REPORT
CONFIRMATORY GEOTECHNICAL INVESTIGATIONS
ESW PIPELINE CORRIDOR
BYRON STATION - UNITS 1 AND 2
COMMONWEALTH EDISON COMPANY

PREPARED FOR SARGENT & LUNDY ENGINEERS

Dames & Moore

D&M Job No. 5643-120-07
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DMO-26

Attention: Mr. R. J. Netzel
Senior Structural Project Engineer

Gentlemen:

This letter transmits 10 copies of our "Report, Confirmatory Geotechnical Investigations, ESW Pipeline Corridor, Byron Station - Units 1 and 2, Commonwealth Edison Company."

If you have any questions or require any additional information, please feel free to contact us.

Respectfully submitted,

DAMES & MOORE

Michael L. Kiefer

Michael L. Kiefer
Partner

MLK:id

Ten Copies Submitted

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ESW PIPELINE CORRIDOR
BYRON NUCLEAR POWER STATIONS - UNITS 1 AND 2
COMMONWEALTH EDISON COMPANY

INTRODUCTION

This report presents a summary of previous investigations and the results of the recent confirmatory investigations performed to document the subsurface stability of the Essential Service Water (ESW) pipeline corridor at the Byron Nuclear Power Station - Units 1 and 2, Commonwealth Edison Company (Figures 1 and 2). The confirmatory investigations were performed in response to the Nuclear Regulatory Commission (NRC) request (letter to Commonwealth Edison Company, dated June 1, 1982) that additional subsurface information be provided in order to determine the adequacy of the foundation support for the ESW pipeline.

The purposes of the confirmatory investigations were to demonstrate that the stability of the ESW pipeline will not be influenced by solution features within the bedrock and settlement resulting from compression of the in-situ soils which underlie portions of the pipeline.

The scope of the confirmatory investigations included:

1. Drilling two angle borings at least 80 feet into bedrock at each of two locations where major joints project across the ESW pipeline (Areas of Concern 9 and 11) in order to document the conditions of the foundation rock below the ESW pipeline; and

2. Performing laboratory tests on undisturbed samples from two soil borings drilled in Area of Concern 11, correlation of the subsurface conditions with those identified in the FSAR, and analyses to confirm previously estimated pipeline settlement.

The confirmatory investigations presented herein substantiate the conclusions that subsidence of the bedrock below the pipeline due to solution phenomenon is not possible and that settlement of the pipeline supported on soil (Areas of Concern 11 and 12) is acceptable and agrees with those values previously presented.

PREVIOUS INVESTIGATIONS

Extensive investigations have been performed at the site dating back to 1972. Detailed documentation of this work is presented in the FSAR, including pipeline construction surveillance and a recent geologic investigation of solution features. The geotechnical investigations which were performed subsequent to the issuance of a construction permit are listed below:

- Grouting Program, FSAR Attachments 2.5-A and 2.5-B: Pressure grouting of the plant foundation was performed and included vertical borings at 20-foot centers and correlation of grout takes with stratigraphic horizons and joint patterns.

- Fault Investigation, FSAR Attachment 2.5-C: A thorough assessment was made of the nature of faults exposed in the bedrock, the relationship of these features to regional structural geology and seismicity, and the age of displacement.

- Pipeline Construction Surveillance, FSAR Attachment 2.5-G: Inspection of about 2-1/2 miles of bedrock exposed on the trench floor, about 80 percent of the excavation, provided direct examination of the bedrock surface and nature of the upper 5 to 10 feet of bedrock along the corridor.

- Solution Feature Investigation, FSAR Attachment 2.5-I: A summary of this investigation, completed in 1982, is presented in the following section.

This report references data collected during the previous investigations by referring to specific sections and figures in the FSAR.

GEOLOGIC INVESTIGATION OF SOLUTION FEATURES

INTRODUCTION

The purpose of this investigation was to study solution features in the dolomite bedrock along the pipeline corridor. This study was initiated in December, 1981 following Nuclear Regulatory Commission (NRC) staff review of the Byron Station - Units 1 and 2 Final Safety Analysis Report (FSAR). This review raised concern on the part of the NRC staff about the method of formation and age of depressions formed on the bedrock surface along the pipeline corridor.

SCOPE OF WORK

The study focused on two solution features that are considered to be representative and which are located adjacent to the pipeline corridor.The first feature is a closed depression on the ground surface, about 800 feet east of Razorville Road and 4000 feet northwest of Units 1 and 2 (Figure 2). The second feature is a buried bedrock depression which underlies the ESW pipeline corridor at coordinates 49+20N, 32+70E.

The purposes of the investigation were to:

1. Determine the bedrock stratigraphy beneath the two areas by drilling borings;

2. Determine the soil stratigraphy and configuration of the bedrock surface beneath the surface depression by trenching across the feature to directly expose the soil and bedrock; and

3. Substantiate the mechanism of formation of the bedrock depressions, the age of the features, and the potential for similar features to develop in the future.

The report documenting the results of this investigation is presented in the FSAR Attachment 2.5-I. The following section provides a summary of the investigation.

CONCLUSIONS

The evidence gathered from the borings and trenching conclusively shows that bedrock depressions were formed by ancient solution widening of a joint system, as stated in the FSAR. No cavities were encountered beneath the solution features, nor is there any evidence to indicate that collapse or subsidence has occurred or is possible in the bedrock. Specifically, this study revealed the following:

- The trench east of Razorville Road revealed a continuous, irregular bedrock surface that forms a depression on the bedrock surface. The attitude of bedding shows flat-lying bedrock that has not been disturbed by collapse or local movement.
- The floor of this trench contained closely spaced joint sets in the bedrock underlying the solution basin east of Razorville Road that had been solution widened to form steep-sided depressions of several feet in depth on the bedrock surface.
- The oldest glacial deposit in the depression is Illinoian till which is older than about 125,000 years and possibly 200,000 years or more. Wisconsinan deposits overlying the till have blanketed the depression, causing the gradual and undisturbed infilling of the feature.
- Continuous stratigraphic control was established beneath the trenched solution basin by correlation of a bentonite bed in borings drilled within and adjacent to the feature.
- The same bedrock conditions were found at the buried bedrock depression in the plant area (Area of Concern 11) and indicates that solution widening along preexisting joint systems is the common mechanism of formation for both features.
- Field observation, literature search, and chemical analyses indicate that the rate of solution activity presently taking place at the site is imperceptible.

This study provides the basis to conclude that the solution features and associated ground surface depressions at the site are not related to collapse or subsidence of subsurface cavities and are not sinkholes, as defined in the geological literature. The features are, on the other hand, solution basins, developed by ancient differential solutioning along joints. In addition, as it can be concluded that sinkholes cannot develop at the site during the life of the plant, subsidence of the bedrock along the pipeline corridor by such a phenomenon is not possible.

Independent opinions were also obtained from representatives of the Illinois State Geological Survey (ISGS). Their opinions are based on their knowledge of the geology of Illinois, a site inspection trip, and previous investigations of the site geology. Principal ISGS participants were Drs. Dennis R. Kolata and Leon R. Follmer, whose summaries of observations made during their visit to the site on December 14, 1981 are included in the FSAR, Attachment 2.5-I.

CONFIRMATORY GEOLOGIC INVESTIGATION

INTRODUCTION

This section presents the results of a confirmatory geologic investigation performed for the ESW pipeline at the Byron Station. The purpose of this investigation was to address NRC staff concerns with respect to the adequacy of the foundation support for the ESW pipeline as stated in the NRC's Request for Additional Information dated June 1, 1982.

The NRC staff was concerned that a prominent northwest - southeast lineament related to well developed surface drainage might represent a significant subsurface solution feature. The specific locations identified are Areas of Concern 9 and 11 which are located in areas where the prominent northwest - southeast trending lineament crosses the ESW pipeline corridor (Figure 4). Area of Concern 9 is located along the east - west run of the ESW pipeline between Station 24+60E and 27+60E at approximately N63+24 (Figure 2). Area of Concern 11 is located within the fenced plant area between 45+20N and 53+00N at approximately 32+70E (Figure 2). Previous investigations of these areas have been described in the FSAR, Attachments 2.5-G and 2.5-I. The geological investigation described below confirms the original interpretation of the general subsurface profile in Areas of Concern 9 and 11 and confirms our previous conclusions that: linear drainage features are joint controlled; cavities are not present beneath the solution features; and solution collapse and/or subsidence has not occurred nor is possible in the areas where bedrock lows occur

EXPLORATION REQUIREMENTS AND ACCEPTANCE CRITERIA

The NRC requested that two angle borings be drilled at an inclination of 45 degrees in both Areas of Concern 9 and 11 to evaluate the bedrock stability below the ESW pipeline. The borings were to extend at least 80 lineal feet into bedrock. It was also requested that the following drilling data, in addition to core recovery and rock quality designation (RQD), be recorded during rock coring: drill rod drops and drilling fluid losses, coring pressure, rate of penetration, bit rotation speed, and drill bit conditions.

The NRC provided geologic acceptance criteria for evaluating the results of this confirmatory investigation in the June 1, 1982 letter. The acceptance criteria were clarified in letters from the applicant to the NRC dated July 20, 1982 and confirmed by the NRC to the applicant dated July 29, 1982. A summary of the geologic acceptance criteria are:

Acceptance Criteria 1:

The subsurface stability and foundation support are considered acceptable if the results of this investigation show that there are no open or partially filled joints having a width in excess of 4.5 feet. Filled joints are acceptable. In addition, if the percentage of open joints in 50 feet of rock coring, beginning at rock surface, is less than 20 percent, the conditions are acceptable.

Acceptance Criteria 2:

If an open joint width (W) is greater than 4.5 feet, the NRC staff will accept the adequacy of the foundation support if the results show that alluvial (soil) support extends at least to a depth of 2W below the pipeline. If alluvial (soil) support depth is less than 2W, grouting below the unreinforced pipeline run where voids are encountered, will be required.

SCOPE OF WORK

The confirmatory investigation was designed to:

1. Determine by drilling angle borings the extent of open or partially filled joints at two locations along the ESW pipeline at projected intersections with major joint trends and drainage lineaments (Areas of Concern 9 and 11);
2. Confirm the absence of voids in the upper 50 feet (vertical) of bedrock;
3. Document compliance with the NRC acceptance criteria; and
4. Assess the bedrock stability of the pipeline foundation.

Dames & Moore's field investigation consisted of drilling two angle borings at least 80 feet into bedrock and two vertical borings to the top of bedrock in both Areas of Concern 9 and 11. Dames & Moore also observed and recorded primary and secondary drilling data, as described below.

METHOD OF INVESTIGATION

The field investigation was performed between August 9, 1982 and August 20, 1982. Rock core from borings SF-8 through SF-11 was obtained with an NX-size wireline, double-tube, split core barrel (10 feet in length). The rock core from each boring was geologically logged and photographed upon completion of the field work. Four soil borings, SF-8A through SF-11A, were drilled vertically to the top of bedrock in the vicinity of each of the four angle borings, in order to define the soil stratigraphy.

The primary data collected during this investigation included the lithologic conditions, core recovery, RQD, rate of penetration (time required to core each foot), drill rod drop (if any), and drilling fluid return. In

addition, other drilling data was collected for correlation with the primary data, including coring pressure, bit rotation speed, and bit conditions.

A more detailed description of the field investigation is presented in Appendix A, along with the Log of Borings and graphical presentation of the drilling data.

RESULTS OF FIELD INVESTIGATION

All four angle borings were terminated within the Dunleith Formation of the Galena Group. The Dunleith Formation forms the bedrock surface within the areas investigated, including the solution feature investigated in 1981/82 and the plant site. Consistent with previous investigations, the Dunleith Formation consists of buff, finely crystalline dolomite which is thin to medium bedded. Fractures and vugs are generally weathered to a brownish-yellow. Locally, and generally near the bedrock surface, more highly weathered zones are altered to a yellow dolomitic sand.

Borings SF-8 and SF-9 were drilled in Area of Concern 11 at an angle of 45° on north and south azimuths, respectively (Figure 3). A generalized subsurface cross section (Figure 5) indicates that the bedrock topography at the locations of these borings is consistent with previous investigations (FSAR Attachment 2.5-G, Plate 4b and Attachment 2.5-I, Figure 9). A more detailed cross section through the northern portion of Area of Concern 11 is presented on Figure 6. The bedrock conditions at this location agree with those documented in Area of Concern 11 in the 1981/82 investigation (FSAR, Attachment 2.5-I).

Borings SF-10 and SF-11 were drilled in Area of Concern 9 at an angle of 45° on west and east azimuths, respectively (Figure 3). These

borings are located near the head of a northwest-trending linear drainage feature and are within the bedrock surface low defined as Area of Concern 9 in the FSAR, Attachment 2.5-G. A cross section through Area of Concern 9 is presented on Figure 7. This unexaggerated profile adds more detail and generally confirms the exaggerated subsurface profile presented in FSAR, Attachment 2.5-G (Plate 4C). The surface of the dolomitic sand which represents the remanent bedrock surface is consistent across the cross-section. However, as would be expected in a joint-controlled, drainage feature, differential weathering along joints has created an irregular bedrock surface, as interpreted at Boring SF-11A.

No drill rod drops were recorded while drilling borings SF-8 through SF-10. A 0.2 foot drill rod drop and loss of drilling fluid was noted when Boring SF-11 intersected the borehole of Boring SF-10. This intersection was confirmed by probing, by examining the recovered core from Boring SF-11 which showed the outline of the Boring SF-10 borehole, and by observing the return of grout out of Boring SF-10 while grouting Boring SF-11.

The areas drilled during this confirmatory geologic investigation are located along the projection of a major northwest-southeast trending joint set. The jointing is apparent in the four borings by the amount of fractured rock and the low RQD values within several intervals in the core. Boring logs and drilling parameter data indicate that the borings did not encounter any voids. Intervals of relatively low core recovery and RQD can be correlated with near surface weathering and with zones of highly fractured and weathered rock intersected by the borings. For example, RQD and recovery in Borings SF-8 between elevations 800 and 790 can be correlated with a zone of tightly

of tightly spaced fractures. In this zone, there was no loss of drilling fluid, no increase in bit rotation speed, and no drill rod drops (Appendix A, Figure A-2.5).

CONCLUSIONS

Areas of Concern 9 and 11 are located at intersections of the ESW pipeline corridor with major northwest-southeast trending joint sets. The joints encountered in the four angle borings are tight (closed) and no voids (open joints) were encountered within the upper 50 feet (vertical) of the bedrock. The results of this investigation confirmed the adequacy and stability of the foundation bedrock below the ESW pipeline corridor and satisfy the geologic acceptance criteria proposed by the NRC staff. Although these borings intersected major joint sets which contained highly fractured zones, generally having higher permeabilities, no increase in bedrock solution activity was noted and no voids were encountered.

This investigation reconfirmed the conclusion that solution features were developed by differential solutioning along joints; and that major joint trends do not represent locations of potential bedrock instability. It can therefore be concluded that subsidence or solution collapse of the bedrock due to solution phenomena is not possible along the pipeline.

CONFIRMATORY SOIL INVESTIGATION

The NRC requested that additional borings be drilled and that undisturbed soil samples be obtained in Areas of Concern 11 and 12. The objectives of this program were to: 1) determine the compressibility and consolidation characteristics of two layers identified during construction surveillance (FSAR, Attachment 2.5-G) as an organic clayey silt (topsoil) layer and the underlying silty clay layer, and 2) establish (reaffirm) the total and differential settlement of the ESW pipeline.

Four borings were drilled in March and April 1982 in order to obtain undisturbed soil samples and install four observation wells (one in soil and one in bedrock at two locations) to provide documentation of the ground-water conditions along the ESW pipeline (SER license condition, February 1982). The locations of the borings (OW-1 through OW-4) are shown in Figure 3. Undisturbed soil samples were obtained in Borings OW-1 and OW-2A. A description of the field procedures is presented in the Appendix. Boring logs are presented in Figures A-2.1 through A-2.4.

Laboratory tests, including consolidation, Atterberg limits, organic content, and particle size analyses were performed on the soils obtained. The results of the laboratory tests are presented in Appendix A. A summary of the soil properties are presented on Table 1.

The results of the OW-series of borings, as well as the SF-borings, confirm the interpretation of the subsurface conditions, presented in the FSAR, Attachment 2.5-G. A generalized subsurface profile through Area of Concern 11 which includes the OW and SF borings is presented on Figure 5. No unusual soil conditions were encountered and the interpretation of the general subsurface profile and soil properties along the pipeline remains unchanged,

with one minor exception. The soil layer previously identified as organic clayey silt (buried topsoil) is considerably thinner than previously indicated, and in fact was only encountered in Boring OW-2. In addition, the organic content was determined to be 3.4 percent and the Atterberg limits indicate that the soil should be classified CL/CL-ML according to the Unified Soil Classification System. As a result, this layer should not be classified as organic as previously reported.

All four piezometers installed in the OW borings were dry during the monitoring period of April through August 1982. This indicates that the ground water level is below Elevation 810 feet (MSL) in Area of Concern 11.

The results of the consolidation tests (Appendix A, Figures A-3) show that the soil profile encountered is preconsolidated to loads well in excess of the existing overburden. This is in agreement with consolidation tests on similar soils from the plant site area (FSAR, Figures 2.5-53 through 2.5-55).

Settlement analyses were performed for Areas of Concern 11 and 12. The results of the analyses are presented in Table 2. The analyses show a maximum total settlement of 0.5 inches and a maximum differential settlement of 0.2 inches over a distance of 100 feet in Area of Concern 11. In Area of Concern 12, maximum total settlement was calculated to be 0.4 inches, and the maximum differential settlement was calculated to be 0.2 inches over a distance of 100 feet. These settlements are in agreement with those previously estimated in response to NRC questions (see NRC Question and Response 241.6).

FINAL CONCLUSIONS

The confirmatory investigations described in this report demonstrate that the stability of the ESW pipeline will not be influenced by solution features within the dolomite bedrock and settlement resulting from compression of the in-situ soils which underlie portions of the pipeline not supported directly on rock. These conclusions are substantiated by data collected during these recent investigations and previous studies which indicate:

- Depressions on the bedrock surface are the result of differential weathering and solution widening along joints;
- The horizontally bedded and continuous strata beneath solution basins and buried bedrock depressions indicate that these features did not form as a result of solution collapse;
- The rate of solution activity presently occurring at the site is imperceptible;
- Major joint trends do not represent locations of potential bedrock instability;
- The soil encountered beneath sections of the pipeline, not supported on rock, is preconsolidated to loads well in excess of the existing overburden; and
- Settlement analyses for Areas of Concern 11 and 12 are in agreement with those previously estimated in response to NRC questions.

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Tables, figures and appendices are attached and complete this report.

Respectfully submitted,

DAMES & MOORE

Michael L. Kiefer
Partner

David F. Fenster
Project Geologist

Charles S. Kuntz
Senior Geologist

TABLE 1

SUMMARY OF SOIL PROPERTIES

BORING AND SAMPLE NO.	DEPTH (feet)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING NO. 200 SIEVE (%)
OW-1, 3	14.5	13.4	117	24	12	
OW-1, 4	17.8	13.6	115	19	7	
OW-1, 5	20.5	9.2	124	12	2	
OW-1, 6	22.8	10.5	125	14	4	
OW-2A, 1	16.3	18.3	108	22	7	
OW-3, 3A	14.5	11.2		16	4	36
OW-3, 4	16.0	13.2				24
OW-3, 5	17.0	13.0			NP	18
OW-3, 6C	18.0	12.5		15	5	
OW-3, 6A	19.0	13.0		13	3	
OW-3, 9B	23.0	10.4			9*	

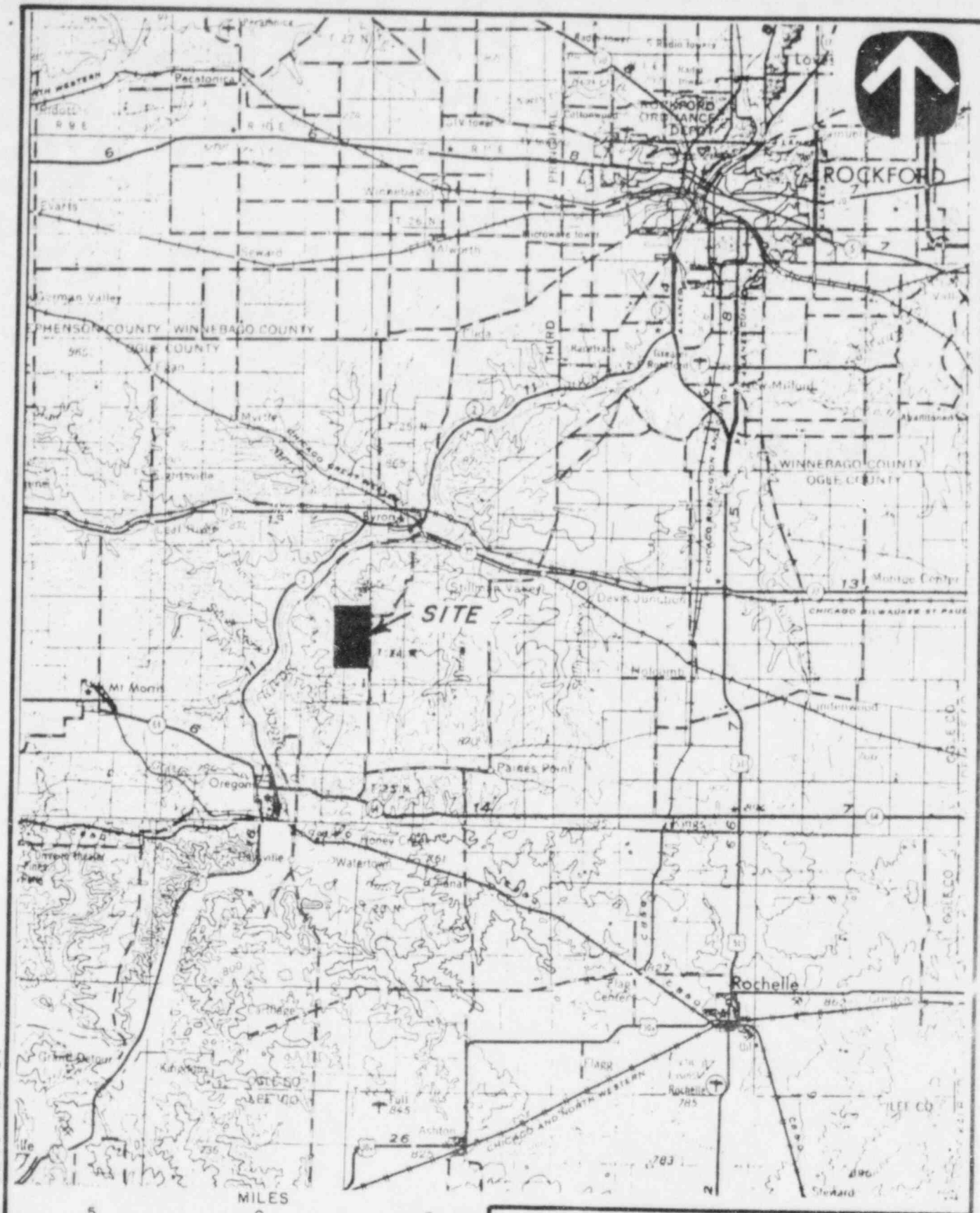
*Plastic limit, inadequate sample for Liquid Limit.

NP= Non-plastic.

TABLE 2

SUMMARY OF PIPELINE SETTLEMENTS

AREA OF CONCERN NO.	STATION	CALCULATED SETTLEMENT (inches)
11	N51+20	0.2
11	N50+20	0.4
11	N49+20	0.5
11	N48+20	0.5
11	N46+20	0.3
11	N45+20	0.4
11	N43+90	0.3
12	N41+50	0.4
12	N40+50	0.2
12	N38+50	0.2
12	N37+00	0.2



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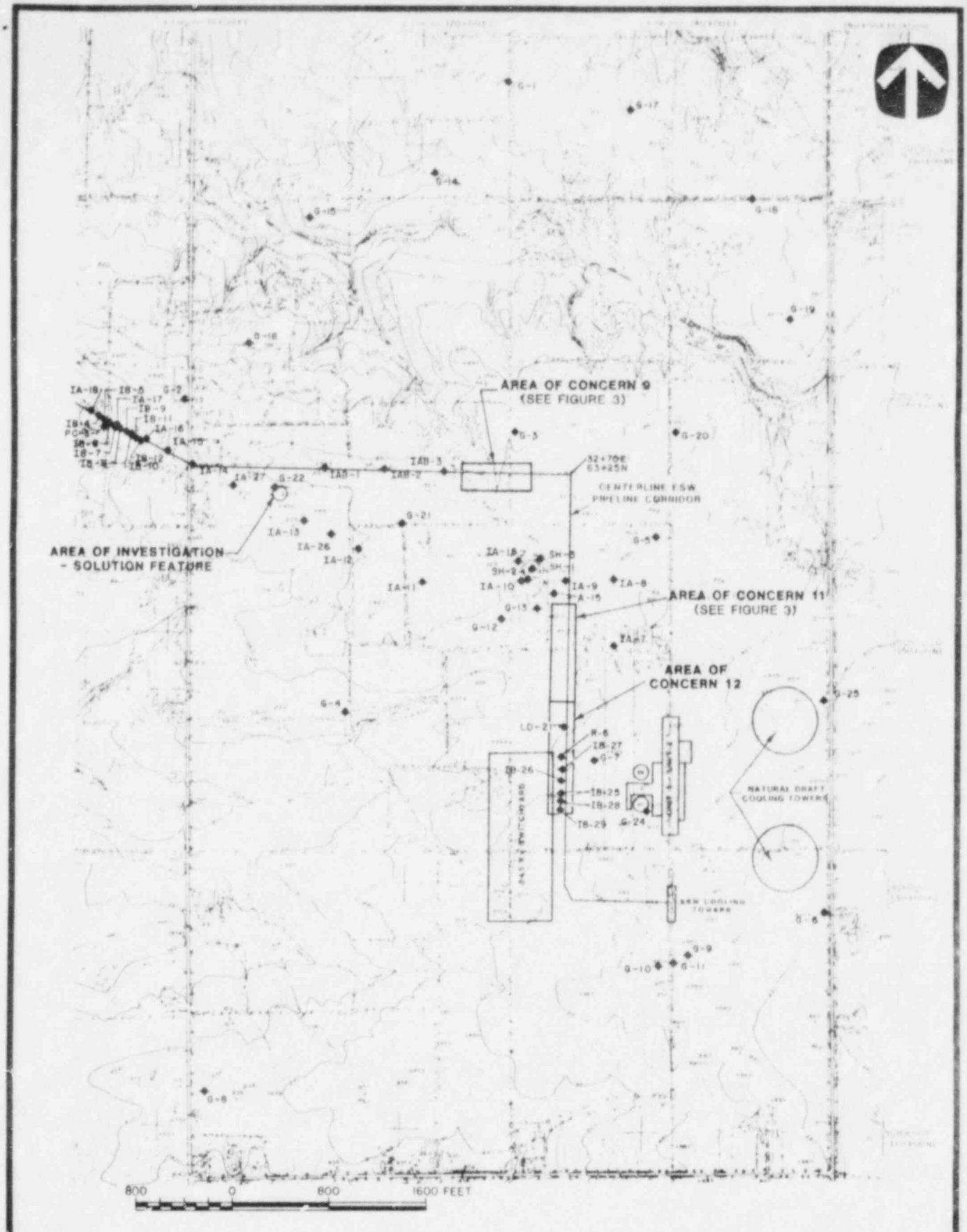
BASE MAP REFERENCE:
MODIFIED FROM: UNITED STATES GEOLOGICAL SURVEY, 1963 AND 1969; ROCKFORD, ILLINOIS; WISCONSIN, AND AURORA, ILLINOIS 1:250,000 MAPS.

BYRON STATION

CONFIRMATORY INVESTIGATIONS

FIGURE 1

REGIONAL LOCATION MAP

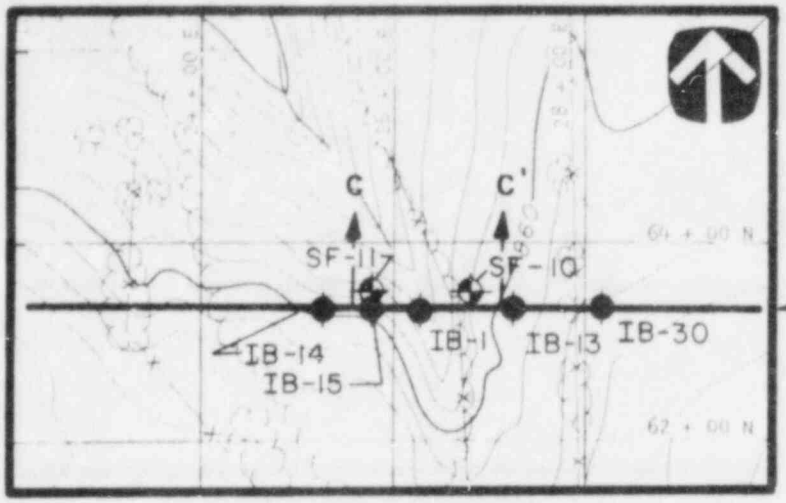


NOTES:
1. COORDINATES IN PARENTHESES REFER TO PLANT COORDINATE SYSTEM. OTHER COORDINATES REFER TO STATE PLANE SYSTEM.
2. ELEVATIONS REFER TO MEAN SEA LEVEL.
3. BORINGS LOCATED IN AREAS OF CONCERN 9 AND 11 ARE SHOWN ON FIGURE 3.

BASE MAP REFERENCE:
TOPOGRAPHIC MAP WAS COMPILED BY CHICAGO AERIAL SURVEY, FRANKLIN PARK, ILLINOIS.

BYRON STATION
CONFIRMATORY INVESTIGATIONS

FIGURE 2
PLOT PLAN -
LOCATIONS OF INVESTIGATIONS

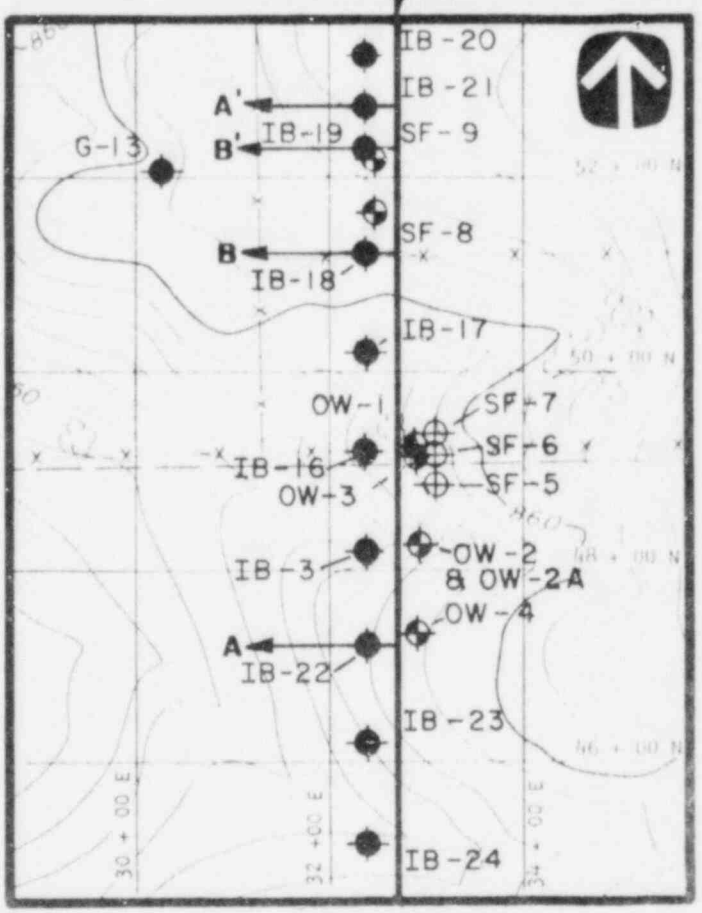


AREA OF CONCERN 9

CENTERLINE
ESW PIPELINE CORRIDOR

EXPLANATION:

- SF-8 — INDICATES LOCATION OF BORINGS DRILLED IN 1982.
- SF-7 — INDICATES LOCATION OF BORINGS DRILLED IN 1981.
- IB-9 — INDICATES LOCATION OF BORINGS DRILLED IN PREVIOUS INVESTIGATIONS



AREA OF CONCERN 11

NOTES:

1. SEE FIGURE 2 FOR LOCATION OF AREAS INVESTIGATED.
2. COORDINATES REFER TO PLANT COORDINATE SYSTEM.
3. LOCATION OF BORINGS SF-8A THROUGH SF-11A ARE SHOWN ON LOGS OF BORINGS AND FIGURES 6 AND 7.
4. SEE FIGURES 5, 6, AND 7 FOR CROSS SECTIONS A-A', B-B' AND C-C', RESPECTIVELY.

200 0 200
FEET

MAP REFERENCE:

COMPILED BY CHICAGO AERIAL SURVEY; PROJECT 8063; DATED APRIL 1971.

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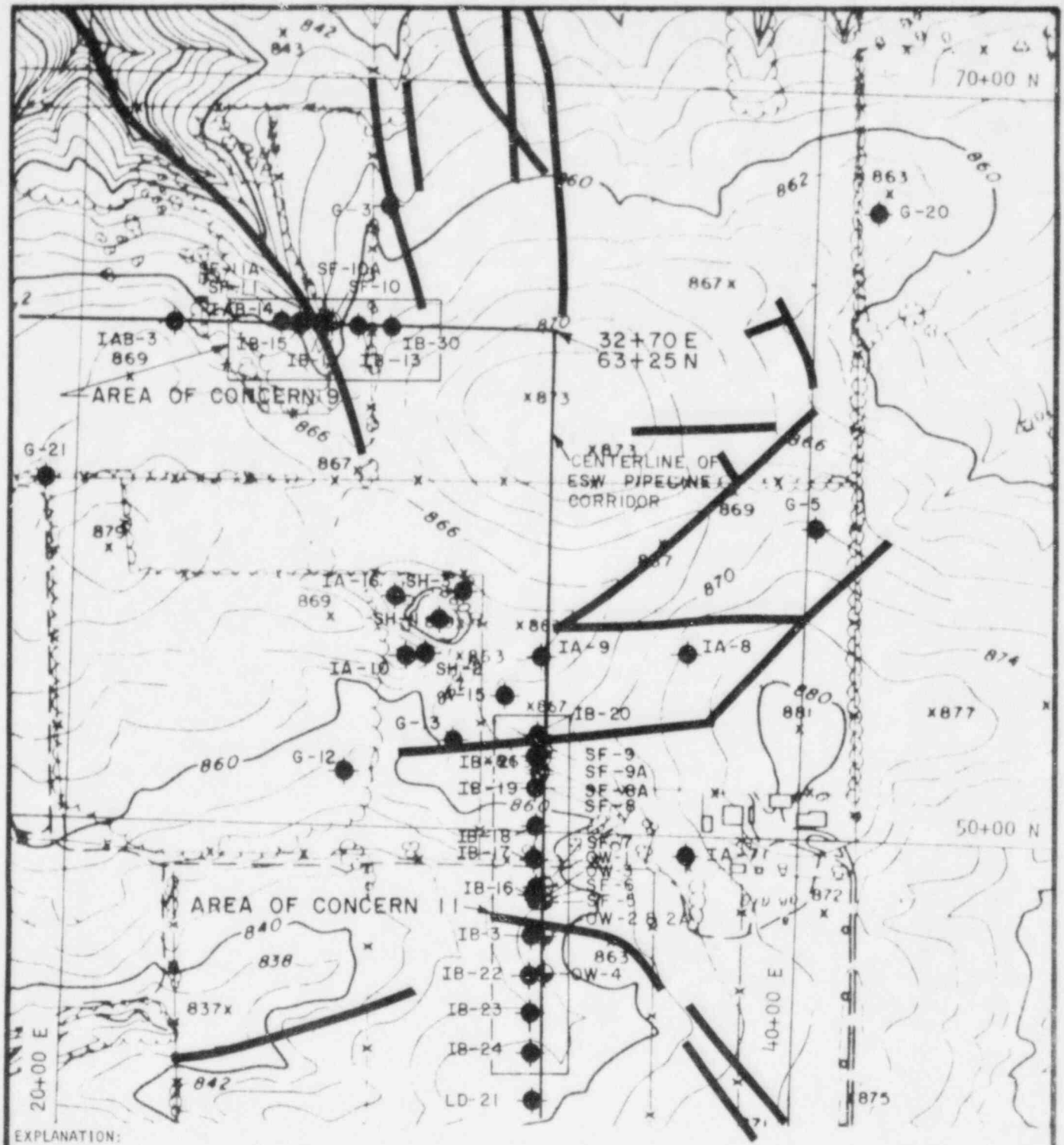
BYRON STATION
CONFIRMATORY INVESTIGATIONS

FIGURE 3

PLOT PLAN - AREAS OF CONCERN 9 AND 11



EXPLANATION:

SF-8 — INDICATES LOCATION OF BORINGS DRILLED IN 1982.

SF-7 — INDICATES LOCATION OF BORINGS DRILLED IN 1981.

IB-9 — INDICATES LOCATION OF BORINGS DRILLED IN PREVIOUS INVESTIGATIONS

NOTE:

1. MAJOR LINEAMENTS SHOWN ARE FROM FSAR, FIGURE 2.5-101.

BASE MAP REFERENCE:

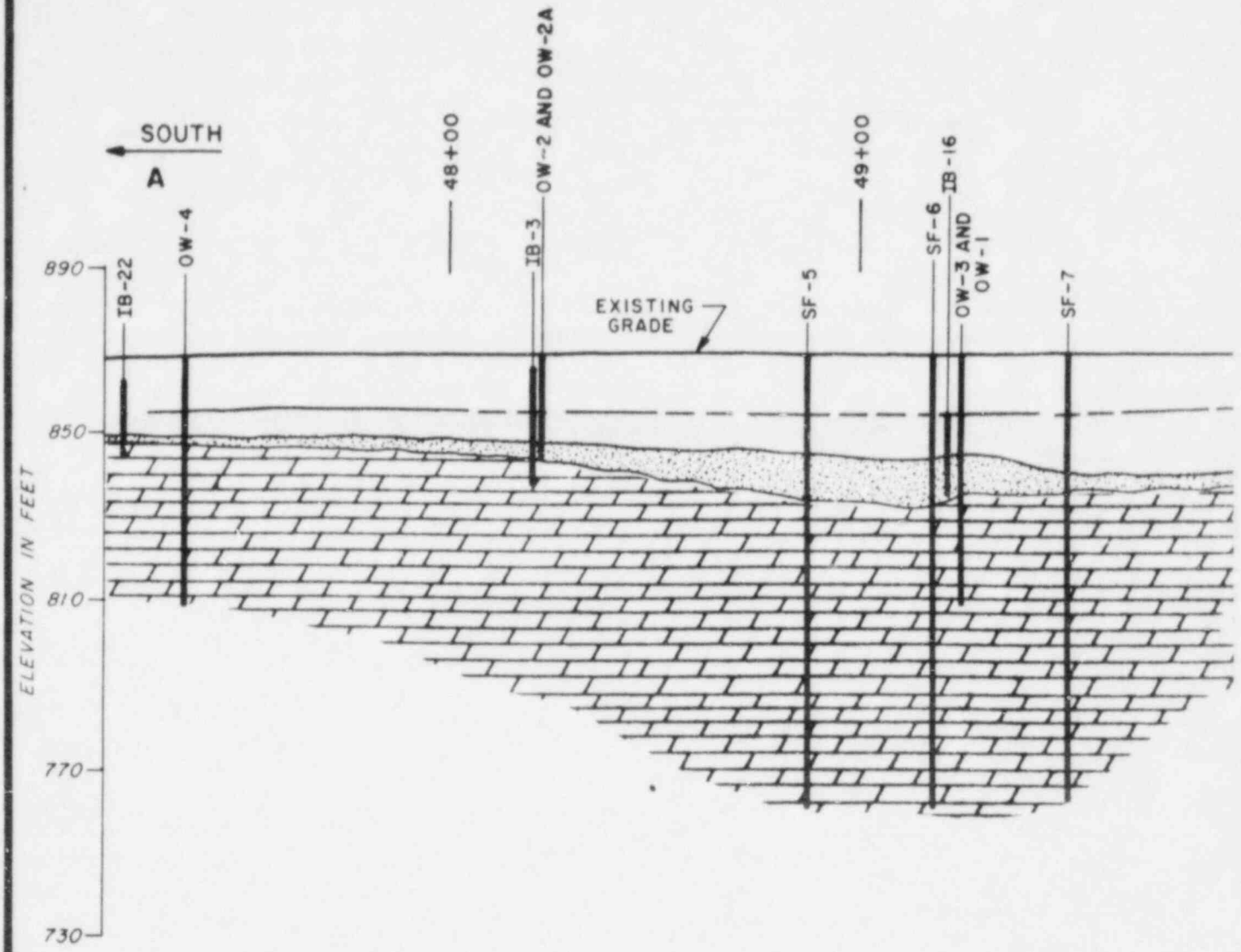
TOPOGRAPHIC MAP WAS COMPILED BY CHICAGO AERIAL SURVEY, FRANKLIN PARK, ILLINOIS.

BYRON STATION

CONFIRMATORY INVESTIGATIONS

FIGURE 4

MAJOR LINEAMENTS - AREAS OF CONCERN 9 AND 11



NOTES:

1. SEE FIGURE 3 FOR LOCATION OF BORINGS.
2. IB BORINGS WERE DRILLED WEST OF SF BORINGS AND PROJECTED TO THIS PROFILE. SOIL CONDITIONS MAY VARY RELATIVE TO PROFILE SHOWN.
3. IB BORINGS WERE DRILLED DURING JULY, 1977 AT PREVIOUS GRADE.
4. SF BORINGS WERE DRILLED DURING DECEMBER, 1981 AND AUGUST, 1982 AT EXISTING GRADE.
5. OW BORINGS WERE DRILLED DURING MARCH, 1982 AT EXISTING GRADE.
6. CROSS SECTIONS ARE INTERPETED FROM BORINGS. CONDITIONS BETWEEN BORINGS MAY DIFFER FROM THAT SHOWN.
7. COORDINATES REFER TO PLANT COORDINATE SYSTEM.
8. ELEVATIONS REFER TO FEET ABOVE MEAN SEA LEVEL.

40 0

NO VERT

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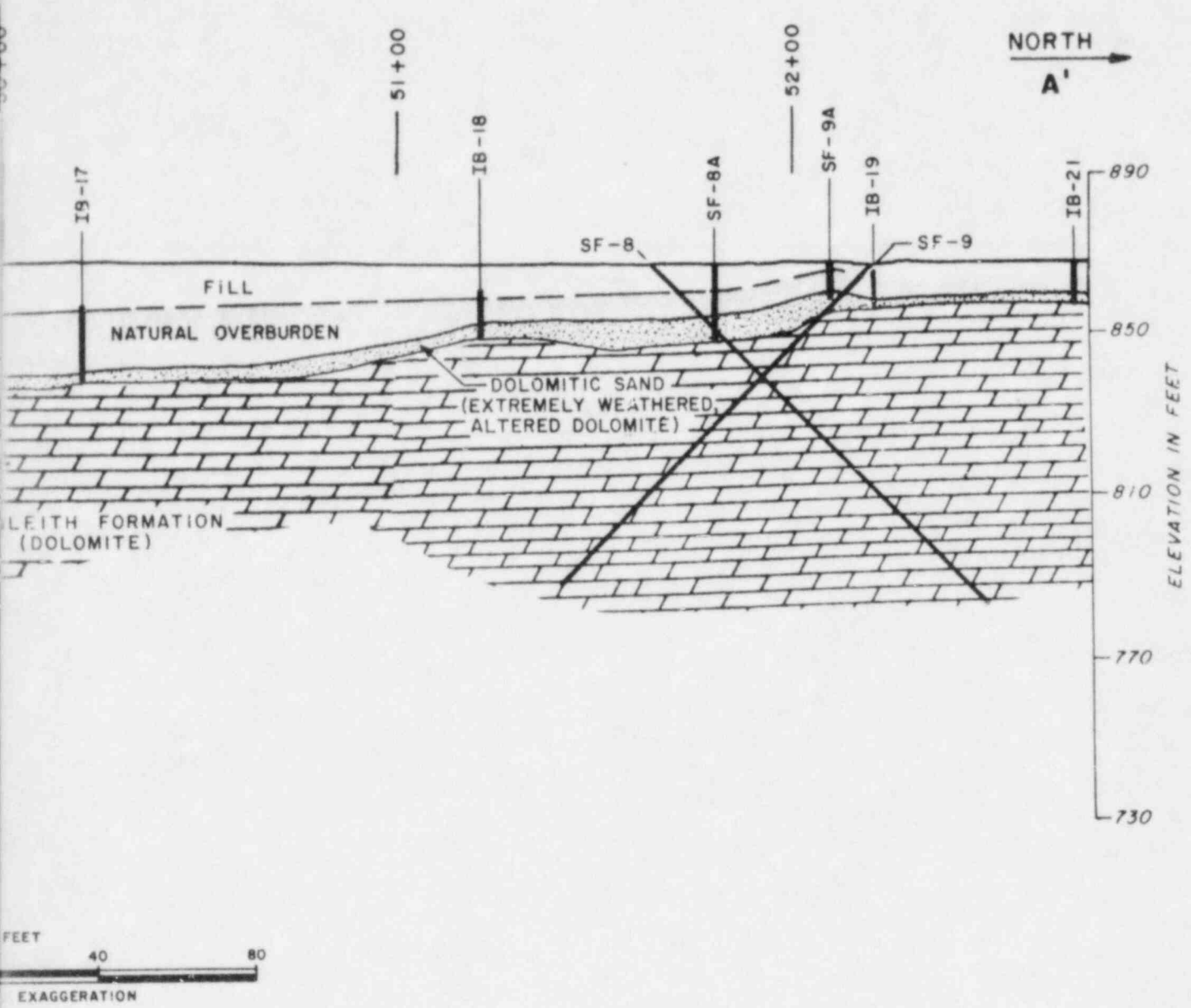
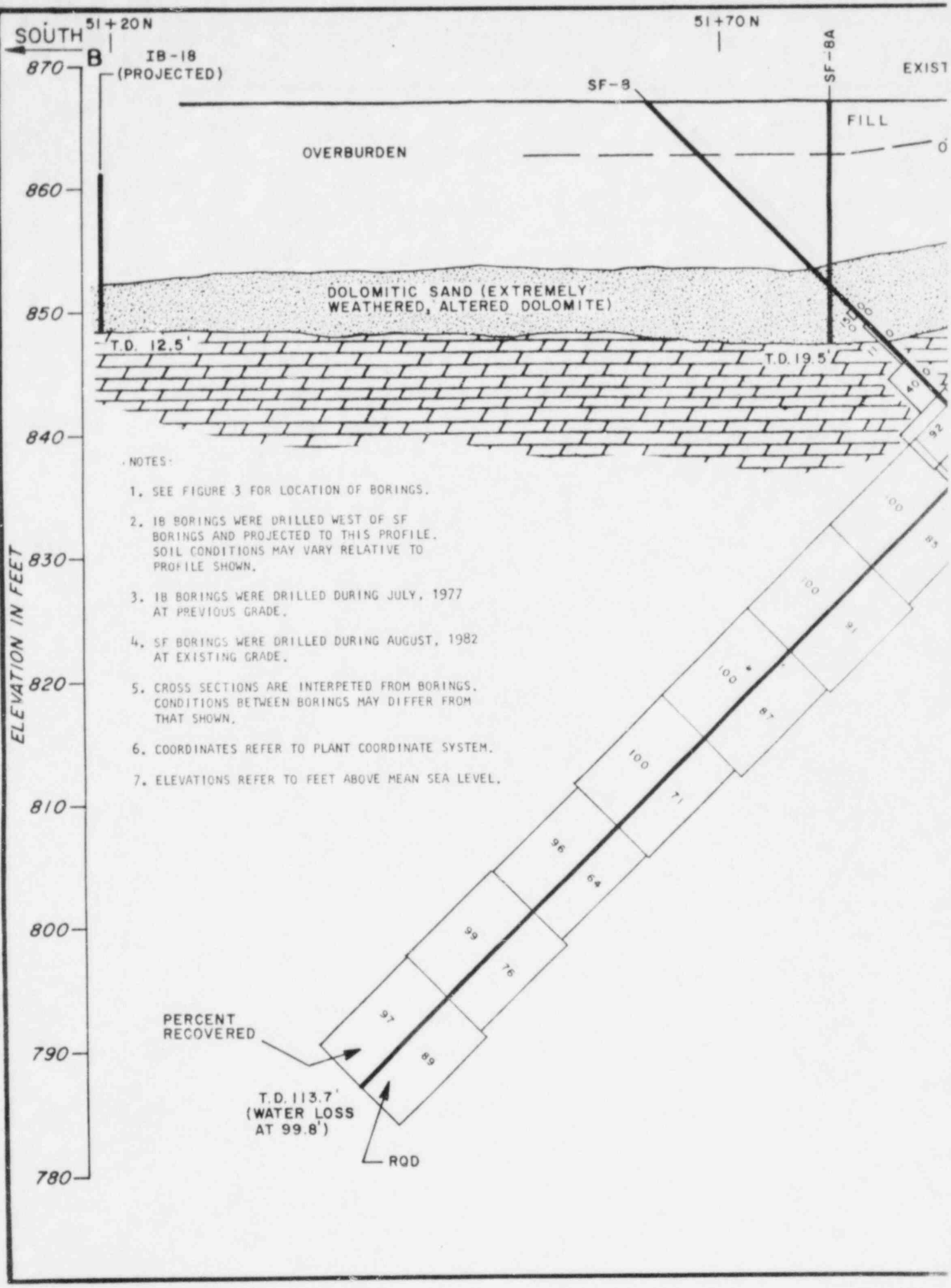


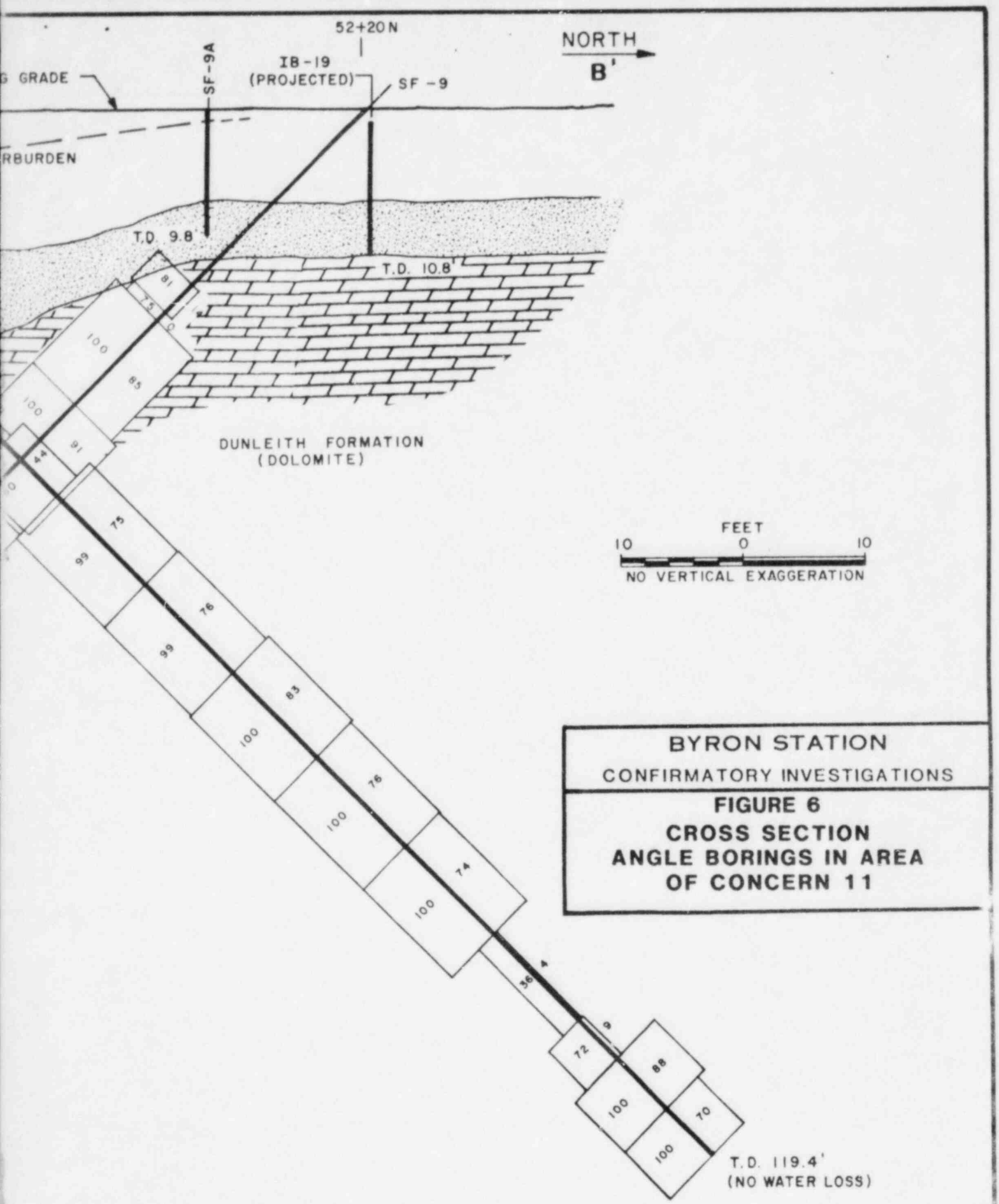
FEET
40
80
EXAGGERATION

BYRON STATION
CONFIRMATORY INVESTIGATIONS

FIGURE 5

GENERALIZED SUBSURFACE CROSS SECTION AREA OF CONCERN 11


SOUTH
B
51+20N
IB-18
(PROJECTED)
51+70N
SF-8A
EXIST
SF-8
FILL
OVERBURDEN
0
DOLOMITIC SAND (EXTREMELY WEATHERED, ALTERED DOLOMITE)
T.D. 12.5'
T.D. 19.5'
870
860
850
840
830
820
810
800
790
780
ELEVATION IN FEET
NOTES:
1. SEE FIGURE 3 FOR LOCATION OF BORINGS.
2. IB BORINGS WERE DRILLED WEST OF SF BORINGS AND PROJECTED TO THIS PROFILE. SOIL CONDITIONS MAY VARY RELATIVE TO PROFILE SHOWN.
3. IB BORINGS WERE DRILLED DURING JULY, 1977 AT PREVIOUS GRADE.
4. SF BORINGS WERE DRILLED DURING AUGUST, 1982 AT EXISTING GRADE.
5. CROSS SECTIONS ARE INTERPETED FROM BORINGS. CONDITIONS BETWEEN BORINGS MAY DIFFER FROM THAT SHOWN.
6. COORDINATES REFER TO PLANT COORDINATE SYSTEM.
7. ELEVATIONS REFER TO FEET ABOVE MEAN SEA LEVEL.
PERCENT RECOVERED
T.D. 113.7'
(WATER LOSS AT 99.8')
RQD
5643-120-07

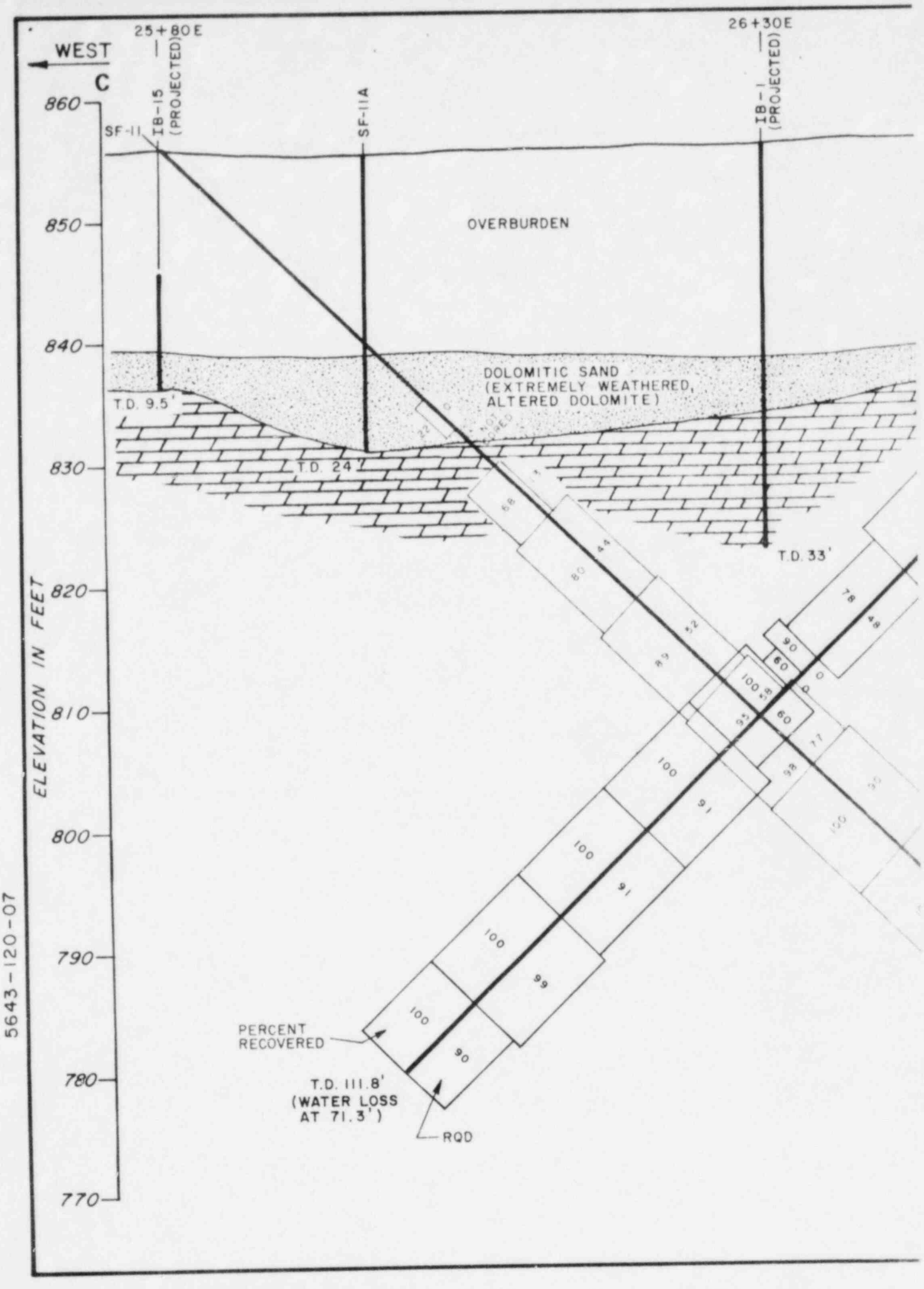


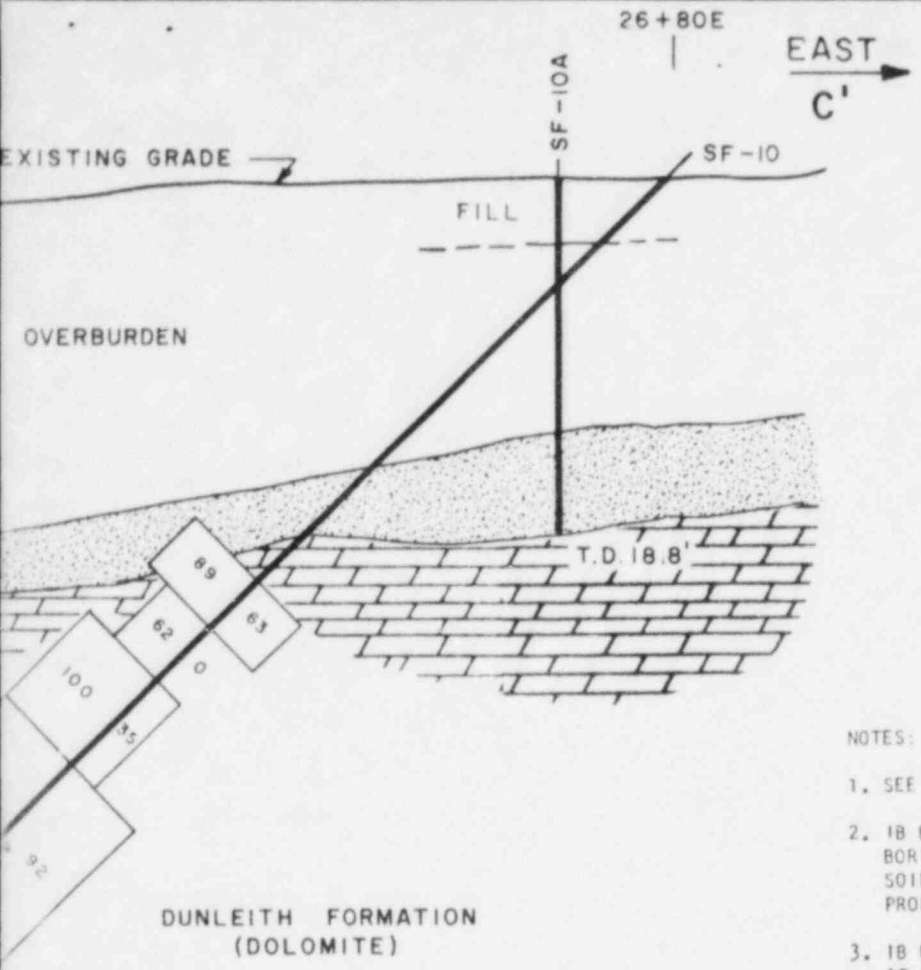
BYRON STATION

CONFIRMATORY INVESTIGATIONS

FIGURE 6

CROSS SECTION
ANGLE BORINGS IN AREA
OF CONCERN 11

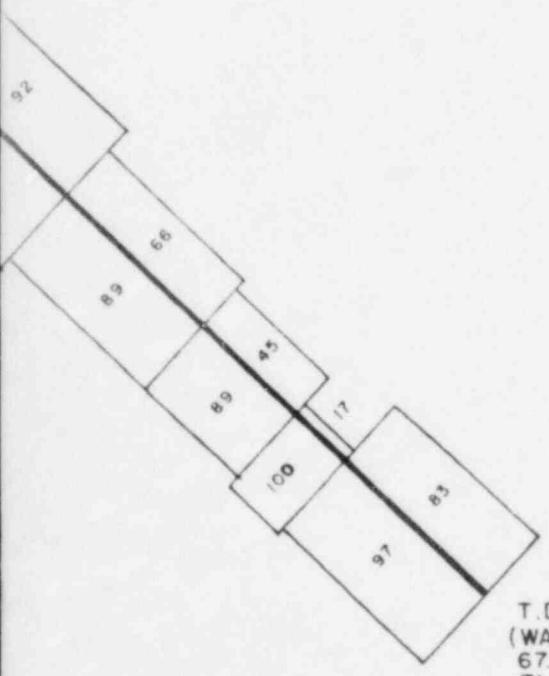

WEST
C
25+80E
26+30E
IB-15 (PROJECTED)
SF-11
SF-11A
IB-1 (PROJECTED)
860
850
840
830
820
810
800
790
780
770
ELEVATION IN FEET
OVERBURDEN
DOLOMITIC SAND
(EXTREMELY WEATHERED, ALTERED DOLOMITE)
T.D. 9.5'
T.D. 24'
T.D. 33'
T.D. 111.8'
(WATER LOSS AT 71.3')
PERCENT RECOVERED
RQD
5643-120-07



DUNLEITH FORMATION
(DOLOMITE)

NOTES:

1. SEE FIGURE 3 FOR LOCATION OF BORINGS.
2. 18 BORINGS WERE DRILLED WEST OF SF BORINGS AND PROJECTED TO THIS PROFILE. SOIL CONDITIONS MAY VARY RELATIVE TO PROFILE SHOWN.
3. 18 BORINGS WERE DRILLED DURING JULY, 1977 AT PREVIOUS GRADE.
4. SF BORINGS WERE DRILLED DURING AUGUST, 1982 AT EXISTING GRADE.
5. CROSS SECTIONS ARE INTERPETED FROM BORINGS. CONDITIONS BE WEEN BORINGS MAY DIFFER FROM THAT SHOWN.
6. COORDINATES REFER TO PLANT COORDINATE SYSTEM.
7. ELEVATIONS REFER TO FEET ABOVE MEAN SEA LEVEL.



T.D. 123.7'
(WATER LOSS AT 67.7' TO 70.5' AND 71.2')

NO VERTICAL EXAGGERATION

BYRON STATION
CONFIRMATORY INVESTIGATIONS

FIGURE 7

CROSS SECTION ANGLE BORINGS IN AREA OF CONCERN 9

APPENDIX A

FIELD INVESTIGATION AND LABORATORY TESTS

This appendix presents the methods used during performance of the geotechnical investigations which were performed to confirm the subsurface stability of the ESW pipeline. The studies consisted of two separate field investigations conducted in March 1982 and August 1982. The methods used in conducting each investigation are presented in the following sections.

CONFIRMATORY SOILS INVESTIGATION

Additional geotechnical investigations were conducted to install ground-water observation wells and obtain undisturbed soil samples. The field program, performed in March 1982 consisted of drilling four borings which ranged in depth from 22.3 feet to 60.4 feet below the ground surface at the locations shown on Figure 3. Surveying services were provided by the Commonwealth Edison Co. Drilling, utilizing a truck-mounted Mobil B-40 drill rig, was subcontracted to D&G Drilling, Inc. of New Lenox, Illinois.

The borings were drilled using 4-inch solid flight augers in the upper 6 to 12 feet of soil and completed using rotary wash techniques. Standard Penetration Tests (SPT) were performed in Borings OW-1, OW-2, OW-3, and OW-4. The SPT sampling was performed in accordance with ASTM D 1586-67. Undisturbed samples were taken in Borings OW-1 and OW-2 with a 3.0-inch ID Osterberg Piston Sampler in accordance with ASTM Standard D 1587-67. The sample depths and SPT values are presented on the log of each boring (Figures A-2.1 through A-2.4). Rock was cored in Borings OW-3 and

OW-4 with a NX-size wireline core barrel (10 feet in length). The percent of rock core recovered and Rock Quality Designation (RQD) values are presented on the Boring Logs.

Piezometers were installed under the direction of Sargent & Lundy in Borings OW-1, OW-2A, OW-3, and OW-4 utilizing 2-inch ID PVC pipe. The bottom portion of each piezometer consisted of 3 feet to 10 feet of slotted 2-inch ID PVC screen. The screened interval in each boring is presented on the boring logs.

Laboratory tests were performed on samples obtained from borings OW-1, OW-2A, and OW-3. The laboratory tests were performed in general accordance with the NRC Regulatory Guide 1.138 and applicable ASTM standards. The tests were conducted in the Dames & Moore Park Ridge, Illinois laboratory. The tests performed included:

1. Moisture and Density Determination (ASTM D2216, D2974)
2. Atterberg Limits (ASTM D423, D424, D427)
3. Grain Size Determination (ASTM D421, D422, D2217)
4. Consolidation Tests (ASTM D2435)
5. Organic Content (ASTM D2974)

The results of the laboratory tests are presented in: Figures A-2.1 through A-2.4 (Log of Borings); Figure A-3, Consolidation Test Data; and Figure A-4, Particle Size Analysis.

CONFIRMATORY GEOLOGIC INVESTIGATION

The field program was performed in Areas of Concern 9 and 11 between August 9 and August 20, 1982 and included drilling four vertical borings through the soil to the bedrock surface and four angle borings at least 80 feet into bedrock.

Surveying services were provided by the Commonwealth Edison Company. Drilling, utilizing a truck-mounted Mobil B-40 drill rig, was subcontracted to D&G Drilling, Inc. of New Lenox, Illinois. Four borings, SF-8 through SF-11, were drilled on a 45° angle. NX-size casing was installed through the soil utilizing a casing advancer. The casing was set several feet into the highly weathered dolomite in each boring. Rock core was obtained with an NX-size wireline, double-tube, split inner core barrel, 10 feet in length. Soil borings were drilled vertically using 4-inch solid flight augers. Standard Penetration Test (SPT) soil samples were obtained at 2-1/2 foot intervals with a 2-inch O.D. split spoon sampler and retained in glass jars. SPT sampling was performed in accordance with ASTM standard D 1586-67. Soil borings were terminated several feet into the bedrock. The logs of borings are presented on Figures A-2.5 through A-2.8.

Various data relating to drilling parameters were recorded mechanically and visually during the rock coring operations. Mechanically recorded data included rate of penetration, hydraulic feed pressure and drilling speed (RPM) of the drill stem. The rate of penetration and coring pressure were recorded on a Geolograph Model G7 RPW installed on the drill rig. The RPM was recorded using a Geolograph rotary transducer and an Esterline Angus Model MS401B 4-inch strip chart recorder. Additional visual

observations and measurements were made and included bit drops, circulating fluid return, core recovery, RQD, and rate of penetration (manually recorded). The data recorded both mechanically and visually have been summarized for each of the angle borings and are presented graphically on Figures A-2.5 through A-2.8.

--ooOoo--

KEY TO SAMPLES:

32 ◪ — THE NUMBER OF BLOWS REQUIRED TO DRIVE THE 2.0" O.D. BY 1.4" I.D. STANDARI SPOON SAMPLER 12" OR LENGTH INDICATED WITH A 140 POUND HAMMER FALLING 30"

◪ — DEPTH OF DISTURBED SAMPLE OBTAINED WITH THE SPLIT SPOON SAMPLER.

P — INDICATES SAMPLER WAS HYDRAULICALLY PUSHED.

P ■ — DEPTH OF UNDISTURBED SAMPLE OBTAINED WITH 3.0" I.D. OSTERBERG PISTON SAMPLER.

WEATHERING TERMINOLOGY

FRESH: THE ROCK SHOWS NO DISCOLORATION, LOSS OF STRENGTH, OR ANY OTHER EFFECT OF WEATHERING.

SLIGHTLY WEATHERED: THE ROCK IS SLIGHTLY DISCOLORED, BUT NOT NOTICEABLY LOWER IN STRENGTH THA THE FRESH ROCK.

MODERATELY WEATHERED: THE ROCK IS DISCOLORED AND NOTICEABLY WEAKENED. BUT 2-INCH DIAMETER DRILL CORES CANNOT USUALLY BE BROKEN UP BY HAND, ACROSS THE ROCK FABRIC.

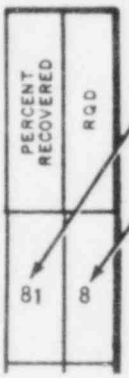
HIGHLY WEATHERED: THE ROCK IS USUALLY DISCOLORED AND WEAKENED TO SUCH AN EXTENT THAT 2-INCH DIAMETER CORES CAN BE BROKEN UP READILY BY HAND, ACROSS THE ROCK FABRIC. WET STRENGTH USUALLY MUCH LOWER THAN DRY STRENGTH.

EXTREMELY WEATHERED: THE ROCK IS DISCOLORED AND IS ENTIRELY CHANGED TO A SOIL, BUT THE ORIGINA FABRIC OF THE ROCK IS MOSTLY PRESERVED. THE PROPERTIES OF THE SOIL DEPEND UPON THE COMPOSITION AND STRUCTURE OF THE PARENT ROCK.

BEDDING TERMINOLOGY

AVERAGE BED THICKNESS	TERM
0.001 FOOT	THINLY LAMINATED
0.001 TO 0.01 FOOT	LAMINATED
0.01 TO 0.1 FOOT	THIN BEDDED
0.1 TO 1.0 FOOT	MEDIUM BEDDED
1.0 FOOT	THICK BEDDED

RECOVERY TERMINOLOGY

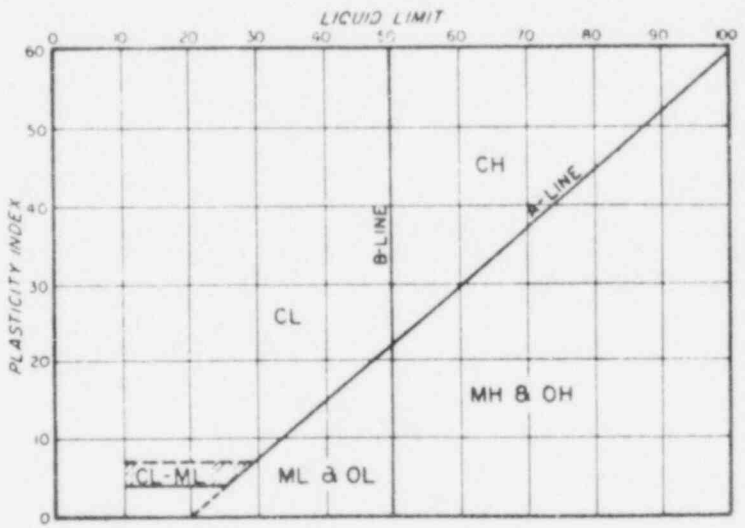


PERCENT RECOVERED INDICATES TOTAL AMOUNT OF CORE RECOVERED FOR EACH RUN, EXPRESSED AS A PERCENTAGE OF THE TOTAL LENGTH OF THE CORE RUN.

ROCK QUALITY DESIGNATION (RQD) - A MODIFIED CORE RECOVERY PERCENTAGE IN W ALL PIECES OF CORE OVER 4 INCHES LONG ARE COUNTED AS RECOVERY. THE MODIFI SUM OF CORE RECOVERED IS THEN EXPRESSED AS A PERCENTAGE OF THE TOTAL LENG OF THE CORE RUN.

ROCK QUALITY TERMS

PERCENT RQD	DESCRIPTIVE ROCK QUALITY
0 - 25	VERY POOR
25 - 50	POOR
50 - 75	FAIR
75 - 90	GOOD
90 - 100	EXCELLENT



PLASTICITY CHART

KEY TO

G_s

CONSOL

NOTES:
1. ELEV
2. COOR SYST

5643-120-07

MAJOR DIVISIONS			GRAPHIC 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
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	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
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE				SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	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
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	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

RATORY TESTS:

CIFIC GRAVITY TEST

SOLIDATION TEST

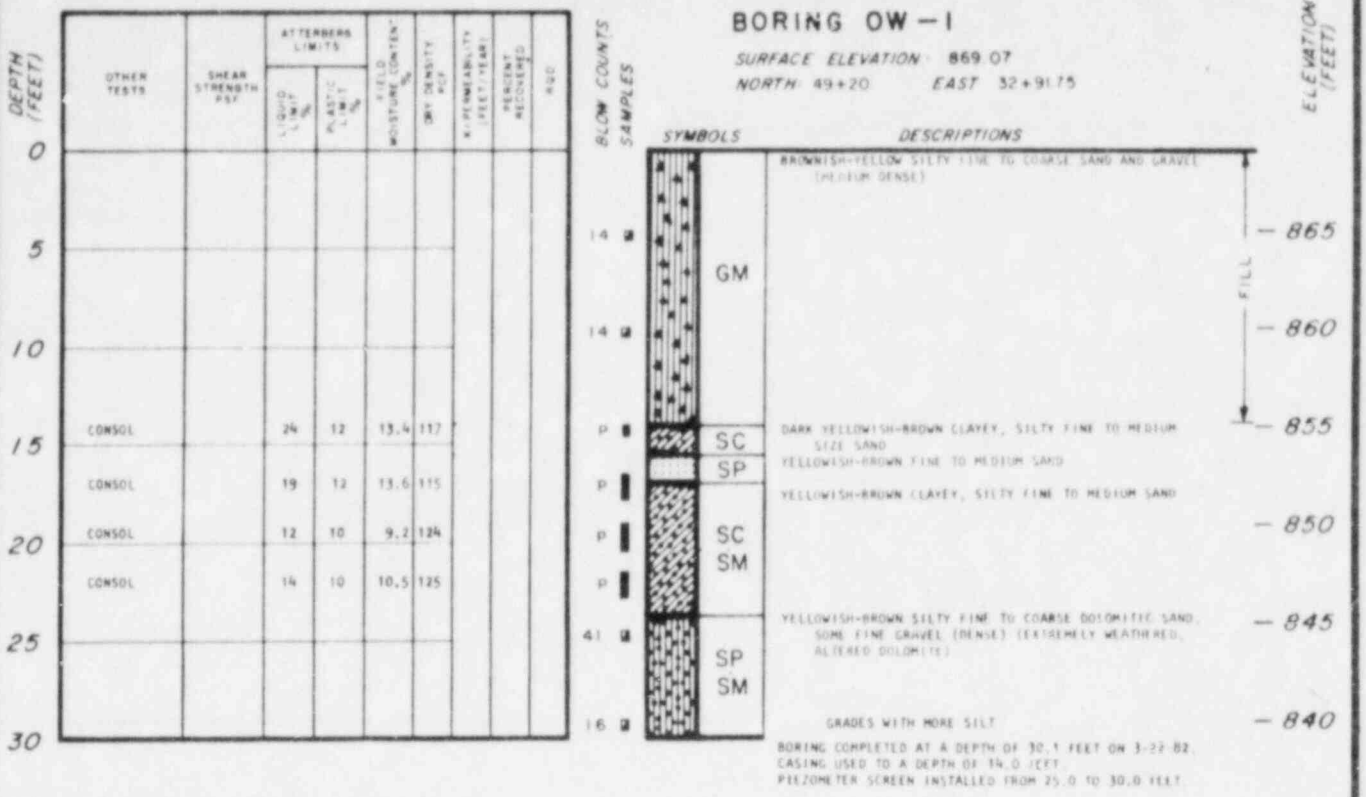
S REFER TO MEAN SEA LEVEL.
ES REFER TO PLANT COORDINATE

BYRON STATION
CONFIRMATORY INVESTIGATIONS

FIGURE A-1
KEY TO LOG OF BORINGS

BORING OW-1

SURFACE ELEVATION 869.07
NORTH 49+20 EAST 32+91.75



BORING COMPLETED AT A DEPTH OF 30.1 FEET ON 3-22-82.
CASING USED TO A DEPTH OF 14.0 FEET.
PIEZOMETER SCREEN INSTALLED FROM 25.0 TO 30.0 FEET.

KEY TO SAMPLES:

14 — THE NUMBER OF BLOWS REQUIRED TO DRIVE THE 2.0" O.D. BY 1.4" I.D. STANDARD SPLIT SPOON SAMPLER 12" OR LENGTH INDICATED WITH A 140 POUND HAMMER FALLING 30".

14 ■ DEPTH OF DISTURBED SAMPLE OBTAINED WITH THE SPLIT SPOON SAMPLER.

P — INDICATES SAMPLER WAS HYDRAULICALLY PUSHED.

P ▮ DEPTH OF SAMPLE OBTAINED WITH 3.0" I.D. OSTERBERG PISTON SAMPLER.

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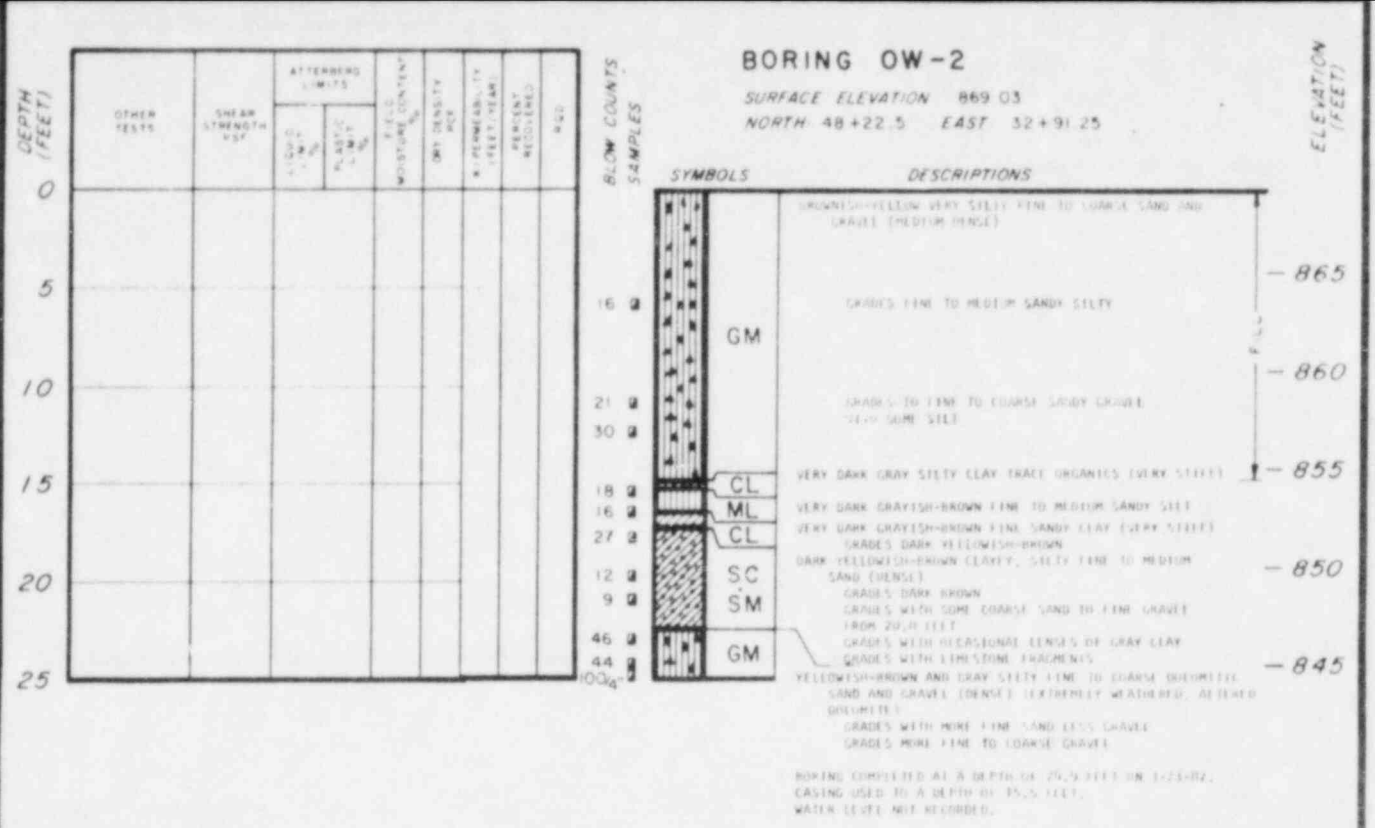
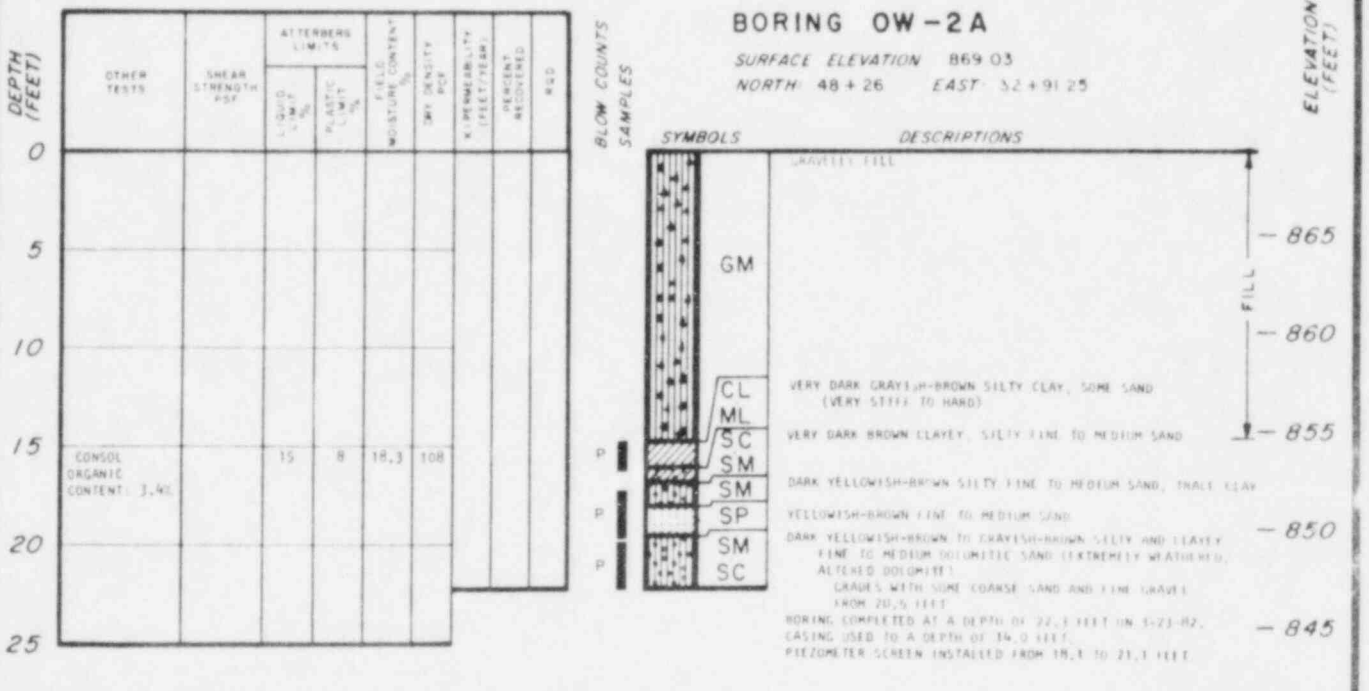
BYRON STATION
CONFIRMATORY INVESTIGATIONS

FIGURE A-2.1
LOG OF BORING OW-1





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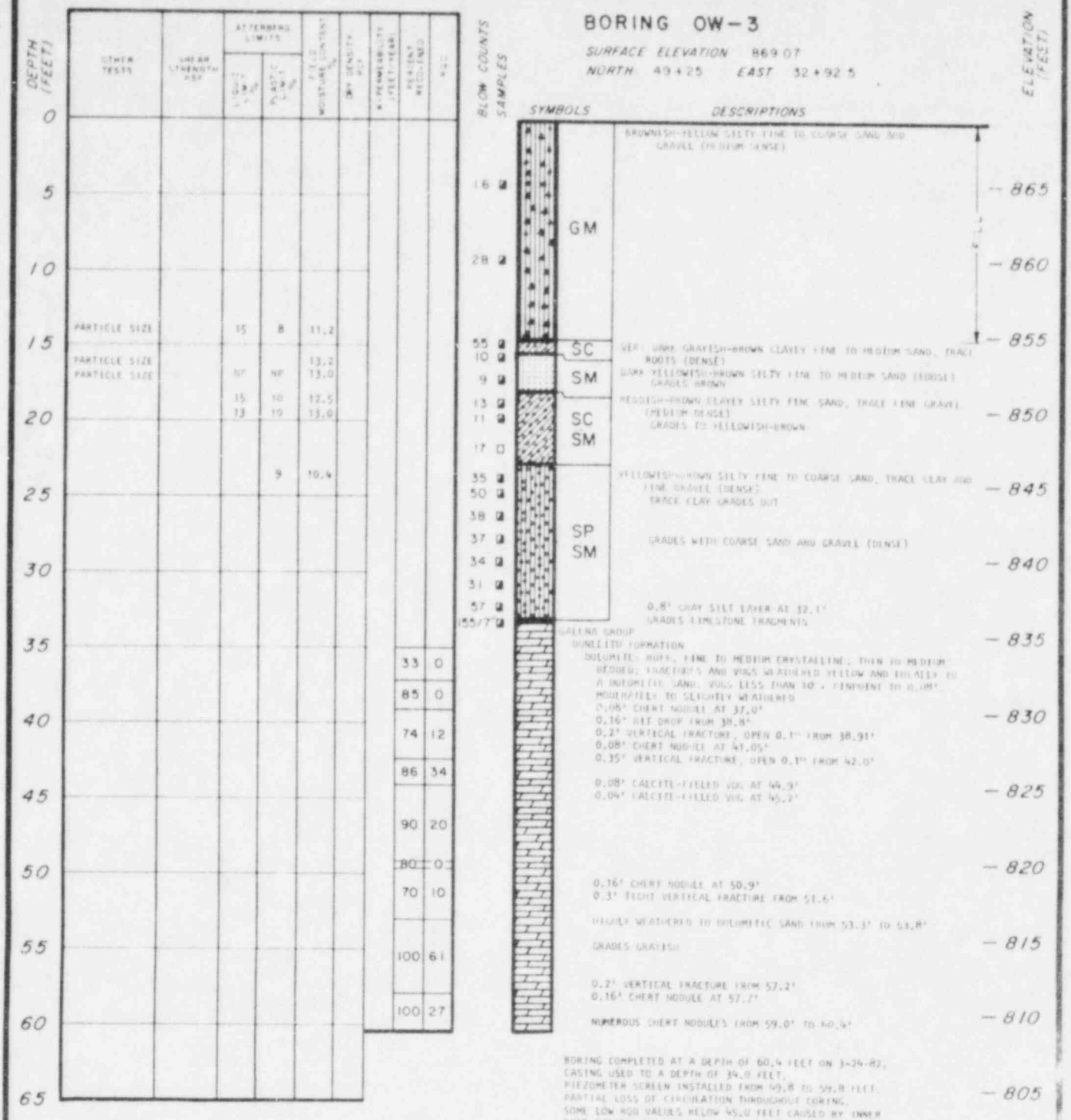
BYRON STATION

CONFIRMATORY INVESTIGATIONS

FIGURE A-2.2

LOG OF BORINGS OW-2 & OW-2A



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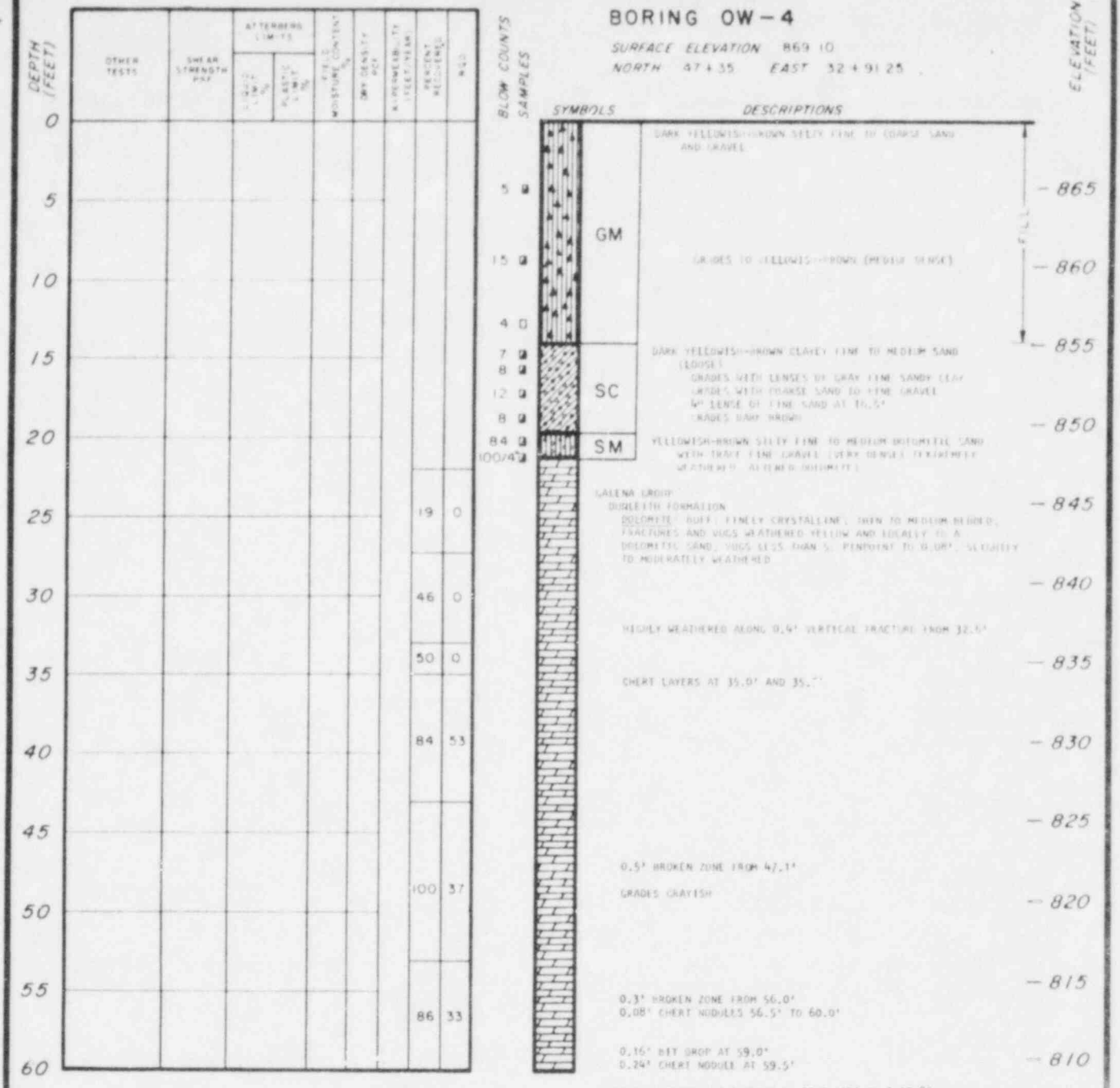
CONFIRMATORY INVESTIGATIONS

FIGURE A-2.3

LOG OF BORING OW-3



BORING COMPLETED AT A DEPTH OF 60.0 FEET ON 3-22-82.
CASING USED TO A DEPTH OF 19.5 FEET.
PIEZOMETER SCREEN INSTALLED FROM 50.0 TO 60.0 FEET.
PARTIAL LOSS OF CIRCULATION THROUGHOUT CORING.

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BYRON STATION

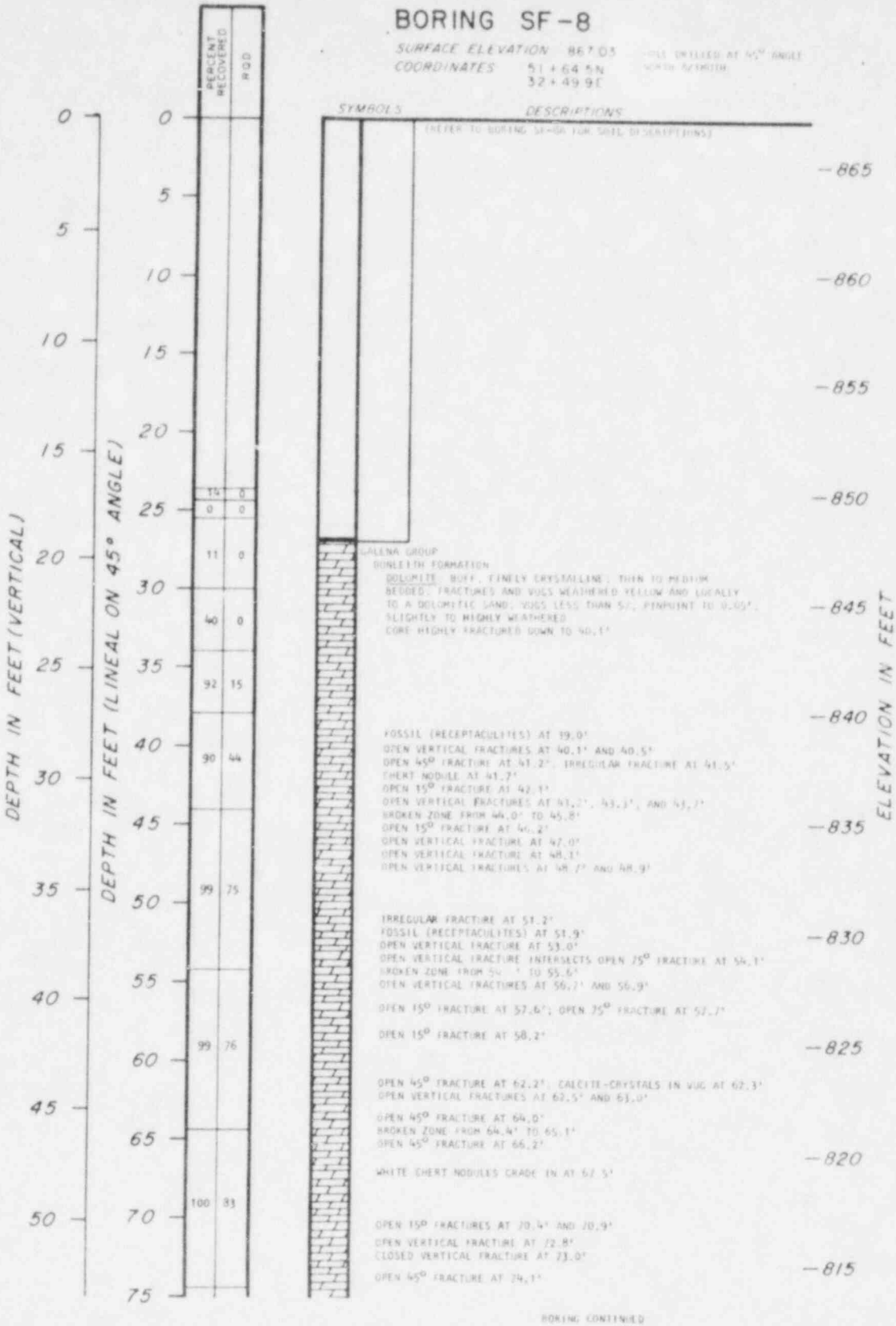
CONFIRMATORY INVESTIGATIONS

FIGURE A-2.4

LOG OF BORING OW-4

BORING SF-8

SURFACE ELEVATION 867.05 — HOLE DRILLED AT 45° ANGLE
COORDINATES 51+64.5N — NORTH AZIMUTH
32+49.9E



5643-120-07

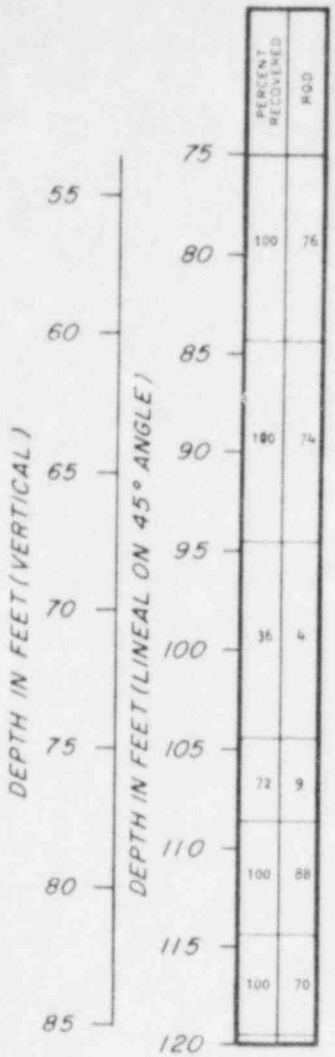
BYRON STATION

CONFIRMATORY INVESTIGATIONS

FIGURE A-2.5

LOG OF BORINGS SF-8 & SF-8A
(SHEET 1 OF 3)

BORING SF-8 CONT'D



SYMBOLS

DESCRIPTIONS

OPEN 45° FRACTURES AT 76.7', 77.2', 77.5' AND 77.7'

YELLOWISH-BROWN SILTY CLAY FILLED FRACTURE - 0.1" THICK AT 80.9' — 810

OPEN 45° FRACTURE AT 82.9'
YELLOWISH-BROWN SILTY CLAY FILLED EARTLY HEALED BEDDING PLANE FRACTURE (VUG-LIKE) - 0.1" THICK AT 83.0'

OPEN 15° FRACTURE AT 85.2'

OPEN VERTICAL FRACTURE THROUGH CHERT NODULE AT 87.3' — 805

OPEN VERTICAL FRACTURE AT 89.0'
CHERT GRADES OUT AT 89.5'
CLOSED VERTICAL FRACTURE AT 90.1'; OPEN VERTICAL FRACTURES AT 90.25' AND 90.7'
OPEN VERTICAL FRACTURE AT 92.0'
GRAYISH-GREEN SHALE PARTING AT 93.3'
OPEN 15° FRACTURE AT 94.9'; OPEN VERTICAL FRACTURE AT 95.1' — 800
HIGHLY FRACTURED ZONE FROM 95.5' TO 108.2'

— 795

OPEN 45° FRACTURE AT 108.9'
OPEN 45° FRACTURE AT 109.4' — 790

PARTLY - HEALED VERTICAL FRACTURE AT 111.6'
OPEN VERTICAL FRACTURE AT 112.4'

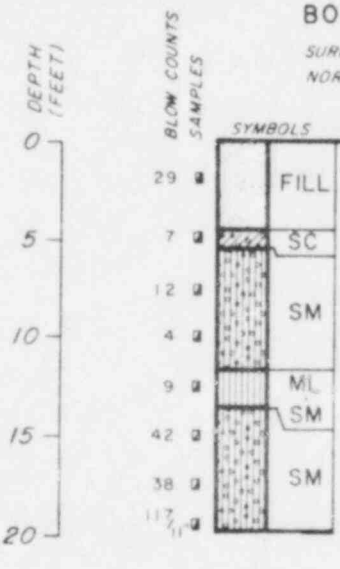
OPEN AND HEALED VERTICAL FRACTURES AT 115.1' — 785
OPEN VERTICAL FRACTURE AT 116.1'
HIGHLY FRACTURED AND WEATHERED ZONE FROM 116.2' TO 117.2';
YELLOWISH-BROWN CLAYEY ZONE AT 117.2'
OPEN VERTICAL FRACTURE AT 117.6'
OPEN VERTICAL FRACTURE AT 118.9'

BORING COMPLETED AT A DEPTH OF 119.4 FEET ON 8-10-82.
3 INCH I.D. CASING USED TO A DEPTH OF 23.2 FEET.
NO LOSS OF CIRCULATION.
NEW DRILL BIT USED. BIT IN GOOD CONDITION AT COMPLETION OF CORING. — 780

ELEVATION IN FEET

BORING SF-8A

SURFACE ELEVATION 866.86
NORTH 51+79.5 *EAST* 32+50.1



SYMBOLS

DESCRIPTIONS

LIGHT BROWN SILTY FINE TO COARSE SAND AND GRAVEL - FILL — 865

DARK BROWN CLAYEY FINE SAND

BROWN SILTY FINE TO MEDIUM SAND — 860

GRADES WITH TRACE OF CLAY

YELLOWISH-BROWN VERY FINE SANDY SILT WITH SEAMS OF SILTY VERY FINE SAND — 855

YELLOWISH-BROWN SILTY FINE DOLOMITIC SAND WITH SOME FINE TO COARSE WEATHERED DOLOMITE FRAGMENTS (EXTREMELY WEATHERED, ALTERED DOLOMITE) — 850

REFUSAL
BORING COMPLETED AT A DEPTH OF 19.5 FEET ON 8-11-82.
DRY UPON COMPLETION.
NO CASING USED.

ELEVATION (FEET)

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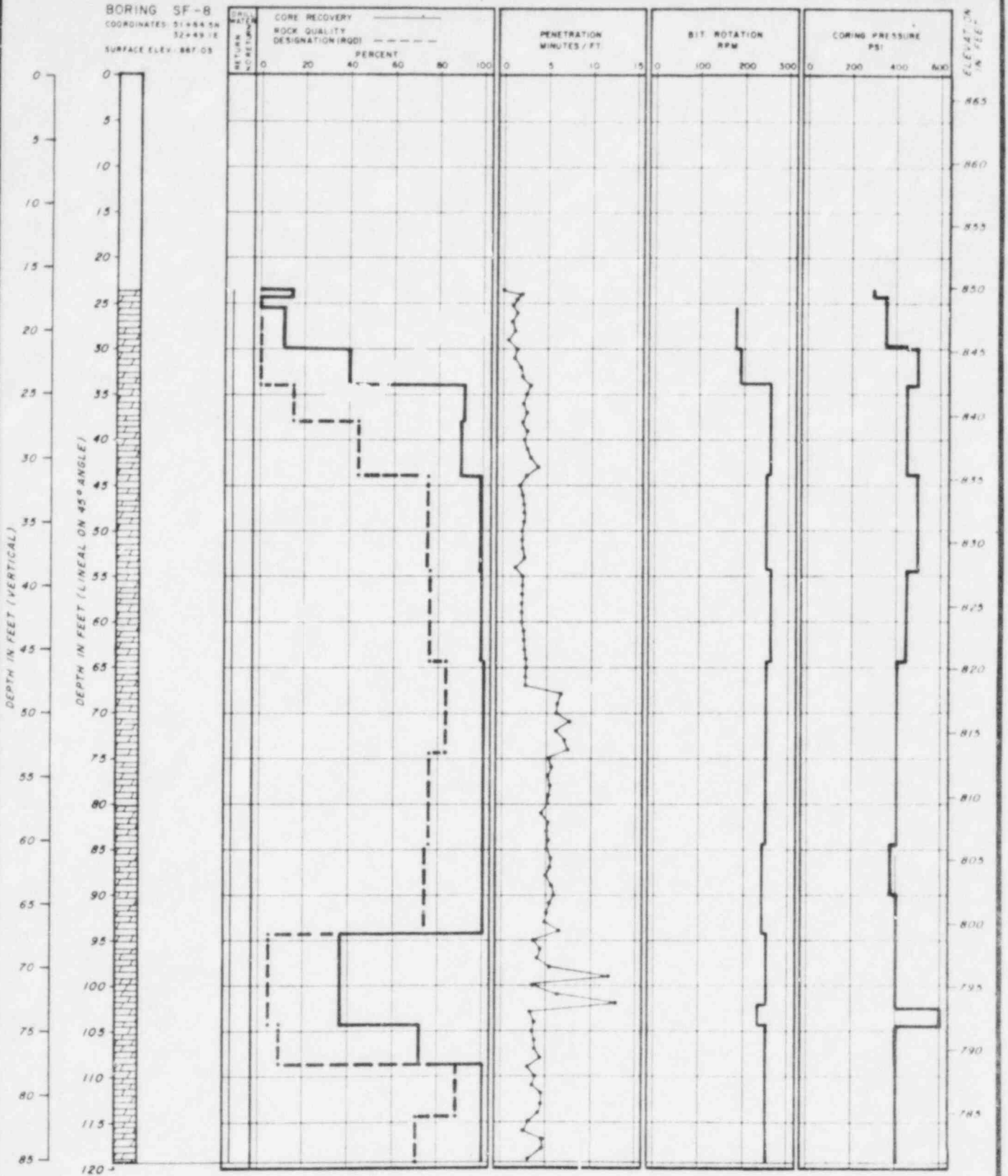
BYRON STATION

CONFIRMATORY INVESTIGATIONS

FIGURE A-2.5

LOG OF BORINGS SF-8 & SF-8A
(SHEET 2 OF 3)



NOTE:

1. NO DRILL ROD DROPS OCCURRED.

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BYRON STATION

CONFIRMATORY INVESTIGATIONS

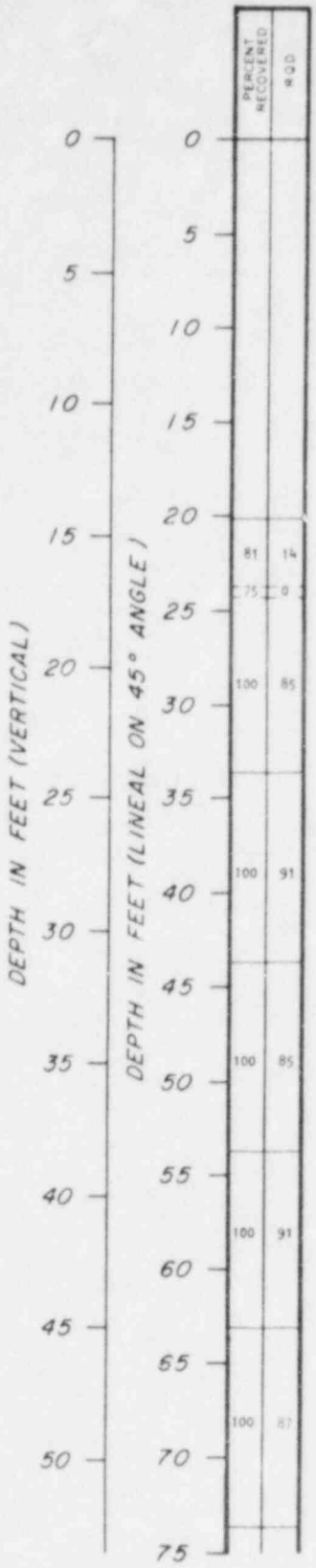
FIGURE A-2.5

LOG OF DRILLING PARAMETERS FOR BORING SF-8

(SHEET 3 OF 3)

BORING SF-9

SURFACE ELEVATION 866.6 HOLE DRILLED AT 45° ANGLE SOUTH AZIMUTH
COORDINATES 52 + 20 N
32 + 49 E



SYMBOLS DESCRIPTIONS

(REFER TO BORING SF-9A FOR SOIL DESCRIPTIONS)

ELEVATION IN FEET

865
860
855
850
845
840
835
830
825
820
815

GALENA GROUP
DUNLEITH FORMATION
DOLOMITE; BUFF, FINELY CRYSTALLINE, THIN TO MEDIUM BEDDED, FRACTURES AND VUGS WEATHERED YELLOW AND LOCALLY TO A DOLOMITIC SAND; VUGS LESS THAN 5%, PINPOINT TO 0.05', SLIGHTLY TO HIGHLY WEATHERED
HIGHLY FRACTURED AND WEATHERED ZONE FROM 20.1' TO 24.1'
OPEN SUBVERTICAL FRACTURE AT 24.4'
WEATHERED TO A DOLOMITIC SAND AT 25.5'

OPEN VERTICAL FRACTURE AT 28.75'

0.1' VUG AT 30.1'
WEATHERED TO A DOLOMITIC SAND AT 30.3'
OPEN 75° FRACTURE AT 31.2'
0.1' VUG AT 31.9'

OPEN 45° FRACTURE FROM 33.7' TO 34.3'
OPEN IRREGULAR FRACTURE AT 34.8'
OPEN SUBVERTICAL FRACTURE AT 36.0'
0.1' VUG AT 36.4'
FOSSIL (RECEPTACULITES) AT 37.2'
OPEN VERTICAL FRACTURE AT 37.2'
OPEN 60° FRACTURE AT 39.1'
0.1' VUGS FROM 39.1' TO 39.6'
OPEN 60° FRACTURE AT 40.5'
OPEN IRREGULAR FRACTURE AT 42.4'
OPEN VERTICAL FRACTURES AT 43.3', 44.1', 45.1', 45.3' AND 46.5'
0.1' VUG AT 44.2'

OPEN IRREGULAR FRACTURES AT 45.1' AND 45.3'

FOSSIL (RECEPTACULITES) AT 49.7'
OPEN SUBVERTICAL FRACTURE AT 50.7'
OPEN VERTICAL FRACTURES AT 51.9', 52.8', AND 53.4'

OPEN IRREGULAR FRACTURE AT 57.0'
OPEN VERTICAL FRACTURES AT 57.5', 58.8', 59.4', AND 61.2'

OPEN IRREGULAR SUBVERTICAL FRACTURE AT 59.8'
OPEN 45° FRACTURE AT 60.8'
OPEN VERTICAL FRACTURE AT 61.2'
0.02' THICK SHALE PARTING WEATHERED TO LIGHT BROWN CLAY AT 61.85'
HIGHLY WEATHERED ALONG BEDDING AT 63.5'
OPEN 45° FRACTURE AT 63.9'

WHITE AND GRAY CHERT GRADES IN AT 66.0'
0.1' VUG AT 66.9'

OPEN SUBVERTICAL FRACTURE AT 68.0' AND 70.6'
OPEN 45° FRACTURE AT 69.2'
OPEN 60° FRACTURES AT 69.9', 71.3', AND 74.3'

OPEN VERTICAL FRACTURE AT 72.6'

BORING CONTINUED

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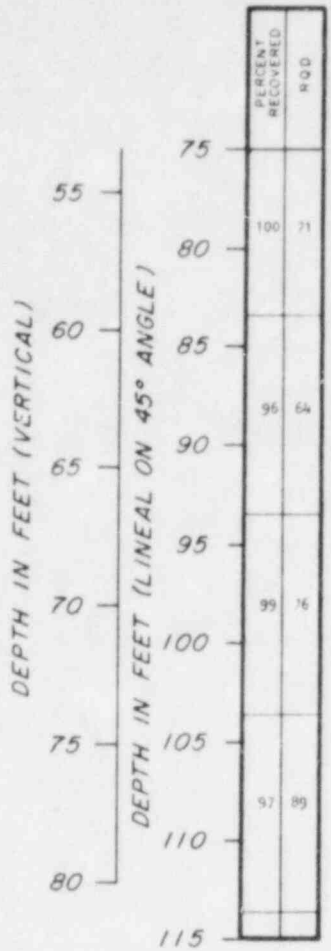
BYRON STATION

CONFIRMATORY INVESTIGATIONS

FIGURE A-2.6

LOG OF BORINGS SF-9 & SF-9A
(SHEET 1 OF 3)

BORING SF-9 CONT'D



SYMBOLS

DESCRIPTIONS

MORE HIGHLY WEATHERED FRACTURES FROM 77.3' TO 77.6'
WITH 0.15' VUG AT 77.4'
OPEN SUBVERTICAL FRACTURES AT 78.8' AND 79.4'

CLOSED SUBVERTICAL FRACTURE AT 80.2'

OPEN VERTICAL FRACTURE AT 82.0'
0.15' VUG AT 82.6'
OPEN SUBVERTICAL FRACTURE AT 84.3', 84.9' AND 85.1'
GREEN SHALE INTERBEDS GRADE IN AT 84.3'; WITH CHERT AT 85.3'
OPEN SUBVERTICAL FRACTURE AT 85.9'

GREEN SHALE PARTING AND 0.1' VUG AT 87.3'
HIGHLY FRACTURED FROM 87.5' TO 87.9'
OPEN VERTICAL FRACTURES AT 87.5', 88.6', 87.3', 88.1', AND 88.8'
0.1' VUG AT 89.3'
OPEN 75° FRACTURES AT 91.0', 91.3' AND 91.5'
OPEN VERTICAL FRACTURE AT 92.1'

OPEN 75° FRACTURE AT 95.4'
OPEN SUBVERTICAL FRACTURES AT 96.5', 96.9', 96.05', AND 96.9'
GREEN SHALE PARTING AT 96.5'
OPEN TO CLOSED VERTICAL FRACTURE AT 97.7'
OPEN SUBVERTICAL FRACTURES AT 98.3' AND 98.7'
HIGHLY TO MODERATELY WEATHERED FROM 99.4' TO 99.75'
TWO INTERSECTING OPEN SUBVERTICAL FRACTURES AT 100.0'
BEDDING PLANE FRACTURE ALONG GREEN SHALE INTERBED AT 100.2'
OPEN 15° FRACTURE AT 100.7'
OPEN VERTICAL FRACTURE AT 102.1'
MODERATELY TO HIGHLY WEATHERED FROM 102.9' TO 103.2'
OPEN 40° FRACTURES AT 104.9', 105.5', AND 107.5'
OPEN SUBVERTICAL FRACTURE AT 104.4'

OPEN 75° FRACTURE AT 106.9'

OPEN SUBVERTICAL FRACTURES AT 108.6', 109.4', AND 109.8'

OPEN 45° FRACTURE AT 110.2'
OPEN 15° FRACTURE AT 111.1'
OPEN 45° FRACTURE AT 111.5'
HIGHLY WEATHERED FROM 112.3' TO 112.7'

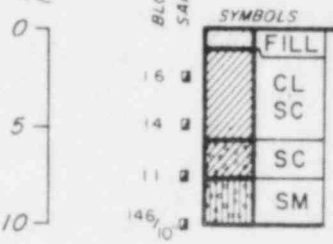
BORING COMPLETED AT A DEPTH OF 113.7 FEET ON 8-12-82.
3 INCH I.D. CASING USED TO A DEPTH OF 20.1 FEET.
LOSS OF CIRCULATION AT 99.8 FEET.
DRILL BIT IN GOOD CONDITION BEFORE AND AFTER CORING.

-810 -805 -800 -795 -790 -785

ELEVATION IN FEET

BORING SF-9A

SURFACE ELEVATION 866.66
NORTH 52+08 EAST 32+52.5



DESCRIPTIONS

BROWN SILTY FINE TO COARSE SAND AND GRAVEL - FILL

DARK BROWN FINE TO COARSE SANDY CLAY WITH LAYERS OF CLAYEY FINE TO COARSE SAND WITH GRAVEL

DARK BROWN CLAYEY FINE TO MEDIUM SAND WITH LAYERS OF SILTY SAND

YELLOWISH-BROWN SILTY FINE DOLOMITIC SAND WITH SOME FINE TO COARSE WEATHERED DOLOMITE FRAGMENTS (EXTREMELY WEATHERED, ALTERED DOLOMITE)

BORING COMPLETED AT A DEPTH OF 9.8 FEET ON 8-13-82 - DRY UPON COMPLETION.
NO CASING USED.

-865 -860 -855

ELEVATION (FEET)

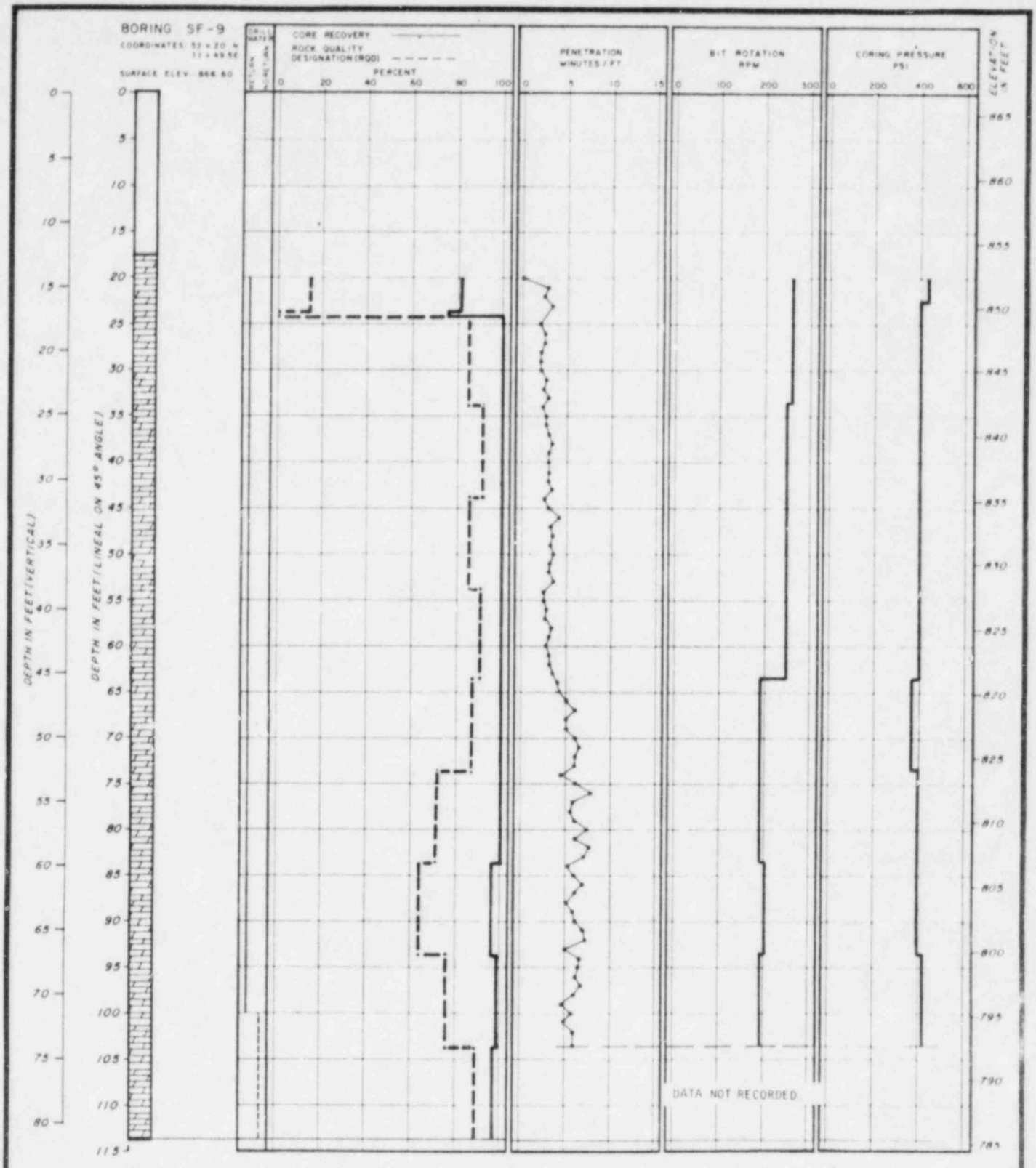
5643-120-07

BYRON STATION

CONFIRMATORY INVESTIGATIONS

FIGURE A-2.6

LOG OF BORINGS SF-9 & SF-9A
(SHEET 2 OF 3)



NOTE:

1. NO DRILL ROD DROPS OCCURRED.

5643-120-07

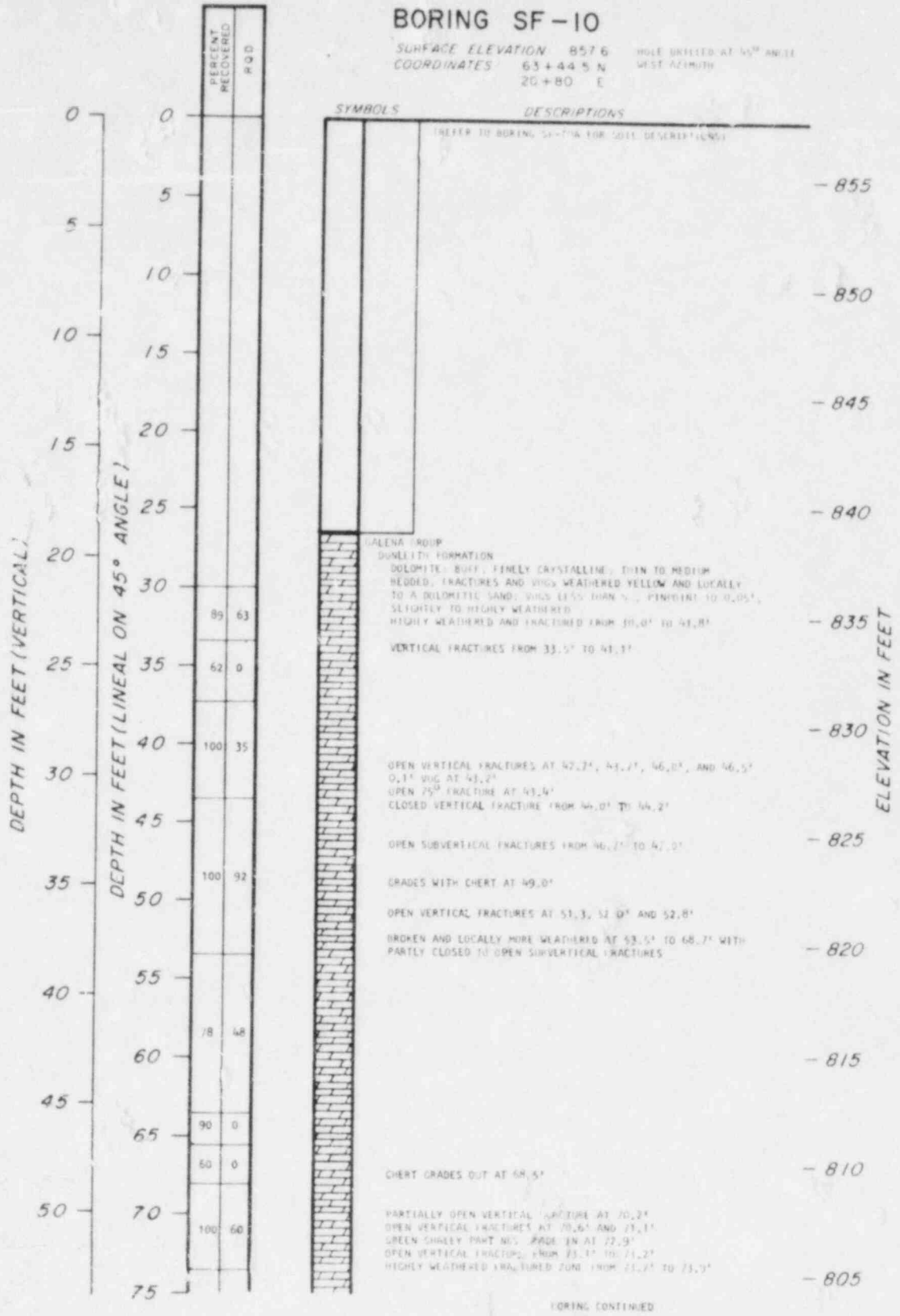
BYRON STATION
CONFIRMATORY INVESTIGATIONS

FIGURE A-2.6

LOG OF DRILLING PARAMETERS FOR BORING SF-9
(SHEET 3 OF 3)

BORING SF-10

SURFACE ELEVATION 857.6 HOLE DRILLED AT 45° ANGLE
COORDINATES 63+44.5 N WEST AZIMUTH
20+80 E



5643-120-07

BYRON STATION

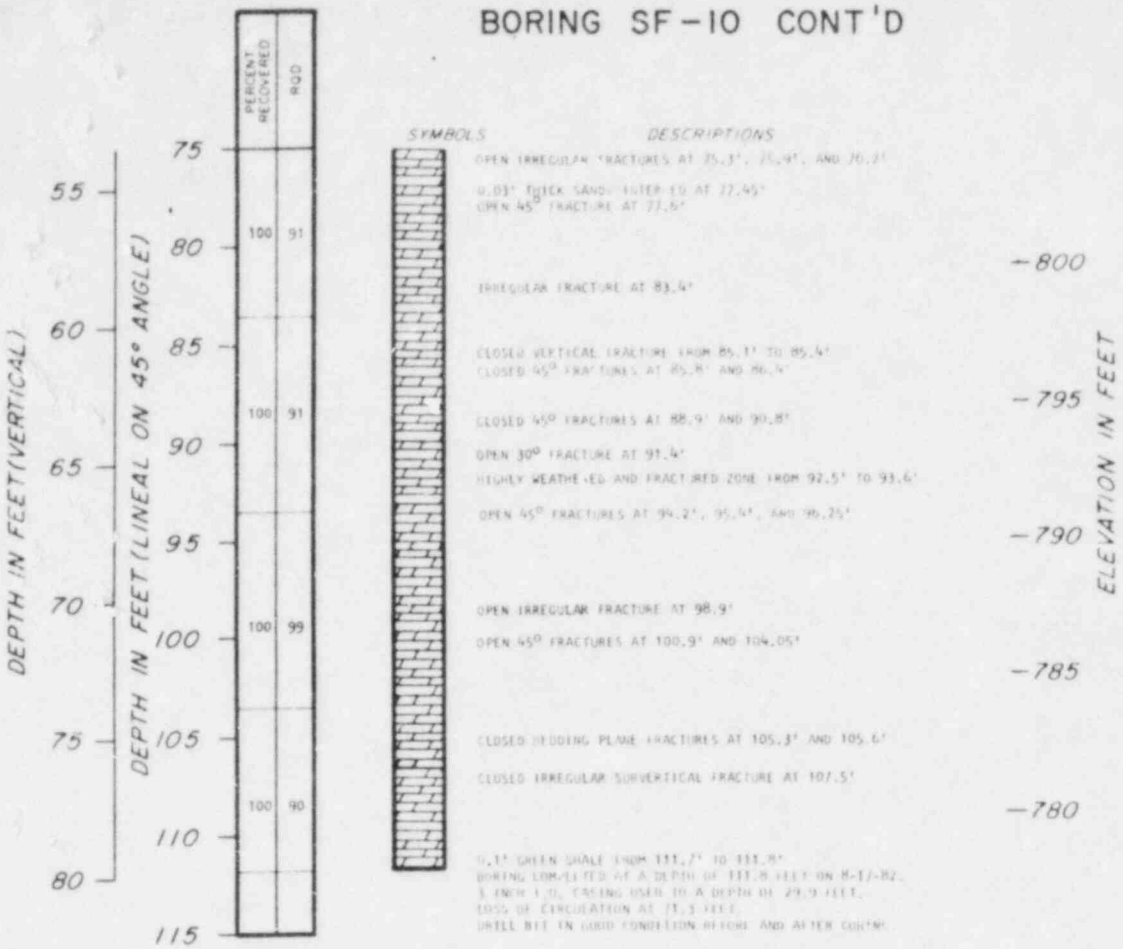
CONFIRMATORY INVESTIGATIONS

FIGURE A-2.7

LOG OF BORINGS SF-10 & SF-10A

(SHEET 1 OF 3)

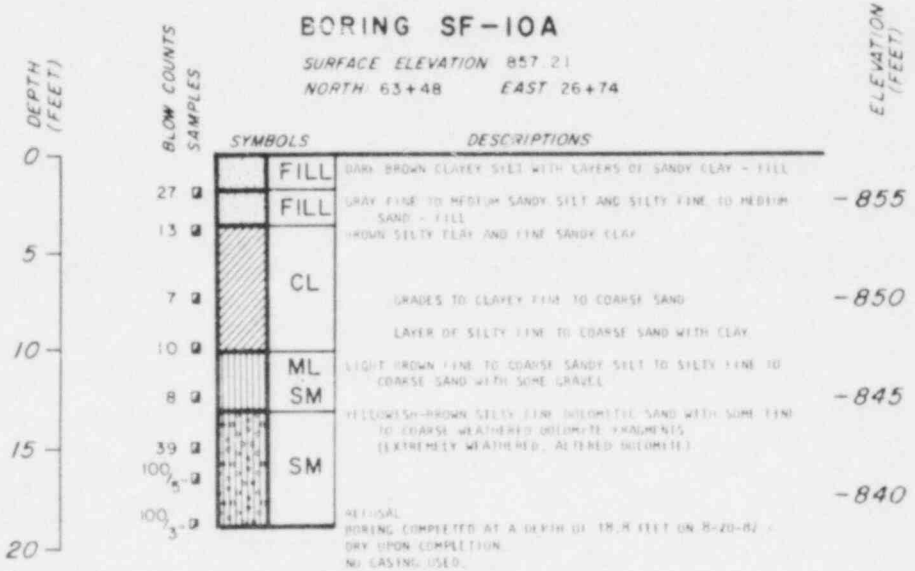
BORING SF-10 CONT'D



BORING SF-10A

SURFACE ELEVATION 857.21

NORTH 63+48 EAST 26+74



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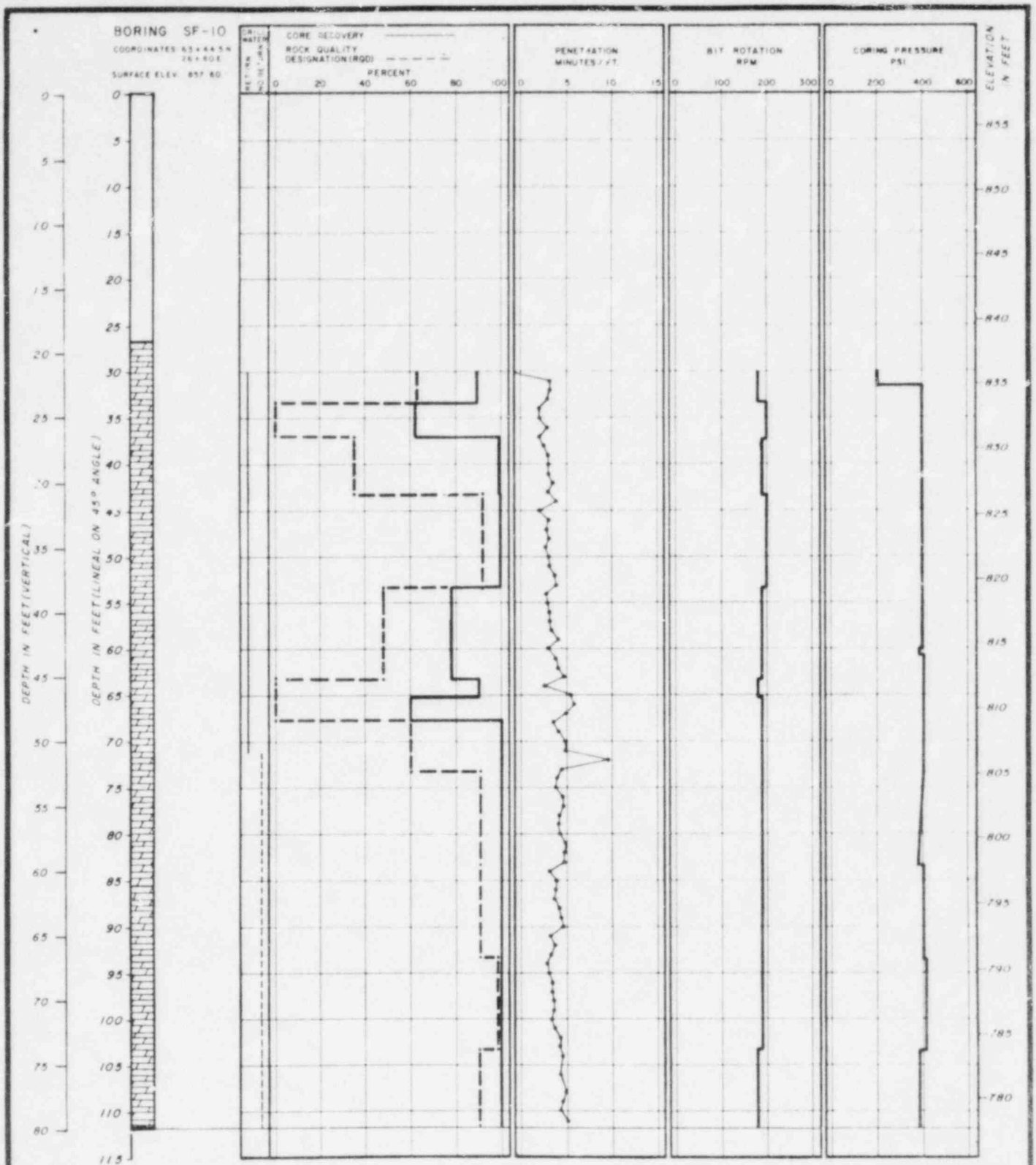
BYRON STATION

CONFIRMATORY INVESTIGATIONS

FIGURE A-2.7

LOG OF BORINGS SF-10 & SF-10A

(SHEET 2 OF 3)



NOTE:

1. NO DRILL ROD DROPS OCCURRED.

5643-120-07

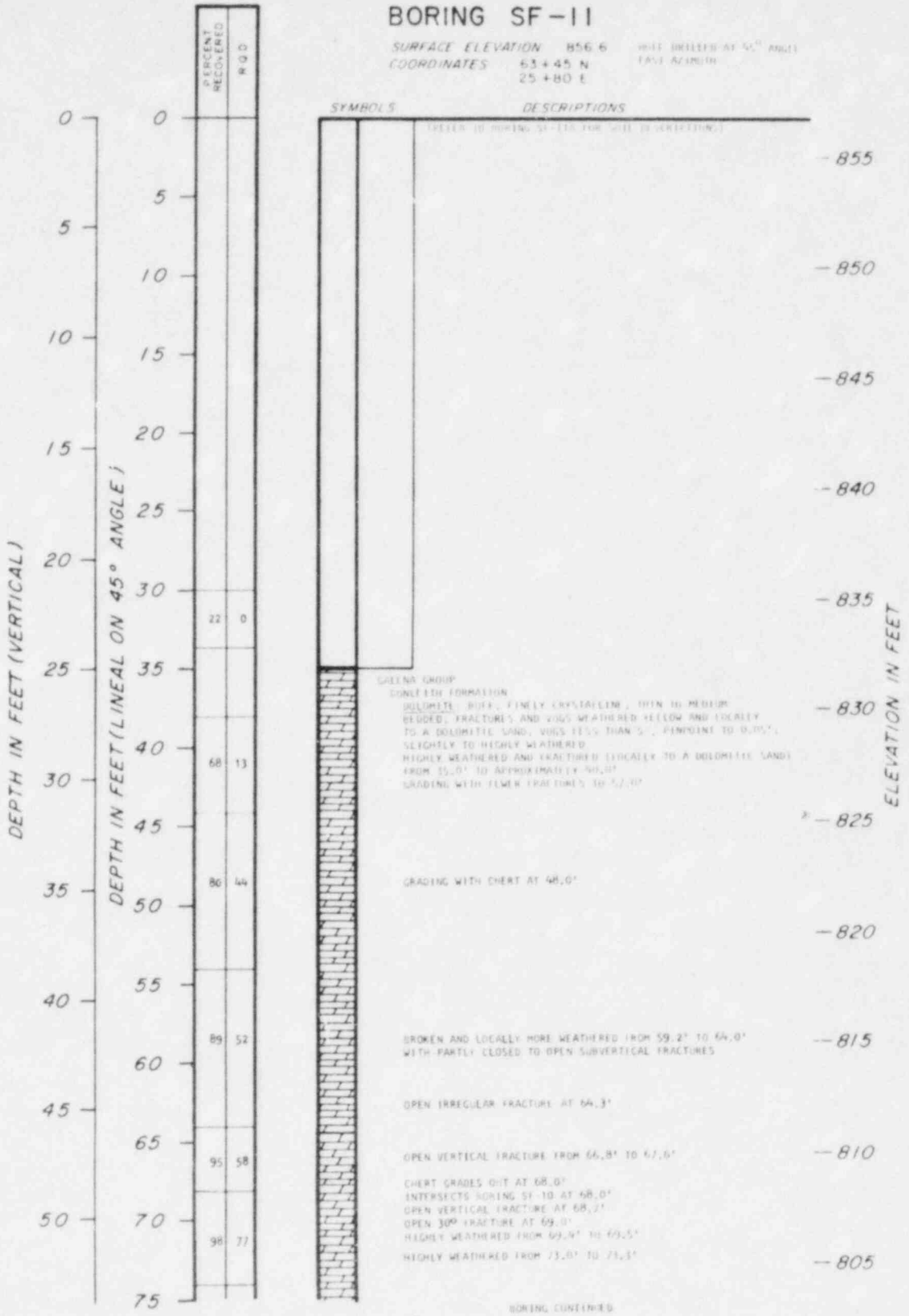
BYRON STATION
CONFIRMATORY INVESTIGATIONS

FIGURE A-2.7

LOG OF DRILLING PARAMETERS FOR BORING SF-10
(SHEET 3 OF3)

BORING SF-11

SURFACE ELEVATION 856.6 HOLE DRILLED AT 45° ANGLE
COORDINATES 63+45 N EAST AZIMUTH
25+80 E



5643-120-07

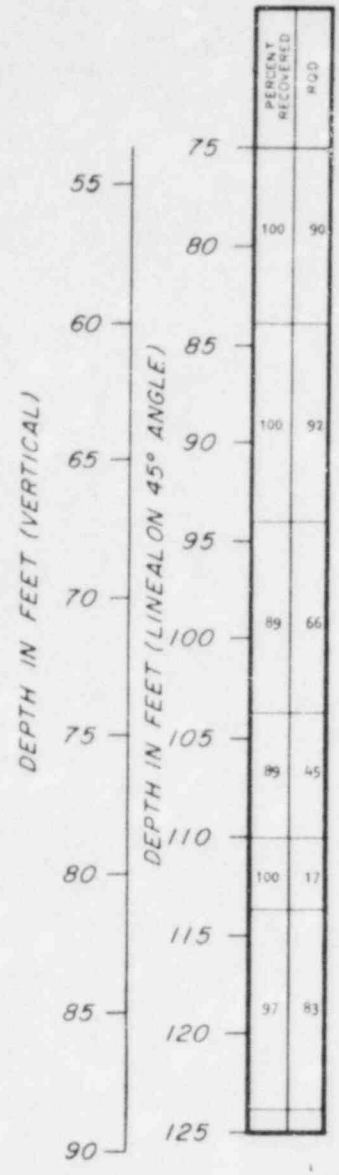
BYRON STATION

CONFIRMATORY INVESTIGATIONS

FIGURE A-2.8

LOG OF BORING SF-11
(SHEET 1 OF 4)

BORING SF-11 CONT'D



SYMBOLS

DESCRIPTIONS

OPEN SUBVERTICAL FRACTURES AT 75.1', 75.3', AND 76.2'
OPEN VERTICAL FRACTURE FROM 75.2' TO 76.0'

OPEN SUBVERTICAL FRACTURE AT 80.4' — 800

OPEN VERTICAL FRACTURE AT 82.5'

OPEN VERTICAL FRACTURE AT 86.6' — 795

OPEN SUBVERTICAL FRACTURE AT 93.6'
OPEN 15° FRACTURE AT 94.4'
OPEN 45° FRACTURE AT 96.8'
OPEN 60° FRACTURE AT 95.6' — 790

STRIKE-SLIP SLICKENSLIDES ON SUBVERTICAL FRACTURE SURFACE AT 102.0'
IN SUBVERTICAL FRACTURE ZONE FROM 98.6' TO 112.2', SOME APPARENT
CHLORITE ON FRACTURE SURFACES, 0.05" THICK CLAY-FILLED FRACTURES
FROM 98.2' TO 99.6'
ROCK IS LOCALLY A HEALED BRECCIA — 785

— 780

GREEN SHALE INTERBED AT 110.2'

HIGHLY BROKEN AND FRACTURED, LOCALLY HIGHLY WEATHERED FROM 112.2' TO
113.2' WITH PARTLY CLOSED TO OPEN SUBVERTICAL FRACTURES
OPEN SUBVERTICAL FRACTURE FROM 113.8' TO 114.0' — 775

CLOSED VERTICAL FRACTURE AT 117.3'

GRADES WITH CHERT AT 118.6'

OPEN 30° FRACTURE AT 120.3'
OPEN SUBVERTICAL FRACTURE FROM 120.5' TO 121.1' — 770

BORING COMPLETED AT A DEPTH OF 121.7 FEET ON 8-19-82.
3 INCH I.D. CASING USED TO A DEPTH OF 58.0 FEET.
LOSS OF CIRCULATION AT 66.0 AND 71.2 FEET.
DRILL BIT IN GOOD CONDITION BEFORE AND AFTER CORING.

ELEVATION IN FEET

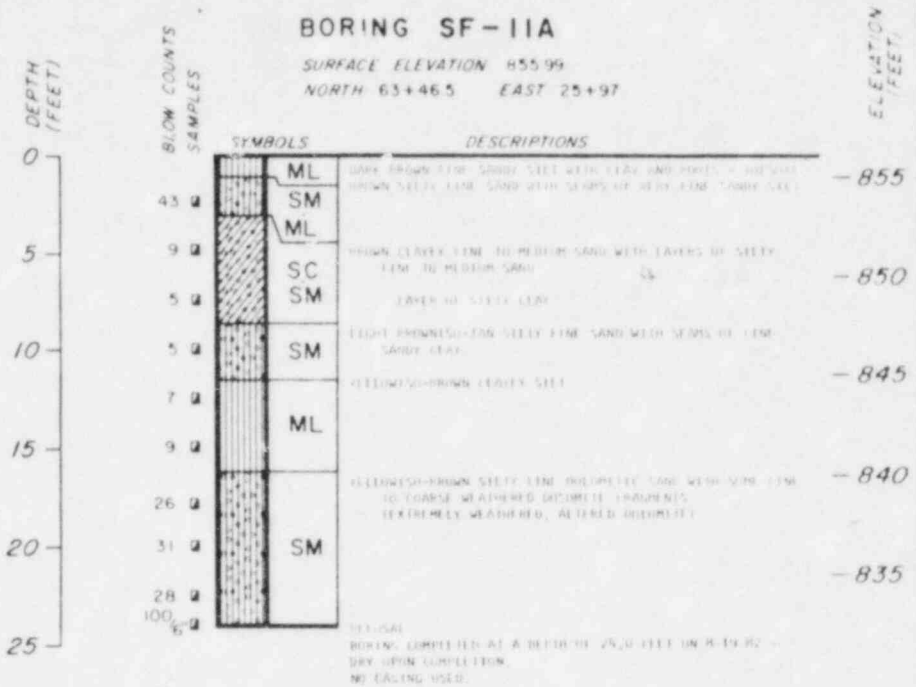
5643-120-07

BYRON STATION

CONFIRMATORY INVESTIGATIONS

FIGURE A-2.8

LOG OF BORING SF-11
(SHEET 2 OF 4)



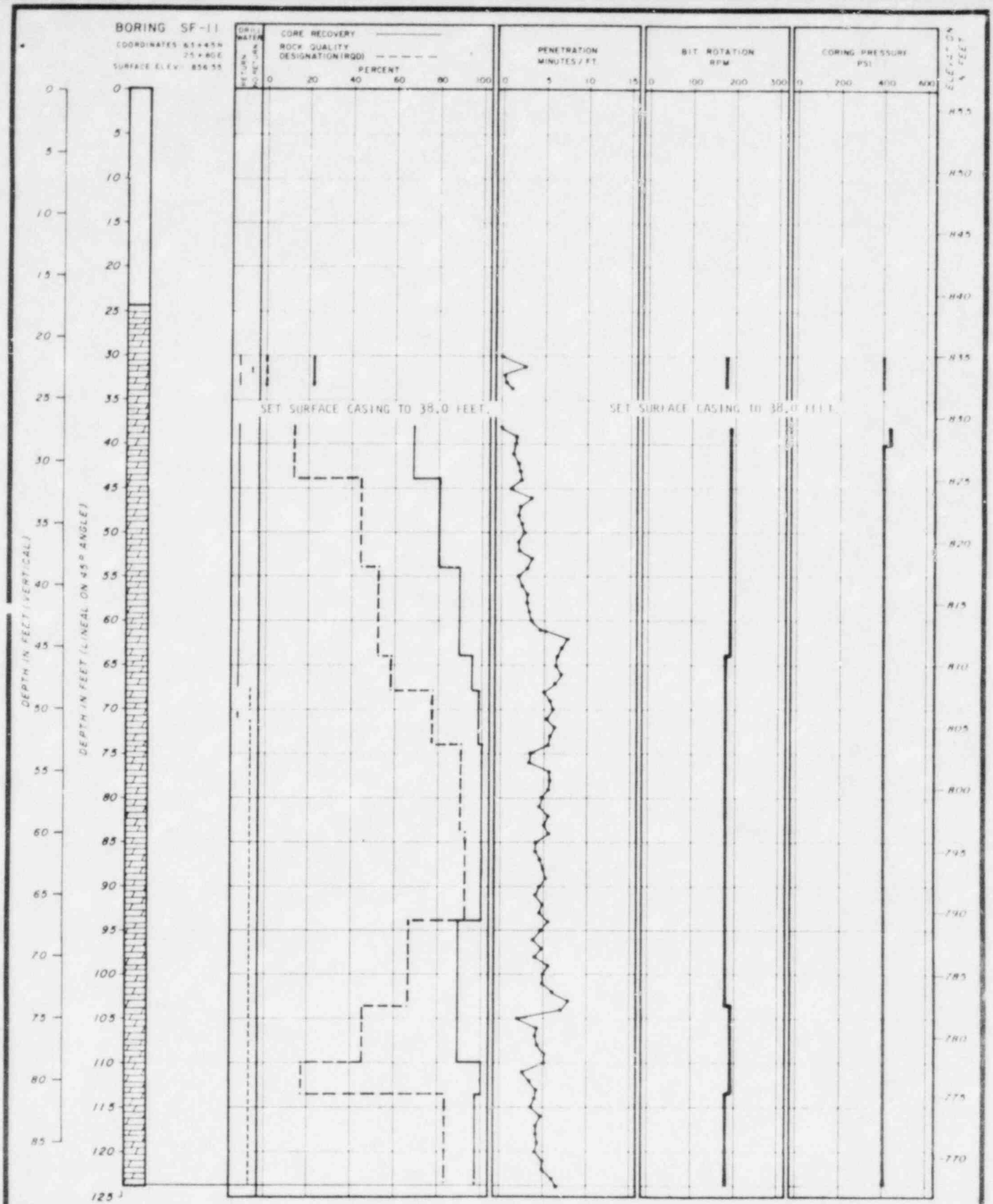
5643-120-07

BYRON STATION

CONFIRMATORY INVESTIGATIONS

FIGURE A-2.8

LOG OF BORING SF-11A
(SHEET 3 OF 4)



NOTE

1. NO DRILL ROD DROPS OCCURRED.

5643-120-07

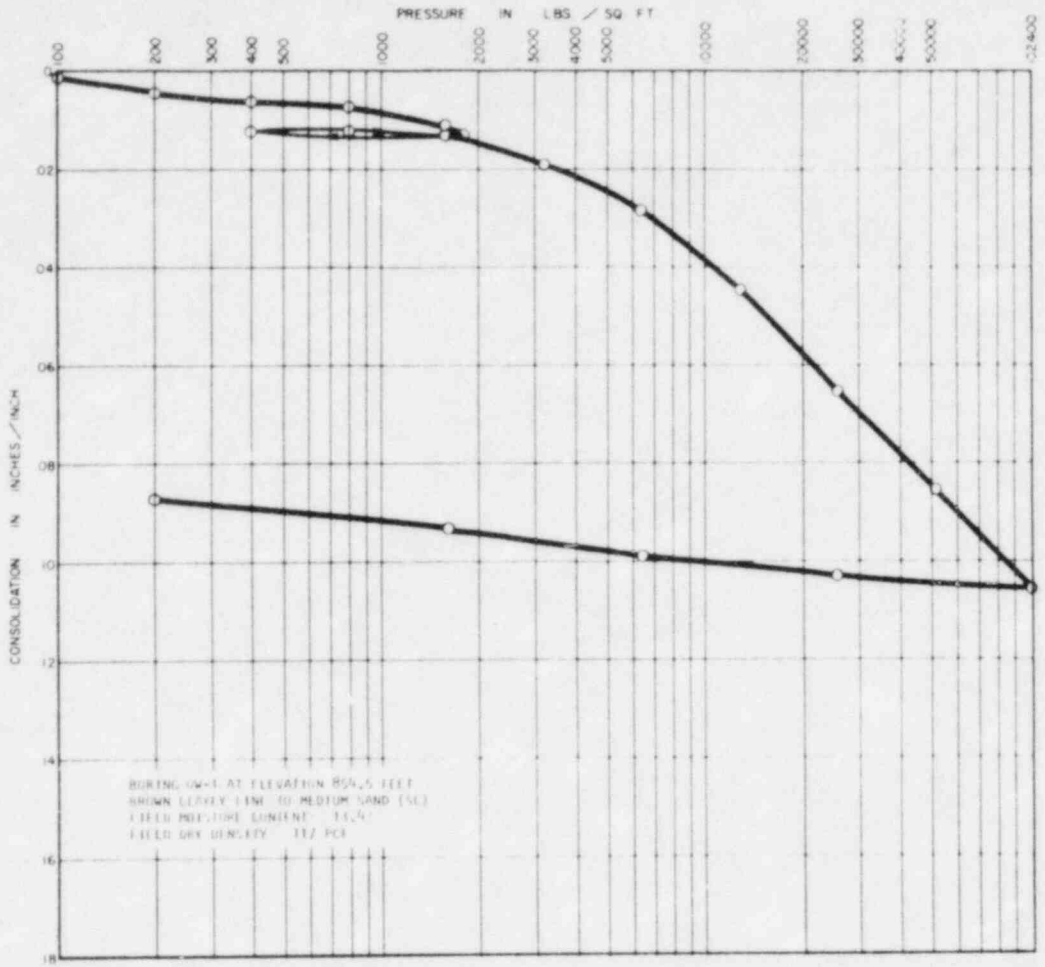
BYRON STATION

CONFIRMATORY INVESTIGATIONS

FIGURE A-2.8

LOG OF DRILLING PARAMETERS FOR BORING SF-11

(SHEET 4 OF 4)



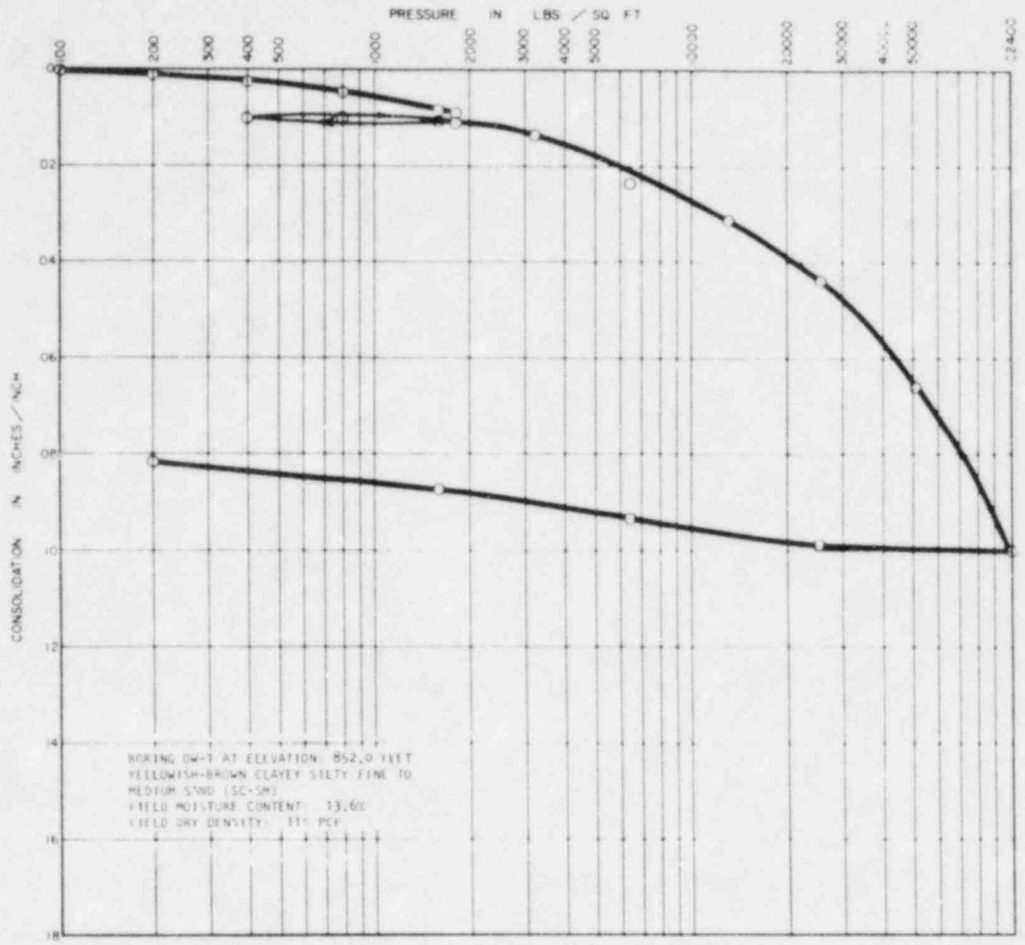
5643-120-07

BYRON STATION

CONFIRMATORY INVESTIGATIONS

FIGURE A-3.1

CONSOLIDATION TEST DATA



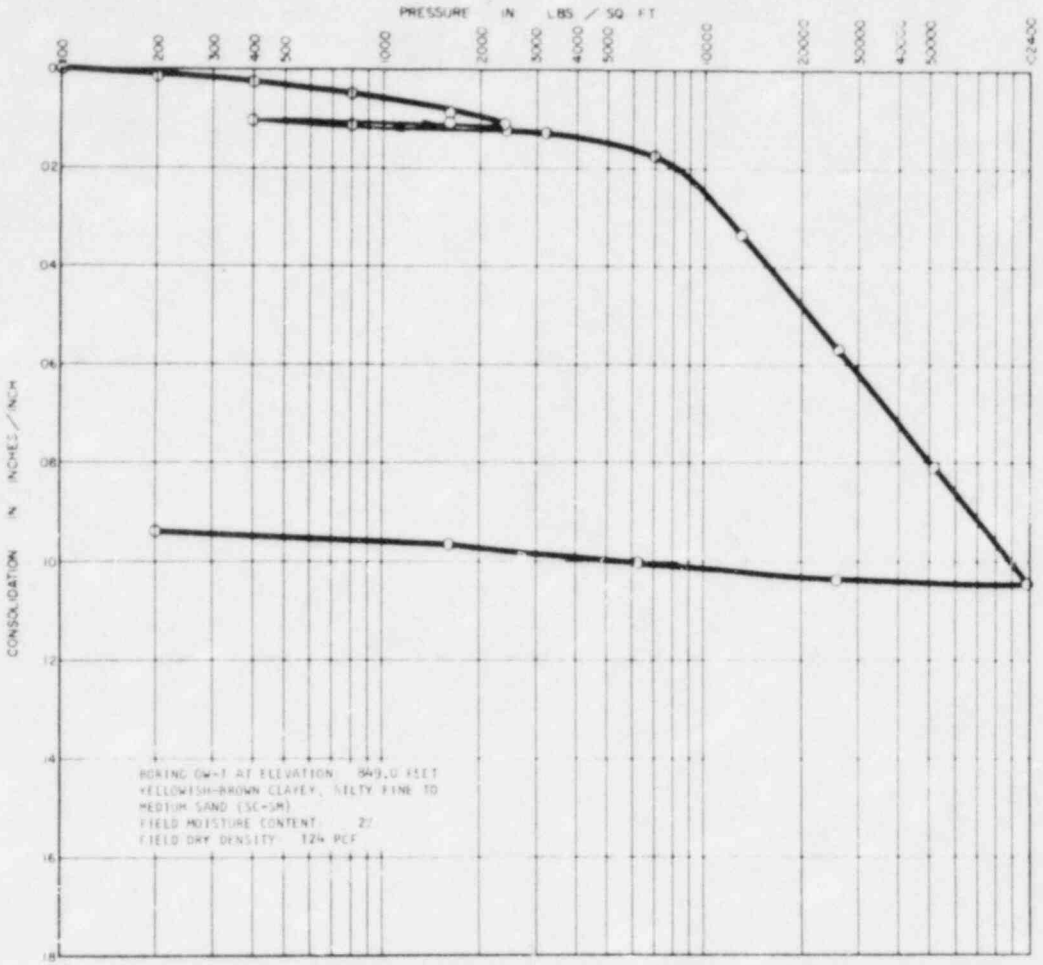
5643-120-07

BYRON STATION

CONFIRMATORY INVESTIGATIONS

FIGURE A-3.2

CONSOLIDATION TEST DATA



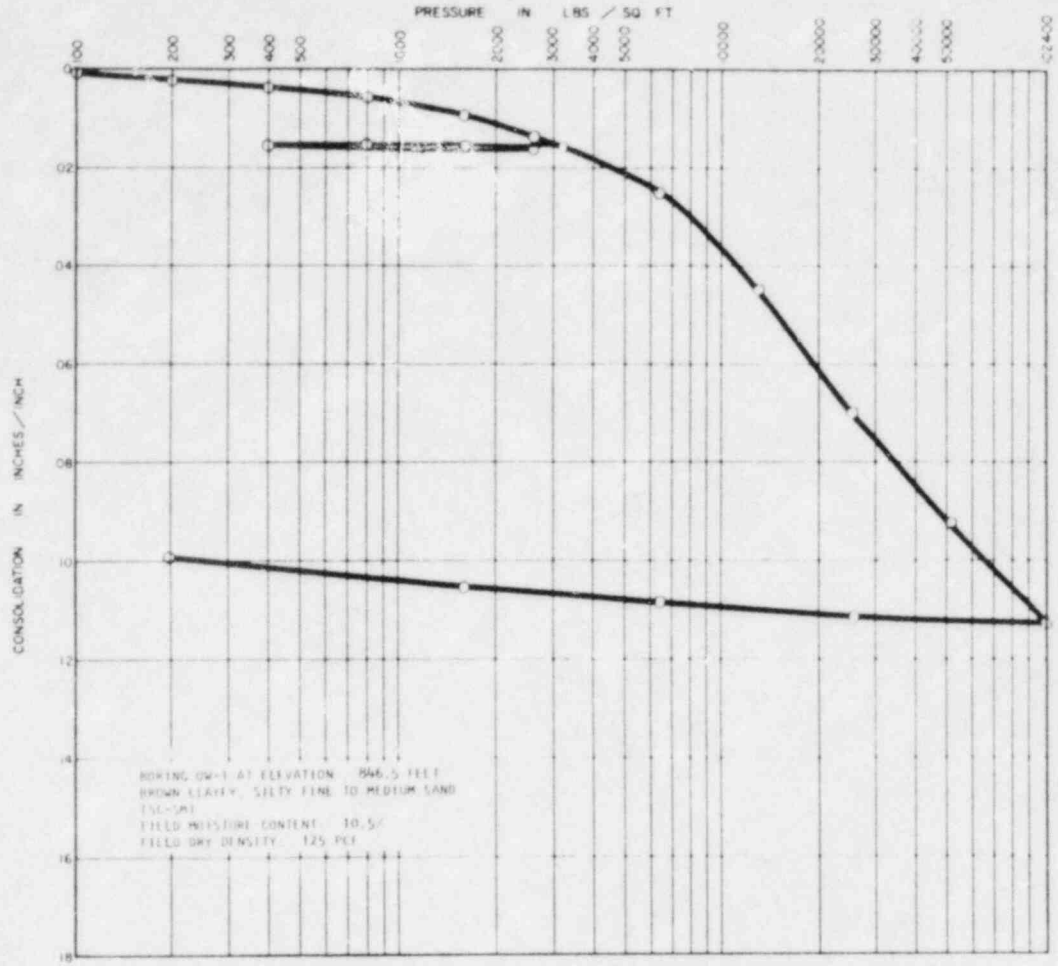
5643-120-07

BYRON STATION

CONFIRMATORY INVESTIGATIONS

FIGURE A-3.3

CONSOLIDATION TEST DATA



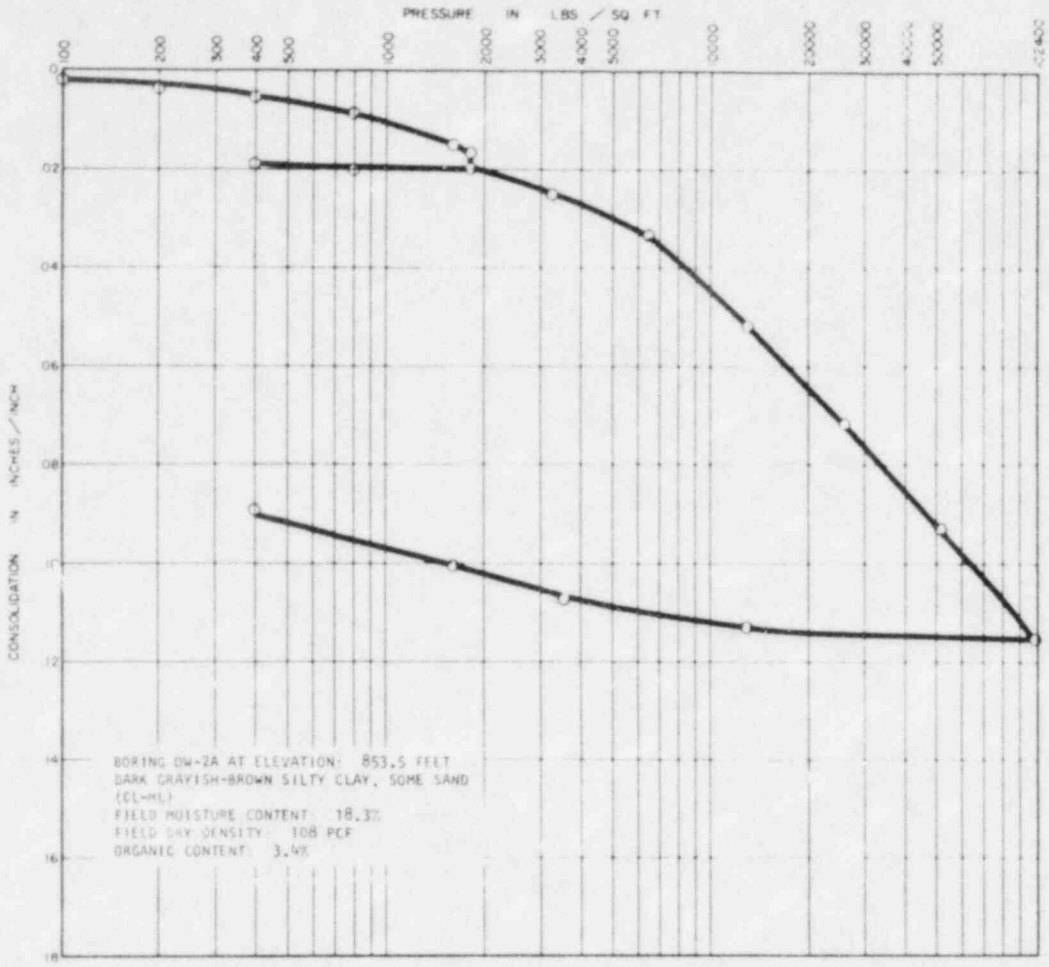
5643-120-07

BYRON STATION

CONFIRMATORY INVESTIGATIONS

FIGURE A-3.4

CONSOLIDATION TEST DATA



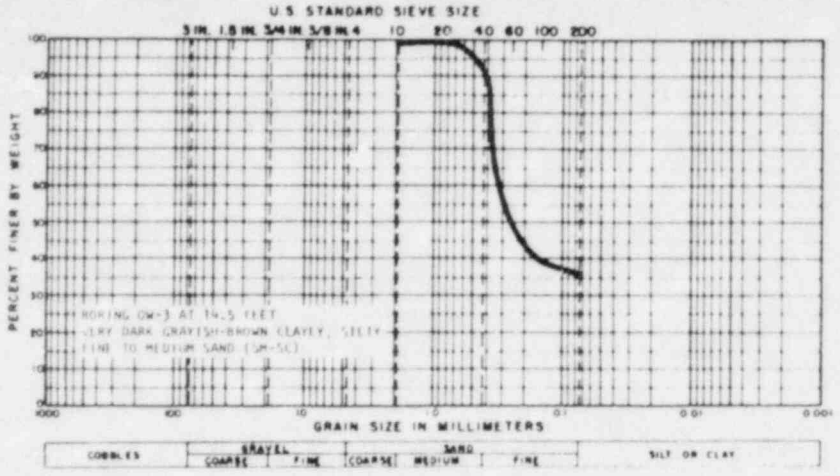
5643-120-07

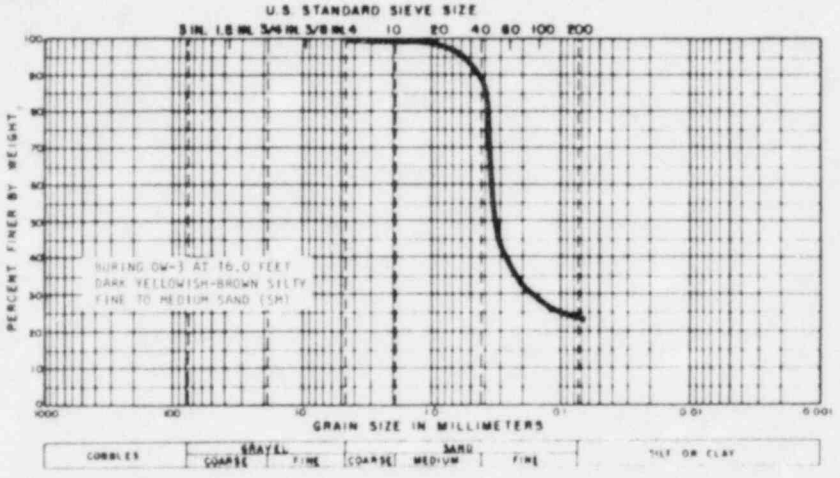
BYRON STATION

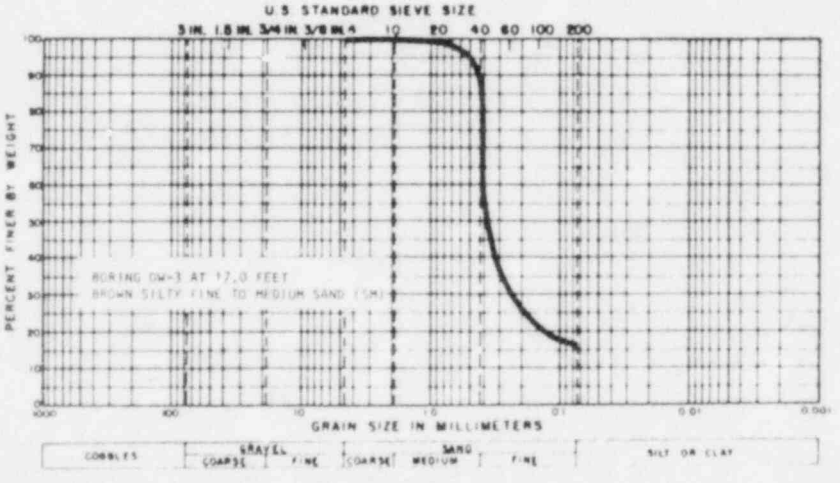
CONFIRMATORY INVESTIGATIONS

FIGURE A-3.5

CONSOLIDATION TEST DATA







5643-120-07

BYRON STATION

CONFIRMATORY INVESTIGATIONS

FIGURE A-4

PARTICLE SIZE ANALYSES