FEET
BASE OF MODERATE SURFACE WEATHERING AT 171.0 FEET

— 1470

75° IRON OXIDE STAINED FRACTURE AT 173.7 FEET

— 1465

OCCASIONAL STAINED, TIGHT FRACTURE OR VUG FILLING
AT 182.0 FEET

— 1460

60° IRON OXIDE STAINED FRACTURE AT 184.3 FEET

— 1455

NEAR VERTICAL IRON OXIDE STAINED TIGHT AND OPEN
FRACTURES FROM 187.2 TO 189.8 FEET

— 1450

WEAK FRACTURE ZONE FROM 192.7 TO 193.4 FEET

— 1445

WEAK FRACTURE ZONE FROM 195.5 TO 196.0 FEET; SOME
RED CLAY FILLING

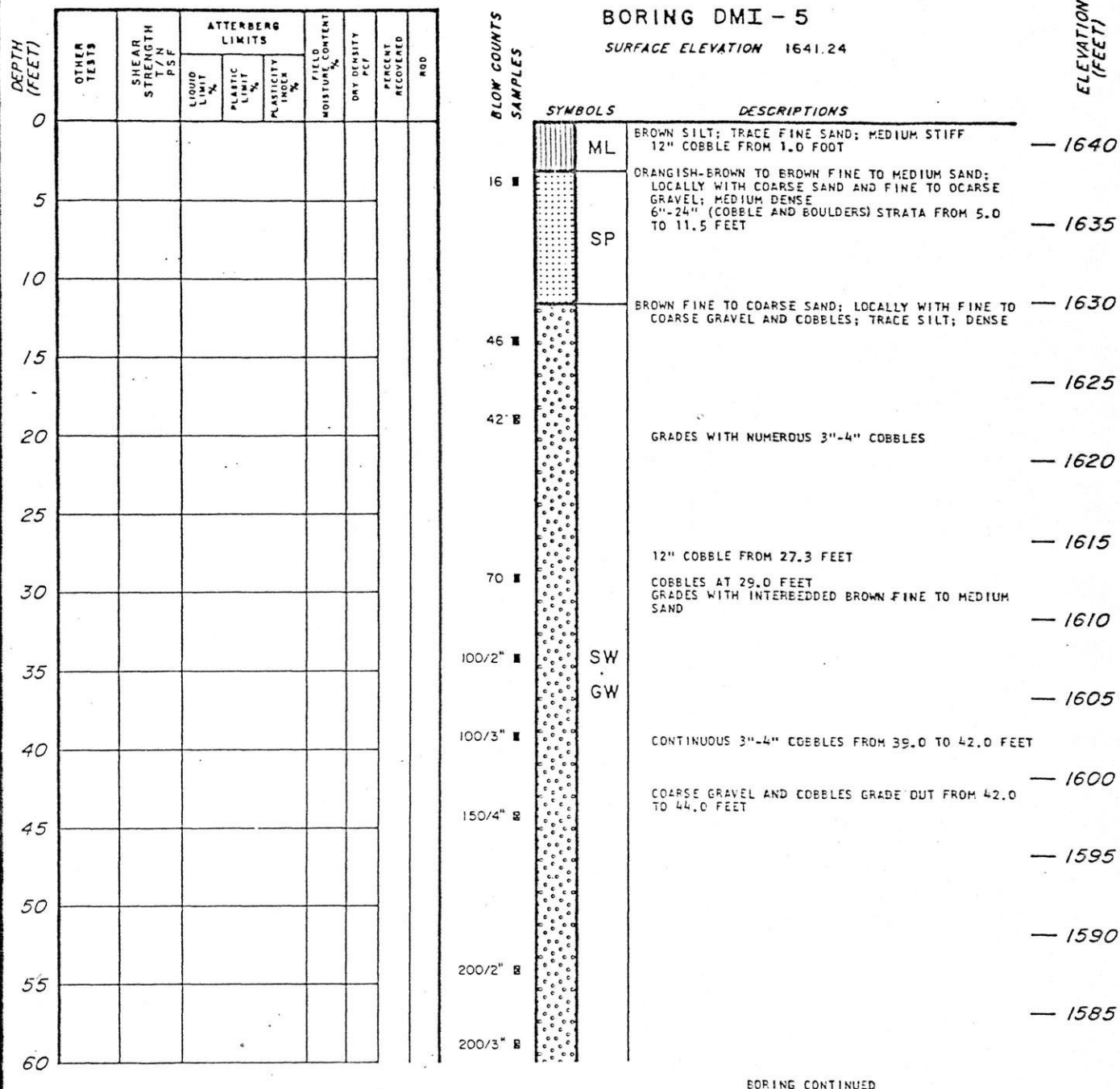
— 1440

3" WEAK FRACTURE ZONE AT 198.5 FEET; SOME GRAY CLAY
FILLING

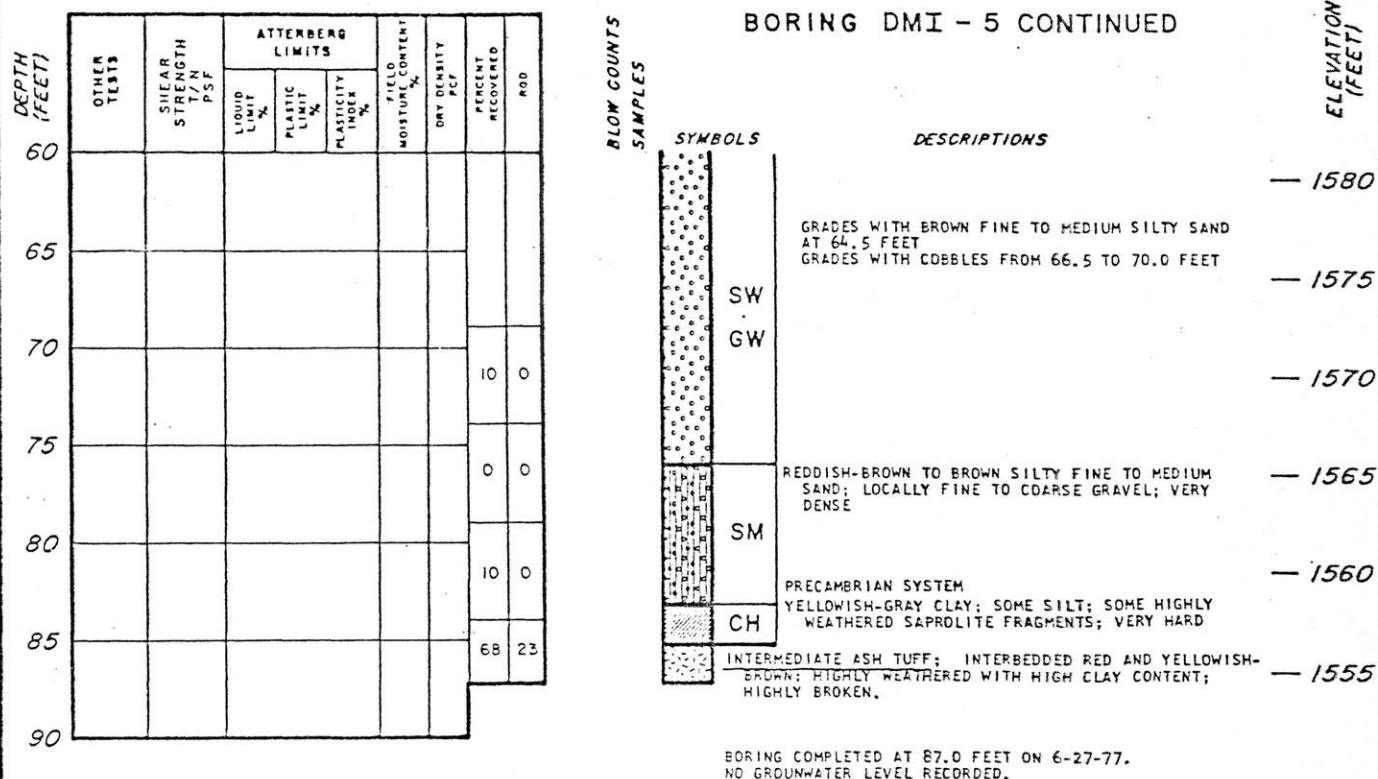
BORING COMPLETED AT 200.5 FEET ON 6-8-77.

— 1435

LOG OF BORINGS



LOG OF BORINGS



LOG OF BORINGS

8837-058-07

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH T/N PSF	ATTERBERG LIMITS			FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	ROD
			LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %				
0									
5									
10									
15									
20									
25									
30									
35									
40									
45									
50									
55									
60									
65						B.1	122		
70									
75									

BORING DMI - 7

SURFACE ELEVATION 1647.69

ELEVATION
(FEET)

BLOW COUNTS
SAMPLES

SYMBOLS

DESCRIPTIONS

	SP	BROWN FINE SAND; LOOSE (ROAD FILL - 6")	
	ML	BROWN SILT; TRACE FINE TO COARSE GRAVEL; MEDIUM STIFF	— 1645
16	SM	REDDISH-BROWN TO BROWN SILTY FINE TO MEDIUM SAND; SOME COARSE SAND AND FINE TO COARSE GRAVEL; MEDIUM DENSE	
40		TAN FINE TO COARSE SAND; INTERBEDDED WITH BROWN FINE TO MEDIUM SAND LAYERS; LOCALLY WITH FINE TO COARSE GRAVEL; OCCASIONAL COBBLE (4"-6"); TRACE SAND SIZE BLACK SHALE FRAGMENTS; MEDIUM DENSE	— 1640
53		GRADES VERY DENSE	— 1635
		GRAVEL GRADES OUT AT 16.0 FEET	
65	SW	GRADES TO TAN FINE TO MEDIUM SAND; SOME BLACK SHALE FRAGMENTS	— 1630
65/4"	SP	GRADES LOCALLY TO SOME FINE TO COARSE GRAVEL	
		GRADES LOCALLY TO FINE TO COARSE SAND WITH FINE TO COARSE GRAVEL	— 1625
45		GRADING TO MEDIUM TO COARSE SAND	— 1620
86		GRADING FINE TO COARSE SAND WITH FINE TO COARSE GRAVEL	— 1615
80	GP	FINE GRAVEL; SOME COARSE GRAVEL AND FINE TO COARSE SAND; VERY DENSE	— 1610
100/5"	SW	TAN FINE TO COARSE SAND; SOME FINE GRAVEL; LOCALLY WITH COARSE GRAVEL; VERY DENSE	— 1605
200		FINE TO COARSE GRAVE WITH BROWN FINE TO COARSE SAND; OCCASIONAL COBBLE; VERY DENSE	— 1600
		8" COBBLE FROM 47.8 FEET	
190	GW	GRADES FINE TO COARSE SAND WITH FINE TO COARSE GRAVEL; OCCASIONAL COBBLE; VERY DENSE	
	SW	GRADES CONTINUOUS 6"-8" COBBLES FROM 54.5 TO 63.0 FEET	— 1595
			— 1590
110	SW	BROWN FINE TO COARSE SAND; SOME FINE GRAVEL; VERY DENSE; LOCALLY TRACE SILT	— 1585
			— 1580
		GRADES SOME FINE TO COARSE GRAVEL	
110		BROWN FINE TO MEDIUM SILTY SAND; TRACE FINE TO COARSE GRAVEL; VERY DENSE	— 1575

BORING CONTINUED

LOG OF BORINGS

8837-058-07

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH KIP PSF	ATTERBERG LIMITS			FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	ROD	BLOW COUNTS SAMPLES	SYMBOLS	DESCRIPTIONS	ELEVATION (FEET)
			LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %								
75												GRADES LOCALLY WITH COARSE GRAVEL	— 1570
80													
85						6.9				60	SM SW	GRADES REDDISH-BROWN SAND; TRACE RED CLAY AND SILT; SOME FINE TO COARSE GRAVEL GRAVEL GRADES OUT	— 1565 — 1560
90													
95											CH	PRECAMBRIAN SYSTEM RED CLAY; WITH HIGHLY WEATHERED SAPROLITE; SOME GREENISH-CLAY SILT POCKETS; VERY HARD	— 1555
100								93	38			INTERMEDIATE LAPILLI TUFF; SUBANGULAR MAFIC FRAGMENTS (20%); MEDIUM GRAINED TUFF MATRIX (80%).	— 1550
105								100	72				— 1545
110								64	52			FAULT ZONE FROM 106.2 TO 110.0 FEET	— 1540
115								100	92			VERY WEAK FRACTURED ZONE FROM 114.0 TO 115.0 FEET	— 1535
120								100	100				— 1530
125								100	100			WEAK FRACTURE ZONE FROM 122.3 TO 123.2 FEET WEAK FRACTURE ZONE FROM 125.2 TO 126.8 FEET	— 1525 — 1520
130								100	80			NUMEROUS FILLED FRACTURES, 1/16" THICK FROM 128.5 TO 132.0 FEET AND < 1/8" TO 1" THICK FROM 134.0 TO 136.5 FEET	— 1515
135								100	100			INTERMEDIATE ASH TUFF; COARSE GRAINED; UNIFORM TEXTURE; OCCASIONAL CHLORITIC FRAGMENTS	— 1510
140								100	100				— 1505
145								100	100				— 1500
150													

BORING CONTINUED

LOG OF BORINGS

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH 1/4" W PSF	ATTERBERG LIMITS			FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	MOB
			LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %				
150								100	100
155									
160								100	100
165									
170								98	98
175									
180								94	86
185									
190								100	100
195									
200								100	100
205								100	100
210								100	100
215								100	100
220								100	100
225									

BLOW COUNTS
SAMPLES

BORING DMI - 7 CONTINUED

ELEVATION
(FEET)

SYMBOLS

DESCRIPTIONS

INTERMEDIATE LAPILLI TUFF; MAFIC CHLORITIC FRAGMENTS (40 TO 60%); MEDIUM GRAINED ASH MATRIX (40 TO 60%)

OCCASIONAL FILLED FRACTURE, < 1/16" THICK FROM 150.0 TO 178.0 FEET

— 1495

— 1490

— 1485

— 1480

— 1475

VERY WEAK FRACTURE ZONES FROM 178.0 TO 178.5 FEET AND FROM 182.5 TO 183.0 FEET

— 1470

INTERMEDIATE ASH TUFF; VARIABLE TEXTURE; LOCALLY LAPILLI TUFF. OCCASIONAL FILLED FRACTURE, < 1/16" THICK FROM 182.0 TO 195.0 FEET

— 1465

— 1460

— 1455

INTERMEDIATE LAPILLI TUFF; MAFIC ANGULAR CHLORITIC FRAGMENTS (50%); MEDIUM GRAINED ASH MATRIX (50%)

— 1450

— 1445

— 1440

INTERMEDIATE ASH TUFF; FINE GRAINED, LAMINATED TEXTURED FROM 205.0 TO 224.0 FEET; MEDIUM GRAINED, MASSIVE FROM 224.0 TO 230.0 FEET; COARSE GRAINED, MASSIVE FROM 230.0 TO 237.0 FEET; OCCASIONAL FILLED FRACTURES, < 1/16" THICK FROM 202.0 TO 212.0 FEET SEVERAL FRACTURES EVERY 1/2" TO 1" FROM 212.0 TO 215.0 FEET

— 1435

— 1430

FRACTURE ZONE FROM 219.0 TO 220.0 FEET

BROKEN ZONE FROM 222.0 TO 223.5 FEET

— 1425

OCCASIONAL FILLED FRACTURE, < 1/16" TO 1/8" THICK FROM 224.5 TO 226.0 FEET

BORING CONTINUED

LOG OF BORINGS

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH T _{1/2} IN PSF	ATTERBERG LIMITS			FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	MOQ
			LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %				
225								100	100
230								100	100
235								100	100
240									
245								100	100
250								100	100
255									

BLOW COUNTS
SAMPLES

BORING DMI - 7 CONTINUED

ELEVATION
(FEET)

SYMBOLS

DESCRIPTIONS



— 1420

OCCASIONAL FILLED FRACTURE, < 1/16" THICK FROM
233.0 TO 236.0 FEET

— 1415

FELSIC - INTERMEDIATE LAPILLI TUFF; MAFIC CHLORITIC
ANGULAR FRAGMENTS (50%); COARSE FELSIC ASH (70%)

— 1410

OCCASIONAL FILLED FRACTURE, < 1/16" THICK FROM
241.0 TO 250.2 FEET

— 1405

— 1400

STRONG FRACTURE ZONE FROM 250.2 TO 252.8 FEET

— 1395

BORING COMPLETED AT 252.8 FEET ON 5-29-77.

LOG OF BORINGS

8837-058-07

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH T/N PSF	ATTERBERG LIMITS			FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	NO.
			LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %				
0									
5									
10									
15									
20									
25									
30						4.8	107		
35									
40									
45									
50									
55									
60						11.2	121		
65									
70									
75									

BORING DMI-8

SURFACE ELEVATION 1647.29

BLOW COUNTS
SAMPLES

SYMBOLS

DESCRIPTIONS

0	ML	GRAYISH-BROWN SILT; SOME ORGANICS; WITH LEAVES AND FINE ROOTS (TOPSOIL - 12")	— 1645
15		BROWN FINE SILTY SAND; SOME COARSE SAND; TRACE FINE GRAVEL; MEDIUM DENSE	
15	SM	GRADES BROWN FINE TO MEDIUM SILTY SAND; SOME COARSE SAND AND FINE TO COARSE GRAVEL; SOME 3"-4" COBBLES; MEDIUM DENSE	— 1640
25		TAN MEDIUM TO COARSE SAND; TRACE FINE SAND AND FINE GRAVEL; LITTLE SAND SIZE BLACK SHALE FRAGMENTS; LOCALLY TRACE SILT; MEDIUM DENSE	— 1635
25		GRADES WITH FINE TO COARSE GRAVEL FROM 15.0 TO 17.0 FEET	— 1630
120		GRADES TAN FINE TO MEDIUM SAND; VERY DENSE	
70		GRADES LOCALLY WITH SOME FINE TO COARSE SAND AND FINE TO COARSE GRAVEL BELOW 21.5 FEET; OCCASIONAL 3"-4" COBBLE	— 1625
76	SP		— 1620
104			— 1615
105			— 1610
100/4"		6" COBBLE FROM 13.5 FEET	— 1605
100/4"		BROWN FINE TO COARSE SAND; LITTLE FINE TO COARSE GRAVEL; OCCASIONAL COBBLE; VERY DENSE	— 1600
200	SW	FINE TO COARSE GRAVEL CONTENT INCREASING	— 1595
100/0"		FINE TO COARSE GRAVEL WITH 6"-12" COBBLES; VERY DENSE	
100	GW		— 1590
100		ORANGISH-BROWN AND BROWN FINE TO COARSE SAND; SOME FINE GRAVEL; SOME COARSE GRAVEL; VERY DENSE	— 1585
100	SW	GRADES TRACE SILT POCKETS	
100		18" BOULDER FROM 61.5 FEET	— 1580
102		REDDISH-BROWN SILTY FINE SAND; TRACE COARSE SAND AND FINE TO COARSE GRAVEL; VERY DENSE	— 1575
102	SM	GRADES LOCALLY WITH COARSE GRAVEL AND COBBLES	

BORING CONTINUED

LOG OF BORINGS

BORING DMI - 8 CONTINUED

ELEVATION
(FEET)

DEPTH (FEET)	OTHER TESTS	SHEAR STRAIN T/N PSF	ATTERBERG LIMITS			FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	PCD
			LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %				
75									
80									
85									
90									
95									
100								60	0
105								66	34
110								44	10
115								100	76
120								37	18
125								90	90
130								100	17
135								57	9
140								100	87
145								100	60
150									

BLOW COUNTS
SAMPLES

200/7"

120

SYMBOLS

DESCRIPTIONS

GRADES ORANGISH-BROWN

GRADES WITH INTERBEDDED GREENISH-GRAY RESIDUAL
SILT LAYERS AND ROCK FRAGMENTS

SM

GRADES REDDISH-BROWN

PRECAMBRIAN SYSTEM

SAPROLITE; HIGHLY WEATHERED; APPEARS TO BE INTERMEDIATE
CAPILLI TUFFINTERMEDIATE CAPILLI TUFF; RED; STRONG IRON OXIDE
STAINING; MODERATE TO HIGH SURFACE WEATHERING; HIGHLY
FRACTURED FROM 98.5 TO 111.0 FEET; WITH CLAY LINED
FRACTURES; LOCALLY HIGH CLAY CONTENT
MODERATELY FRACTURED; COMPETENT FRACTURE FROM 101.0
TO 102.7 FEET

BASE OF HIGH WEATHERING AT 111.5 FEET

GRADES YELLOWISH-GRAY TO GRAY; FINE TO MEDIUM
GRAINED; SLIGHT SURFACE WEATHERING; SLIGHTLY
FRACTUREDFRACTURE ZONE FROM 113.8 TO 114.4 FEET; SOME CLAY
FILLING; MODERATE IRON OXIDE STAINING
LOCALLY MODERATE TO HIGHLY FRACTURED FROM 116.2 FEETSLIGHTLY WEATHERED; SLIGHTLY FRACTURED FROM 125.0
FEETRED; HIGHLY WEATHERED; LOCALLY VERY CLAYEY; HIGHLY
FRACTURED FROM 129.4 TO 139.7 FEETGRADES GRAY; MEDIUM GRAINED; SLIGHTLY WEATHERED;
SLIGHTLY FRACTURED75° OPEN FRACTURE AT 141.0 FEET
MODERATELY FRACTURED; MODERATE IRON OXIDE STAINING
FROM 142.0 TO 143.0 FEET; SOME CLAY FILLING, 1/8"WEAK FRACTURE ZONE FROM 145.5 TO 146.3 FEET; STRONG
IRON OXIDE STAINING; TRACE QUARTZ FILLING
70°-VERTICAL CLOSED FRACTURES FROM 146.3 TO 148.0
FEETVERTICAL FRACTURES, 1/8"; MODERATE IRON OXIDE STAINING
FROM 148.0 FEET; MODERATELY WEATHERED; SOME CLAY
FILLING

BORING CONTINUED

LOG OF BORINGS

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH T/N PSF	ATTERBERG LIMITS			FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	RQD	BLOW COUNTS SAMPLES	SYMBOLS	DESCRIPTIONS	ELEVATION (FEET)
			LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %								
150								100	60			SLIGHTLY WEATHERED BEDDING PLANE; FRACTURED FROM 150.0 TO 155.0 FEET MODERATELY TO HIGHLY WEATHERED FROM 155.0 TO 159.8 FEET VERTICAL BEDDING PLANE FRACTURES; OPEN AND CLOSED; LOCALLY CLAYEY FROM 158.8 TO 159.8 FEET	— 1495
155								100	100			TRACE YELLOW STAINING ALONG INFREQUENT FRACTURES FROM 161.0 FEET SLIGHTLY WEATHERED FROM 162.5 FEET; WEAK IRON OXIDE STAINING ALONG WEAK VERTICAL FRACTURE ZONES	— 1490
160								100	80			MODERATELY FRACTURED; MUCH BREAKAGE ALONG WEAK VERTICAL BEDDING PLANES WITH STRONG IRON OXIDE STAINING	— 1485
165								74	28			MODERATE TO COARSE GRAINED AT 170.0 FEET ROCK BREAKING WEAKLY ALONG BEDDING PLANES; SOME MICRO-FRACTURES BEGINNING TO APPEAR, ABOUT 5/FOOT FROM 170.0 TO 180.3 FEET MOTTLED GRAY AND WHITISH-GRAY FROM 174.2 FEET; SLIGHTLY WEATHERED	— 1480
170								100	76				— 1475
175								100	92				— 1470
180								94	54			RED; STRONG IRON OXIDE CONTENT; MODERATELY TO HIGHLY WEATHERED; HIGHLY FRACTURED AND WEATHERED ZONES EVERY 6"-18"; OCCASIONAL QUARTZ FILLING; LOCALLY CLAYEY; MICROFRACTURES, 10-20/FOOT FROM 180.3 TO 211.5 FEET	— 1465
185								100	34				— 1460
190								100	52				— 1455
195								58	0			FAULT ZONE FROM 193.3 TO 197.4 FEET 2" QUARTZ INCLUSION FROM 195.0 FEET	— 1450
200								60	33			2" QUARTZ INCLUSION FROM 201.0 FEET	— 1445
205								92	92				— 1440
210								100	70			MOTTLED RED AND GRAY FROM 211.5 TO 230.0 FEET; MODERATELY WEATHERED; MODERATELY FRACTURED ALONG VERTICAL BEDDING PLANES; MODERATE IRON OXIDE STAINING; SEVERAL MICROFRACTURES PER FOOT	— 1435
215								100	54			WEAK HIGHLY FRACTURED ZONE FROM 217.4 TO 218.7 FEET; SOME CLAY CONTENT 4"-6" WEAK HIGHLY FRACTURED ZONES EVERY 1'-2'	— 1430
220								75	34				— 1425
225													

BORING CONTINUED

LOG OF BORINGS

BORING DMI - 8 CONTINUED

ELEVATION
(FEET)

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH T/N PSF	ATTERBERG LIMITS			FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	ROD
			LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %				
225								100	55
								100	0
230								100	94
235								100	80
240								88	64
245								100	96
250								100	68
255								100	41
								100	87
260								100	65
265									

BLOW COUNTS
SAMPLES

SYMBOLS

DESCRIPTIONS

HIGHLY FRACTURED ZONE FROM 228.0 TO 230.0 FEET

— 1420

GRAY; SLIGHTLY WEATHERED; SLIGHTLY FRACTURED FROM
230.0 TO 240.0 FEET; SOME BREAKAGE ALONG NEAR VERTICAL
BEDDING PLANES
MODERATE IRON OXIDE STAINING FROM 233.5 TO 236.3
FEET

— 1415

— 1410

MOTTLED RED AND GRAY FROM 240.0 TO 251.5 FEET;
LOCALLY SLIGHT TO MODERATE IRON OXIDE STAINING;
SLIGHTLY TO MODERATELY WEATHERED; MODERATELY FRACTURED,
SOME LIMONITE STAINING IN FRACTURES; SOME BREAKAGE
ALONG WEAK BEDDING PLANES

— 1405

— 1400

COARSE GRAINED FROM 251.5 TO 255.0 FEET; SLIGHTLY
FRACTURED, 60°-75° OPEN FRACTURES EVERY 6"-8"

— 1395

FINE GRAINED FROM 255.0 FEET; SLIGHTLY WEATHERED;
MODERATE TO HIGH BREAKAGE ALONG HIGH ANGLE BEDDING
PLANES
GRAY CLAY FILLED FRACTURE, 1/16" AT 257.5 FEET

— 1390

GRAY CLAY FILLED FRACTURE, 1/2" AT 260.5 FEET

— 1385

BORING COMPLETED AT 264.0 FEET ON 6-12-77.
WATER LEVEL RECORDED AT 62.5 FEET UPON COMPLETION.

8837-058-07

LOG OF BORINGS

DAMES & MOORE

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH T/N PSF	ATTERBERG LIMITS			FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	NO.
			LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %				
0									
5									
10									
15									
20									
25									
30									
35		3600/2500 4400/4500				13.6	115		
40									
45						7.5	127		
50									
55									
60								100	93
65									
70								100	77
75									

BORING DMI - 9

SURFACE ELEVATION 1633.82

BLOW COUNTS
SAMPLES

SYMBOLS

DESCRIPTIONS

ELEVATION
(FEET)

BLOW COUNTS SAMPLES	SYMBOLS	DESCRIPTIONS	ELEVATION (FEET)
7	ML	BROWN SILT WITH ROOTS; MEDIUM STIFF (MODIFIED LOESS)	— 1630
10	SW SP	COARSE GRAVEL WITH 6"-24" COBBLES AND GOULDERS WITH INTERBEDDED REDDISH-BROWN FINE SILTY SAND; MEDIUM DENSE	— 1625
27	SP	ORANGISH-BROWN MEDIUM SAND; SOME BROWN FINE TO COARSE SAND; SOME BLACK SHALE FRAGMENTS; LOOSE	— 1620
62		GRADES TAN; MEDIUM DENSE	— 1615
60/3		TAN FINE TO COARSE SAND; LOCALLY SOME FINE TO COARSE GRAVEL; VERY DENSE OCCASIONAL 3"-4" COBBLE	— 1610
60	SW	GRADES WITH OCCASIONAL LAYERS OF FINE SAND	— 1605
100/2			— 1600
96	SP	BROWN FINE TO MEDIUM SAND; TRACE COARSE SAND AND FINE GRAVEL TRACE SILT; VERY DENSE	— 1595
200		6" COBBLE FROM 41.0 FEET FINE TO COARSE GRAVEL WITH FINE TO COARSE SAND WITH COBBLES; TRACE SILT VERY DENSE	— 1590
200/5	GW SW	8" COBBLE FROM 44.5 FEET	— 1585
200/4		GRADES TRACE YELLOWISH-GRAY AND RED CLAY	— 1580
	CH	PRECAMBRIAN SYSTEM MOTTLED YELLOWISH-GRAY AND RED CLAY; SOME SILT; WITH HIGHLY WEATHERED SAPROLITE FRAGMENTS; VERY HARD	— 1575
		FELSIC ASH TUFF; GREENISH-GRAY; LOCALLY WITH BROWN MOTTLING; FINE GRAINED; SLIGHTLY TO MODERATELY WEATHERED; SLIGHTLY FRACTURED. SOME BREAKAGE ALONG WEAK NEAR VERTICAL BEDDING PLANES 3" WEAK FRACTURE ZONE FROM 61.1 FEET	— 1570
		STRONG IRON OXIDE STAINED, WEAK FRACTURE ZONE FROM 65.2 TO 65.9 FEET GRADES GRAY; MEDIUM GRAINED FROM 65.9 FEET; LOCALLY MODERATE IRON OXIDE STAINING	— 1565
		FELSIC - INTERMEDIATE LAPILLI TUFF; CHLORITIC MAFIC FRAGMENTS (20 - 50%), GENERALLY SUBANGULAR; FELSIC LAPILLI TUFF (60 - 70%) NEAR VERTICAL FRACTURE FROM 70.0 TO 71.0 FEET; SOME CLAY FILLING OCCASIONAL CLAY FILLED HORIZONTAL FRACTURE EVERY 2"-6" FROM 71.7 TO 73.0 FEET SLIGHTLY WEATHERED, UNFRACTURED FROM 73.9 FEET	— 1560

BORING CONTINUED

LOG OF BORINGS

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH T/N PSF	ATTERBERG LIMITS			FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	ROD
			LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %				
75								100	100
80								100	100
85									
90								100	97
95									
100								100	100
105									

BLOW COUNTS
SAMPLES

BORING DMI - 9 CONTINUED

ELEVATION
(FEET)

SYMBOLS

DESCRIPTIONS

80° OPEN FRACTURE FROM 80.0 FEET
DARK GRAY; MEDIUM TO COARSE GRAINED FROM 81.0 FEET

0° OPEN FRACTURE FROM 83.6 FEET

70° OPEN FRACTURE FROM 87.7 FEET
0° OPEN FRACTURE FROM 88.2 FEET
WEAK BEDDING PLANE BREAK, NEAR VERTICAL FROM 90.2 TO
90.8 FEET
45° OPEN, IRON OXIDE STAINED FRACTURE FROM 91.2 FEET
80° OPEN FRACTURE FROM 91.5 FEET

60° OPEN FRACTURE FROM 94.0 FEET

NEAR VERTICAL FRACTURE FROM 97.2 TO 97.7 FEET

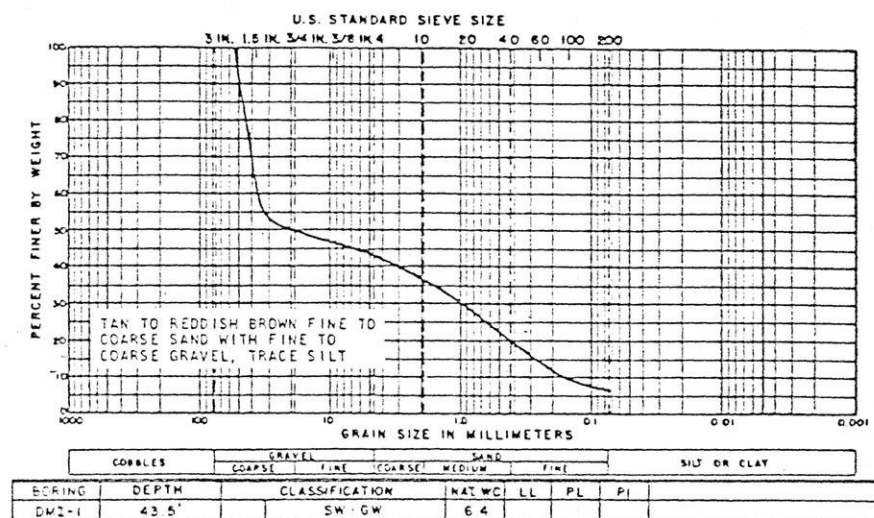
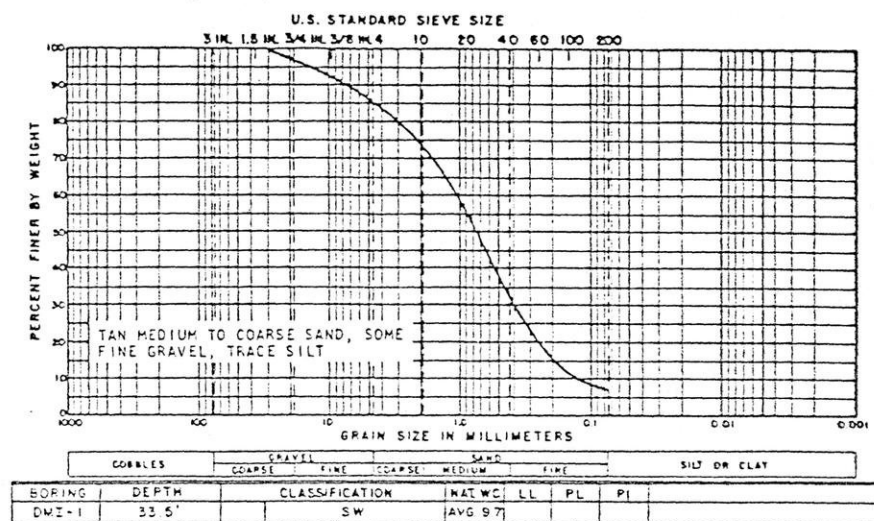
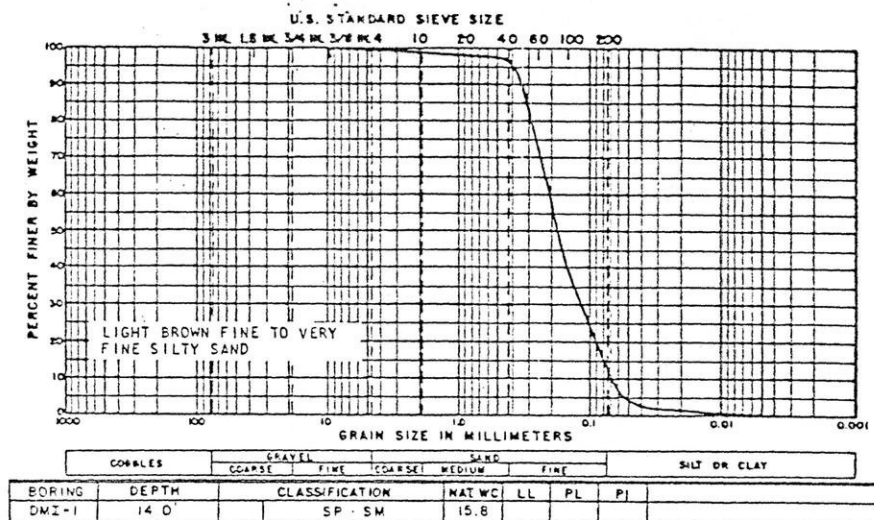
45° OPEN, IRON OXIDE STAINED FRACTURE FROM 99.7 FEET

BORING COMPLETED AT 104.0 FEET ON 6-24-77.
WATER LEVEL RECORDED AT 24.5 FEET UPON COMPLETION.
WATER LEVEL RECORDED AT 41.0 FEET AT 0800 ON 6-25-77.

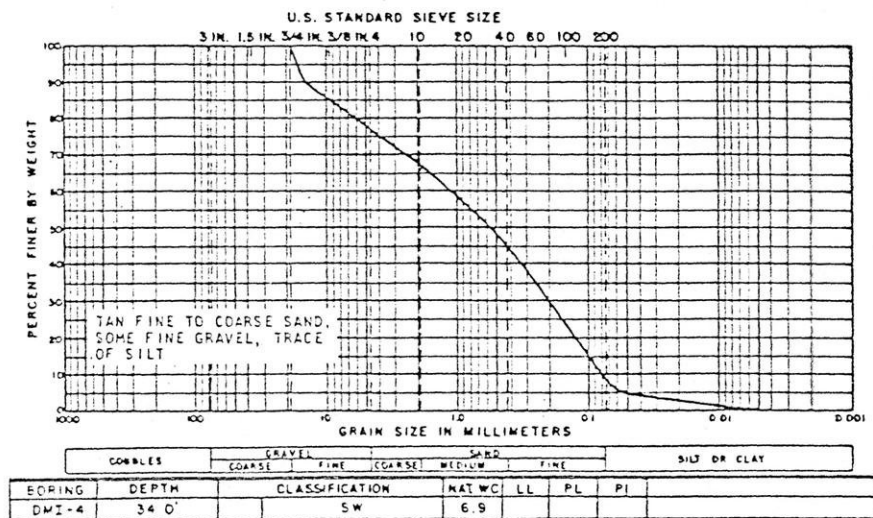
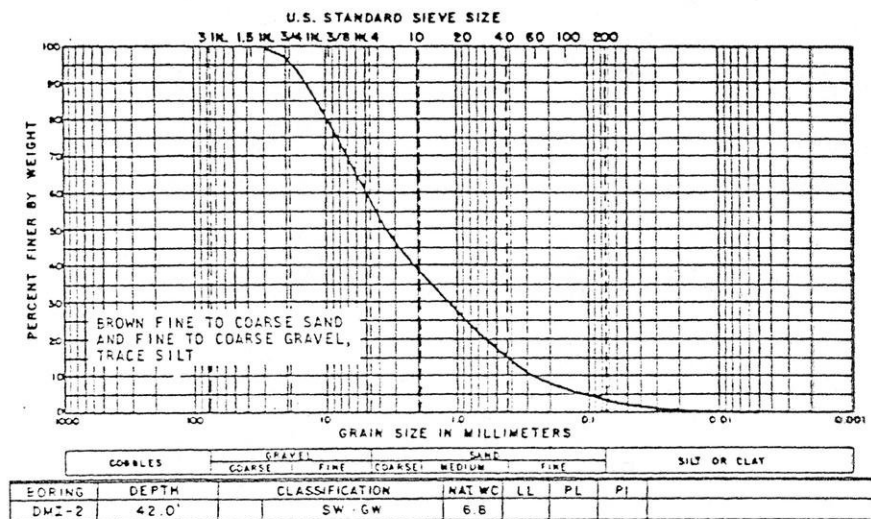
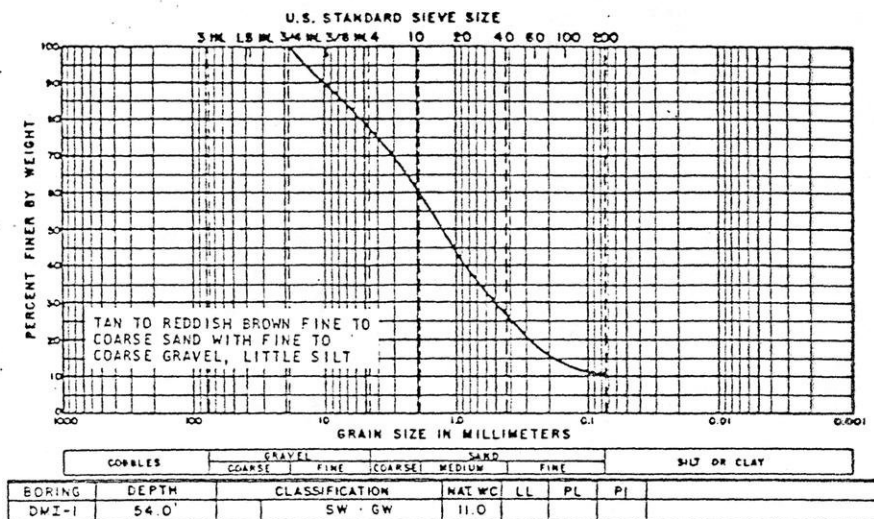
LOG OF BORINGS

DAMES & MOORE

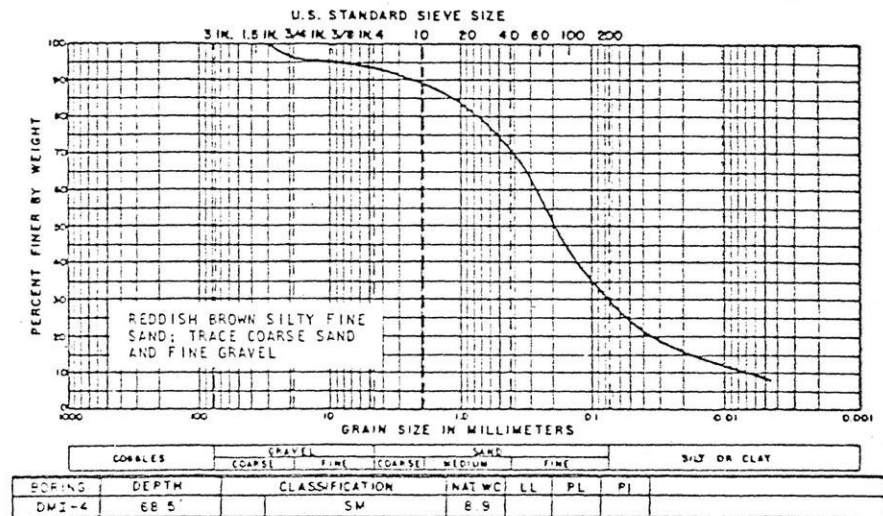
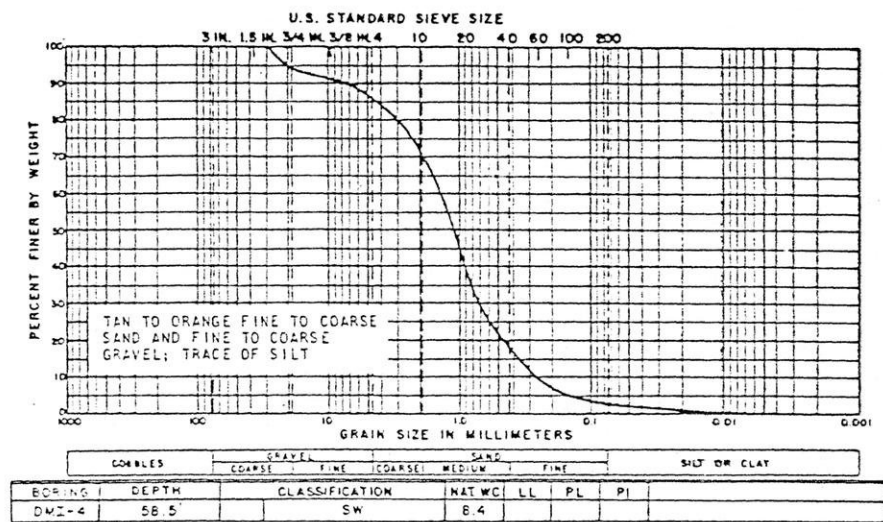
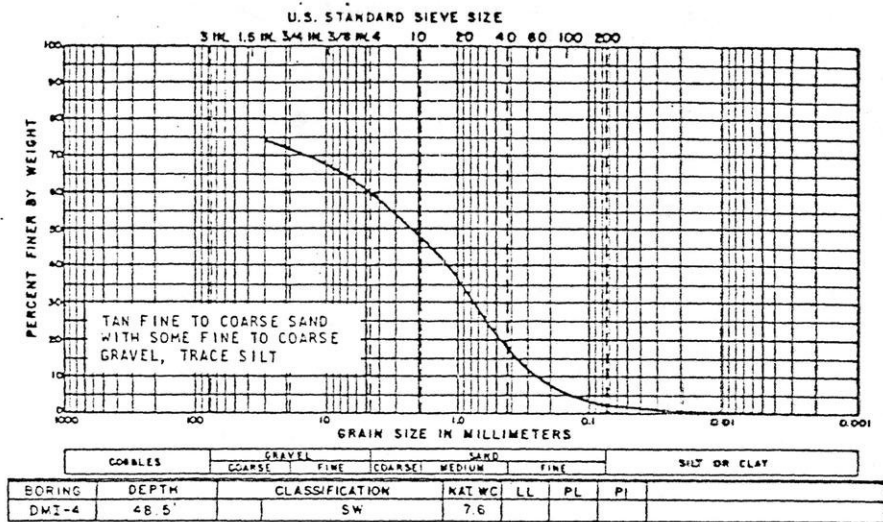
APPENDIX B - GRAIN SIZE ANALYSIS



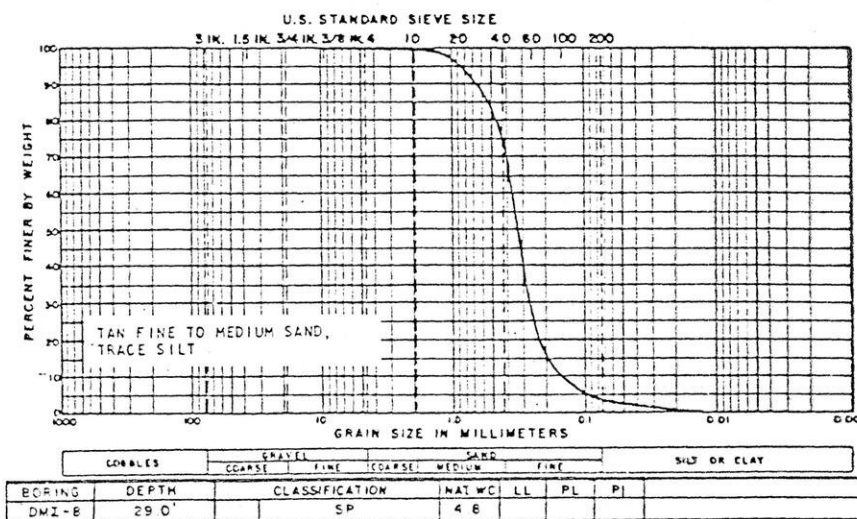
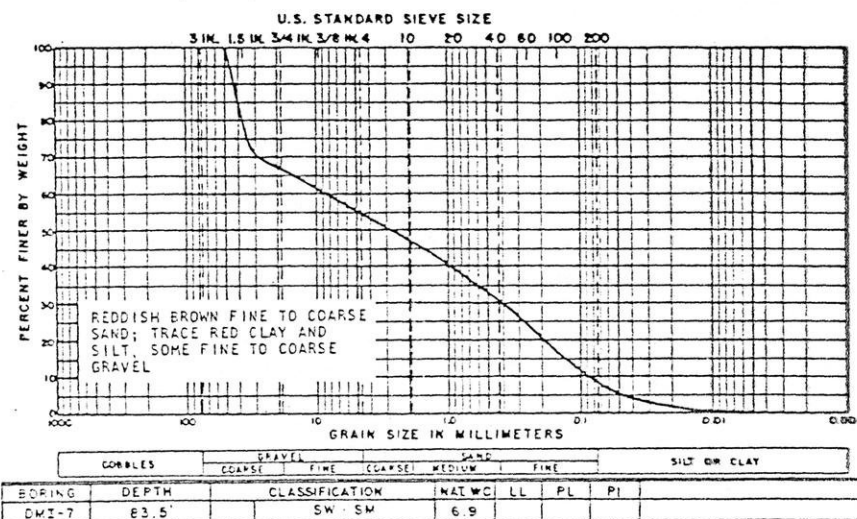
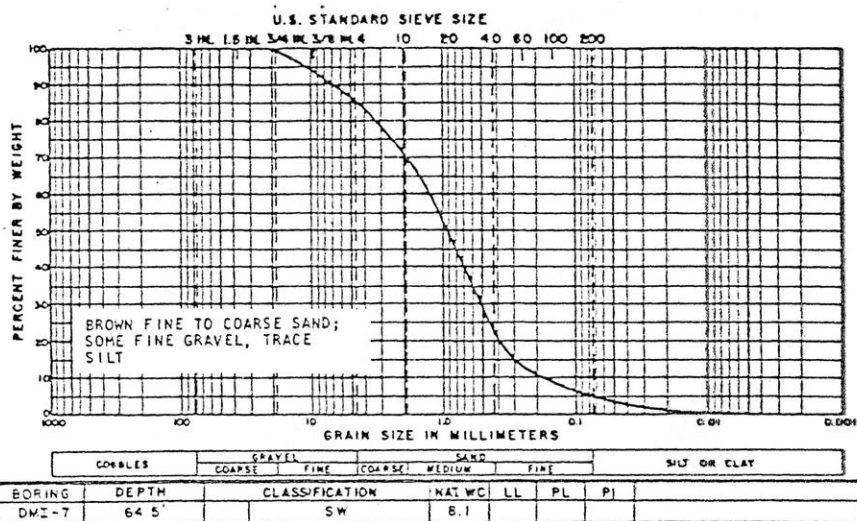
PARTICLE SIZE ANALYSES



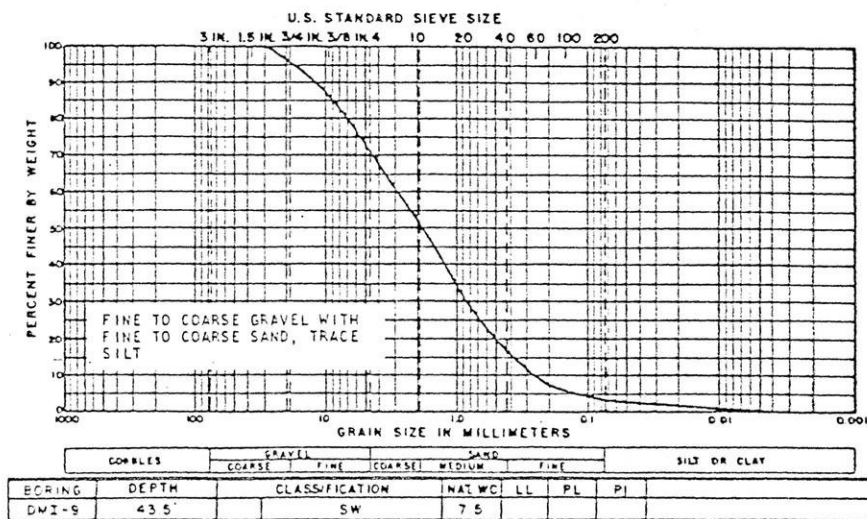
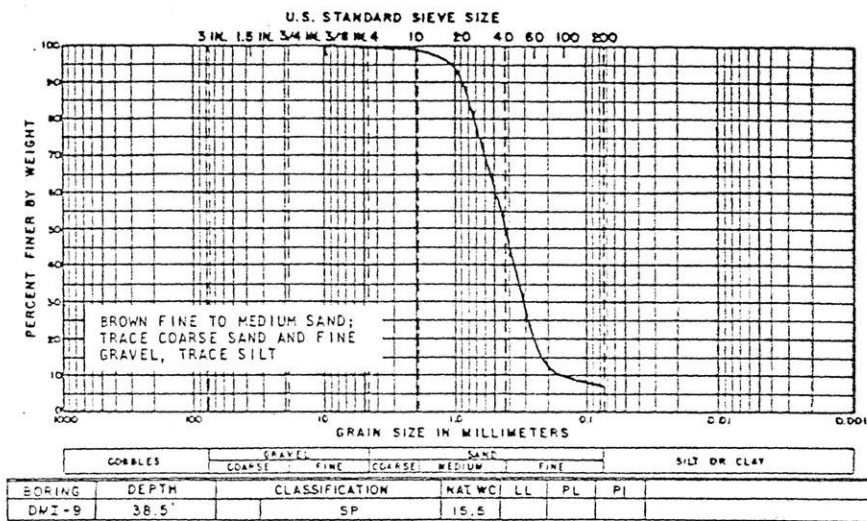
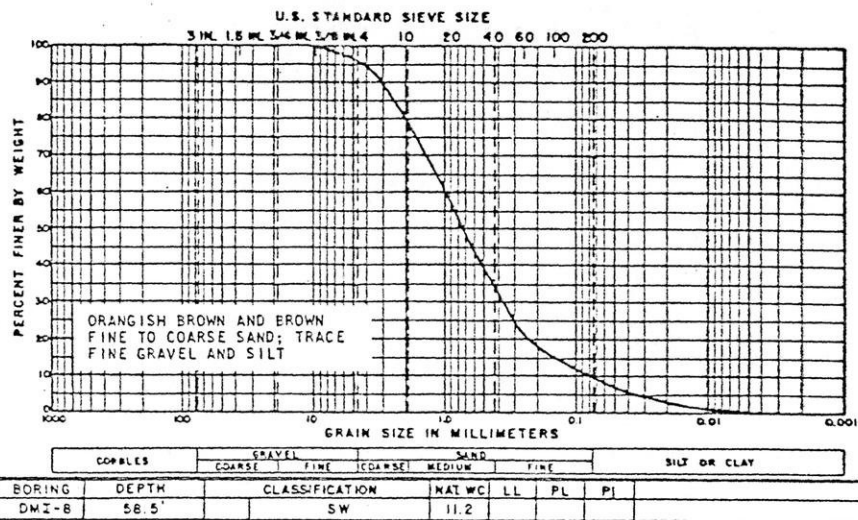
PARTICLE SIZE ANALYSES



PARTICLE SIZE ANALYSES



PARTICLE SIZE ANALYSES



PARTICLE SIZE ANALYSES

APPENDIX C - EXXON BORING LOGS

Handwritten: Lian 5/19/77

EXXON COMPANY, U.S.A.

June 15, 1977

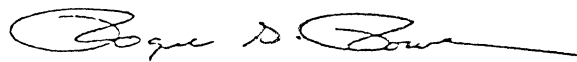
TO: E. R. May

FROM: R. G. Rowe

SUBJ: Dames & Moore Incline Test Hole DMI-1

The decline is located at a depth of 32.0'-42.0' in the middle part of the glacial overburden. The Precambrian schist begins at 61.0', and is moderately weathered to the bottom of the hole at 109.0'. Locally, the rock may or may not hold a back.

Two bad faults with strong clay gouges exist at 72.6'-73.8' and 100.7'-102.4'.


Roger G. Rowe

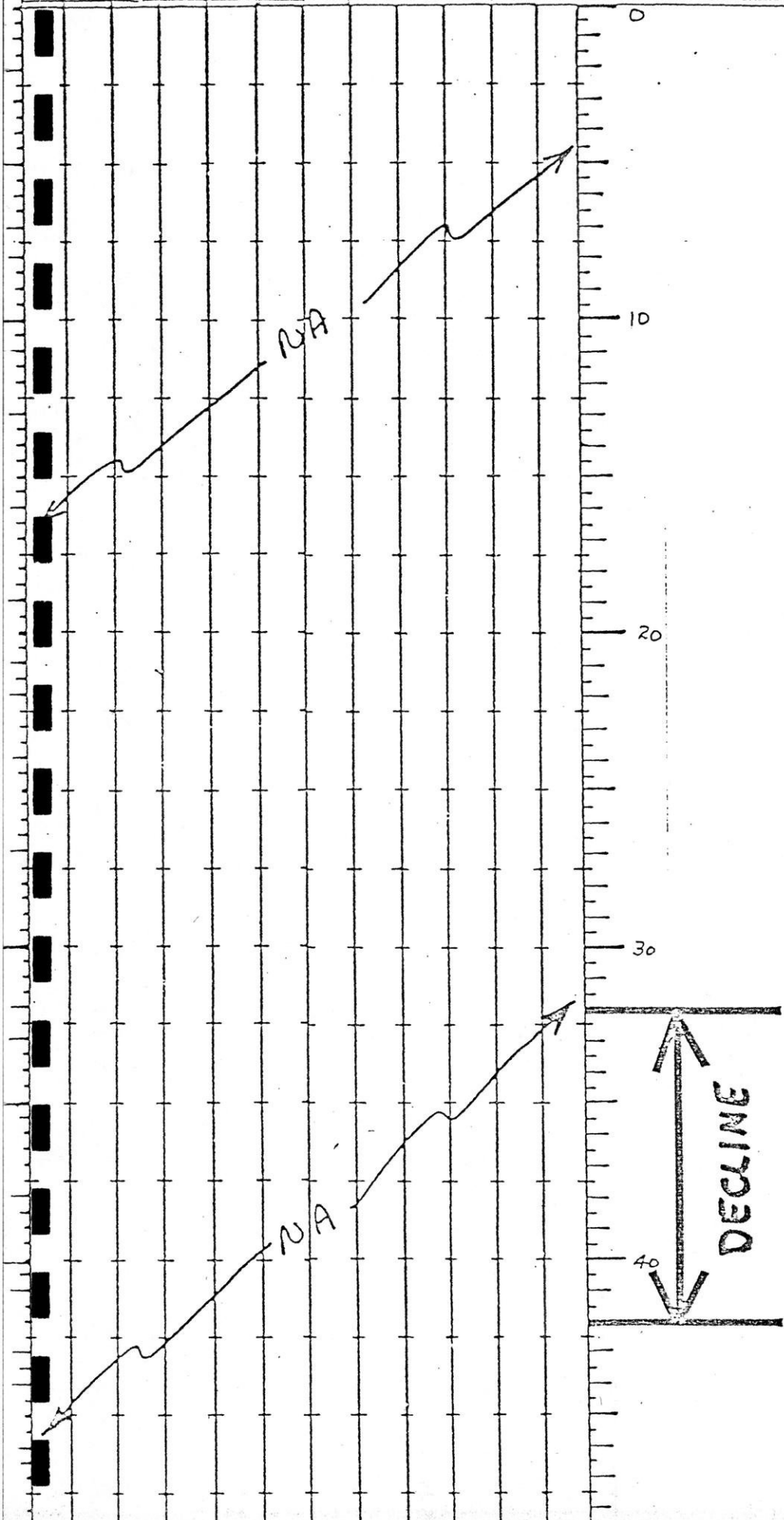
RGR/jfk

DAMES & MOORE
JUN 21 1977
DARK RIDGE, IL

Project No.	Bedding	to core pos.	Subsides	Drifts	Alteration	Extremely weathering	FACIES	CORE LENGTH	FRACTURE / FAULT DATA					
									Angle to horizon	Filling	Thick	SIZE	%	REMARKS

PROJECT CRANDON DRINKS & MOORE # I-1
 Coord _____ Page 1 Date 6/77
 Collar elev _____ By R. Rowe Scale 1"=5'

Fracture / Fault
 RATE
 MIN / FT
 R.M. / SEC



GLACIAL Debris
 (Overburden)

[illegible]

For zone 79

2500 RPM - 300 PSI

EXXON COMPANY, U.S.A.

June 27, 1977

MEMORANDUM

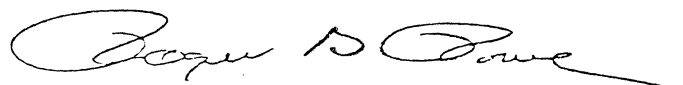
TO: E. R. May

FROM: R. G. Rowe

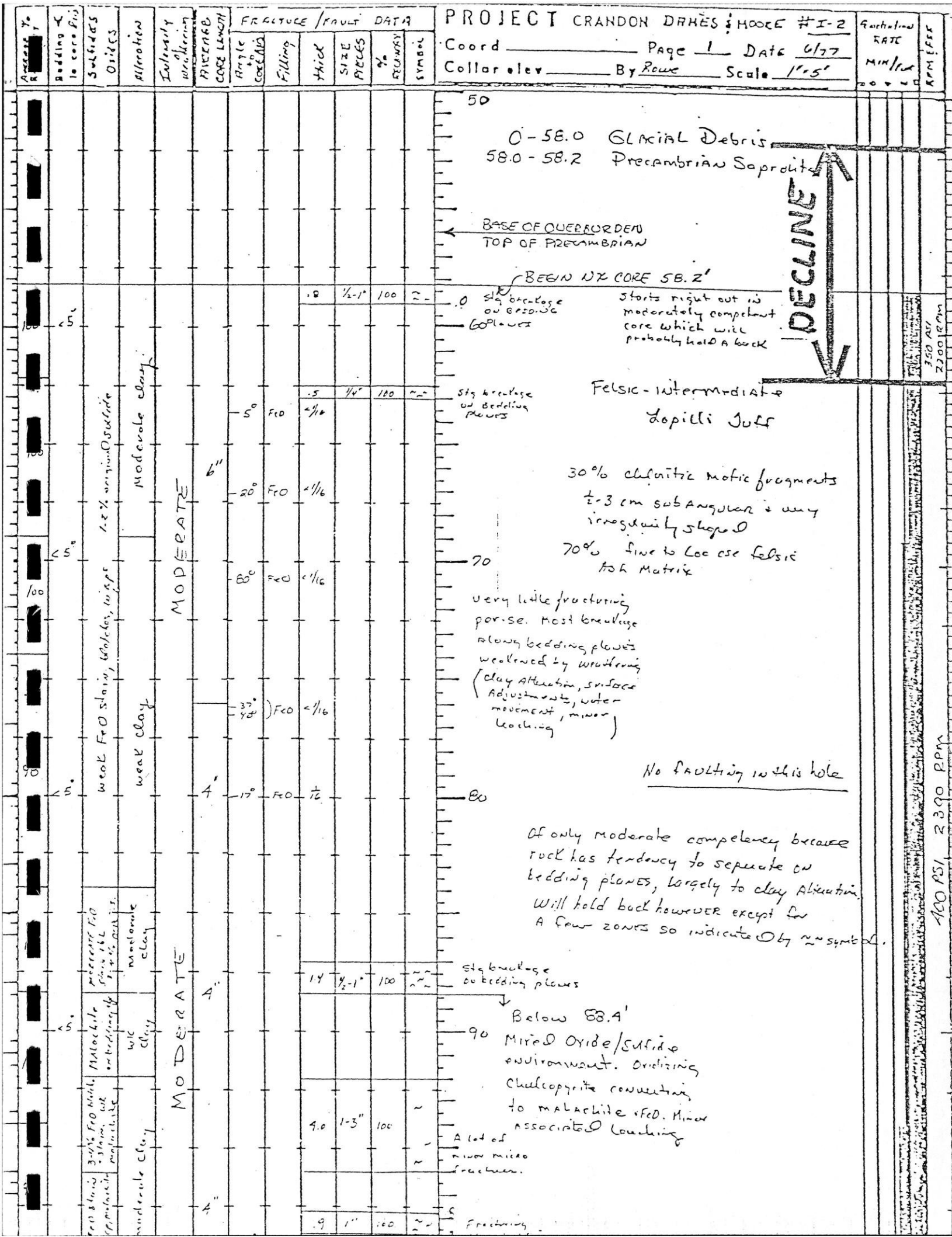
SUBJ: Dames And Moore Incline Test Hole I-2

Hole I-2 is a competent hole from top to bottom. There are no fracture zones per se, and most of the breakage of core is along bedding planes, primarily as the result of moderate clay weathering of the rock.

The decline cuts the section at the overburden-Precambrian interface. The top of the Precambrian is moderately competent and will probably hold a back with rock bolting.


Roger G. Rowe

RGR/jfk



FRACTURE / FAULT DATA					
Angle Core Axis	Filling	Thick	Size Pieces	% Recovery	Symbol

50

0-58.0 GLACIAL Debris
58.0-58.2 Precambrian Saprolite

BASE OF OVERBURDEN
TOP OF PRECAMBRIAN

BEGIN NX CORE 58.2'

Stg breccage
on base of
60' plane

Starts right out in
moderately competent
core which will
probably hold a buck

DECLINE

Felsic-intermediate
Lapilli Tuff

30% clastic mafic fragments
± 3 cm sub angular & very
irregularly shaped
70% fine to coarse felsic
Ash Matrix

Very little fracturing
por-se. Most breccage
along bedding planes
weakened by weathering
(clay alteration, surface
adjustments, water
movement, minor
leaching)

No faulting in this hole

Of only moderate competency because
rock has tendency to separate on
bedding planes, largely to clay alteration.
Will hold buck however except for
A few zones so indicate by ~ symbol.

Stg breccage
on bedding planes

Below 88.4'

Mixed Oxide/Sulfide
environment. Oxidizing
Chalcopyrite converting
to malachite & FeO. Minor
associated leaching

A lot of
minor micro
fractures.

Fracturing

100 PSI, 2300 RPM

EXXON COMPANY, U.S.A.

June 13, 1977

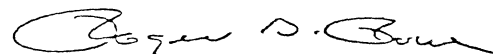
TO: E. R. May

FROM: R. G. Rowe

SUBJ: DMI-3 Test Hole

Attached is the log for DMI-3 with the new and correct position of the decline between 79'-89' in depth. The ground is strongly weathered in this zone. There is a strong fracture zone of 79.3'-82.3', which could cause a lot of problems. Recovery was only 25 percent, which could mean that a lot of fine material, perhaps clay rich, has been lost.

At this point in the decline, with only 11.3' strong weathered rock in the hanging wall and then saprolite, the back will likely not stand up.



Roger G. Rowe

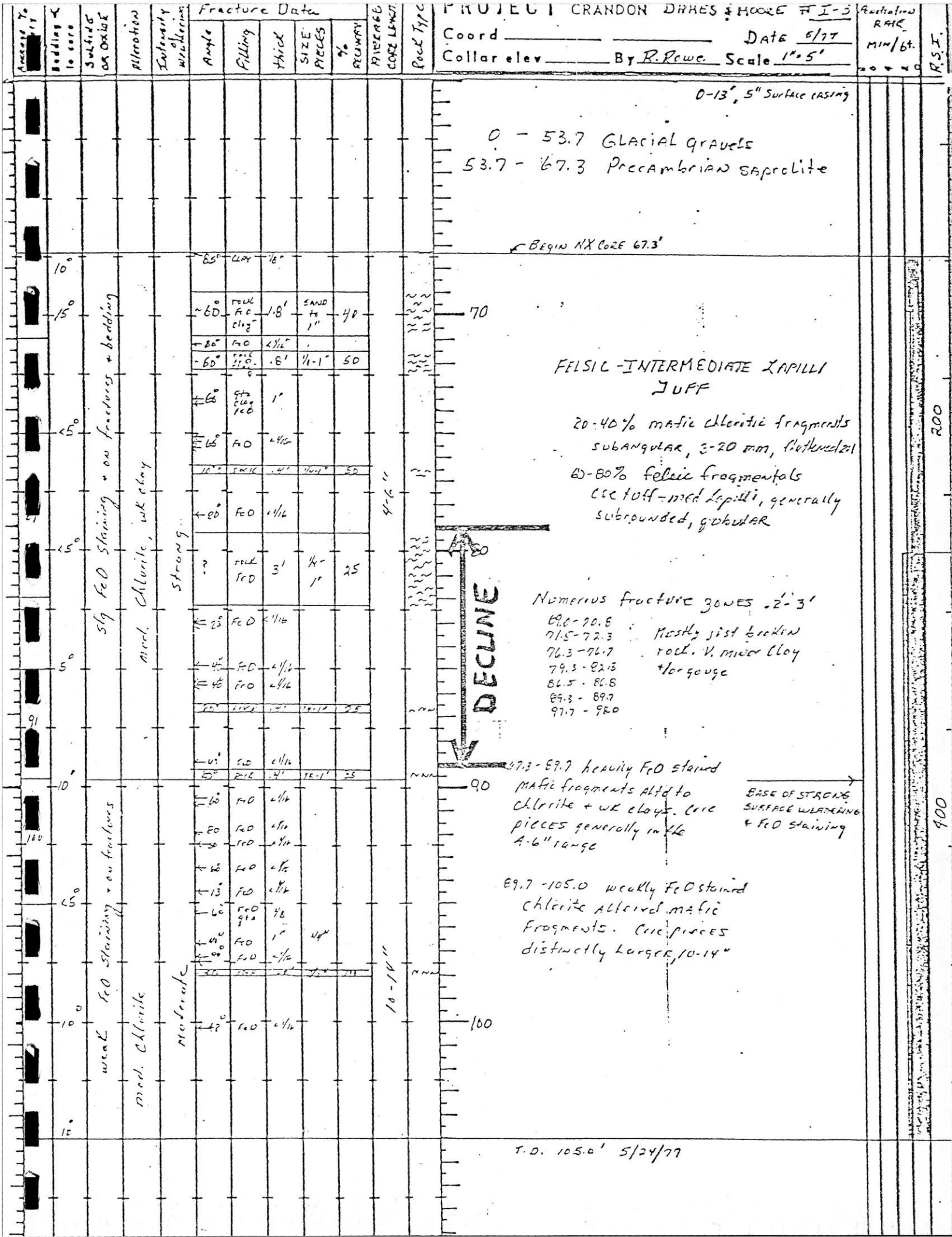
RGR/jfk

Attachment

JAMES & MOORE

JUN 21 1977

CHRYSLER RIDGE, IL



0-13" 5" Surface casing

0 - 53.7 GLACIAL GRAVELS
53.7 - 67.3 Precambrian Saproelite

BEGIN NX CORE 67.3'

FELSIC-INTERMEDIATE LAPILLI
JUFF

20-40% mafic chloritic fragments
SUBANGULAR, 3-20 mm, flattened
60-80% felsic fragmentals
ccc toff-med lapilli, generally
subrounded, globular

Numerous fracture zones 2'-3'
69.0-70.6 : Mostly just broken
71.5-72.3 : rock, v. minor clay
76.3-76.7 : + for gouge
79.3-82.3
84.5-86.8
89.3-89.7
97.7-98.0

DECLINE

87.3-89.7 heavily FeD stained
MAFIC fragments Altd to
chlorite + wk clays. ccc
pieces generally in the
4-6" range

BASE OF STRONG
SURFACE WEATHERING
& FeD STAINING

89.7-105.0 weakly FeD stained
chlorite Altd mafic
fragments. ccc pieces
distinctly larger, 10-14"

T.D. 105.0' 5/24/77

EXXON COMPANY, U.S.A.

June 13, 1977

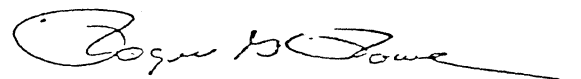
TO: E. R. May

FROM: R. G. Rowe

SUBJ: Dames And Moore Incline Test Holes , *DMI-4*

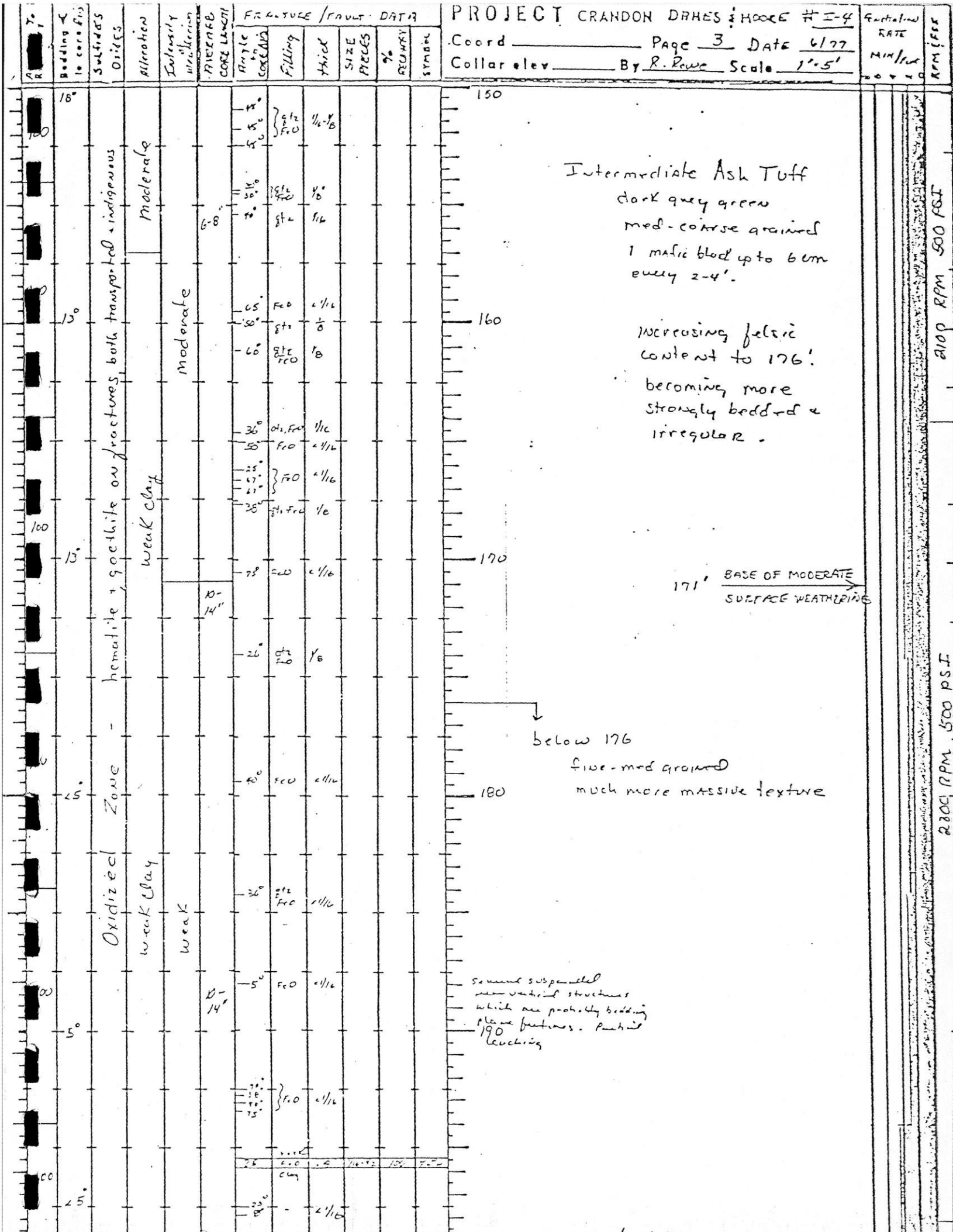
Hole DMI-4 core began in a strong saprolite zone (79.2'-98.0') and very abruptly went into strong weathered rock (98.0'-125.2'). The decline will cut through this section at 106.0'-116.0' within the strong weathered zone.

A strong clay fracture zone at 102.7'-103.6' will definitely not hold a back. Only 4.7' above that clay fracture is strong saprolite, so there is nothing to sink rock bolts into. Strongly weathered and fractured rock continues to a depth of 125.2'. Below 125.2' the rock will probably hold a fair back, because we are dealing dominantly with thin, individual quartz, FeO fractures without any clay, representing oxidized indigenous sulfides.



Roger G. Rowe

RGR/jfk



Intermediate Ash Tuff
dark grey green
med-coarse grained
1 mafic block up to 6 cm
every 2-4'.

Increasing felsic
content to 176'.
becoming more
strongly bedded &
irregular.

171' BASE OF MODERATE
SURFACE WEATHERING

below 176
fine-med grained
much more massive texture

several suspended
non-ventral structures
which are probably bedding
plane features. Partial
leaching

2800 RPM 500 PSI
2100 RPM 500 PSI

EXXON COMPANY, U.S.A.

June 28, 1977

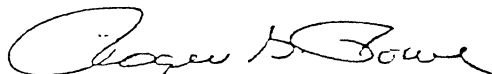
MEMORANDUM

TO: E. R. May

FROM: R. G. Rowe

SUBJ: Dames And Moore Incline Test Hole I-5

Hole I-5 hit the top of the Precambrian at 83.0 feet. The hole only penetrated 4 feet of Precambrian saprolite (83.0-87.0) before the pipe broke off and the hole was lost. Consequently, we know the depth of overburden, but did not learn anything significant about the Precambrian itself.

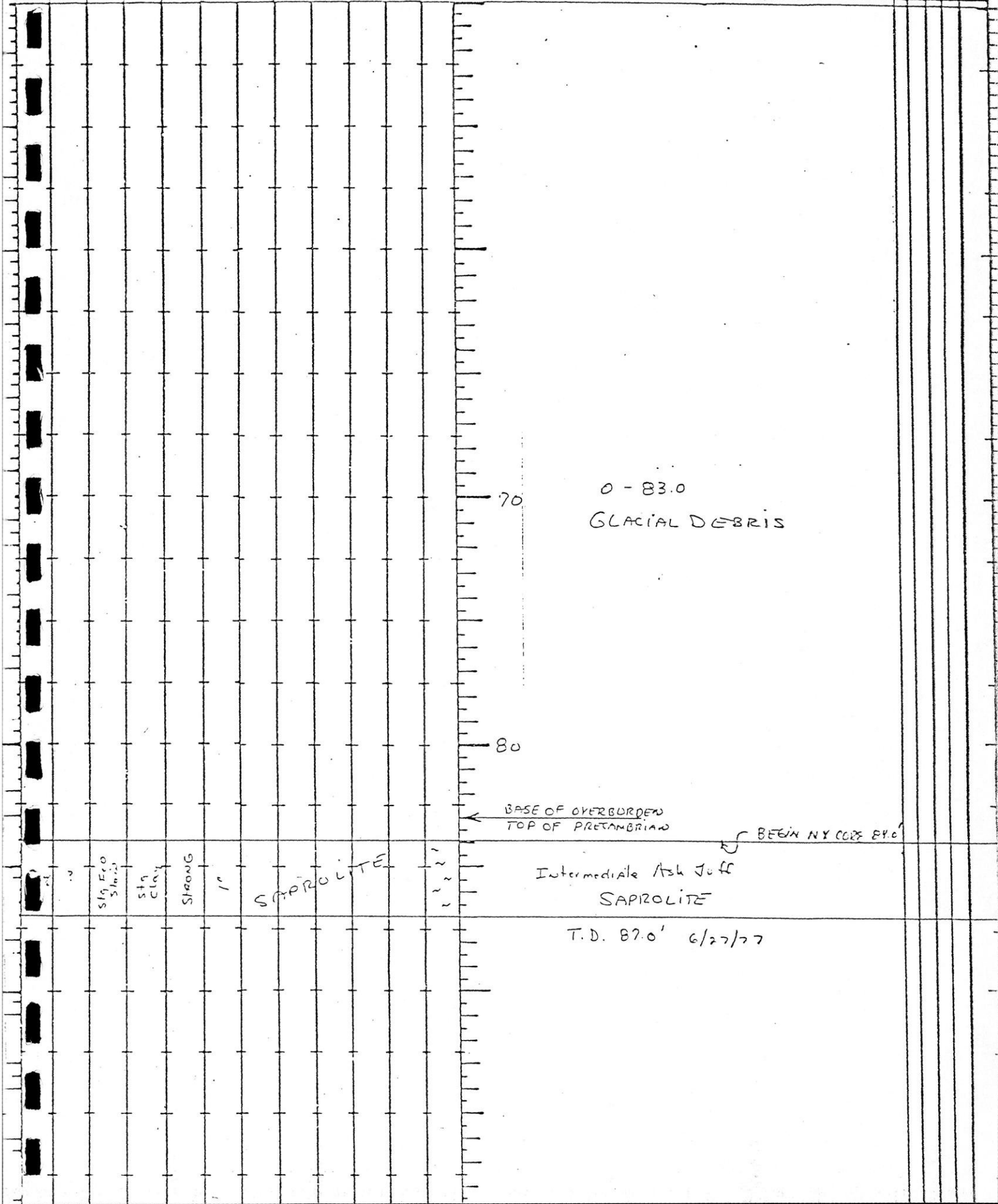

Roger G. Rowe

RGR/jfk

Att.

Assay No.	Bedding to core plus	Sulfides	Oxides	Alteration	Intensity of Alteration	Pithead Core Length	FRACTURE / FAULT DATA					
							Angle to Core Axis	Filling	Thickness	Size Pieces	% Recovery	Symbol

PROJECT CRANDON DRILL MOORE #I-5			
Coord _____	Page <u>1</u>	Date <u>6/77</u>	Rotation RATE MIN/REV
Collar elev _____	By <u>Rowe</u>	Scale <u>1"=5'</u>	



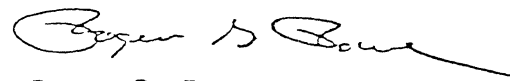
EXXON COMPANY, U.S.A.

June 13, 1977

TO: E. R. May
FROM: R. G. Rowe
SUBJ: DMI-7 Test Hole

Attached is log DMI-7 with the new and correct position of the decline between 180'-190' in depth. It still looks as though there will be no problems.

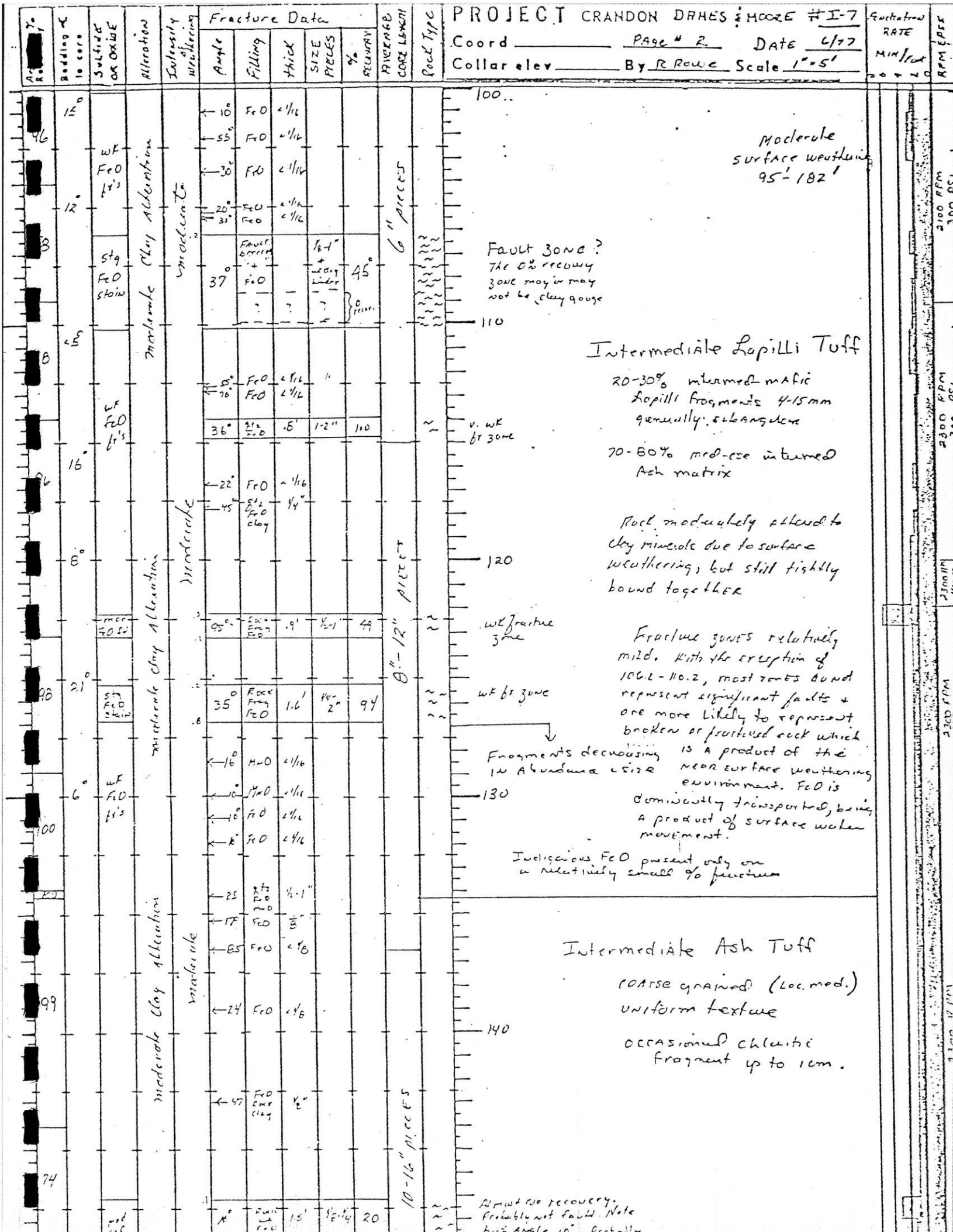
Two minor fracture zones at 178' and 181.5' are only .5' wide and do not contain any clay.


Roger G. Rowe

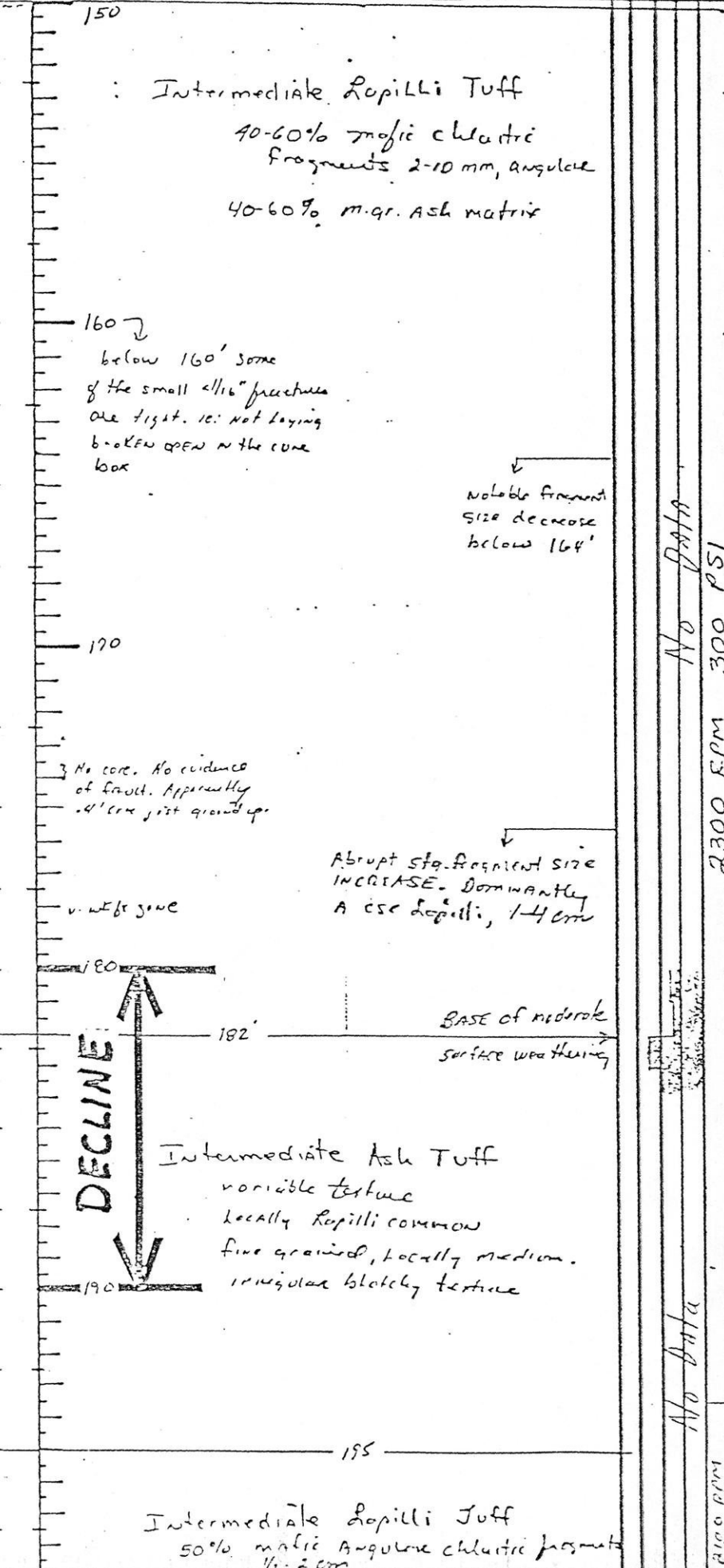
RGR/jfk

Attachment

PROJECT CRANDON DRILL HOLE # I-7										Penetration RATE MIN/foot	
Coord _____		PAGE 1	DATE 6/77								
Collar elev _____		By R. Rowe		Scale 1"=5'							
Bedding to core	Sulfide on oxide	Alteration	Intensity of weathering	Fracture Data				RIVERMID CORE LENGTH	Rock Type		
				Angle	Filling	Thick	SIZE PIECES				
				%							



40°	FeO	1/2"	100	
10°	FeO	1/8"		
11°	FeO	c 1/16		
13°	FeO	c 1/16		
15°	FeO	c 1/16		
16°	FeO	c 1/16		
16°	FeO	c 1/16		
22°	FeO	c 1/16		
16°	FeO	c 1/16		
19°	FeO	c 1/16		
20°	FeO	c 1/16		



No Data

2300 RPM 300 PSI

No Data

2300 RPM 300 PSI

200

Intermediate Lapilli Tuff
As described previous page

209'

210

Intermediate Ash tuff

209-224 fine grained
waxy, laminated texture

212-225 Partial bedding
of veinlets, discontinuous
veinlets + occasional
small fragments 2-3 mm

No evidence of
220 this is a fault.
Looks like high
S(15") br fillings

sharp contact

224-230 med grained
massive

230

230-237 coarse grained
massive

237

240

Felsic-intermediate Lapilli Tuff

~30% mafic clastic Angular
fragments + bands

70% cse felsic Ash w/r
small lapilli, generally
subrounded to globular

Local Ash -

PROJECT CRANDON DAMS : MOORE #I-7
Coord _____ Page # 5 DATE 4/77
Collar elev _____ By R. Powe Scale 1" = 5'

~~EXXON~~ COMPANY, U.S.A.

June 20, 1977

MEMORANDUM

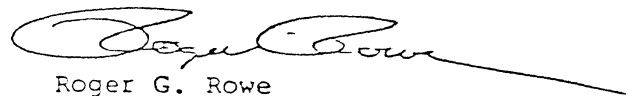
TO: E. R. May

FROM: R. G. Rowe

SUBJ: Dames And Moore Test Hole DMI-8

Hole DMI-8 is incompetent from top to bottom as the result of being cut by, and being under the structural influence of strong faulting. This has resulted in a shattering-microfracturing of most of the rock in this hole. In addition, the rock has a strong tendency to separate along the bedding planes.

The decline cuts through the section at 208-218'. The hanging wall consists of a major fault zone from 193.3-197.4', with a strong sphere of shattering and intense clay alteration streaching from 180.3-211.5'. This zone will likely be difficult to hold up, as it has been shattered and contains perhaps 10-20 microfractures per foot.


Roger G. Rowe

RGR/jfk

Attachment

cc: L. D. Hayes
M. K. Lawson
Mark Koehler
Dean Gregg

[illegible]

PROJECT CRANDON DRKES : MOORE # I-8

Coord _____ Page 2 Date 6/77

Collar elev _____ By R. Bour Scale 1"=5'

Graphical RATE MIN/IN

RPM EFF

100

Supracrust. Alkalic
v. stg. FeO staining elsewhere
rock type & textures. Appears
to be Intermediate Lapilli
Tuff.

110

Fracture zone

120

No RECOVERY
Drillers shift reports indicate top
part of interval stg. Fe'd
An bottom part may have been
mal functioning core barrel ??

Intermediate
Lapilli Tuff

130

30% 1-3 cm intermediate
Angular fragments

70% matrix consisting
of intermediate size
Ash, locally slightly
more felsic.

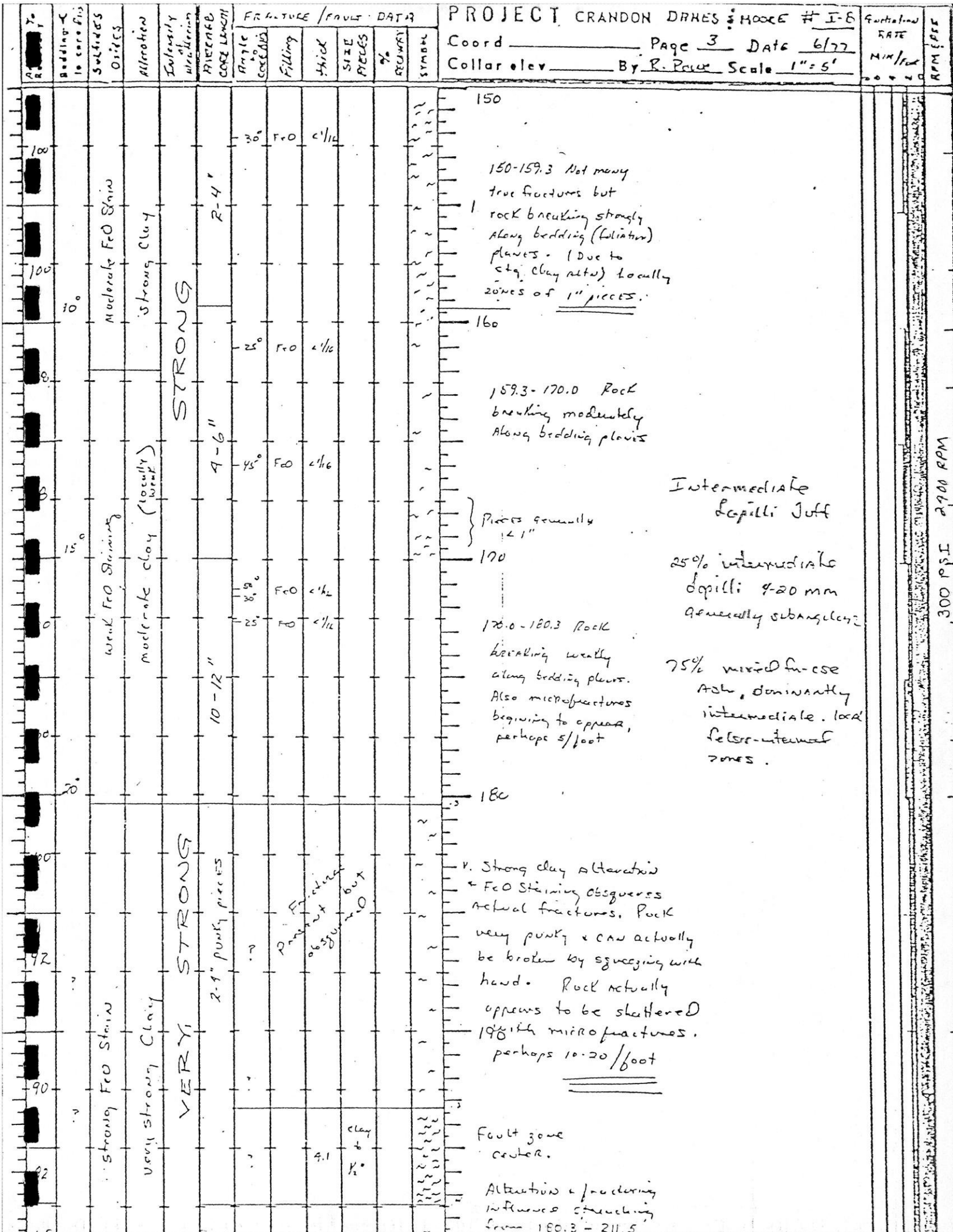
Fault zone
gouge zone
present

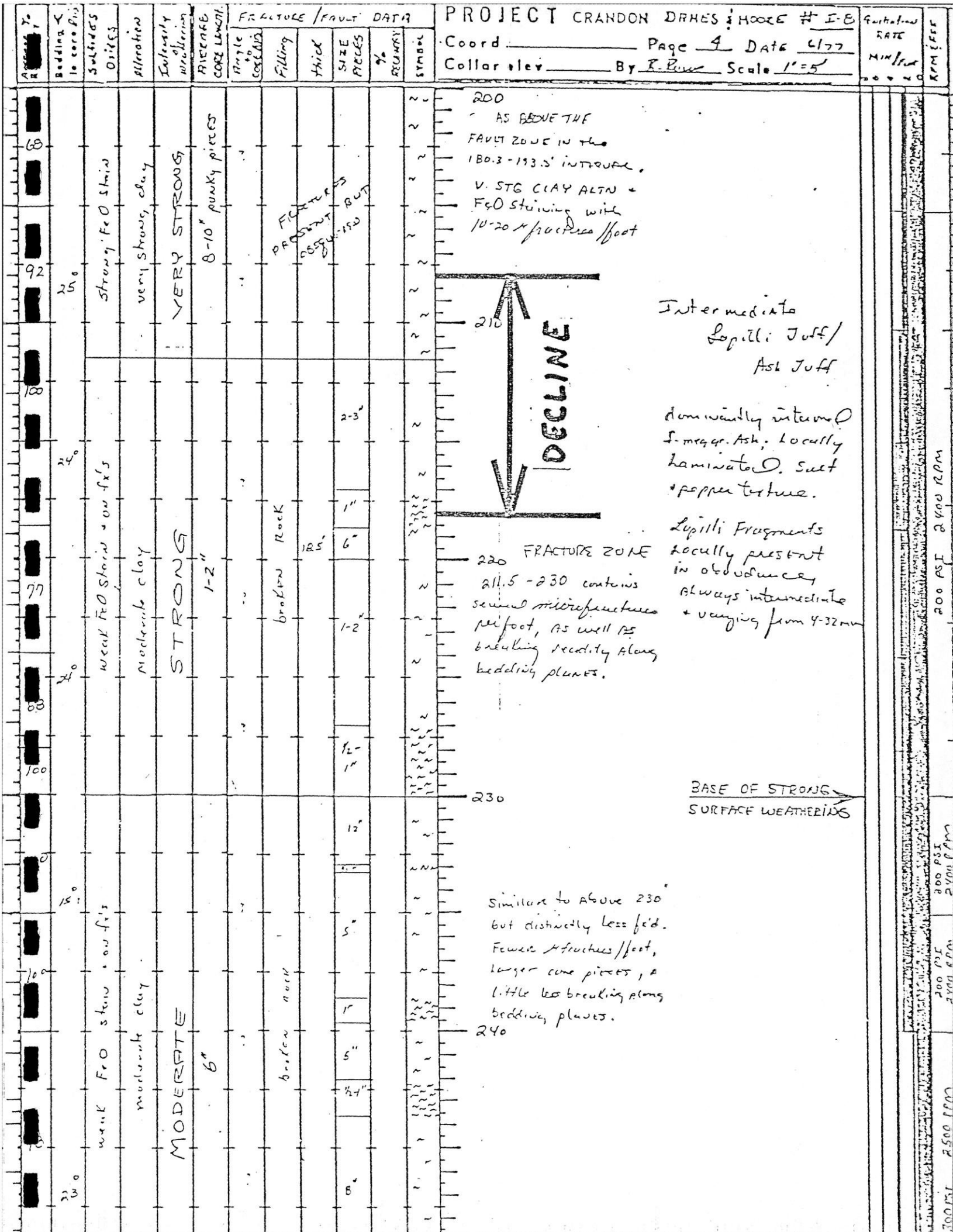
140

300 PSI 1800 RPM

300 PSI 2100 RPM

350 PSI

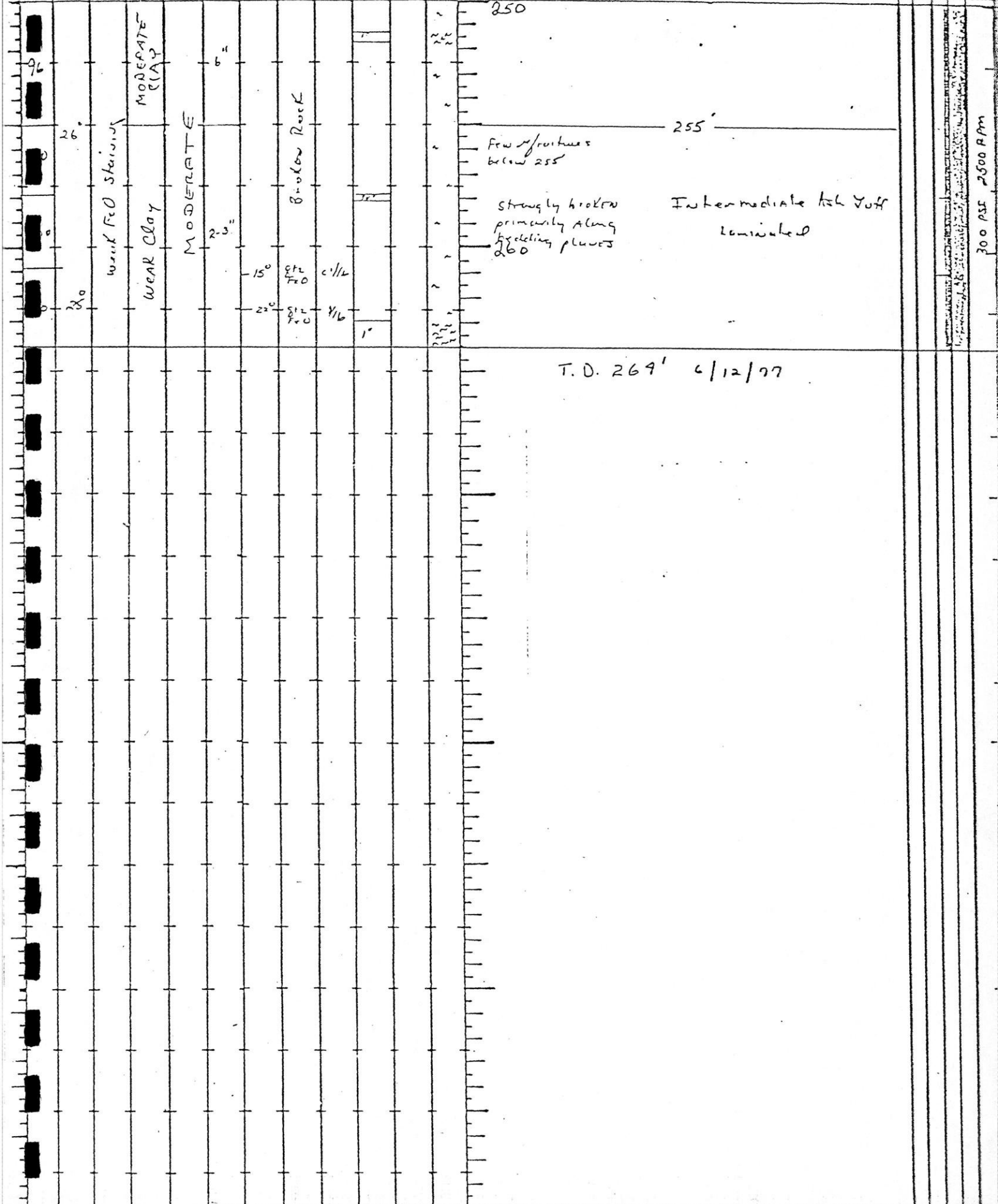




A	Bedding & in core fill	SOLIDS	OILIES	Alteration	Intensely weathering	Average Core Length	FRACTURE / FAULT DATA					
							Angle	Filling	thick	SIZE	%	REMARKS
							COE LENS			PIECES		

PROJECT CRANDON DRAES & MOORE # I-E
 Coord _____ Page 5 Date 6/77
 Collar elev _____ By R. POWE Scale 1" = 5'

Rotation
 RATE
 MIN/Hr
 RPM/EE



EXXON COMPANY, U.S.A.

June 28, 1977

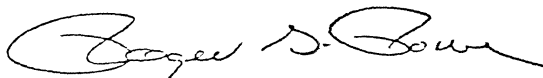
MEMORANDUM

TO: E. R. May

FROM: R. G. Rowe

SUBJ: Dames And Moore Incline Test Hole I-9

Hole I-9 was spudded where the decline begins in the overburden. The bedrock is competent where coring begins at 60.0'. There is no significant fracturing or faulting in this hole.



Roger G. Rowe

RGR/jfk

Att.

[illegible]

June 27, 1977

MEMORANDUM

TO: E. R. May

FROM: R. G. Rowe

SUBJ: Dames And Moore Incline Test Hole I-11

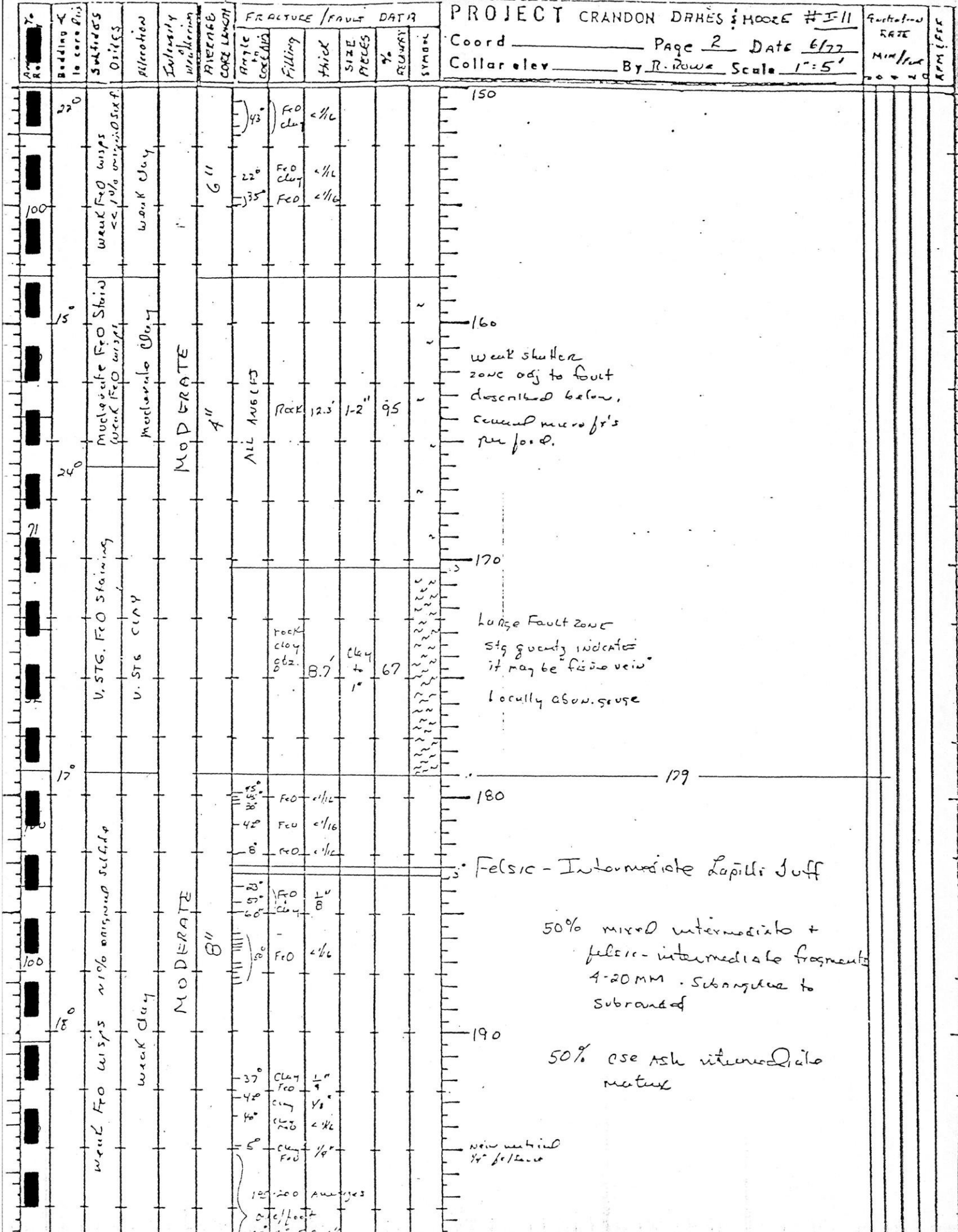
Hole I-11 was spudded at -45° and was designed to test for the presence of a N/W trending fault zone, which is suspected to encounter the decline at the bend near I-4. Strong faulting/fracturing was encountered at 158.0-179.0 and 221.6-236.0.

Above and in between these zones the rock is reasonably competent and will probably hold a back. Below 236.0 the rock is very competent. This indicates the suspected N/W trending fault may not be represented by a single, thin, discrete fault break, but may be expressed as a wider zone of fractured rock. This zone could widen, narrow, or splay out in short vertical or horizontal distances.



Roger G. Rowe

RGR/jfk



FRACTURE / FAULT DATA						
Angle to core axis	Filling	thick	SIZE PIECES	% REPAIR	SYMBOL	

220	weak FeO wisp weak FeO wisp weak FeO wisp	weak clay	6"	43° FeO clay < 1/16 22° FeO clay < 1/16 35° FeO < 1/16		
150	moderate FeO stain weak FeO wisp	moderate clay	4"	ALL ANGLES Rock 12.3' 1-2" 95		
240	U. STG. FeO staining	U. STG. clay		Rock clay 662 8.7' clay 1" 67		
270	weak FeO wisp	weak clay	8"	37° FeO clay 1/4" 40° FeO clay 1/8" 40° FeO clay < 1/16 50° FeO clay 1/4" 100-200 Angles 0.1/1000 2.5/1000		

150

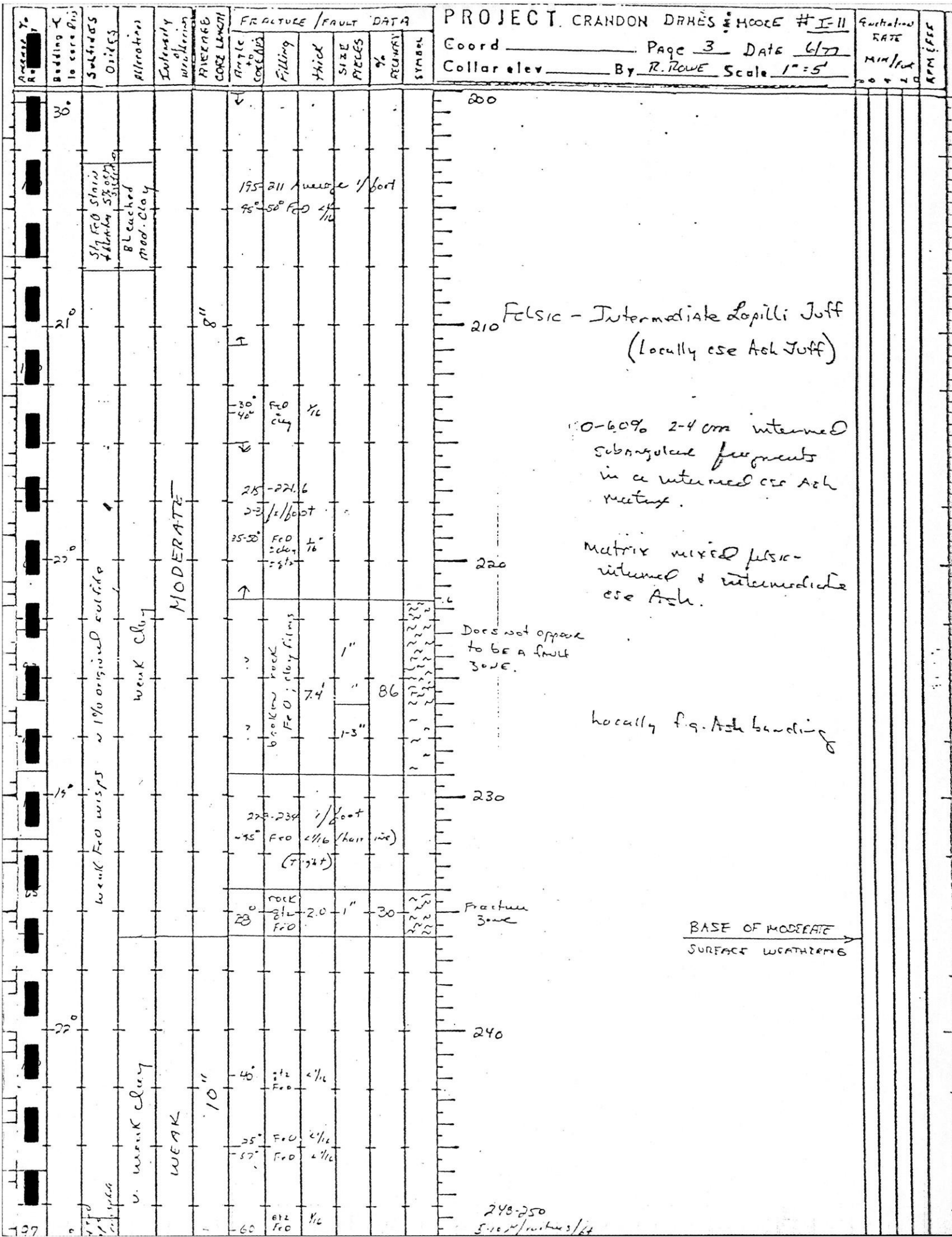
160
weak shatter zone adj to fault described below, several microf's per foot.

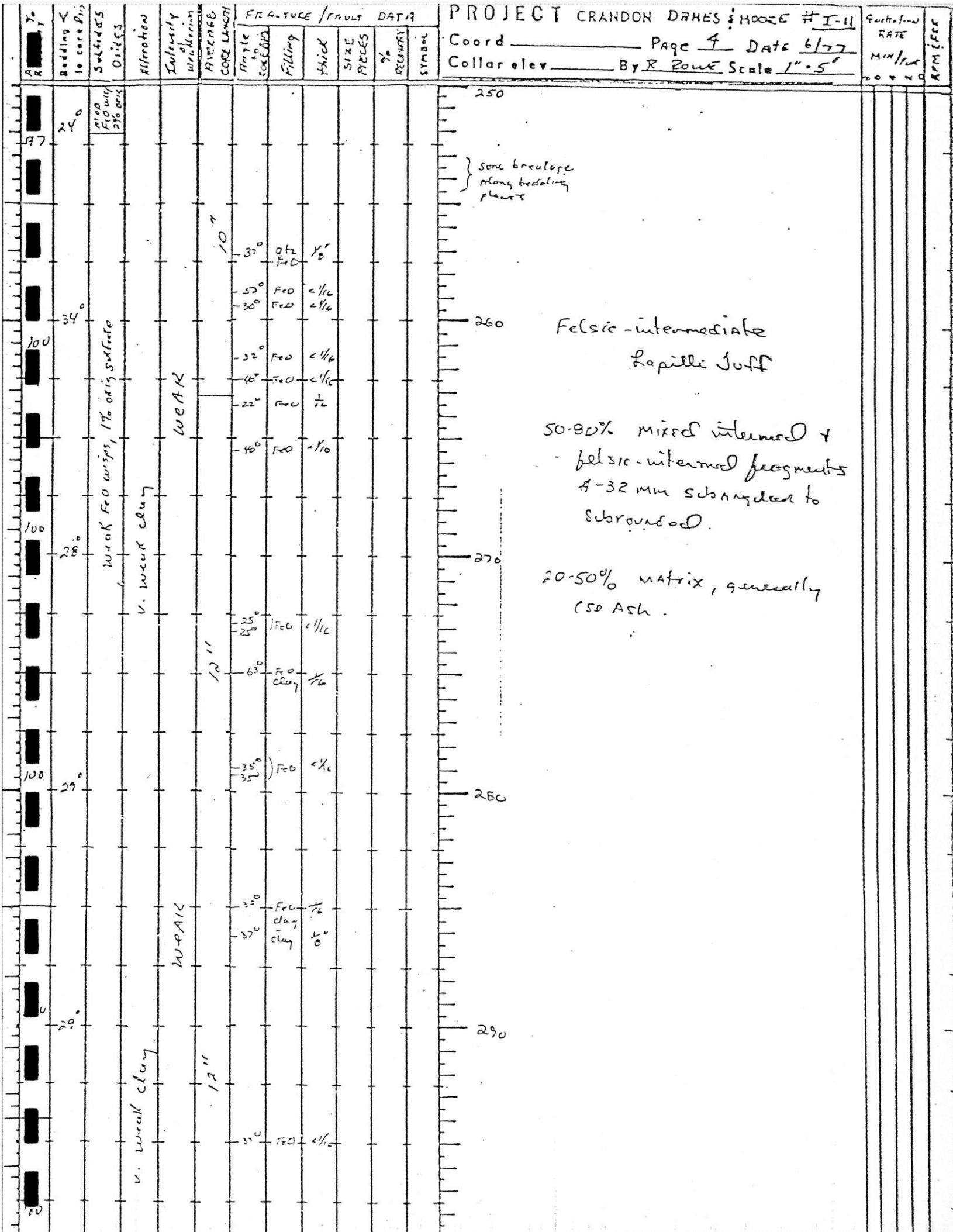
170
Large Fault zone
Stg quantity indicates it may be fissure vein
locally ason. zone

179

180
Felsic - Intermediate Lapilli Juff
50% mixed intermediate + felsic-intermediate fragments
4-20 MM. Subangular to subrounded

190
50% cse Ash intermediate matrix
new material 1/4" below





R. No.	Bedding $\angle$ to core dip	Sulfides	Oxides	Alteration	Intensity of weathering	Average Core Length	FRACTURE / FAULT DATA						
							Angle to Core Axis	Filling	Thick	SIZE PIECES	% RECOVERY	SYMBOL	
100	30°						37°	Clay FeO	1/2"				
							38°	FeO	< 1/16				
							42°	St + FeO	2"				
							42°	St + FeO	1/2				
							45°	St + FeO	1/16				
	28°					12"							
100							32°	Flux	1/16				
							35°						
							40°	St + FeO	1/2				
							35°	St + FeO	1/2				
	6°						60°	FeO	< 1/16				
						12"	45°	FeO St	1/2				
							40°	St + FeO	1/2				
	36°						45°	FeO	< 1/16				
							45°	FeO	1/8				
							10°	St + FeO	1/16				
	43°						20°	St + FeO	1/4				
100							80°	FeO	< 1/16				
							37°	FeO	1/4				
						12"	15°	FeO	1/2				
							8°	FeO	1/2				



