Mine refuse disposal facility: feasibility report. 1985

Exxon Minerals Company
Houston, Texas: Exxon Minerals Company, 1985

Report

Project

FEASIBILITY STUDY
FOR
MINE REFUSE DISPOSAL FACILITY
CRANDON PROJECT

Client

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Project # 14028

Date NOVEMBER 26, 1985

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1.0 INTRODUCTION

1.1 Purpose and Scope

Exxon Minerals Company (Exxon) has conducted extensive studies to determine the feasibility of developing a mine/mill complex for the mining and processing of ores from a sulfide deposit of zinc and copper located in Forest County, Wisconsin. The proposed development is known as the Crandon Project. The estimated potential recoverable ore reserve will sustain a mine/mill operation for a period of about 29 years.

The Crandon Project will generate solid waste of two distinct types that will require disposal. Solid wastes will be created as a direct result of mining, ore processing, and water treatment and these are referred to in other reports as "mine waste". A large portion of this solid waste will be backfilled into the mine. Fine portions of the processed ore will be unsuitable for incorporation into mine backfill, consequently, a surface facility will be needed for its disposal. A separate feasibility report has been completed and submitted to the DNR under NR 182 for the proposed mine waste disposal facility (MWDF).

The second type of waste will be generated during the construction and operation of the proposed mining complex. This solid waste is referred to hereafter as "mine refuse".

This report was prepared under the guidelines set forth in NR 180.13 (6) in order to receive the Department of Natural Resources approval on the feasibility of constructing a mine refuse disposal facility (MRDF).

The scope of work for this project included the excavation of test pits, testing of representative soil samples, as well as the compilation of

extensive previous work in the Crandon Project area that provides the required information for NR 180.13 (6). This report presents the results of additional field and laboratory work that provide information defining the nature of the glacial deposits overlying the site. In addition, an updated drawing of the groundwater potentiometric surface and site specific geologic cross sections are also presented.

1.2 Applicable Regulations

The Wisconsin DNR documented the regulations that pertain to the MRDF feasibility study in a letter to Exxon dated October 21, 1985. A copy of this letter is in Appendix A. The DNR letter indicated that the MRDF feasibility study should be developed in accordance with NR 180.13, Wisconsin Administrative Code. Additional comments by the DNR concerning applicable statutes and regulations are summarized as follows:

Section 144.44 (2)(nr) exempts any facility which is a part of a mining operation from the needs and design life requirements of Chapter 144.

Section 144.445 (12) (d) specifies that Section 144.445, which relates to the landfill siting negotiation/arbitration process, does not apply to waste facilities which are part of a mining operation.

NR 140.03 states that groundwater quality requirements of NR 132 and NR 182 apply to facilities on a mining site. NR 132.17 (9) indicates that the groundwater standards of NR 182 apply to mine sites. Therefore, NR 182.075 Groundwater Standards are applicable to the MRDF.

It is required by Section 144.44 (2) (f) 6 and 7 (Act 426, Laws of 1983) that an analysis of alternatives to land disposal of solid waste be included in the feasibility report.

Licensing will take place under Section 144.43-.47 and NR 180. Therefore, the plan review and licensing fees of NR 180.05 apply to this project.

The appropriate tonnage fee is contained in Section 144.441 (4) (a). A groundwater fee will be imposed as specified in Section 144.441 (7) (c). In addition, an environmental repair fund fee will be imposed as specified in Section 144.442 (1m) and (cm).

The MRDF is part of a mining site and, as such is an "approved mining facility" as defined in Section 144.441 (1). Therefore, the 30 year long-term care period will apply.

The applicable financial responsibility standards will be those found in Section 144.443.

1.3 Previous Reports

The major portion of the information provided in this feasibility report comes from extensive work that has been reported previously by many sources. The attempt of this report is to present the information that applies to the MRDF in a logical and readible form. Major references will be cited as they apply to important facts. A complete list of references may be found in the MWDF Feasiblity Report (Exxon, 1985b) which has been submitted to the DNR.

1.4 General Information

The general information as required by NR 180.13 (6) (c) is provided below:

Project Title -	Crandon Project Feasibility Study Mine Refuse Disposal Facility Exxon Minerals Company
Primary Contact -	Permitting Manager Exxon Minerals Company P. O. Box 813 Rhinelander, Wisconsin 54501 Telephone: (715) 369-2800
Consultant -	STS Consultants Ltd. 540 Lambeau Street Green Bay, Wisconsin 54303
Owner -	Exxon Corporation c/o Exxon Minerals Company, a division of Exxon Corporation P. O. Box 813 Rhinelander, Wisconsin 54501
Site Location -	N1/2, NW1/4, NE1/4, of Section 32, Township 35N, Range 13E, Town of Lincoln, Forest County, Wisconsin
Proposed Licensed Acreage -	7.0 acres refuse disposal area 12.0 acres including dikes and compliance boundary

Total Crandon Project Area

3228 acres owned by Exxon
4711 acres under land purchase option or mining lease
21 acres under easements
7960 acres total

Proposed Site Life - 36 years

Disposal Capacity- 122,000 yd^3 including daily cover(approx 41,000 yd^3/cell)

Estimated Waste Types and Quantities to be Disposed at Facility - A brief description and estimated quantities of the wastes are presented below:

Construction Refuse and Waste - Refuse - solid waste from construction personnel, packaging waste, and scrap metals.

Waste - non-salvageable and non-burnable building materials.

Operating Wastes - Paper and garbage, plastic, wood, metal, and miscellaneous materials.

Demolition Wastes - Solid waste from operating and construction/demolition personnel and insulation, drywall and minor scrap wood and metal that is non-salvageable, non-burnable or not suitable for direct burial.

Cover Frequency - Daily when wastes are disposed.

Industries Served - Exxon Minerals Company, no other municipalities or industries will use this facility.

2.0 REGIONAL INFORMATION

2.1 Topography

The location of the MRDF is situated in the northern highlands region of Wisconsin, which is characterized by hills of moderate elevation with a complex surface water drainage system. The present landscape is principally the result of processes associated with continental glaciation that occurred during the Wisconsin glacial stage. The glacial topography in the region reflects the complex interplay of the Green Bay and Langlade ice lobes that were present during the Woodfordian glacial advance.

The elevation range within a 3 to 5 mile radius of the MRDF site is from 1,535 feet (468 meters) to 1,850 feet (564 meters). The upland areas generally trend to the southwest and are composed primarily of till. Material deposited by melt water adjacent to the ice front displays a hummocky and irregular topography. This glacial outwash sometimes occurs as valley fill material and is generally flat lying as are the lacustrine deposits that are derived from ancient lake beds. The topography and landforms are shown on Plan Sheet 2 (Existing Conditions-Land Use Map).

2.2 Surface Hydrology

The proposed Crandon Project is in the upper portion of the Wolf River drainage basin in Northeast Wisconsin. In this region, numerous lakes and wetlands are interconnected by relatively slow flowing streams with shallow gradients.

The MRDF is situated on the divide between the Pickerel Creek and the Swamp Creek drainage basins. The Pickerel Creek basin drains south and west into the Wolf River, while the Swamp Creek basin drains north and west into the Wolf River.

The principal components affecting surface water hydrology are precipitation, surface soils, topography, and the upland and wetland vegetation. The combination of these factors, causes the surface water drainage rate to be slow with no discernable streams or channels. This is especially true in upper reaches of the watersheds. Lakes and wetlands in the region occur under either perched or groundwater discharge conditions.

2.3 Glacial Deposits

Five general types of glacial deposits are found near the Crandon Project. Each is distinquished by particle size distribution, shape of the gradation curve, percent passing the No. 200 sieve (P-200), degree of sorting, and depositional features which can be seen in representative samples. The five categories of deposits are: glacial till, basal till, coarse grained stratified drift, fine grained stratified drift and lacustrine deposits. Figure 2.1 presents the P-200 distribution for the various glacial deposits at the Crandon Project based on the gradation curves for samples from the EX borings (STS Consultants Ltd., 1984b).

In 80 samples of the glacial till that were analyzed, an average P-200 of 20% occurred in the range of 6 to 45%. The majority of the samples had a P-200 in the range of 10 to 30%. All the glacial till samples were classified as SM-SP or SM under the Unified Soil Classification System. A typical description of the till is slightly silty fine to medium sand to silty fine to coarse sand. The composite gradation curve for the 80 samples of glacial till (Figure 2.2) shows that the till samples have a characteristic gradation curve shape. The till consists of a well graded (poorly sorted) mixture of silt, sand, gravel and cobbles with only a trace of clay (less than 10%). The glacial till deposits are extensive across the site and form many upland areas.

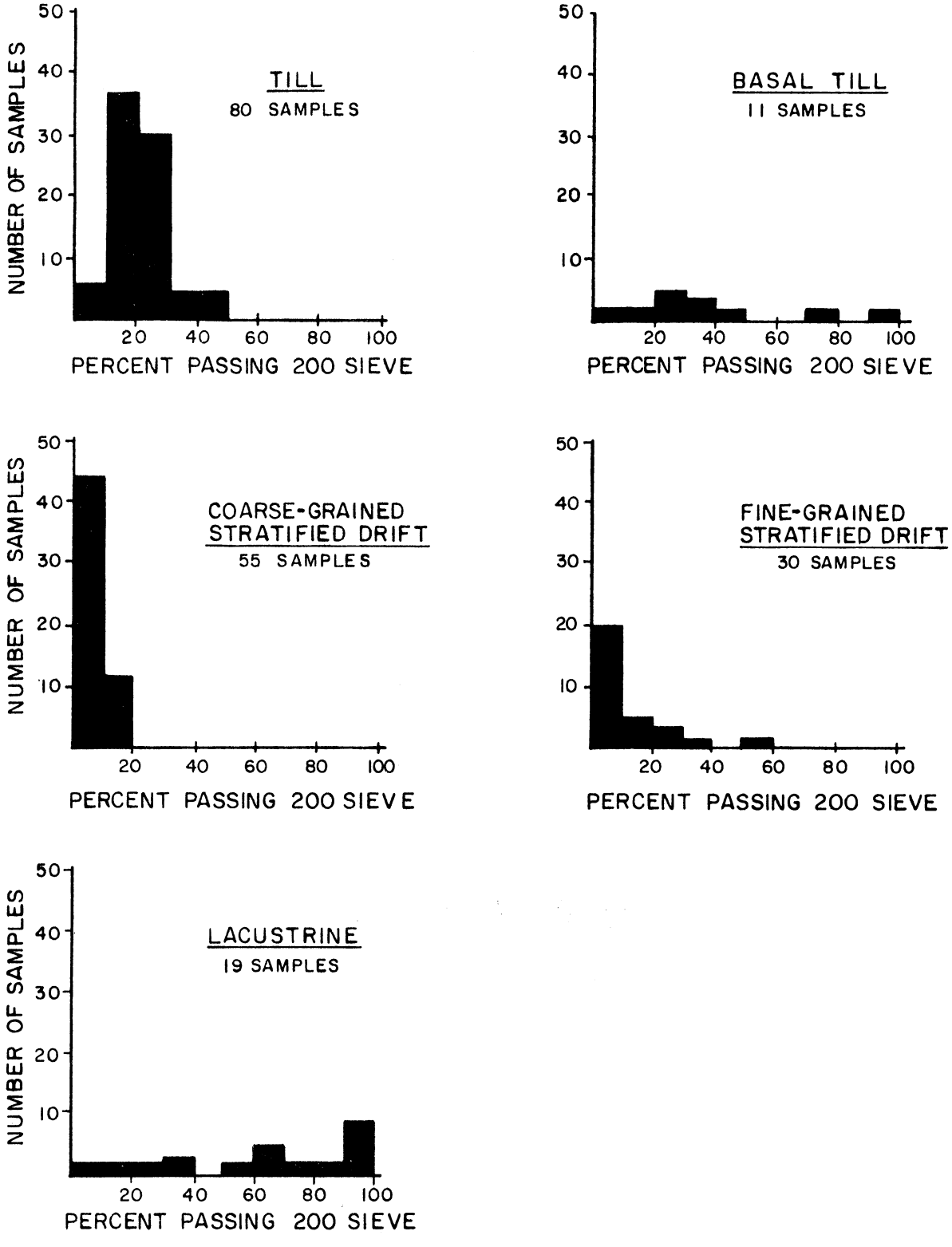

FIGURE 2.1: P200 DISTRIBUTION FOR VARIOUS GLACIAL DEPOSITS CRANDON PROJECT

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GREEN BAY, WIS. 54303

J.J.T.	J.A.S.	5-25-84	12959

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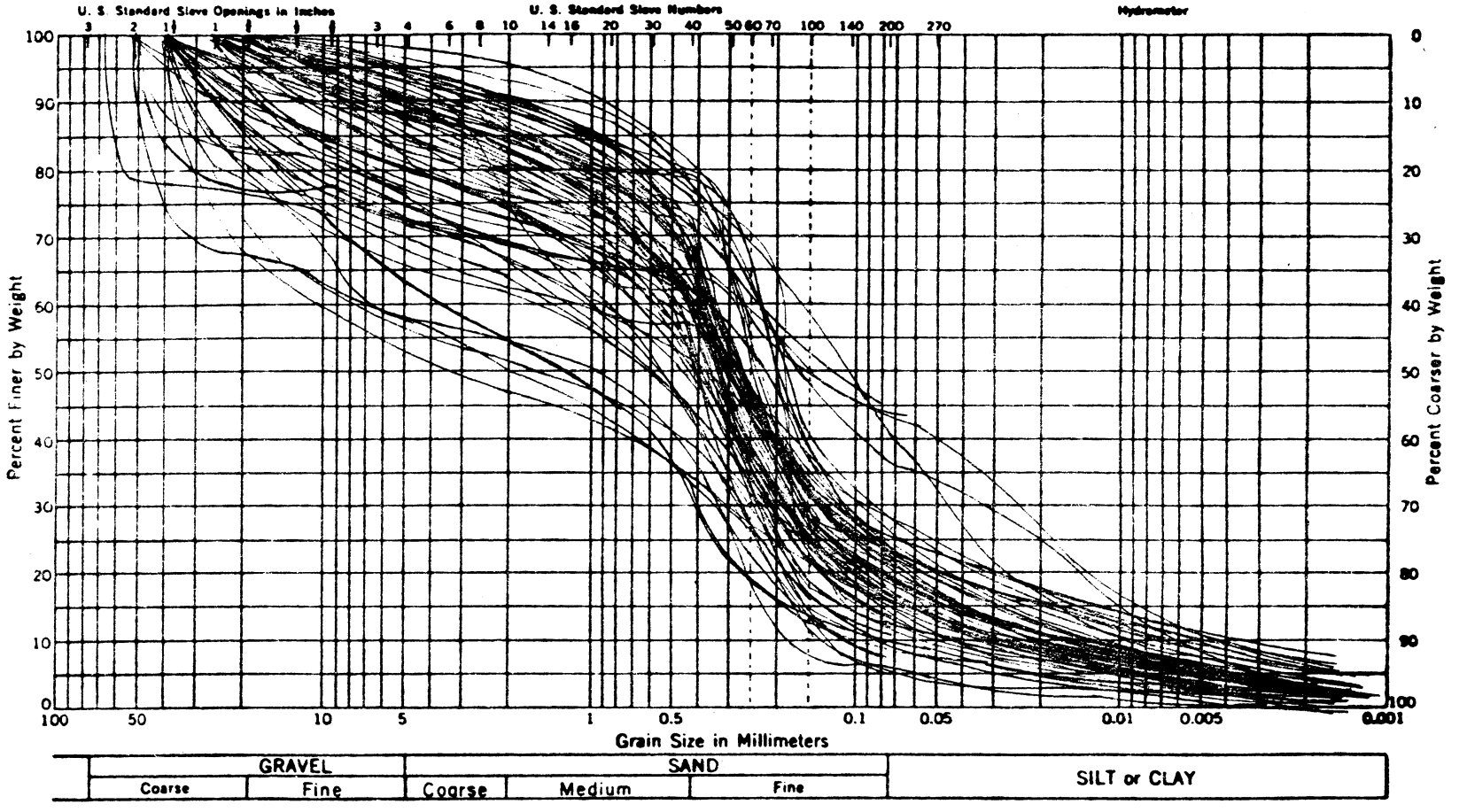

SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
					Glacial Till SM-SP, SM

FIGURE 2.2

COMPOSITE GRADATION CURVES

GLACIAL TILL

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540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	6-4-84	12959

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Glacial till is found on the bedrock surface in portions of the site. It was designated as basal till because it could be distinquished from the other till deposits generally by color and grain size distribution. The basal till generally had a reddish brown color and a higher P-200 content. The basal till layer was relatively thin, usually less than 30 feet thick.

A typical description of the basal till is silty fine to coarse sand (SM), slightly silty fine to coarse gravel (GM-GP), or fine to coarse sandy silt (ML). The composite gradation curve for the basal till (Figure 2.3) is similar to the surficial till except that the samples had slightly higher P-200 content.

Fifty-five (55) samples of the coarse grained stratified drift were analyzed and had a range of 1 to 16% passing the No. 200 sieve with an average P-200 of 7% (Figure 2.4). The coarse grained stratified drift is composed of well sorted silty fine to medium sand to well graded sand and gravel. Samples were often distinquished by the presence of stratification indicating fluvial deposition which is absent in the till samples.

The fine grained stratified drift is characterized by well sorted, uniformly graded, fine grained glacial outwash deposits. Figure 2.5 is the composite gradation curve for 30 fine grained stratified drift samples from the EX borings. The average P-200 was 11% in a range of 2 to 51%. A general description of these deposits is fine sand, silty fine sand, and fine sandy silt which were classified as SP, SM-SP, SM or ML. The fine grained and coarse grained stratified drift together form the primary aquifer zone at the Crandon Project site. Both these units are characteristic of glacial outwash deposits.

The lacustrine category includes relatively fine grained sediments deposited at the bottom of lakes, both during glacial times and more recent

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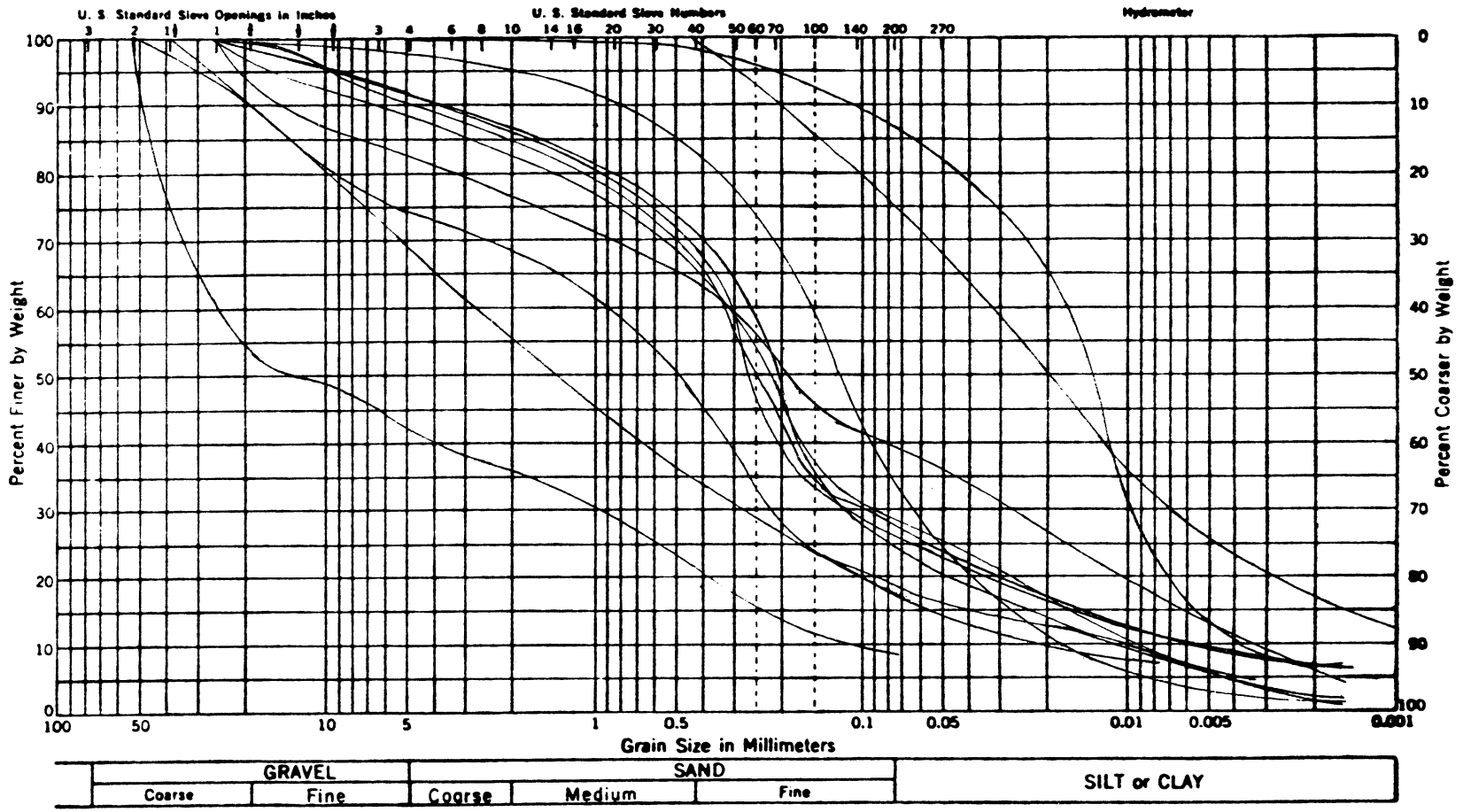

SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
					Basal Till SM, ML, GM-GP

FIGURE 2.3
COMPOSITE GRADATION CURVES
BASAL TILL

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540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	6-4-84	12959

FIGURE 2.3
- 2-6 -

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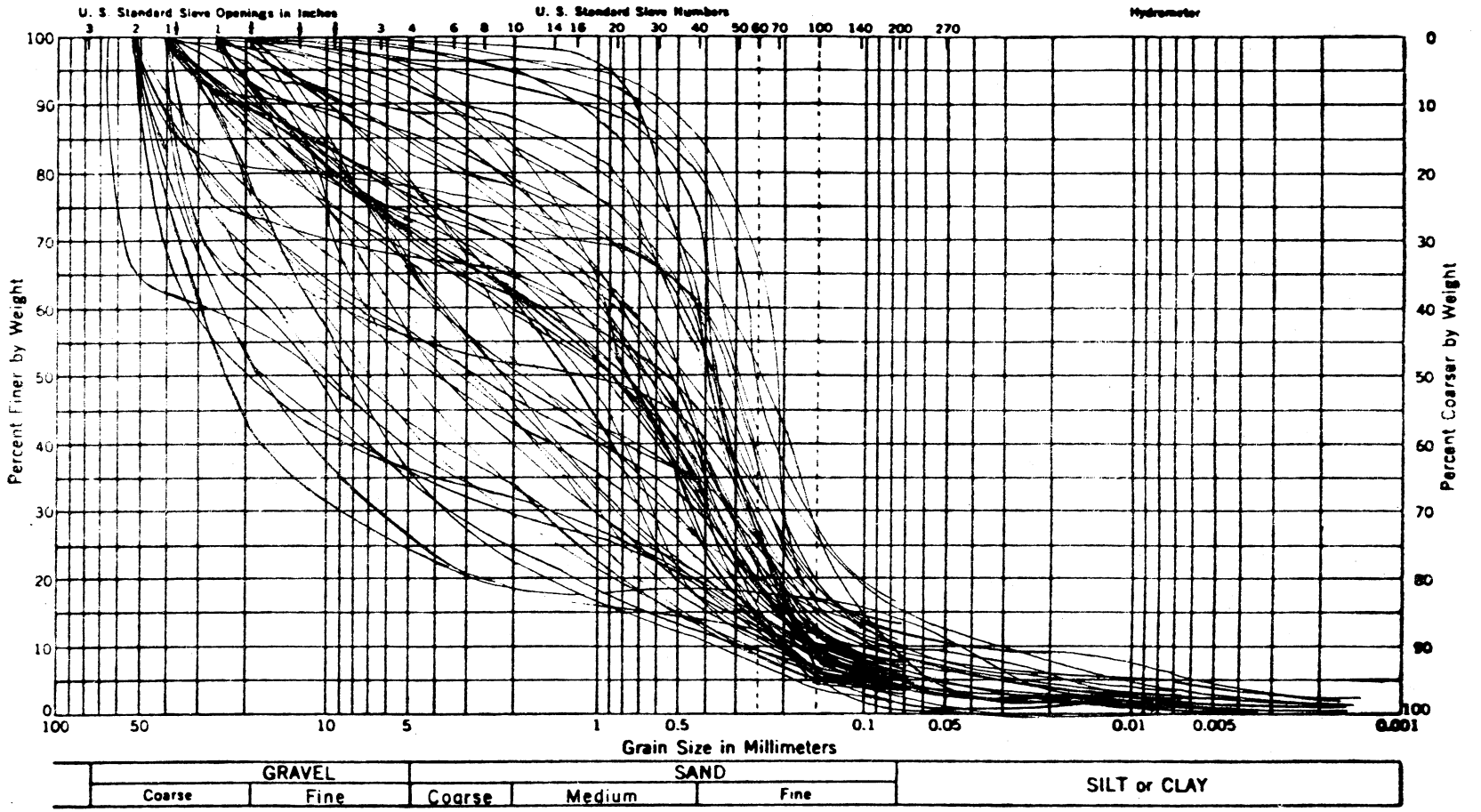

SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
					Coarse Grained Stratified Drift
					SP, SW, SM-SP, SM, GP-GM, GP, GW, GM

FIGURE 2.4
COMPOSITE GRADATION CURVES
COARSE GRAINED STRATIFIED DRIFT

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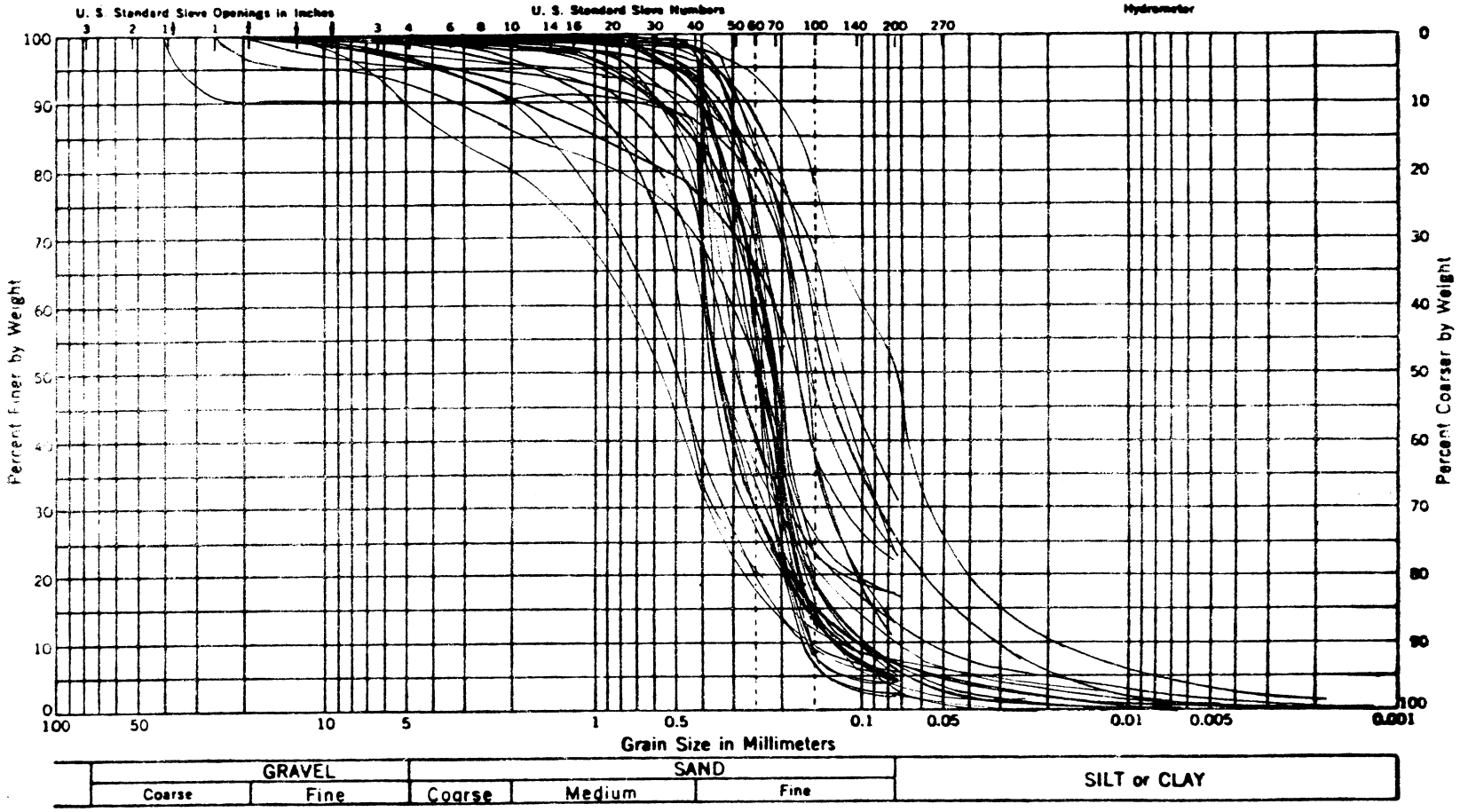
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	6-4-84	12959

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
					Fine Grained Stratified Drift
					SP, SM-SP, SM, ML

FIGURE 2.5
COMPOSITE GRADATION CURVES
FINE GRAINED STRATIFIED DRIFT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	6-4-84	12959

(post-glacial) deposits in the bottoms of Little Sand, Oak, Skunk, Duck and Deep Hole Lakes. The average P-200 of 66% for 19 samples occurred in the range of 9 to 98%. The lacustrine sediments were characterized by their fine grained nature and presence of varves. The varves were generally very thin layers (less than 1/4 inch thick) of very fine sand, silt and moderate to high plasticity clay reflecting the seasonal and annual fluctuations in deposition. The composite drawing of the lacustrine gradation curves is Figure 2.6 (STS Consultants Ltd., 1984b).

2.4 Bedrock

The bedrock in northern Wisconsin is composed of Precambrian igneous and metamorphic rocks and represents an extension into Wisconsin of Precambrian basement rocks of the Canadian shield. The bedrock beneath the Crandon Project is composed primarily of metamorphosed volcanic tuffs (Golder, 1981).

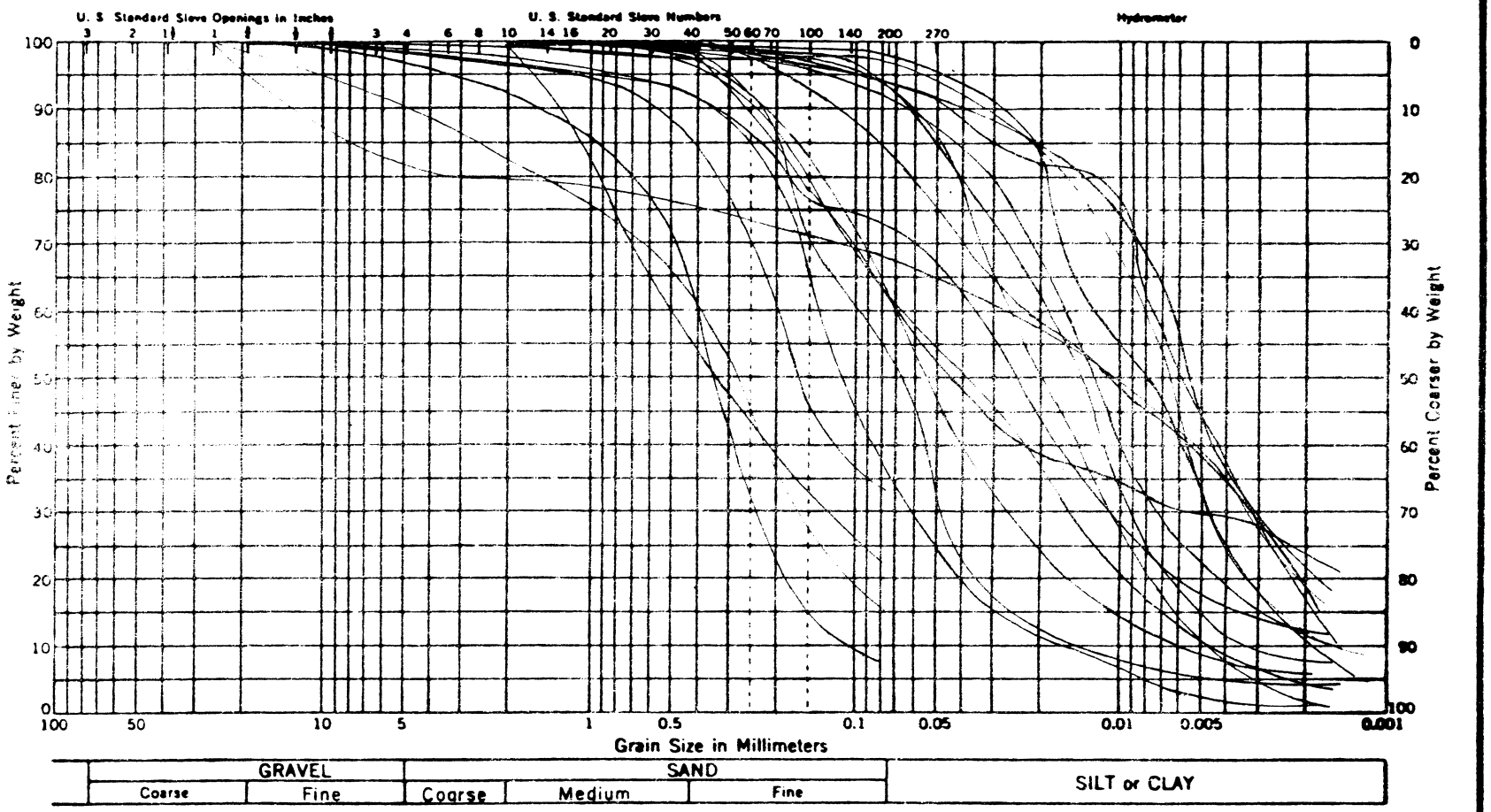
In north central Wisconsin, the regional bedrock surface slope is downward to the east and southeast. At the MRDF site, the bedrock surface elevation is approximately 1,411 feet (430 meters) MSL and is approximately 260 feet (79 meters) below the ground surface. Plan Sheet 3, Top of Bedrock Contour Map, shows the bedrock surface in the vicinity of the proposed MRDF. Its irregularity is a result of erosion and glaciation.

2.5 Hydrogeology

In the northern portion of the Wolf River Basin, groundwater occurs generally under unconfined conditions in glacial drift aquifers (Olcott, 1968). Only relatively small quantities of water are available from the fractured crystalline bedrock.

2.5.1 Water Table Depth - The results of water level measurements in

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
					Lacustrine SM-SP, SM, ML, CL
					Note: Gradation Curves Represent
					Composite Samples and Not Individual
					Varves

FIGURE 2.6
COMPOSITE GRADATION CURVES
LACUSTRINE SEDIMENT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	6-4-84	12959

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wells have been used to construct the Regional Potentiometric Contour Map (Plan Sheet 4). This map shows the elevation of the groundwater surface in the region of the MRDF. Groundwater is at its highest elevation under the upland area which coincides with the divide between the Pickerel and Swamp Creek drainage basins. Plan Sheet 4 shows the proposed MRDF above this groundwater high. The depth to the water table in the upland portion of Plan Sheet 4, ranges from approximately 3 feet (1 meter) in the area around Skunk Lake to approximately 160 feet (50 meters) at the highest point in the area. The depth under the proposed MRDF is approximately 125 feet (38 meters). The water table elevation decreases in a pattern that reflects the Swamp Creek drainage to the north and Pickerel Creek drainage to the south.

2.5.2 Recharge and Discharge Areas - Groundwater flow occurs, in general, in directions perpendicular to the contours shown on Plan Sheet 4. The flow is from upland or recharge areas to lowland discharge areas. A summary of the vertical groundwater gradients at the EX piezometers and well points is presented in Table 2.1. The gradients are small, indicating that flow is primarily horizontal in the area. A positive gradient indicates an upward vertical flow component, while a negative value indicates a downward component.

The area around the proposed MRDF is a recharge area where downward gradients were measured in the surficial till deposits. No significant vertical gradients were measured in the coarse and fine grained stratified drift units underlying the till. Groundwater flow is predominantly horizontal in the aquifer materials (STS Consultants Ltd., 1984b).

There are 5 perched lakes in the area where the lake level is above the regional potentiometric surface. This condition exists in Little Sand,

TABLE 2.1

Summary of Vertical Groundwater Gradients At EX Piezometers and Well Points (5-24-84)

EX Piezometer	Head Difference (M)	Average Length Between Gravel Packs (M)	Minimum Length Between Gravel Packs (M)	Average Gradient	Maximum Gradient
1AL - 1AU	0.05	7.24	4.88	0.007	0.010
1AU - 1BL	0.00	18.59	16.46	none	none
1BL - 1BU	-0.16	8.96	5.49	-0.018	-0.029
2AL - 2AU	-0.19	24.99	22.85	-0.008	-0.008
2AU - 2BL	-0.12	10.92	9.45	-0.011	-0.013
3AL - 2AU	-0.05	10.36	8.23	-0.005	-0.006
3AU - 3BL	0.00	12.19	10.06	none	none
3BL - 3BU	0.01	9.14	7.01	none	none
3BU - 3CL	0.25	10.08	7.93	0.025	0.032
4AL - 4AU	0.13	7.01	4.72	0.019	0.027
4AU - 4BL	-0.12	8.84	6.86	-0.014	-0.018
4BL - 4BU	-0.06	7.77	5.64	-0.008	-0.011
4BU - 4CL	-0.44	5.21	1.83	-0.085	-0.240
5AL - 5AU	not stabilized	-	-	-	-
5AU - 5BL	not stabilized	-	-	-	-
5BL - 5CL	-0.53	12.53	9.14	-0.042	-0.058
6AL - 6AU	0.00	17.07	14.94	none	none
6AU - 6BL	-0.61	11.28	9.14	-0.054	-0.067
6BL - 6BU	0.26	17.36	14.63	0.015	0.018
7AL - 7BL	0.26	14.63	12.50	0.018	0.021
7BL - 7BU	1.39	11.58	9.60	0.120	0.145
7BU - 7CL	-0.01	19.52	16.76	none	none
8AL - 8AU	0.53	17.98	15.85	0.030	0.033
8AU - 8BL	0.94	9.14	7.01	0.103	0.134
8BL - 8BU	-0.02	19.26	17.06	none	none
9AL - 9AU	0.65	9.75	7.62	0.067	0.085
9AU - 9BL	-0.01	17.07	14.93	none	none
9BL - 9BU	-0.09	19.24	14.63	-0.005	-0.006
10AL-10AU	-0.07	15.09	12.80	-0.005	-0.006
10AU-10BL	0.08	16.15	13.72	0.005	0.006
10BL-10BU	-0.35	17.16	14.17	-0.020	-0.025
11AL-11AU	0.00	13.11	10.36	none	none
11AU-11BL	0.02	16.15	14.02	none	none
11BL-11BU	-0.04	9.75	7.62	-0.004	-0.005
11BU-11CL	-0.03	16.24	7.01	none	none
12AL-12AU	-0.03	18.44	15.85	none	none
12AU-12BL	0.07	15.09	12.50	0.005	0.006
12BL-12BU	-0.11	22.42	16.76	-0.005	-0.007
13AL-13BL	not stabilized	-	-	-	-
13BL-13BU	not stabilized	-	-	-	-
13BU-13CL	-0.10	11.74	8.23	-0.009	-0.012
13CL-13DL	-0.02	10.48	7.93	none	none

TABLE 2.1

Summary of Vertical Groundwater Gradients At EX Piezometers and Well Points (5-24-84)

EX Piezometer	Head Difference (M)	Average Length Between Gravel Packs (M)	Minimum Length Between Gravel Packs (M)	Average Gradient	Maximum Gradient
14AL-14AU	0.03	19.81	17.68	none	none
14AU-14BL	0.01	13.11	10.97	none	none
14BL-14BU	-0.05	16.55	11.58	-0.003	-0.004
15AL-15AU	0.76	31.32	28.80	0.024	0.026
15AU-15BL	-0.02	22.64	19.20	none	none
16AL-16AU	0.02	10.82	8.53	none	none
16AU-16BL	-0.14	18.09	9.14	-0.008	-0.015
WP1L-WP1U	-0.23	-	7.31	-	-0.032
WP2L-WP2U	-0.20	-	7.19	-	-0.028
WP3L-WP3U	0.00	-	5.79	-	none
WP4L-WP4U	0.19	-	5.73	-	0.033
WP5L-WP5U	WP5L is flowing		-	-	-
WP6L-WP6U	-1.14	-	7.16	-	-0.159
WP7L-WP7U	0.06	-	7.31	-	0.008

NOTES: 1) Positive value indicates upward gradient
2) Negative value indicates downward gradient
3) No significant gradient if head difference is $\leq$0.03 M.

Reference: STS Consultants Ltd., 1984b

Skunk, Duck, Deep Hole and Oak Lakes. Additional information concerning the soils under the lakes can be found in reports by STS Consultants Ltd. (1982 and 1984a).

2.5.3 Groundwater Divides - Plan Sheet 4 shows that the proposed MRDF is situated in an area of groundwater recharge. A groundwater divide may be drawn through the area trending northwest-southeast. Groundwater flows from the recharge area to the east-northeast and discharges to Hemlock Creek or it flows to the north-northwest and discharges to Swamp Creek or it flows to the west-southwest and discharges to the Pickerel Creek drainage basin. Significant upward gradients were measured at EX-7 and EX-8 adjacent to Hemlock Creek. Upward gradients were also noted at well points adjacent to Swamp Creek. The indication is that both Hemlock and Swamp Creeks are groundwater discharge areas. The vertical gradient data indicate that Hemlock Creek is a flow boundary with no significant underflow.

2.5.4 Aquifers and Aquifer Use - The region around the Crandon Project is sparsely populated. Municipal and private domestic water supplies are the principal demands on groundwater. Small volumes of groundwater are required by industries in the area, but are usually obtained from the nearest municipal system. Groundwater is used for irrigation in the area of Mole Lake. Most wells obtain water from the glacial drift. There are currently no potable wells present within 0.8 miles of the proposed MRDF site.

2.6 Water Quality

2.6.1 Surface - Water quality data for streams and lakes around the Crandon Project indicate that the water is generally of high quality.

Values of pH ranged from slightly acidic to neutral. The range of hardness is from soft to moderately hard with low to high levels of alkalinity. Measurements of total solids and specific conductance are low to moderate. Dissolved metal concentrations are low. Low levels of suspended sediment are characteristic of the streams and lakes in the region. This is due, generally, to the predominant forest land cover, gentle slopes, low stream flow velocities, and lack of fine grained stream bottom material.

2.6.2 Groundwater - Analyses of groundwater samples from the glacial drift reported in the Revised Environmental Impact Report (Exxon Minerals Company, 1985a), indicate that groundwater quality meets Federal and State drinking water standards with the exception of some reported values for cadmium, iron, and manganese. The groundwater is characterized by moderate hardness, moderate alkalinity, low levels of metals, and a neutral pH.

3.0 LAND USE INFORMATION

The discussion in this chapter addresses the present land use in the area of the Crandon Project. The information provided has been extracted from the Revised Mine Waste Disposal Facility Feasibilty Report (Exxon Minerals Company, 1985b).

3.1 Present Land Use

3.1.1 Land Ownership - The area to be used for the proposed MRDF is presently owned by Exxon Corporation. Plan Sheet 5, Land Ownership and Zoning Map, presents the ownership status of land in the general vicinity of the proposed MRDF. With the exception of two tracts northeast of the proposed MRDF, the majority of the land within a one mile radius of the proposed site that is not owned by Exxon Corporation is privately held (Plan Sheet 5).

3.1.2 Zoning - The proposed MRDF is an integral part of the Crandon Project which is subject to the Forest County ordinance in Chapter 15-Planned Development. At the present time, there are no sections or requirements which would prohibit or unduly restrict the construction or operation of the Crandon Project.

The proposed MRDF is entirely within the Town of Lincoln. The zoning ordinance in effect is based on the county ordinance. Exxon has filed a Mining Plan Development Application for approval by the Town of Lincoln.

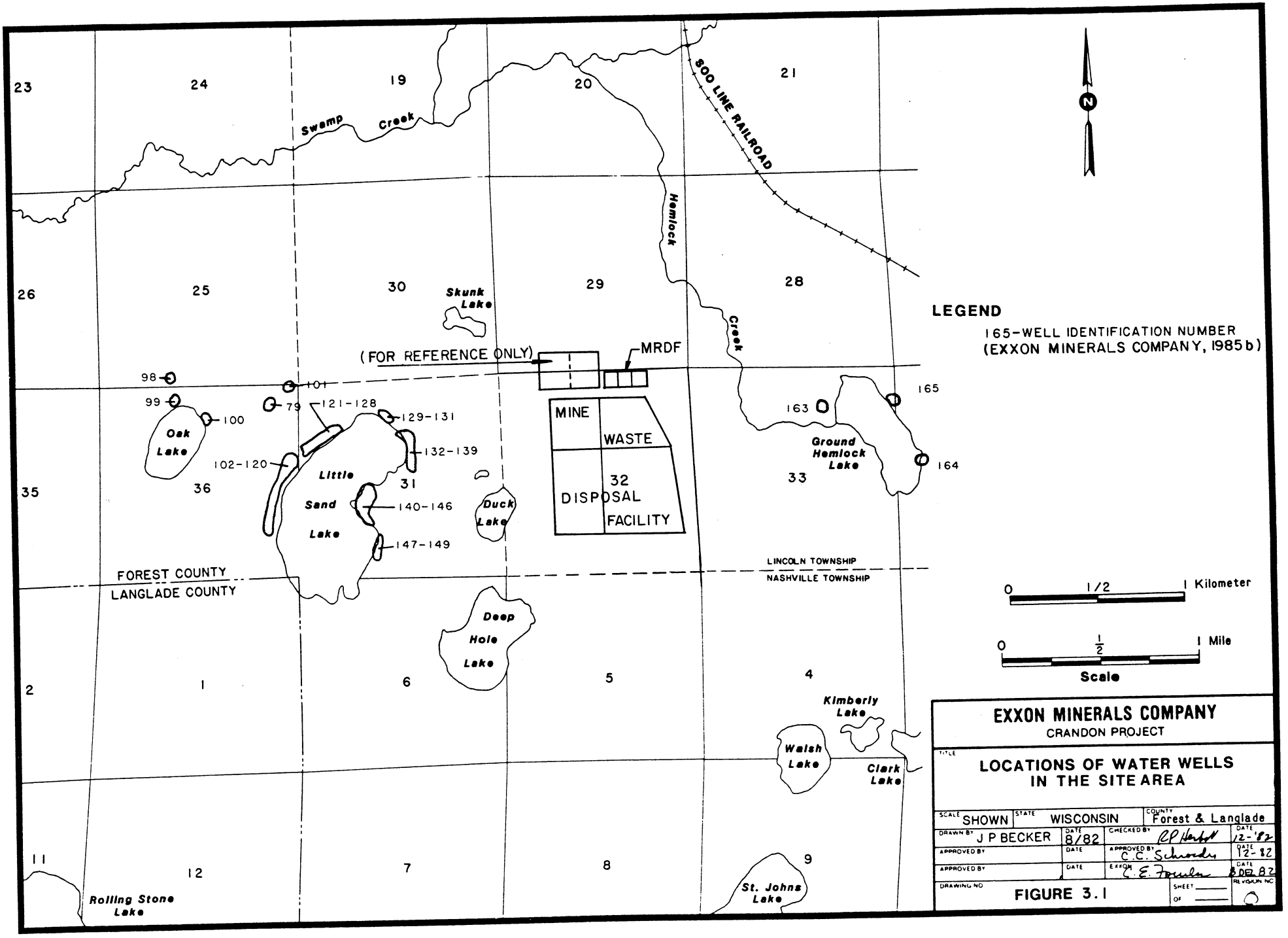
3.1.3 Recreational, Historical, Archaeological Features - The region around the proposed MRDF location is primarily forested upland and forested wetland. There are numerous lakes and streams in the area. Recreational activities, such as hunting, fishing, swimming, boating, camping, snowmo-

biling, and sightseeing, are the primary uses of such areas. Plan Sheet 2 shows the existing conditions and land use classification for the region around the proposed MRDF location. There are no State or Federally designated scenic areas, such as state parks, scientific areas, or natural landmarks within a 5 mile radius of the site.

Fifty-four (54) archaeological and historical sites were identified in the regional study area of 25 miles around the Crandon Project location. No such sites have been identified within the boundaries of the proposed MRDF. A conclusion of a previous study was that no important archaeological resources would be threatened by the development of the MWDF (Salzer and Birmingham, 1978 / Overstreet and Brazeau, 1982). A similar conclusion applies to the development of the MRDF.

3.1.4 Access Road and Weight Restrictions - Operation of the proposed MRDF and transportation of refuse from all sites of the Crandon Project will occur on private property held by the Exxon Minerals Company. All access roads will be privately held. As a result, no weight restrictions will apply.

3.1.5 Private Water Wells - The proposed MRDF is in a sparsely populated section of upland forest. An inventory of wells within a 5 mile area shows that the nearest wells are adjacent to Ground Hemlock and Little Sand Lakes (Figure 3.1).



EXXON MINERALS COMPANY
CRANDON PROJECT

TITLE
LOCATIONS OF WATER WELLS IN THE SITE AREA

SCALE SHOWN	STATE WISCONSIN		COUNTY Forest & Langlade		
DRAWN BY J P BECKER	DATE 8/82	CHECKED BY CP Hartwell	DATE 12-'82		
APPROVED BY	DATE	APPROVED BY C.C. Schroeder	DATE 12-82		
APPROVED BY	DATE	EXXON E. E. Fowler	DATE 8 DEC 82		
DRAWING NO	FIGURE 3.1	SHEET ___ OF ___	REVISION NO 0		

4.0 TERRESTRIAL AND AQUATIC ECOSYSTEMS

This section presents a summary of information on the terrestrial and aquatic ecosystems of the region around the proposed MRDF. This information is presented in greater detail in Chapter 2 of the Revised Environmental Impact Report for the Crandon Project (Exxon Minerals Company, 1985a).

4.1 Terrestrial Ecosystems

4.1.1 Regional Flora and Fauna - The proposed MRDF is situated in a transitional region between the southern Wisconsin hardwood forest and the northern Wisconsin coniferous forest. Three communities of the northern coniferous forest are identified: mesic, xeric, and lowland. Sugar maple, yellow birch, and hemlock are the dominant species in the mesic community. The xeric community is composed of jack pine, red pine, white pine, red maple and red oak. The lowland community is composed of the tamarack-black spruce bog forest, white cedar-balsam fir coniferous swamps, and black ash-yellow birch-hemlock hardwood swamps.

The wetland vegetative communities found in northeastern Wisconsin include: bog, shrub swamp, deciduous swamp, coniferous swamp, marsh, and aquatic bed. Plan Sheet 2 identifies wetland areas in the region of the MRDF according to this classification. A shrub layer dominated by heath species and an herbaceous layer dominated by sedge species are characteristic of the bog community. Shrub swamps are characterized by a deciduous vegetation with alder being a predominant species. White cedar and balsam fir are the dominant species in the coniferous swamp wetlands. Marshes are composed primarily of sedges and blue-joint grass, while aquatic beds are dominated by water lilies and bur reed.

The transitional nature of the vegetation zone around the MRDF is reflected in the faunal species present. Animals common in both the northern coniferous forest and southern deciduous forest are found. The large mammals commonly found include white tail deer and black bear. Five Wisconsin DNR-designated deer yards, where deer often congregate during periods of deep snow or severe low temperatures, have been identified in the general vicinity of the MRDF. However, the location of the proposed MRDF is not situated in any of the deer yards.

Small animals found in the area around the proposed Crandon Project site include: snowshoe hare, gray squirrel, water shrew, southern bog lemming, and woodland jumping mouse. In addition, muskrat, river otter, beaver, and racoon, all of which are commercially harvested, are present.

A large number of bird species is known to occur in northeastern Wisconsin, with approximately 196 species having been observed in Forest County alone. Raven, ruby-crowned kinglet, and evening grosbeak which are typical of the northern forest, are commonly found together with species characteristic of the southern forest including great crested flycatcher, black and white warbler, and red-eyed vireo. Most of the species of birds that inhabit the forest migrate south during the winter.

Meadow or marsh type wetlands comprise less than 1% of the area within 5 miles of the proposed MRDF. Therefore, water fowl are not attracted to the area in large numbers.

Northeastern Wisconsin is known to be within the ranges of 34 amphibian and reptile species. Twenty three of these have been identified in Forest County. Species found in both the northern and south forests such as mink frog, blue spotted salamander, water snake, bullfrog, and pickerel frog are found together near the Crandon Project.

4.1.2 Site Specific Flora and Fauna - Forested upland is the most abundant vegetation type in the southern portion of Forest County where the proposed MRDF is located. Plan Sheet 2 which shows the relationship between the MRDF location and wetland locations, indicates that no wetland vegetation will be disturbed by construction of the proposed MRDF.

Twenty-nine (29) of the mammal species reported in Forest County have been observed in the site area. These observations include white tail deer and black bear. The five most abundant small mammals in the area appear to be the deer mouse, southern red-backed mole, masked shrew, short-tailed shrew, and eastern chipmunk.

Raptors, game birds, water fowl, marsh birds, and songbirds have been observed in and adjacent to the proposed MRDF. The lack of marsh areas with open water dictate that few water fowl are attracted to the area. Song birds were the most numerous species in the site area.

4.2 Aquatic Ecosystems

4.2.1 Regional Flora and Fauna - Surface water within the 5 mile area around the MRDF can be classified as recharge and discharge lakes and streams. Chemical parameters of pH and hardness are important in controlling the aquatic flora present in the surface water bodies. The dominant species of phytoplankton, periphyton, and aquatic macrophytes characterize the aquatic flora within each water body type.

Golden-brown algae, blue-green algae, green algae, and diatoms all occur in both phytoplankton and periphyton populations. Generally, the golden-brown algae dominate the phytoplankton populations in the lakes. However, seasonal variations do occur in the composition and abundance of phytoplankton. Periphyton populations are primarily composed of diatoms in the lakes and streams.

Water chemistry and lake morphometry control which type of aquatic macrophyte dominates in the lakes of the region around the MRDF. Water milfoil, blackstem pondweed, whitestem pondweed, and coontail are typical of hard water bodies. In soft water bodies, the population is composed of water lobelia, bur reed, pipewort, mud plaintan, and pondweed.

Additional components of the aquatic ecosystems in the area around the MRDF come from the populations of zooplankton, benthic macroinvertebrates, and fish communities. Rotifer and copepod zooplankton species occur in the hard water lakes of the area. Copepods dominate in soft water lakes with clear water, while the dominant species in brown stained or bog lakes are rotifers.

The benthic macroinvertebrates present in a lake depend upon the habitat characteristics of substrate types, current velocity, and dissolved oxygen content. In lakes and the bottom areas of slow water streams, the most abundant benthic macroinvertebrates are midge larvae. Mayfiles and caddisflies are commonly found in streams with gravel and rubble substrate and fast flowing waters.

Fish fauna are dominated by black bullhead, white sucker, yellow perch, and/or some species of the sunfish family in the hard water lakes and the Wolf River. Yellow perch are the most abundant species in a more narrow faunal species range that occurs in the soft water lakes of the region. Small head water creeks provide the appropriate habitat for brook trout and molted sculpin, while large creeks are generally dominated by minnows.

4.2.2 Site Specific Flora and Fauna - No mapable streams or wetland areas exist within the limits of the proposed MRDF. Therefore, there would be no impact upon aquatic flora or fauna due to the development of the proposed MRDF.

4.3 Threatened and Endangered Species

The location of the proposed MRDF does not directly disrupt any habitat utilized by species listed as endangered or threatened by either Federal or State government (Exxon Minerals Company, 1985b).

No mammals were observed in the area within 5 miles of the proposed MRDF that are listed as endangered species by the Federal or State government. No mammals in Wisconsin are listed as threatened by either the Federal government or the State of Wisconsin.

The bald eagle is listed as a threatened species at the federal level and as an endangered species at the state level. Four bald eagle territories have been identified in the 5 mile area around the proposed MRDF. Three of the four areas appear to contain alternate nest sites.

Five active osprey nests were located within a radius of 5 miles from the proposed MRDF. The osprey is listed as an endangered species at the state level.

The cooper's hawk which is listed as a threatened species by the state has been observed in the area. However, their numbers have declined in response to pesticide induced lowering of productivity.

The endangered species list of the federal government contains no amphibians or reptiles that occur in Wisconsin. The wood turtle and tremblay's salamander are two species whose ranges make it possible that they occur in the region of the proposed MRDF. However, neither of these species was observed in the area (Exxon Minerals Company, 1985a).

5.0 SITE SPECIFIC INFORMATION

5.1 Topography and Surface Drainage

The proposed MRDF is situated in a wooded upland area on the divide between the Pickerel Creek and Swamp Creek drainage basins. The facility, as proposed, is composed of three equally sized cells arranged in an east-west orientation. The total area occupied by the facility is approximately 12.0 acres. Plan Sheet 6 shows the site specific topography and the position of the MRDF relative to surface drainage divides. Figure 5.1 shows the nature of the forest cover and topography at the proposed site.

A 13 foot high north-south trending elongated hill is situated with its highest elevation of 1,721 feet in the southwest 1/4 of the middle cell (Cell 2). Cell 1, at the west end of the facility, is proposed to be constructed on the west flank of the hill. Near the southwest corner of Cell 1 is the head of a swale that becomes wider and deeper to the southwest. The land surface at the east end of the facility (Cell 3) slopes gently to the south and southeast from approximate elevation 1,711 to 1,698 feet (521.5 to 517.5 meters) MSL.

No streams or wetlands are present at the site location. Surface drainage that does not infiltrate is achieved by sheetflow through the forest litter. Generally, the southern one half of Cell 1 and the southwest 1/4 of Cell 2 west of the hilltop, drain to the west into Pickerel Creek. The northern 1/2 half of Cell 1 and the northwest 1/4 of Cell 2 drain into Swamp Creek to the north. Surface drainage from the eastern 1/2 of Cell 2 and all of Cell 3 flows east into Hemlock Creek which is a tributary of Swamp Creek.

5.2 Borings and Test Pits

Extensive geotechnical work has been conducted by Exxon during siting and

Figure 5.1 Looking North in Proposed MRDF Cell 1 from Test Pit 85-9 (Photo by STS Personnel, October 1985)

design studies for the MWDF. The DNR agreed that the borings completed around the proposed MWDF supplemented by backhoe test pits at the MRDF site would be sufficient for the purposes of the MRDF feasibility study (DNR letter 10-21-85, Appendix A).

Plan Sheet 7 is the boring, test pit, well location diagram and cross section index for the proposed MRDF. It shows the borings used to identify unconsolidated material and construct cross sections presented in this report. In addition, Plan Sheet 7 shows the locations of test pits excavated specifically for this report.

Soil borings were completed for previous reports at the locations indicated on Plan Sheet 7 to the depth shown on the cross sections (Plan Sheets 8 through 12) by a truck mounted rotary drill rig. Split spoon soil samples were collected in each boring. Boring logs relevant to the MRDF are included in Appendix B.

Eighteen test pits were completed in the vicinity of the proposed MRDF using a backhoe. Test pit locations are indicated on Plan Sheet 7, in the area around the proposed MRDF. The test pit logs are included in Appendix B.

5.3 Monitoring Wells

Piezometers have been previously constructed in Borings EX-9, EX-10, DMB-2, G41-G12, G41-G13, and G41-H9. One to four piezometers were installed at each location. At the EX locations, two piezometers were installed in a single bore hole. The specific construction details for each piezometer installation are shown on Field Well Installation Diagrams and Boring Logs in Appendix B.

5.4 Soils Description

The boring logs from the 9 borings in the vicinity of the proposed MRDF were used to construct 5 geologic cross sections (Plan Sheets 8 through 12). All the borings penetrated one or more of the five glacial deposits described earlier. In general, the borings encountered two till units which were separated by approximately 30 to 130 feet of coarse grained stratified drift. The upper till unit was present at the ground surface and is 5 to 130 feet thick. The lower till unit is 100 to 130 feet thick and overlays coarse grained and/or fine grained stratified drift. The deeper borings penetrate either lacustrine sediments or basal till before terminating in bedrock. The elevation of the bedrock surface is approximately 1,411 feet (430 meters) above sea level.

All the test pits encountered a surficial till consisting of a silty fine to coarse sand (SM) with a trace to little gravel and cobbles. The results of the washed gradation analyses of six samples from the test pits are in Appendix C. The P-200 ranged from 17 to 26%. At a depth of approximately 8 feet, the till was denser and "blocky" exhibiting greater resistance to excavation than the less dense near surface till. Moisture-density relationships were determined in accordance with ASTM D-698 on the surficial and "blocky" deeper till encountered in the test pits. A maximum dry density of the deeper till was 134.5 pcf at an optimum water content of 7.7%. The results on the shallow till indicate that the maximum dry density is 131.3 pcf at an optimum water content of 8.7%. The moisture-density curves are in Appendix C.

The expected depth of excavation of the proposed MRDF is approximately 25 feet. Therefore, the surface till unit as identified in the borings is the only material that should be encountered during construction.

5.5 Water Levels and Site Specific Hydrogeology

Plan Sheet 13 shows the site specific groundwater potentiometric contours of the MRDF. The locations of the water table wells used to construct the drawing are indicated along with the water elevations in the wells as of July 24, 1985. The water table is approximately 100 to 130 feet below the existing ground surface at the proposed MRDF. The elevation of the water table ranges from elevation 1,590 feet (486 meters) west of the proposed site to 1,580 feet (483 meters) near Hemlock Creek. Water level measurements show that there is a seasonal fluctuation in the groundwater table of approximately 3 feet.

The site is east of the groundwater divide between Pickerel Creek and Hemlock Creek. Groundwater flows from the recharge areas along the groundwater divide to the east and northeast towards Hemlock Creek. Dewatering of the aquifer system due to the mining operation will cause the groundwater divide to migrate towards the east. By year 60 after the beginning of mining operations, the original potentiometric surface and groundwater divide will be fully re-established. However, nearly all the recovery will occur in the first few years after cessation of mining operations (D'Appolonia, 1984).

Field permeability tests were conducted by STS Consultants Ltd. (1984b) in the EX piezometers. The results (summarized in Table 5.1) indicate that the coarse-grained stratified drift had the highest permeability followed by the fine-grained stratified drift. The glacial till and basal till had intermediate permeabilities and the lacustrine sediments had the lowest. Data sheets for the piezometers in the MRDF vicinity are in Appendix D.

Seepage was encountered during excavation of the test pits at the proposed location of the MRDF. The seepage generally occurred at the 4-5 foot depth

TABLE 5.1

Field Permeability Test Data
Crandon Project

Statistical Analysis

Geologic Unit	Number of Tests	Range, cm/sec.	Arithmetic Mean, cm/sec.	Geometric Mean, cm/sec.	Standard Deviation cm/sec.
Coarse drift	15	1×10^{-2} to 1×10^{-3}	4×10^{-3}	3×10^{-3}	3×10^{-3}
Fine drift	12	6×10^{-3} to 7×10^{-4}	2×10^{-3}	1×10^{-3}	7×10^{-4}
Till	10	3×10^{-3} to 9×10^{-6}	6×10^{-4}	2×10^{-4}	9×10^{-4}
Basal till	7	9×10^{-4} to 9×10^{-5}	4×10^{-4}	3×10^{-4}	3×10^{-4}
Lacustrine *	4	5×10^{-4} to 1×10^{-5}	2×10^{-4}	9×10^{-5}	2×10^{-4}

* These values are representative only for glacial lacustrine deposits and not for the recent deposits under Little Sand, Skunk, Oak, Deep Hole and Duck Lakes.

in each pit. There was no visible change in the soil characteristics that could explain the seepage. One possible explanation is that the seepage is representative of an extended infiltration event as the result of above average rainfall prior to pit excavation. The seepage level may be coincident with the level of frost penetration.

6.0 WASTE CHARACTERISTICS

6.1 Introduction

An estimate of all wastes associated with the Crandon Project is presented in a letter from Exxon Minerals Company to the Department of Natural Resources dated November 9, 1984. A copy of this letter is included in Appendix A. Disposal of potentially hazardous wastes, petroleum, chemical and other speciality wastes will be made at special off-site facilities. The MRDF will be used for the disposal of non-hazardous wastes and refuse only. The wastes and refuse to be disposed of at the MRDF will be generated during a 36 year period of construction, operation, and reclamation of the Crandon Project.

6.2 Construction Refuse and Waste

The total estimated quantity of construction refuse and waste is 1,525 tons. Approximately 60% or 900 tons may be characterized as refuse consisting of solid waste from construction crews, packaging wastes, and scrap metals. This figure is derived from estimated weekly waste quantities. Similar refuse quantities were derived based on estimates of per capita per day waste production. Construction waste totaling 625 tons or 40% of the total construction refuse and waste quantity will consist of waste construction materials, such as concrete form work, metal siding and roofing, metal liner panel, dry wall and insulation. The total construction refuse and waste material will be generated during the 3 year construction period.

6.3 Operation Refuse

The total quantity of operation refuse to be deposited in the MRDF is approximately 47,000 tons. This is estimated using a work force of 650

people generating 2.5 tons of refuse per year for 29 years. It is expected that the refuse will consist of the following materials:

Material	Percentage
Paper and Garbage	75
Plastic	5
Wood	5
Metal	10
Miscellaneous	5

Other solid waste refuse including tires, scrap metal and miscellaneous items of scrap or waste material will be returned to vendors or sold to scrap dealers to be recycled or ultimately reused.

Petroleum products and chemical wastes, including waste oil, hydraulic fluids, lubricants, solvents, degreasers, waste fuels, and waste chemical residue, will be returned to recyclers where suitable. Any non-recyclable waste will be disposed of with a speciality disposer properly licensed to receive such wastes.

Potential hazardous wastes including those from laboratories, machine or repair shops, and spill residues, would be disposed of through a speciality disposer. All applicable regulations covering handling, transfer and disposal of the wastes will be followed.

6.4 Reclamation Refuse and Waste

The total quantity of refuse and waste generated during reclamation of the Crandon Project facilities is estimated to be 2,500 tons. Reclamation wastes consist primarily of solid waste from operating and construction/demolition personnel and insulation, dry wall and minor scrap wood and metal that is non-salvageable, unburnable or not suitable for direct burial.

The total waste quantity anticipated from construction, operation and reclamation is approximately 51,000 tons. Assuming an in-place density for the refuse of 1000 pounds per cubic yard, the waste will consume approximately 102,000 cubic yards. At a 5 parts refuse to 1 part cover ratio, total volume required for refuse and daily cover will be approximately 122,000 cubic yards. The 3 cells as designed have a total capacity of 122,000 cubic yards excluding final cover. The actual lifetime of each cell will be dependent on the waste generation rates.

7.0 LOCATION AND PRELIMINARY DESIGN

7.1 Locational Requirements in NR 180.13(3)

The location and design process for the proposed MRDF followed closely the locational criteria as indicated in NR 180.13(3). Table 7.1 is a listing of the locational criteria in NR 180. Included in this table is the compliance of the proposed MRDF and the reason or evidence for compliance for individual locational criteria.

The facility as designed and located is in compliance with all locational criteria in NR 180.

7.2 Proposed Preliminary Design

7.2.1 Layout, Access, and Filling Sequence - The proposed MRDF is composed of three contiguous cells aligned in an east-west direction; Cell 1 being the western-most cell and Cell 3 being the easternmost cell. Plan Sheet 14 shows the proposed site development of the MRDF and indicates the layout of the three cells. Access to the facility is from the southwest where the top of the dike will be joined to the MWDF access road.

The filling sequence will begin with Cell 1 and end with Cell 3. Cell 2 construction will be completed prior to closure of Cell 1. During the operation of Cell 2, Cell 1 will be reclaimed and Cell 3 will be constructed. Cell 2 will be reclaimed during the operation of Cell 3. Upon termination of operation of Cell 3, its reclamation will begin.

7.2.2 Liner - Seepage of leachate from the refuse material in each cell will be controlled by the construction of a liner in the bottom and along the sides of each cell. The liner consists of two 4 inch lifts of a bentonite modified soil similar to the proposed MWDF liner (Exxon Minerals

TABLE 7.1

Summary of NR 180 Location Criteria

Criteria	MRDF Compliance	Reason or Evidence
180.13(3) No person shall establish, construct, operate, maintain, or permit the use of property for a solid waste land disposal site or facility within the following areas:		
1. Within 1,000 feet of any navigable lake, pond or flowage.	Complies	See Plan Sheet 2
2. Within 300 feet of a navigable river or stream.	Complies	See Plan Sheet 2
3. Within a flood plain.	Complies	See Plan Sheet 2
4. Within 1,000 feet of the nearest edge of the right-of-way of any state trunk highway, interstate or federal aid primary highway or the boundary of any public park, unless the site is screened by natural objects, plantings, fences or other appropriate means so as not to be visible from the highway or park.	Complies	See Plan Sheet 2
5. Within wetlands.	Complies	See Plan Sheet 2
6. Within critical habitat areas.	Complies	See Chapter 4 & 2
7. Within an area where the department after investigation finds that there is a reasonable probability that disposal of solid waste within such an area will have a detrimental effect on any surface water.	Complies	Facility designed with leachate collection system and liner
8. Within an area where the department after investigation finds that there is a reasonable probability that disposal of solid waste within such an area will have a detrimental effect on groundwater quality	Complies	Facility designed with leachate collection system and liner

TABLE 7.1 (continued)

9. With 10,000 feet of any airport runway used or planned to be used by turbojet aircraft or within 5,000 feet of any airport runway used only by piston type aircraft or with such other areas where a substantial bird hazard to aircraft would be created, unless a waiver is granted by the Federal Aviation Administration, but this criteria is only applicable where such site or facility is used for disposing of putrescible waste such that bird hazard to aircraft would be created.	Complies	See Plan Sheet 2
10. Within 1,200 feet of any public or private water supply well	Complies	Non-potable high capacity well to be installed by Exxon north of facility for construction use only (See Plan Sheet 14)

Company, 1985b). The same thickness (8 inches) will be used on the bottom and the sides of each cell. The bentonite modified soil will be manufactured using on-site glacial till materials and sufficient bentonite to achieve a design permeability of 5×10^{-8} cm/sec. The liner collection system is designed to control the head on the liner and to minimize seepage through the liner.

A two layer blanket underdrain of prepared local soil material will be placed above the liner in each of the three cells. The upper layer will serve as a filter which will transmit leachate to the drain layer below and also inhibit migration of fines into the drain layer. The filter layer will be separated from the drain layer by a geotextile filter fabric which will prevent the finer material of the filter layer from entering the drain layer below. The drain layer has been included to provide sufficient hydraulic capacity to accommodate any leachate volumes that are transmitted to the filter layer.

The construction of the liner and underdrain system is depicted in cross section diagrams on Plan Sheets 15 and 17. This liner and underdrain system will be continuous over the bottom and inside slopes of each cell. The inside slopes of the cells will be 4 horizontal to 1 vertical (4H:1V) to facilitate placement of the lining system. These relatively flat slopes will allow the use of conventional construction equipment and will allow required quality control objectives to be met.

7.2.3 Material Balance - The construction of the MRDF requires the use of on-site glacial till material for dike construction and the preparation of liner and final cover. In addition, material is required to be used for daily cover of the refuse. Plan Sheet 14 shows the design of the MRDF with

elevations for the confining embankments and base grades in the bottom of the three cells. The total excavated material will be approximately 116,000 cubic yards. The material required for embankment construction is approximately 22,000 cubic yards. The total volume of soil material needed for daily cover over the life of the operation is approximately 20,500 cubic yards. The final cover volume is approximately 79,000 cubic yards. Approximately 24,000 cubic yards will be required for liner and drain construction. Any imbalances will be handled in conjunction with the other construction and reclamation activities for the MWDF. Table 7.2 provides a summary of the earthwork balance. Calculations are in Appendix E.

7.2.4 Leachate and Gas Control - In the design process, particular attention is paid to the containment and collection of leachate and the release of generated gas from each cell. Leachate will percolate down through the refuse and be transmitted through the filter and drain layers where it will encounter the relatively impermeable liner. On the 4:1 side slopes of the cells, the leachate will readily drain to the bottom of the cell. A 2% grade will be maintained from the northeast to the southwest corner of the bottom of each cell and will direct leachate to the southwest. A 6 inch diameter perforated PVC pipe will be installed along the west and south edges of the cell bottoms to intercept and transmit the leachate to the southwest corners. Construction details of this pipe system are shown on Plan Sheets 14, 15 and 16. Leachate will be collected in a manhole at the southwest corner where a float activated pump will pump the leachate into the reclaim pond. Cleanout access pipes will extend up the interior side slopes to facilitate maintenance of the collection system.

Plan Sheet 16 shows the final grades and positions of gas vents for the MRDF. Gases that are produced from the refuse material will generally

TABLE 7.2

SUMMARY OF MRDF EARTHWORK AND VOLUME ESTIMATES

I. Earthwork Cells 1, 2 and 3:

		Cut Required Cubic Yards	Fill Required Cubic Yards
(1)	Excavation to Base Grades	116,000	
(2)	Dike Construction		22,000
(3)	Liner and Drain Material		24,000
(4)	Final Cover		79,000
(5)	Daily Cover		20,500
	Total	116,000	145,500
	Material Deficit		29,500

II. Design Capacity (excluding final cover)

		Cubic Yards
(1)	Refuse Volume for Each Cell, as estimated	34,000
(2)	Daily Cover for Estimated Refuse for Each Cell	7,000
(3)	Minimum Required Disposal Capacity for Each Cell	41,000
(4)	Cell Capacity as Designed	41,000

migrate to the highest point of refuse in each cell. The final lift of refuse will be graded so that a 2% slope is maintained from the north to the south end of the cell. Final cover will be placed above the refuse in each cell. Two gas vents will be installed through the final cover at the north end of each cell and one gas vent will be installed at the south end. The typical construction of the passive gas vents is shown on Plan Sheet 17.

7.2.5 Operating Procedures - The MRDF is proposed to be operated as a sanitary landfill. Administrative Code NR 180.13 requires that all of the solid waste be completely covered with at least 6 inches of earth after each day of operation. The rate of deposition of refuse in the facility may vary from the construction phase to the operational phase of the Crandon Project. Whether refuse is deposited on a daily or weekly basis, an operator will utilize earth moving equipment to spread the refuse and compact it. Each day's volume of waste will be covered with the 6 inches of earth as required.

The filling will progress from the northeast to the southwest corner in 6 foot lifts. This will allow surface water to drain freely from the sides and through the refuse to the southwest corner of the cell. The surface water will enter the manhole and be pumped to the reclaim pond prior to treatment at the water treatment plant. Access to the manhole in the southwest corner will be maintained during the filling of each cell by addition of sections of 5 foot diameter prefabricated concrete cylinders.

Truck access to the bottom of each cell will be maintained from the southwest corner of the dike down a ramp with a grade of 10% or less. This will consist of a temporary access road constructed on the filter layer using glacial till.

7.2.6 Groundwater and Other Monitoring - The compliance boundary for the proposed MRDF has been established by the DNR at 150 feet from the edge of refuse (10-21-85 DNR Letter in Appendix A). The groundwater monitoring system will provide for an adequate means of assessing the impact of the MRDF on the groundwater system. Two well nests consisting of one water table well and one piezometer will be installed as indicated on Plan Sheet 16. A well south of Cell 2 will be shared by the MWDF and the MRDF and has been designated as a MWDF well. A quarterly sampling program will be maintained for parameters of water elevation, field pH, field conductivity, hardness, alkalinity, COD, chloride and iron as required in NR 180.

Proposed Wells RD2-T and 2-D will serve as downgradient wells after mine dewatering operations have ceased. During mine dewatering, proposed Wells RD1-T and 1-D will serve as downgradient wells.

The leachate pump station will be monitored for water level weekly during the operation of the facility and monthly after installation of the final cover. Analyses will be performed quarterly for the same parameters as those listed above for the groundwater.

The liner performance will be evaluated by collecting samples from leachate collection lysimeters to be installed in the bottom of each Cell. The design details of the lysimeter are provided in typical cross section and longitudinal section on Plan Sheet 17. Sampling will be performed on a quarterly basis for quantity and quality for the same parameters as listed above for the groundwater.

Gas vents will be sampled quarterly for percent methane.

The leachate manhole maintenance in each cell will take place as necessary. Monthly leachate levels will be checked and pumped when required. Leachate

collection pipe clean-out will be performed annually. The performance of the final cover as designed will cause percolation to be shed to the dike seepage areas thereby reducing leachate production. Therefore, after a short period after cell closure, leachate pumping will not be necessary.

7.2.7 Final Grades and Cover - After the refuse capacity of each cell is achieved, a final cover will be constructed that consists of five layers. The bottom layer directly over the refuse will consist of 1 foot of till. This will be placed as part of daily cover or as a grading layer to achieve proper slopes. Overlying the till will be 8 inches of a bentonite modified soil that is constructed in the same manner as the liner. A 40 mil polyethylene membrane will be placed on the bentonite modified soil followed by an 8 inch drain layer of sand and gravel. The purpose of this system is to intercept infiltration and direct it to the perimeter of the cell, thereby reducing infiltration into the refuse. Also, it will minimize the amount of methane in the root zone. The drain will be protected by a filter fabric and 4.5 feet of soil cover. Finally, 6 inches of topsoil will be distributed over the site to provide the proper material for rooting plants. 4H:1V slopes will be constructed up to the final surface which will be a 2 % grade from the north end to the south end of each cell. Cross sections on Plan Sheet 17 show details of the final cover and the seepage beds in the dikes. Final grades are illustrated on Plan Sheet 16.

Following grading of the final cover, herbaceous vegetation will be established to stabilize the soil surface and to minimize erosion. The revegetation program will allow natural ecological succession to occur at the site. Plant communities compatible with adjacent undisturbed communities, will be allowed to develop. It is expected that the root zone in

the final cover will be approximately 30 inches. Natural revegetation by plants will occur similar to the MWDF as described in a report by Ayres Associates (1984).

7.2.8 Final Use - Reclamation and natural revegetation of the proposed MRDF will ensure a gradual return to the surrounding ecosystem. Ultimately, habitat for flora and fauna that exists in the surrounding area will become established.

7.2.9 Financial Responsibility and Long Term Care - The financial responsibility for closure and long term care costs will be demonstrated by Exxon Minerals Company. According to the October 21, 1985 DNR letter included in Appendix A, "The financial responsibility standards of S.144.443 will also be applicable to the solid waste disposal site. The appropriate instruments for assuring closure and long-term care either under NR 132.09(2) and NR 180.15 will be determined at a later date."

7.2.10 Air Curtain Destructor - An air curtain destructor (ACD) will be constructed at a location east of the proposed MRDF as indicated on Plan Sheet 2. It will be used to dispose of clearing and grubbing waste from development of both the MRDF and the MWDF. The dimensions of the ACD will be approximately 20 by 40 feet. A separate application will be made for the permit which will describe construction, location, and use in detail.

8.0 WATER BUDGET

8.1 Introduction

A water budget has been calculated for periods prior, during and following operation of the MRDF in compliance with NR 180.13 (6)(c) 5. The water balance analysis was completed using a computer program developed by the Wisconsin Department of Natural Resources for an IBM-PC microcomputer. Documentation for this program was prepared by Scharch (1985). The water budgets are illustrated on Figures 8.1 and 8.2. Computer print-outs and related calculations are presented in Appendix E. Procedures developed by Fenn, Hanley, and DeGeare (1975) and Thornthwaite and Mather (1964) were used in computing the water budgets.

National Oceanic and Atmospheric Administration (NOAA) data for precipitation and temperature for the years 1951 through 1980 for the Rhinelander Weather Station were used in this analysis. Evapotranspiration losses were assumed to be negligible during the winter months, (December through March). Snowfall was accumulated as storage until March. The depth of root penetration on the final cover was assumed to be 30 inches. Root penetration will be limited by a zone of capillary saturation above the drain layer in the final cover. Ayres Associates (1984) prepared a detailed discussion of the potential root penetration on the final cover. Run-off coefficients were increased by 50% for frozen ground conditions.

8.2 Before Construction

Prior to site development, it was estimated that of the 30.7 inches of annual precipitation, approximately 1.1 inches are run-off and 29.6 inches are surface infiltration. Approximately 21.2 inches of the 29.6 inches of infiltration are lost with evapotranspiration. Accordingly, groundwater

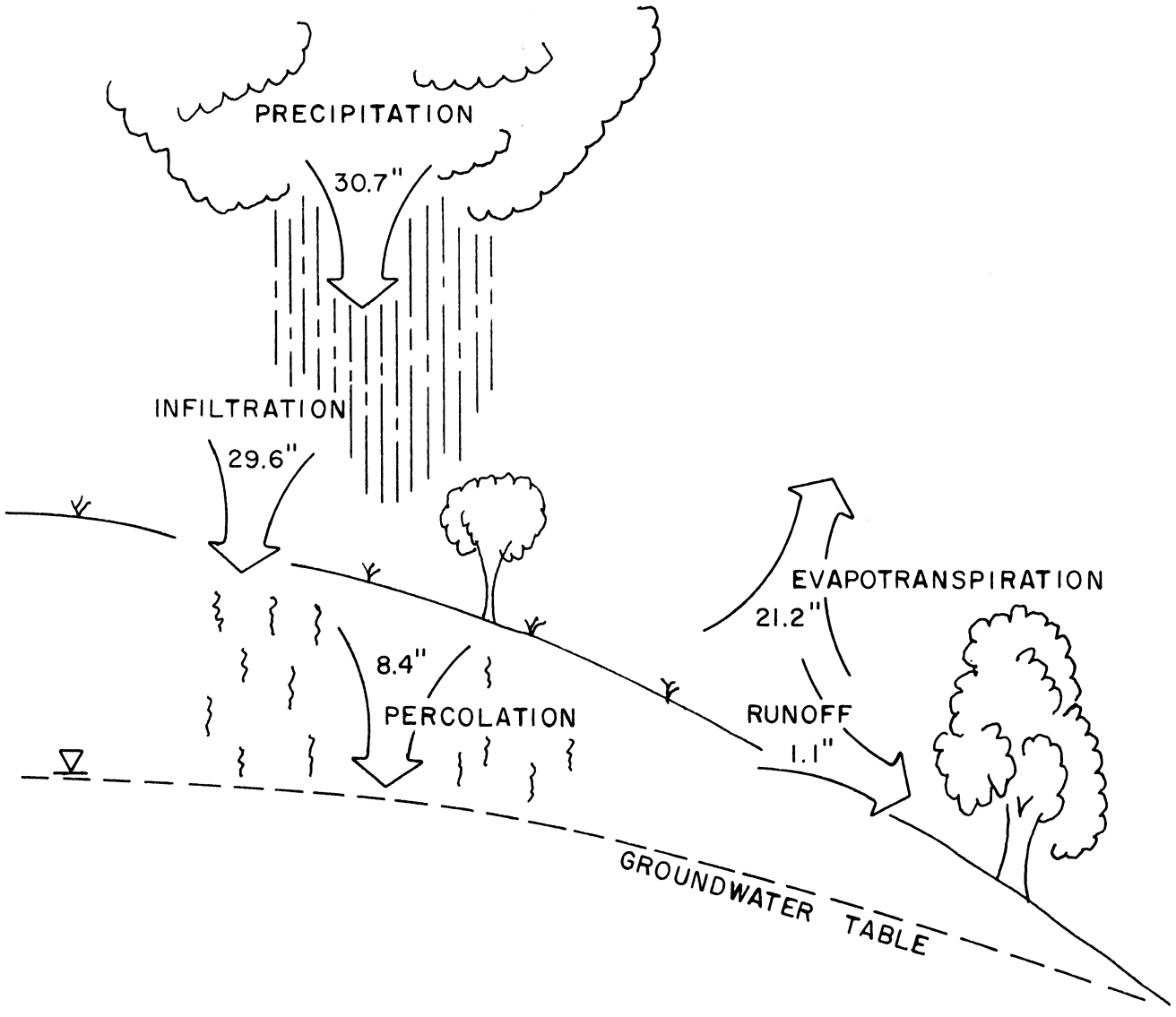
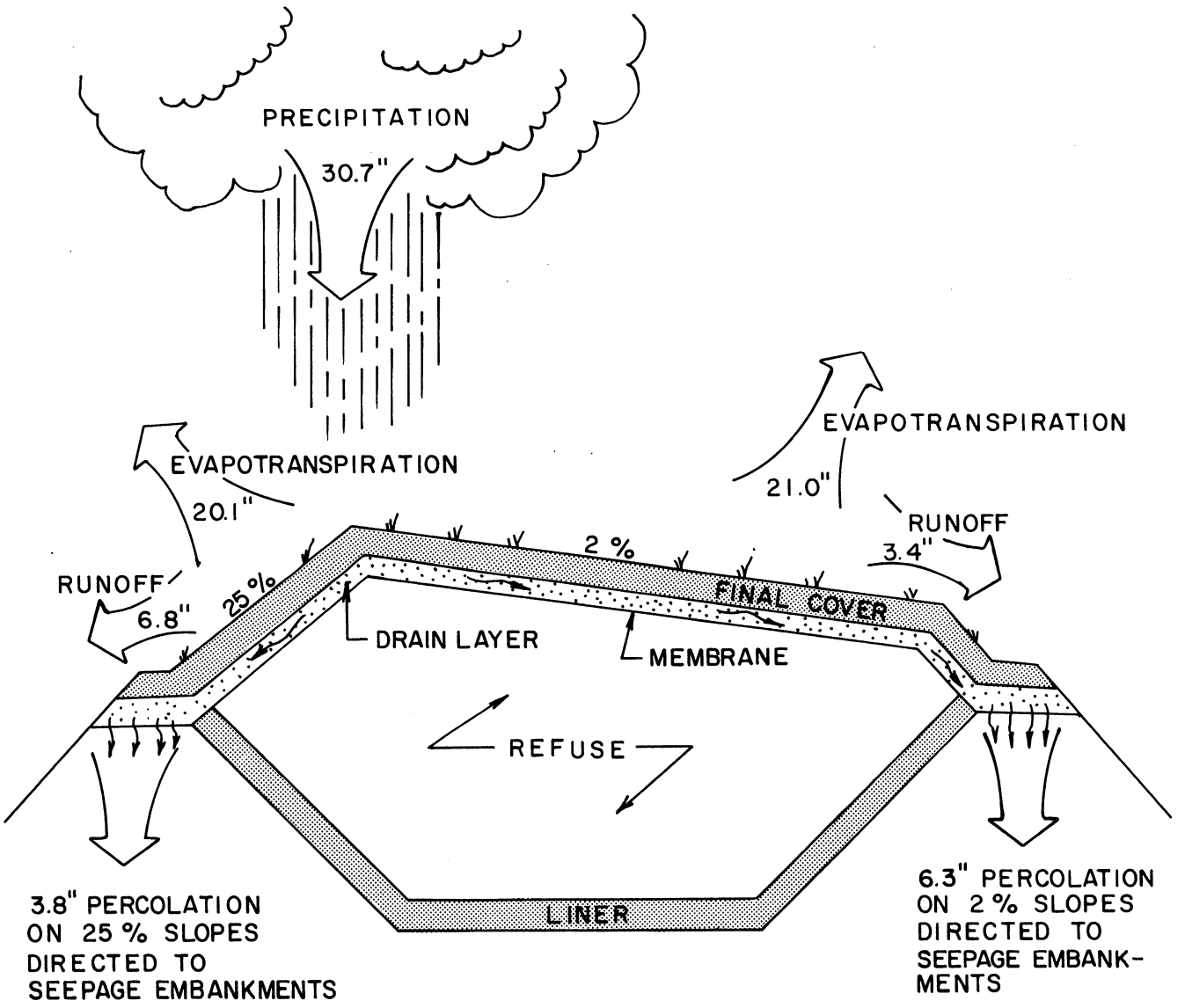


FIGURE 8.1 – EXISTING CONDITIONS
WATER BUDGET FOR MRDF
CRANDON PROJECT

STS CONSULTANTS LTD.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

P.D.P.	J.A.S.	11-20-85	14028



NOT TO SCALE

FIGURE 8.2 – CLOSURE WATER BUDGET FOR MRDF CRANDON PROJECT

STS CONSULTANTS LTD.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

J.J.T.	J.A.S.	11-20-85	14028

recharge (net percolation) is 8.4 inches. A more detailed existing conditions water balance for the MWDF has been prepared by Ayres Associates (1984).

8.3 During Operations

It was assumed that Cell 1 of the MRDF was properly covered and at final grades. Cell 2 was filled with refuse but not final covered. Cell 3 was open and receiving refuse. Actual evaporation from open areas in Cells 2 and 3 could be as much as 50% of the precipitation. Surface water runoff on the closed portions of Cell 1 would be diverted off-site.

These estimates assume that the waste is at field capacity and that all surface water within the open Cells 2 and 3 which does not evaporate will enter into the leachate collection system.

It was determined that excess precipitation on Cells 2 and 3 will total 1,870,000 gallons annually (935,000 gallons per cell). Percolation through the final cover on Cell 1 will enter the drain layer above the membrane and drain to the seepage areas on the embankments instead of infiltrating the refuse.

8.4 Post-Closure - At closure, the MRDF will consist of 3 similarly sloped cells that will have permanent vegetative cover. On the top portions of the cells with a minimum of 2% slope, run-off coefficients of 0.10 to 0.15 are expected. Annual runoff is projected at 3.4 inches and infiltration at 27.3 inches. Evapotranspiration losses will be 21.0 inches and net percolation will be 6.3 inches. Most, if not all, of the percolation is anticipated during the spring of the year.

Approximately 58% of the final cover will have a 2% slope. The remaining 42% of the final cover will have a 25% slope. On the 25% slopes, run-off

coefficients of 0.20 to 0.30 are expected. Run-off is projected at 6.8 inches and infiltration at 23.9 inches. Evapotranspiration losses will be 20.1 inches and net percolation will be 3.8 inches.

Leachate pumping after final cover placement will be necessary only for a few years. Given the configuration of the final cover with a drain and membrane, long term leachate generation will be minimal. The amount of percolation which will drain to the seepage embankments from the 3 cells was estimated at 956,200 gallons annually.

9.0 ENVIRONMENTAL IMPACT ASSESSMENT

9.1 Purpose and Need

This project consists of the development and operation of a privately owned landfill that will be utilized by Exxon Minerals Company for the safe disposal of non-hazardous refuse and waste resulting from the development, operation and closure of the Crandon Project. The proposed facility is composed of 3 cells which will have a combined site life of 36 years. The facility is designed for a refuse capacity (including daily cover) of approximately 122,000 cubic yards. The area to be occupied by the proposed MRDF is 12.0 acres. All refuse and waste to be deposited in the facility will be transported by Exxon Minerals Company on private haul roads.

The need for this facility is linked to the development time table associated with the Crandon Project. Construction of Cell 1 of the MRDF will begin at the onset of construction activities.

9.2 Probable Adverse and Beneficial Effects

9.2.1 Physical - The development of the facility will have a short term adverse effect on the air quality of the area during construction of each cell. Numerous pieces of heavy equipment will be used to construct the facility and hydrocarbon and particulate emissions will be greater than they presently are at the site. The exhaust emissions will not be concentrated in any one location, rather they will be dispersed. The proposed location of the MRDF in an upland area means that air flow across the site will not be restricted and will aid in the dispersion of emissions. The routine landfill operation will generate dust during dry periods due to the equipment traffic. However, operations will take place only as refuse and waste is deposited.

Noise will be experienced during construction and operation of the facility through the use of equipment. Berms and the surrounding vegetation and the remote location of the facility will minimize this impact.

9.2.2 Biological - The design of the MRDF provides for final slopes and soils that will be compatible with those present at the site. The reclamation procedures will foster natural revegetation of the site ultimately allowing its return to the ecosystem present in the area around the facility.

Fauna in the areas adjacent to the MRDF should remain relatively unaffected, except for some noise disturbances during construction and operation.

9.2.3 Social - Establishment of the MRDF and its operation will have minimal social impact. The nearest residences are approximately one mile to the east. The Private Water Supply Section of the DNR does place conditions upon the type of wells which can be constructed within 1200 feet of a landfill. The landfill will preclude the development of this acreage for residential or commercial use.

9.2.4 Economic - Utilization of an off-site municipal facility by Exxon Minerals Company would provide some direct benefit to the particular community through the tippage fees that would be collected. However, an on-site facility would avoid some indirect adverse impacts to the community such as the need for locating and developing a new facility sooner. An on-site facility would eliminate the extra road wear that would result from transportation of the refuse to a distant facility. In addition, fuel costs for transporting the refuse will be minimized.

9.2.5 Other - Development of the proposed MRDF is an integral part of the Crandon Project and contributes to the reduction and containment of any environmental impacts within a relatively small area.

There are no known archaeological and/or historic features or sites in the proposed area of the MRDF.

9.3 Probable Adverse Impacts that Cannot be Avoided

Truck and equipment traffic will generate dust during dry periods and increase engine emission at the proposed landfill site. Methane, carbon dioxide, nitrogen and hydrogen sulfide gases are produced as the result of solid waste decomposition. The engineering plans include gas vents for the proposed site. Noise and vibrations will be produced by machinery operation and truck traffic at the landfill. Leachate collection will minimize groundwater impacts. The construction of dikes and roads and landfilling operations will alter present topographic and drainage patterns at the landfill.

9.4 Irreversible or Irretrievable Commitments of Resources

Development of the proposed MRDF will require the expenditure of non-recoverable energy. Movement of the earth will be done by bulldozers, scrapers, graders, etc. all of which consume diesel fuel or gasoline. It is estimated that during the life of the site (36 years) approximately 116,000 cubic yards of earth will have to be excavated. However, it can be assumed that some similar construction would occur at wherever the wastes are disposed. In addition, the energy costs associated with waste hauling will be lower with an on-site facility.

9.5 Direct, Indirect and Cummulative Effects

A direct effect of developing the MRDF is the modification of the surface

topography of the site. The final site elevation will in places be increased approximately 30 feet. The change in elevation will be unobstrusive because it will be similar to the elevation difference currently evident adjacent to the site. The development of this site is, by itself, limited in the negative impact it will have upon the environment. As designed, the project should not contaminate surface or groundwater resources, degrade air quality, or harm the ecosystem during its operation.

9.6 Alternatives

Variations of the proposed action have been considered. Alternative sites of waste disposal are the City of Antigo Landfill, Town of Nashville Landfill, and Ridgeview Landfill in Manitowoc County. These alternative sites would require transportation of refuse and waste considerable distance on public access roads. In addition, a long term commitment would be required from the communities or corporations involved to receive the waste and refuse.

The November 9, 1984 Exxon letter to the DNR (Appendix A) discusses alternatives to landfilling. Where possible, materials will be reused, returned to vendors, salvaged or properly burned in the air curtain destructor to reduce the amount that needs to be landfilled. Recycling markets do not exist that can handle most of the construction, operating and reclamation refuse that will be generated at the Crandon Project. Therefore, a landfill is necessary.

Forest County does not have a state approved solid waste management plan. Also, there are no county recycling programs that would impact the development of the MRDF.

10.0 CONCLUSIONS ON SITE FEASIBILITY

The proposed location of the Mine Refuse Disposal Facility (MRDF) is on 12 acres in an upland wooded area adjacent to the proposed Mine Waste Disposal Facility (MWDF). The upland location of the proposed MRDF provides for minimal disturbance of surface hydrologic features of streams and lakes. In addition, a large separation distance will exist between the base of the refuse and the water table.

Exxon Corporation owns the land to be developed for the proposed MRDF. No archaeological or historical sites are present at the proposed location. Access to the facility will be on privately owned roads.

The upland location provides for minimal impact on terrestrial and aquatic ecosystems. No threatened or endangered species will be affected by the proposed development.

The on-site soils have been characterized by site specific test pits and related to regional information gathered for the development of the MWDF. The site is generally underlain with a substantial thickness of glacial till and outwash material. The proposed site is an area of groundwater recharge.

The proposed MRDF will provide a safe depository for construction refuse and waste, operation refuse, and reclamation refuse and waste. No hazardous wastes will be deposited in the facility.

The proposed MRDF is in compliance with all location criteria as specified in NR 180.13(3). The three cells will be constructed sequentially maintaining an approximate balance between excavation and fill requirements. Leachate collection, gas vents, and liner performance monitoring features

have been included in the proposed design. The facility will be operated as a sanitary landfill. Reclamation and revegetation will allow the site to be returned to the ecosystem present in the area.

The development of the MRDF as an on-site disposal facility for the Crandon Project helps to reduce the impact upon the physical, biological, social and economic systems of the area. It is an integral part of the Crandon Project.

The conclusion of this report is that the development of the proposed MRDF at the location specified herein, is most feasible, with minimal impact on the environment.

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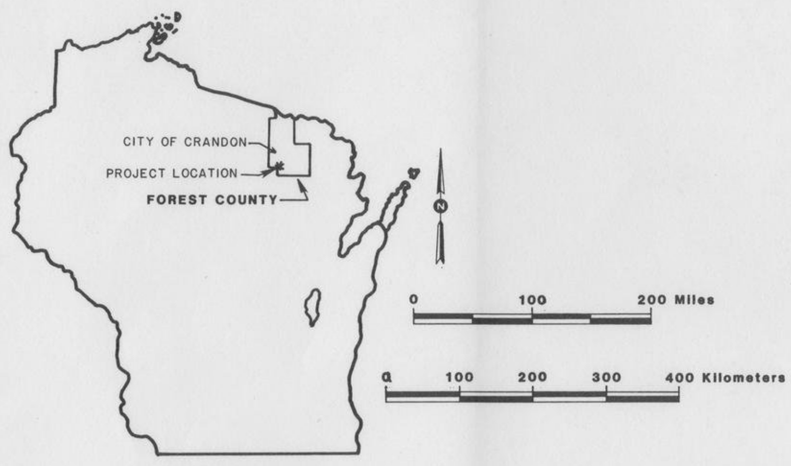
12.0 GLOSSARY

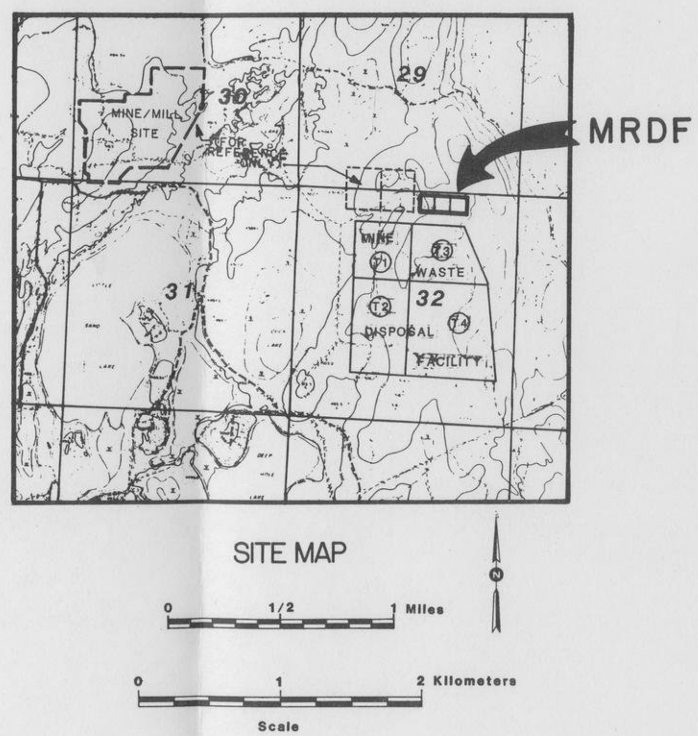
1. Aquifer	soil or rock strata capable of yielding usable quantities of water to wells. As used in this report, it includes both fine and coarse-grained stratified drift.
2. Basal Till	glacial till deposit found on the bedrock surface.
3. Bentonite	clay mineral montmorillonite which has a great ability to absorb water and swell.
4. Glacial Till	non-sorted, non-stratified sediment deposited directly by a glacier.
5. Lacustrine	as used in this report, it refers to soil (usually fine-grained) deposited at the bottom of lakes, both glacial and recent deposits under Little Sand, Oak, Skunk, Deep Hole and Duck Lakes.
6. Outwash	soil deposited by meltwater streams flowing from a glacier. Deposits are usually stratified.
7. Piezometer	groundwater observation well sealed into a particular soil or rock stratum used to measure groundwater or hydrostatic pressure.
8. Perched Lake	the surface water level is above the groundwater potentiometric surface (water table).
9. Potentiometric Surface Map	subsurface contour map showing the elevation of the water table.
10. Stratified Drift	synonymous with glacial outwash.
11. Varves	a series of thin layers of soil representing seasonal sedimentation typically found in lacustrine deposits.

FEASIBILITY STUDY AND PRELIMINARY ENGINEERING PLANS
MINE REFUSE DISPOSAL FACILITY
(MRDF)
CRANDON PROJECT
EXXON MINERALS COMPANY

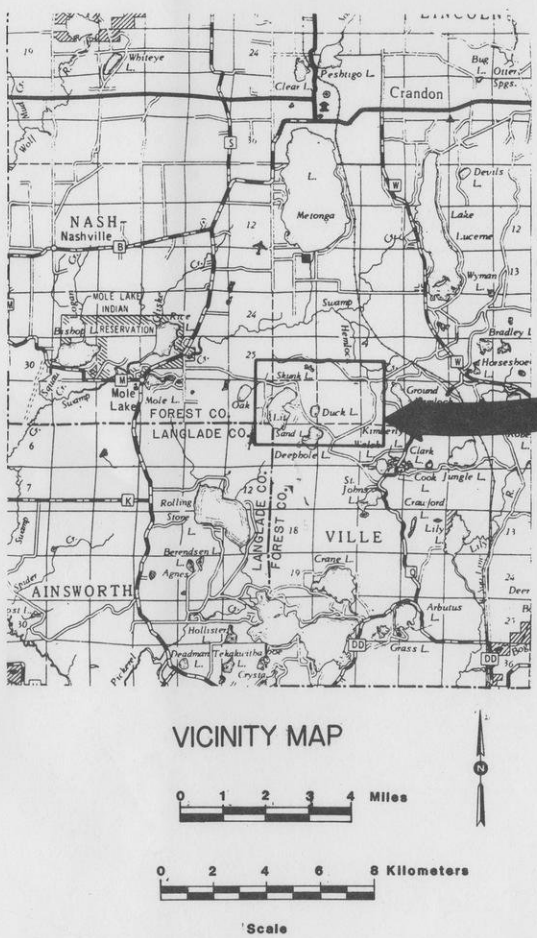
N 1/2, NW 1/4, NE 1/4, SEC. 32, T. 35 N., R. 13 E.
TOWN OF LINCOLN, FOREST COUNTY, WISCONSIN
NR 180.13(6)



COUNTY MAP



SITE MAP



VICINITY MAP

INDEX		
PLAN SHEET	STS DRAWING	TITLE
1	14028-1	TITLE SHEET
2	14028-2	EXISTING CONDITIONS - LAND USE MAP
3	14028-3	TOP OF BEDROCK CONTOUR MAP
4	14028-4	REGIONAL GROUNDWATER POTENTIOMETRIC CONTOURS
5	14028-5	LAND OWNERSHIP AND ZONING MAP
6	14028-6	MRDF SITE SPECIFIC TOPOGRAPHY AND SURFACE DRAINAGE
7	14028-7	MRDF BORING, TESTPIT, WELL LOCATION DIAGRAM AND CROSS SECTION INDEX
8	14028-8	GEOLOGIC CROSS SECTION A-A'
9	14028-9	GEOLOGIC CROSS SECTION B-B'
10	14028-10	GEOLOGIC CROSS SECTION C-C'
11	14028-11	GEOLOGIC CROSS SECTION D-D'
12	14028-12	GEOLOGIC CROSS SECTION E-E'
13	14028-13	MRDF AREA GROUNDWATER POTENTIOMETRIC CONTOURS
14	14028-14	PROPOSED SITE DEVELOPMENT
15	14028-15	TYPICAL CROSS-SECTIONS
16	14028-16	PROPOSED FINAL GRADES AND LONG TERM CARE
17	14028-17	CONSTRUCTION DETAILS

WISCONSIN PROFESSIONAL ENGINEER WILLIAM ... E-8301 Green Bay, Wis.

PREPARED BY

STS CONSULTANTS LTD.

PLAN SHEET 1

STS Consultants Ltd.
540 Lambeau St. Green Bay, Wisconsin
ph.414-494-9656

EXXON MINERALS COMPANY
CRANDON PROJECT

TITLE: TITLE SHEET			
SCALE: AS SHOWN	STATE: WISCONSIN	COUNTY: FOREST	
DRAWN BY: P.D.P.	DATE: 11-18-85	CHECKED BY:	DATE:
APPROVED BY: J.W.K. / J.A.S.	DATE: 11-18-85	APPROVED BY:	DATE:
APPROVED BY:	DATE:	EXXON	DATE:
DRAWING NO: 14028-1		SHEET ___ OF ___	REVISION NO

N-33,000

DEEP HOLE LAKE

DUCK LAKE

SKUNK LAKE

WALSH LAKE

MINE WASTE DISPOSAL FACILITY (FOR REFERENCE ONLY)

RECLAIM POND CELL A (FOR REFERENCE ONLY)

RECLAIM POND CELL B

MINE REFUSE DISPOSAL FACILITY CELL 1 CELL 2 CELL 3

CONSTRUCTION SUPPORT AREA

FUTURE BORROW AREA (FOR REFERENCE ONLY)

AIR CURTAIN DESTRUCTOR (FOR REFERENCE ONLY)

T1 T2 T3 T4

LEGEND

U – UPLAND FOREST
DS – DECIDUOUS SWAMP
CS – CONIFEROUS SWAMP
SS – SHRUB SWAMP
SM – SHALLOW MARSH
AB – AQUATIC BED
B – BOG
RI – RESIDENTIAL/INSTITUTIONAL
RC – RECREATIONAL

NOTES

1. NO THREATENED OR ENDANGERED SPECIES HABITAT
2. NO ARCHAEOLOGICAL OR HISTORICAL SITES

WILLIAM W. PEPPER E-3301 Green Bay, Wis. PROFESSIONAL ENGINEER

0 100 200 300 400 500
SCALE IN METERS
0 400 800 1200 1600
SCALE IN FEET

PLAN SHEET 2

STS Consultants Ltd.
540 Lambeau St. Green Bay, Wisconsin
ph.414-494-9656

EXXON MINERALS COMPANY
CRANDON PROJECT

TITLE
M R D F AREA
EXISTING CONDITIONS/LAND USE

SCALE AS SHOWN	STATE WISCONSIN	COUNTY FOREST					
DRAWN BY C. HACKER	DATE 8/82	CHECKED BY	DATE				
APPROVED BY J.W.K./J.A.S.	DATE 11-15-85	APPROVED BY	DATE				
APPROVED BY	DATE	ERROR	DATE				
DRAWING NO. 14028-2	SHEET OF	REVISION NO. 2					

REVISED	DATE	BY	DESCRIPTION
2	9-25-85	JJT	REVISED POND LOCATIONS
1	8-29-84	D.R.L.	GENERAL REVISIONS

E 690,000 E 691,000 E 692,000 E 693,000 E 694,000 E 695,000 E 696,000 E 697,000 E 698,000

N 38,000 30' N 37,000 N 36,000 29' N 35,000 N 34,000 28'

T 35 N
FOREST CO
LANGLADE CO
T 34 N

— T35N —
T34N

RECLAIM POND
(FOR REFERENCE ONLY)

1 | 2 | 3 MINE REFUSE DISPOSAL FACILITY (MRDF)

MINE WASTE DISPOSAL FACILITY (MWDF)
(FOR REFERENCE ONLY)

RICE LAKE
MOLE LAKE
OAK LAKE
LITTLE SAND LAKE
DEEP HOLE LAKE
DUCK LAKE
HEMLOCK CREEK
SWAMP CREEK

LEGEND

440 — BEDROCK CONTOURS IN METERS ABOVE MSL

CRANDON FORMATION

0 1000 2000 3000
SCALE IN FEET
0 250 500 1000
SCALE IN METERS

REVISED	DATE	BY

WISCONSIN
WILLIAM M. PERRIGO
E-18831
Green Bay, Wis.
PROFESSIONAL ENGINEER

PLAN SHEET 3

STS Consultants Ltd.
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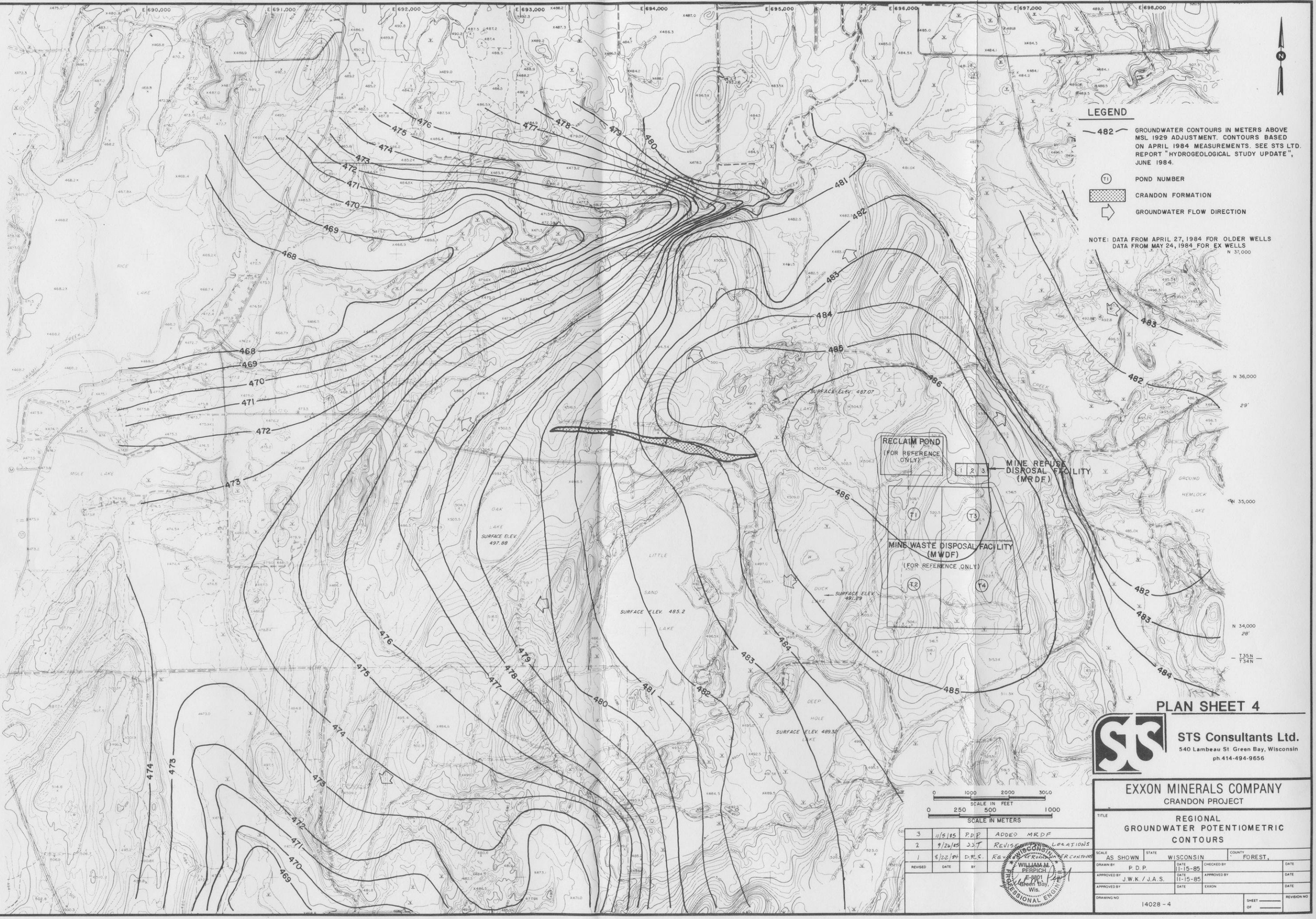
EXXON MINERALS COMPANY
CRANDON PROJECT

TITLE
TOP OF BEDROCK CONTOUR MAP

SCALE AS SHOWN	STATE WISCONSIN	COUNTY FOREST	
DRAWN BY P. D. P.	DATE 11/5/85	CHECKED BY	DATE
APPROVED BY J.W.K. / J.A.S.	DATE 11-15-85	APPROVED BY	DATE
APPROVED BY	DATE	EXXON	DATE
DRAWING NO 14028-3	SHEET — OF —		REVISION NO

DESIGN PRODUCTS CO —



LEGEND

- 482 — GROUNDWATER CONTOURS IN METERS ABOVE MSL 1929 ADJUSTMENT. CONTOURS BASED ON APRIL 1984 MEASUREMENTS. SEE STS LTD. REPORT "HYDROGEOLOGICAL STUDY UPDATE", JUNE 1984.
- (T1) POND NUMBER
- CRANDON FORMATION
- GROUNDWATER FLOW DIRECTION

NOTE: DATA FROM APRIL 27, 1984 FOR OLDER WELLS
DATA FROM MAY 24, 1984 FOR EX WELLS

0 1000 2000 3000
SCALE IN FEET
0 250 500 1000
SCALE IN METERS

REVISED	DATE	BY	
3	11/5/85	P.D.P	ADDED MRDF
2	9/26/85	J.J.T	REVISED WELL LOCATIONS
1	8/22/84	D.R.S.	REVISED WATER CONTOURS

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PLAN SHEET 4

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EXXON MINERALS COMPANY
CRANDON PROJECT

TITLE
REGIONAL
GROUNDWATER POTENTIOMETRIC
CONTOURS

SCALE	STATE	COUNTY
AS SHOWN	WISCONSIN	FOREST,

DRAWN BY P.D.P.	DATE 11-15-85	CHECKED BY	DATE
APPROVED BY J.W.K. / J.A.S.	DATE 11-15-85	APPROVED BY	DATE
APPROVED BY	DATE	EXXON	DATE

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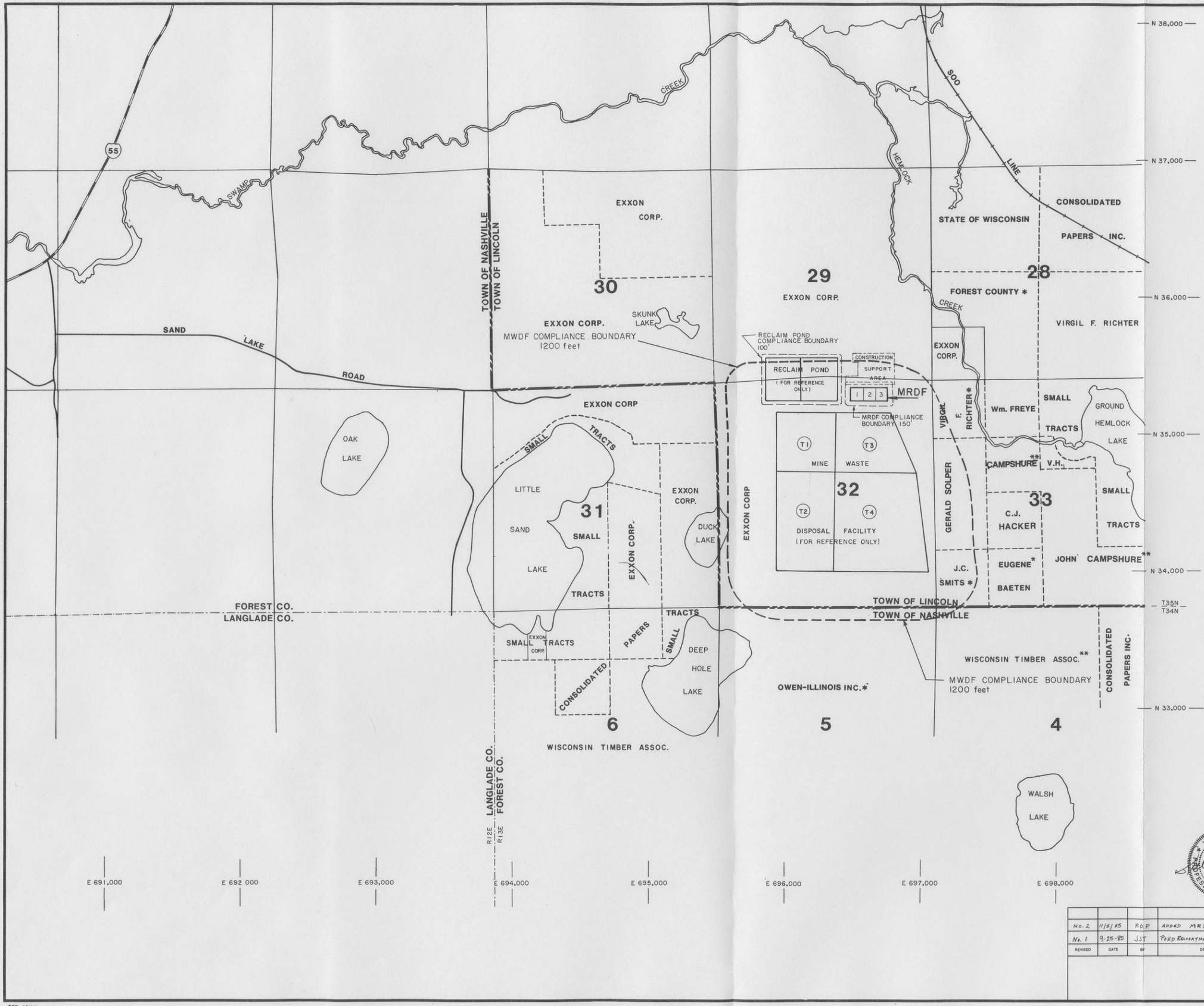
DESIGN PRODUCTS CO —



NOTES:

1) ZONING IS ALL GENERAL RURAL EXCEPT THOSE LANDS WITHIN 300 FEET FROM NORMAL HIGH WATER MARK OF CREEKS AND STREAMS AND 1000 FEET FROM NORMAL HIGH WATER MARK OF LAKES WHICH ARE ZONED AS SHORELINE

2) MAP COORDINATES ARE IN METERS REFERENCED TO WISCONSIN STATE PLANE COORDINATE SYSTEM

3) * EXXON LAND PURCHASE OPTION

4) ** EXXON MINING LEASE

LEGEND

(T1) TAILINGS POND NO. 1

0 250 500 750 1000 Meters

SCALE 1:12,500

0 1000 2000 3000 Feet

PLAN SHEET 5

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PROFESSIONAL ENGINEER

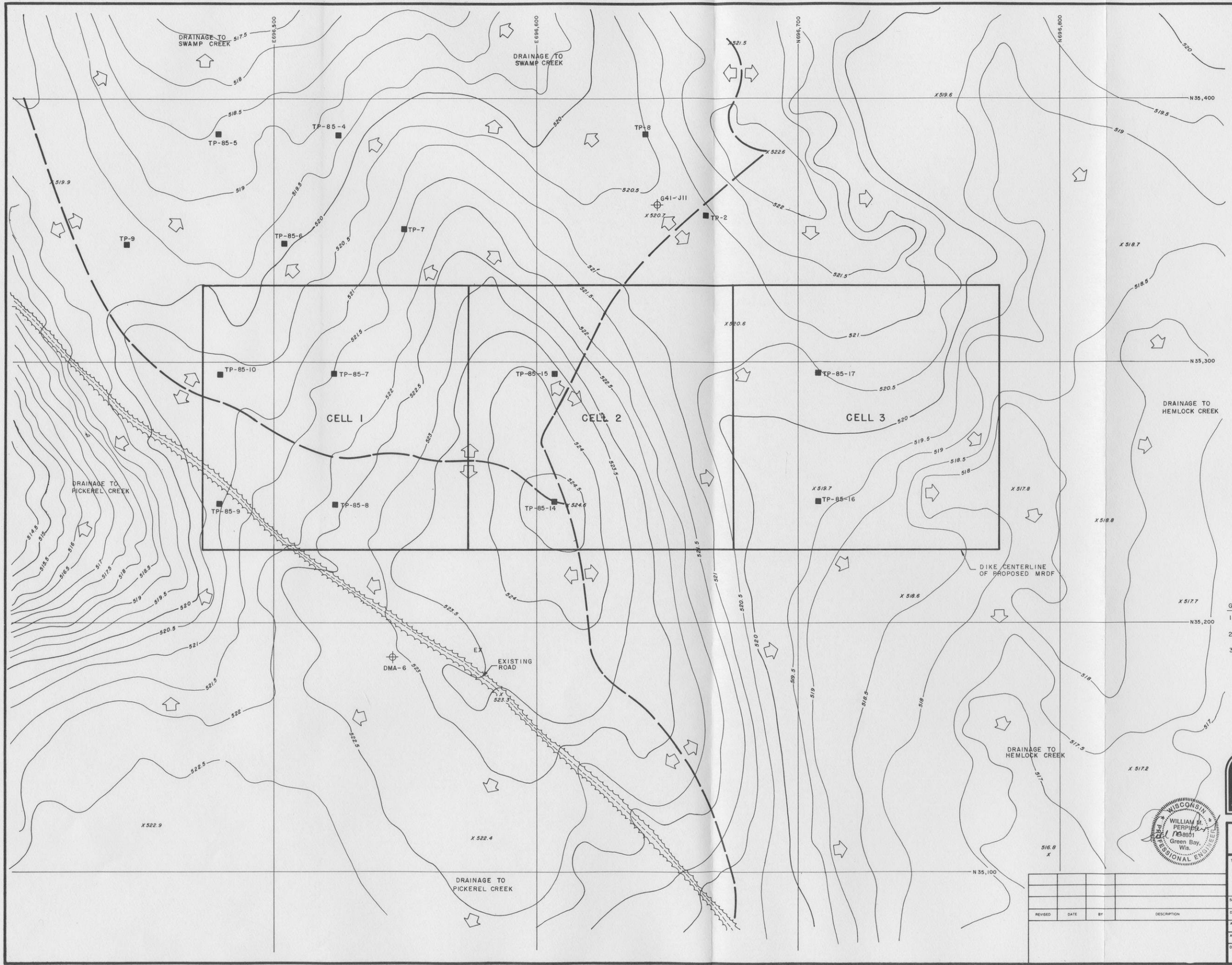
EXXON MINERALS COMPANY
CRANDON PROJECT

TITLE
MINE REFUSE DISPOSAL FACILITY AREA
LAND OWNERSHIP & ZONING MAP

REVISED	DATE	BY	DESCRIPTION
NO. 2	11/8/85	P.D.P.	ADDED MRDF
No. 1	9-25-85	JJT	POND RECREATION + LAND OWNERSHIP

SCALE 1:12500	STATE WISCONSIN	COUNTY FOREST	
DRAWN BY JP BECKER	DATE 9/82	CHECKED BY	DATE
APPROVED BY J.W.K. / J.A.S.	DATE 11-15-85	APPROVED BY	DATE
APPROVED BY	DATE	EXXON	DATE
DRAWING NO. 14028-5	SHEET OF	REVISION NO. 2	

GBB 5/1981



LEGEND

- SOIL BORING LOCATION
- TEST PIT LOCATION
- SURFACE DRAINAGE DIVIDE
- SURFACE DRAINAGE DIRECTION

-N-

0 50 100 150 200
SCALE IN FEET
0 25 50
SCALE IN METERS

GENERAL NOTES:

1. ELEVATIONS IN METERS ABOVE MSL BASED ON 1929 ADJUSTMENT.
2. BASE MAP AND AERIAL PHOTOGRAPHY (1976) BY AERO-METRIC ENGINEERING, INC.
3. GRID COORDINATES IN METERS BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM.

PLAN SHEET 6

STS Consultants Ltd.
540 Lambeau St. Green Bay, Wisconsin
ph.414-494-9656

WISCONSIN
WILLIAM M. PERPICH
Reg. No. 18801
Green Bay, Wis.
PROFESSIONAL ENGINEER

REVISED	DATE	BY	DESCRIPTION

EXXON MINERALS COMPANY
CRANDON PROJECT

TITLE
MRDF SITE SPECIFIC TOPOGRAPHY AND SURFACE DRAINAGE

SCALE AS SHOWN	STATE WISCONSIN		COUNTY FOREST
DRAWN BY P. D. P.	DATE 11-15-85	CHECKED BY	DATE
APPROVED BY J.W.K. / J.A.S.	DATE 11-15-85	APPROVED BY	DATE
APPROVED BY	DATE	EXXON	DATE
DRAWING NO 14028-6		SHEET OF	REVISION NO

NOTES:

1) INSPECTION OF BORINGS AND GROUNDWATER OBSERVATION WELL INSTALLATION AND REPORT REFERENCES FOR LOGS AND DETAILS AS FOLLOWS:

BORING PREFIX	INSPECTION BY	REPORT REFERENCE FOR DETAILS
G40, G41, and TP	GOLDER ASSOCIATES	GOLDER ASSOCIATES, "GEOTECHNICAL REVIEW, CRANDON PROJECT WASTE DISPOSAL SYSTEM, PROJECT REPORT 2", VOLUMES 1, 2, and 3, OCTOBER 81
X	EXXON MINERALS CO	SAME AS ABOVE
DMA, DMB, and DW	DAMES & MOORE	DAMES & MOORE, "EXXON MINERALS COMPANY CRANDON PROJECT, ENVIRONMENTAL BASELINE STUDY", SECTION 2.2, GEOLOGY STUDY and STUDY METHODS, APRIL 1981.
TW-41	GOLDER ASSOCIATES	GOLDER ASSOCIATES, "PUMP TEST and ANALYSES, CRANDON PROJECT WASTE DISPOSAL SYSTEM, PROJECT REPORT 4", SEPTEMBER 1981.
TW-1	DAMES & MOORE	DAMES & MOORE, "INVESTIGATION OF FEASIBILITY OF DEWATERING and OTHER ALTERNATIVES FOR OPEN PIT MINE OPTION, NEAR CRANDON, WISCONSIN", MAY 1977.
FR	UNKNOWN (DATA SUPPLIED BY USGS)	GOLDER ASSOCIATES, "GROUNDWATER POTENTIOMETRIC CONTOURS, CRANDON PROJECT WASTE DISPOSAL SYSTEM, PROJECT REPORT 7", SEPTEMBER 1981.
EX, WP and STS	EXXON, STS LTD.	STS LTD., "HYDROGEOLOGIC STUDY UPDATE", JUNE 1984
TP-84-1	EXXON, STS LTD.	STS LTD., "MWDF LINER MATERIALS TEST PITS", AUGUST 1984
TP-85-1	STS	MRDF FEASIBILITY STUDY NOVEMBER, 1985

LEGEND

- TEST BORING
- TEST BORING INCLUDING GROUNDWATER OBSERVATION WELL
- TEST BORING INCLUDING MULTIPLE GROUNDWATER OBSERVATION WELLS
- GOLDER ASSOCIATES & STS LTD, TEST PIT LOCATION
- GOLDER ASSOCIATES TEST WELL TW-41 LOCATION
- DAMES & MOORE TEST WELL TW-1 LOCATION
- USGS OBSERVATION WELL LOCATION
- BORING AND GEOLOGIC CROSS-SECTION LOCATION
- (T1) POND NUMBER

0 100 200 400 600 800
SCALE IN FEET
0 50 100 150 200 250
SCALE IN METERS

GENERAL NOTES:

1. ELEVATIONS IN METERS ABOVE MSL BASED ON 1929 ADJUSTMENT.
2. BASE MAP AND AERIAL PHOTOGRAPHY (1976) BY AERO-METRIC ENGINEERING, INC.
3. GRID COORDINATES IN METERS BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM.
4. CONTOURS SHOWN WITHIN THE POND CONFINES ARE FINISHED GRADE/TOP OF FILTER LAYER UNLESS OTHERWISE INDICATED.

ACTUAL LOCATION OF WELL IS 75 METERS NORTH

CENTERLINE OF MRDF DIKE

MINE WASTE DISPOSAL FACILITY (FOR REFERENCE ONLY)

RECLAIM POND CELL A (FOR REFERENCE ONLY)

RECLAIM POND CELL B

CELL 1

CELL 2

CELL 3

T-1 T-2 T-3 T-4

CREST 528

PLAN SHEET 7

STS Consultants Ltd.
540 Lambeau St. Green Bay, Wisconsin
ph.414-494-9656

WISCONSIN WILLIAM M. PERRICH E-26601 Green Bay, Wis. PROFESSIONAL ENGINEER

REVISED	DATE	BY	DESCRIPTION

EXXON MINERALS COMPANY
CRANDON PROJECT

TITLE: MRDF BORING, TEST PIT, WELL LOCATION DIAGRAM AND CROSS-SECTION INDEX

SCALE	STATE	COUNTY
AS SHOWN	WISCONSIN	FOREST

DRAWN BY	DATE	CHECKED BY	DATE
P.D.P.	11-13-85		
APPROVED BY	DATE	APPROVED BY	DATE
J.W.K. / J.A.S.	11-15-85		
APPROVED BY	DATE	EXXON	DATE

DRAWING NO: 14028 - 7 | SHEET ___ OF ___ | REVISION NO

A

A'

ELEVATIONS (MSL)
METERS FEET

525 1720
1700
1680
1660
500 1640
1620
1600
1580
475 1560
1540
1520
1500
1480
450 1460
1440
1420
425 1400
1380

EX-10
G41-G12
EX-9
G41-H9

EOB

AU & AL
BU
BL
BU

$K_H = 2 \times 10^{-5}$ cm/sec

BL
$K_H = 2 \times 10^{-3}$ cm/sec

AU
$K_H = 2 \times 10^{-3}$ cm/sec

AU
$K_H = 6 \times 10^{-3}$ cm/sec

AL
$K_H = 2 \times 10^{-5}$ cm/sec

AL
$K_H = 2 \times 10^{-8}$ cm/sec

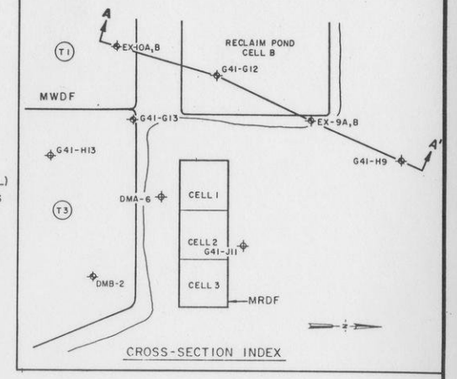
EOB

AU & AL
BU & BL
BU

BL
$K_H = 2 \times 10^{-3}$ cm/sec

EOB

(5-9-85)



CROSS-SECTION INDEX

100 50 0 100 200 300
SCALE IN FEET

25 0 50 100
SCALE IN METERS

VERTICAL EXAGGERATION : 5x

LEGEND

- LACUSTRINE
- TILL
- COARSE GRAINED STRATIFIED DRIFT
- FINE GRAINED STRATIFIED DRIFT
- BASAL TILL
- BEDROCK
- WATER LEVEL IN WELL 7-24-85
- GRAVEL PACK
- WELL SCREEN
- END OF BORING
- K_H = HORIZONTAL FIELD PERMEABILITY (STS,1984)

NOTE: PROJECTIONS OF SOIL STRATA BASED ON DATA FROM BORING LOCATIONS. SOIL CONDITIONS BETWEEN BORINGS MAY VARY.

NOTE: WHERE MULTIPLE PIEZOMETERS OCCUR, THE PIEZOMETER DESIGNATION IS AS FOLLOWS: DEEP BOREHOLE IS LABELED "A", SHALLOW BOREHOLE IS LABELED "B". UPPER PIEZOMETER IS LABELED "U", LOWER PIEZOMETER IS LABELED "L".
Eg: THE UPPER PIEZOMETER IN THE DEEP BOREHOLE AT EX-10 IS DESIGNATED AS EX-10AU.

REVISED	DATE	BY

WISCONSIN
WILLIAM M. DEDRICH
E-16001
Green Bay, Wis.
REGISTERED PROFESSIONAL ENGINEER

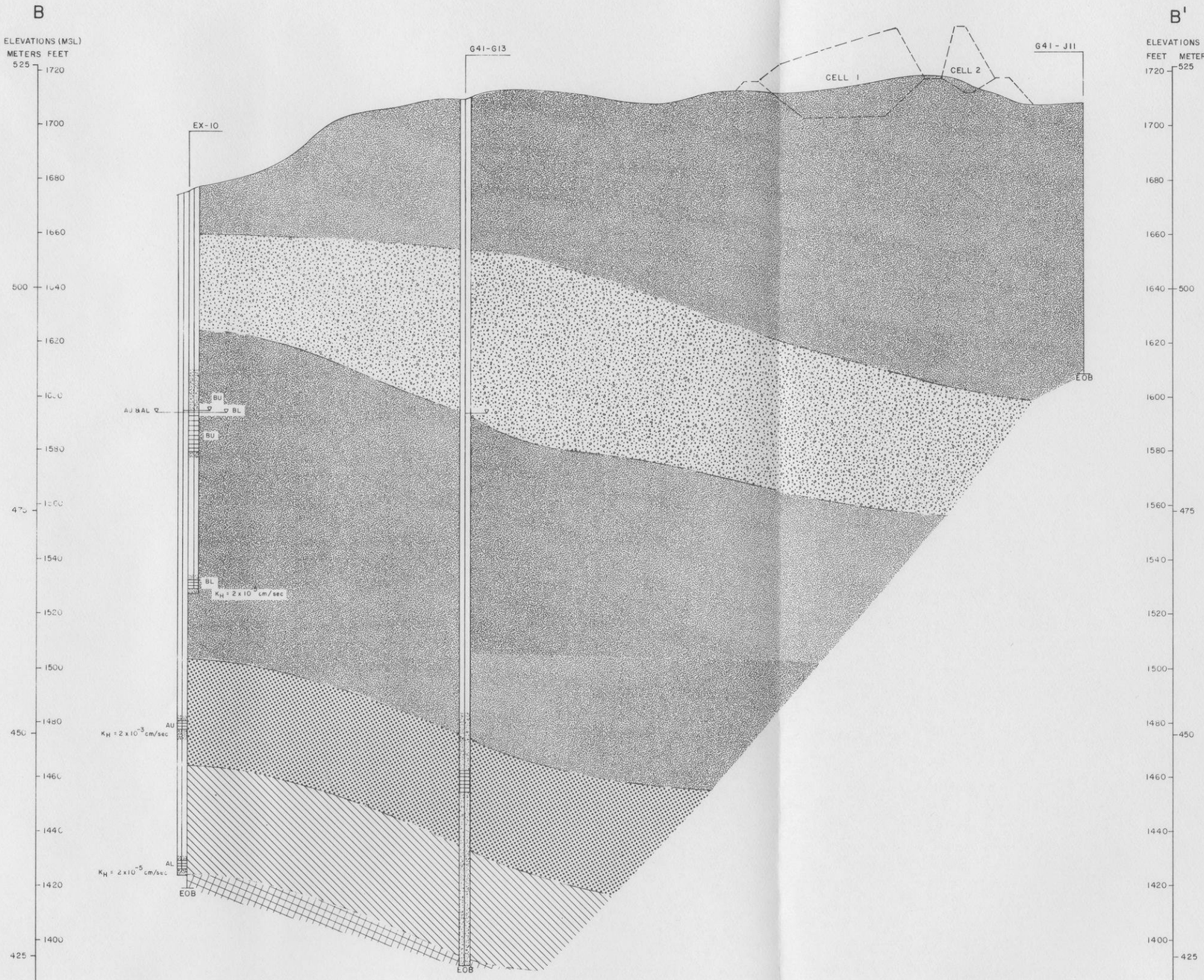
PLAN SHEET 8

STS Consultants Ltd.
540 Lambeau St. Green Bay, Wisconsin
ph.414-494-9656

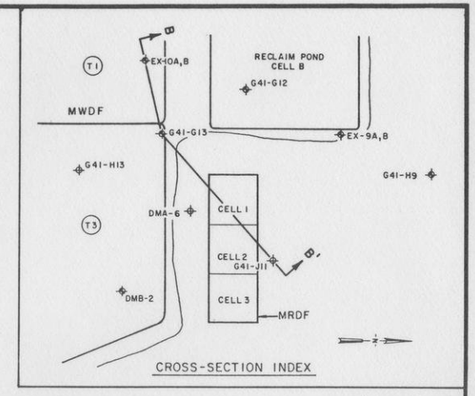
EXXON MINERALS COMPANY
CRANDON PROJECT

TITLE: GEOLOGIC CROSS SECTION A-A'

SCALE: AS SHOWN	STATE: WISCONSIN		COUNTY: FOREST
DRAWN BY: P.D.P.	DATE: 10/28/85	CHECKED BY:	DATE
APPROVED BY: J.W.K. / J.A.S.	DATE: 11/5/85	APPROVED BY:	DATE
APPROVED BY:	DATE:	EXXON:	DATE
DRAWING NO: 14028-8	SHEET ___ OF ___		REVISION NO



NOTE: WHERE MULTIPLE PIEZOMETERS OCCUR, THE PIEZOMETER DESIGNATION IS AS FOLLOWS: DEEP BOREHOLE IS LABELED "A", SHALLOW BOREHOLE IS LABELED "B". UPPER PIEZOMETER IS LABELED "U", LOWER PIEZOMETER IS LABELED "L".
Eg: THE UPPER PIEZOMETER IN THE DEEP BOREHOLE AT EX-10 IS DESIGNATED AS EX-10AU.



100 50 0 100 200 300
SCALE IN FEET

25 0 50 100
SCALE IN METERS

VERTICAL EXAGGERATION : 5x

LEGEND

- LACUSTRINE
- TILL
- COARSE GRAINED STRATIFIED DRIFT
- FINE GRAINED STRATIFIED DRIFT
- BASAL TILL
- BEDROCK
- WATER LEVEL IN WELL 7-24-85
- GRAVEL PACK
- WELL SCREEN
- EOB — END OF BORING
- K_H = HORIZONTAL FIELD PERMEABILITY (STS, 1984)

NOTE: PROJECTIONS OF SOIL STRATA BASED ON DATA FROM BORING LOCATIONS. SOIL CONDITIONS BETWEEN BORINGS MAY VARY.

PLAN SHEET 9

STS Consultants Ltd.
540 Lambeau St. Green Bay, Wisconsin
ph.414-494-9656

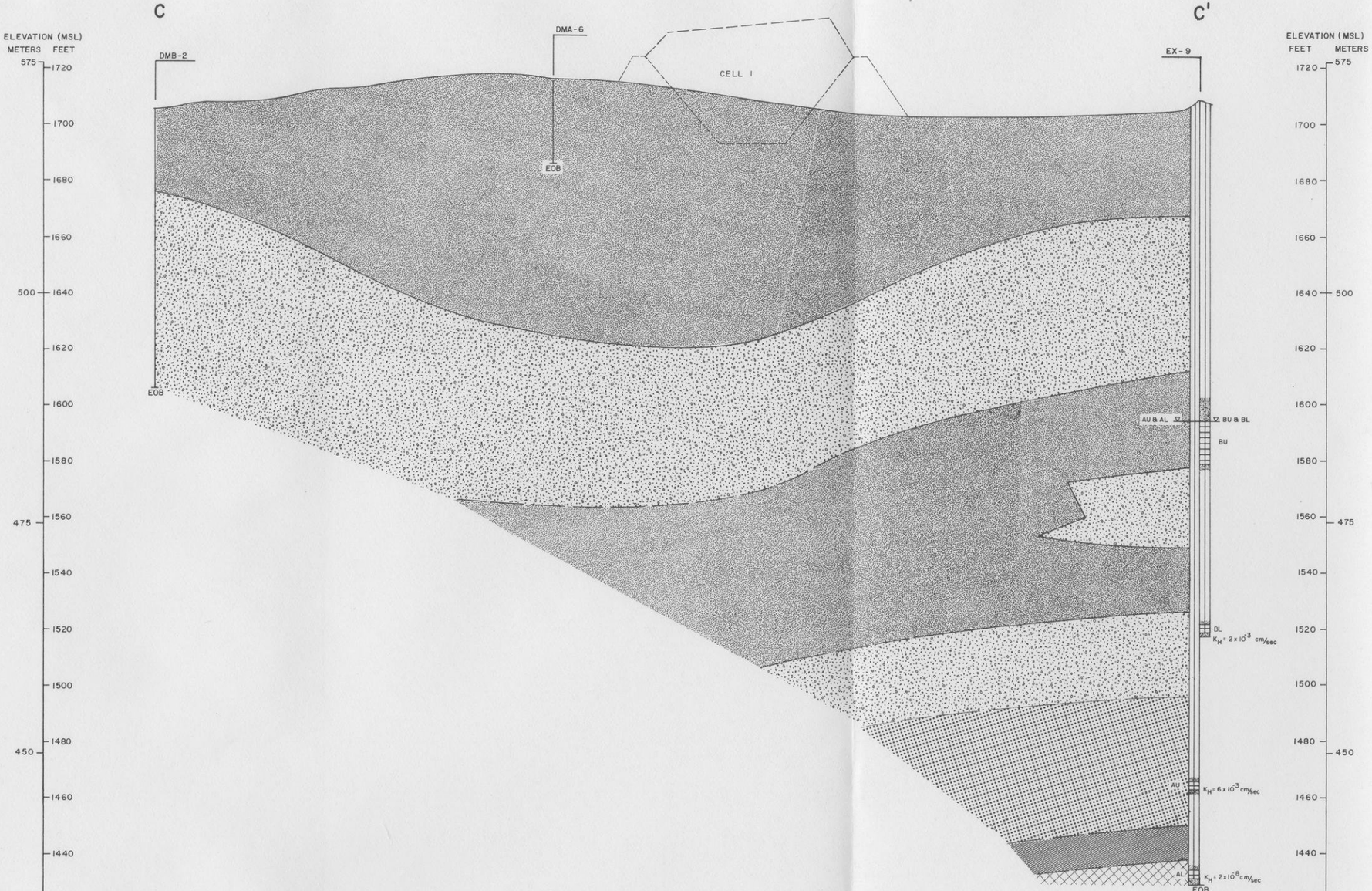
WILLIAM M. PERPICH 5880 Green Bay, Wis. PROFESSIONAL ENGINEER WISCONSIN

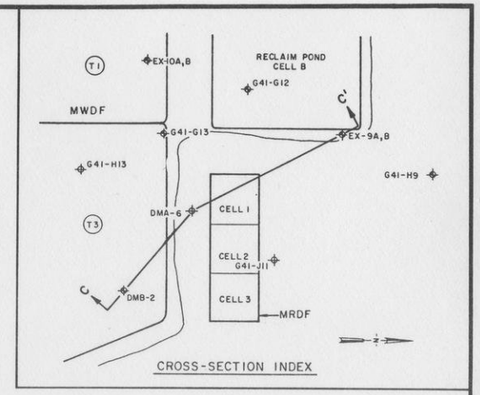
REVISED	DATE	BY	DESCRIPTION

EXXON MINERALS COMPANY
CRANDON PROJECT

TITLE: GEOLOGIC CROSS SECTION B-B'

SCALE: AS SHOWN	STATE: WISCONSIN		COUNTY: FOREST
DRAWN BY: P.D.P.	DATE: 11/4/85	CHECKED BY:	DATE
APPROVED BY: J.W.K. / J.A.S.	DATE: 11/5/85	APPROVED BY:	DATE
APPROVED BY:	DATE	EXXON	DATE
DRAWING NO: 14028-9	SHEET — OF —		REVISION NO





100 50 0 100 200 300
SCALE IN FEET

25 0 50 100
SCALE IN METERS

VERTICAL EXAGGERATION : 5x

LEGEND

- LACUSTRINE
- TILL
- COARSE GRAINED STRATIFIED DRIFT
- FINE GRAINED STRATIFIED DRIFT
- BASAL TILL
- BEDROCK
- ▽ WATER LEVEL IN WELL 7-24-85
- GRAVEL PACK
- WELL SCREEN
- EOB — END OF BORING
- K_H = HORIZONTAL FIELD PERMEABILITY (STS, 1984)

NOTE: PROJECTIONS OF SOIL STRATA BASED ON DATA FROM BORING LOCATIONS. SOIL CONDITIONS BETWEEN BORINGS MAY VARY.

NOTE: WHERE MULTIPLE PIEZOMETERS OCCUR, THE PIEZOMETER DESIGNATION IS AS FOLLOWS: DEEP BOREHOLE IS LABELED "A", SHALLOW BOREHOLE IS LABELED "B". UPPER PIEZOMETER IS LABELED "U", LOWER PIEZOMETER IS LABELED "L".
Eg: THE UPPER PIEZOMETER IN THE DEEP BOREHOLE AT EX-10 IS DESIGNATED AS EX-10AU.

REVISED	DATE	BY	DESCRIPTION

WISCONSIN — WILLIAM M. PERPICH — 17809 — Green Bay, Wis. — PROFESSIONAL ENGINEER

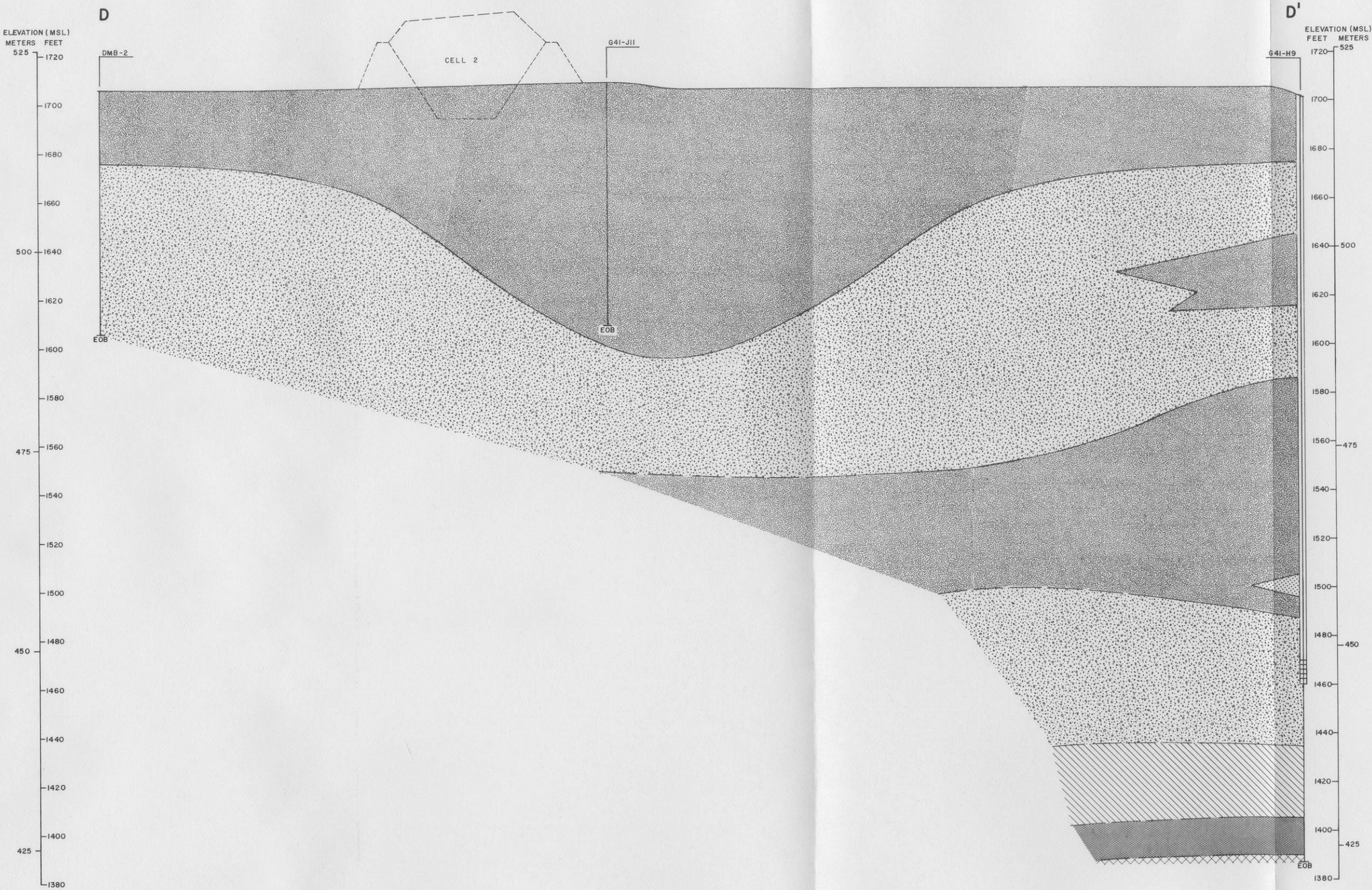
PLAN SHEET 10

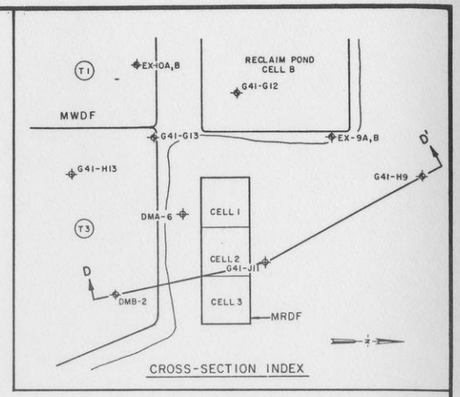
STS Consultants Ltd.
540 Lambeau St. Green Bay, Wisconsin
ph.414-494-9656

EXXON MINERALS COMPANY
CRANDON PROJECT

TITLE
GEOLOGIC CROSS-SECTION C-C'

SCALE AS SHOWN	STATE WISCONSIN		COUNTY FOREST		
DRAWN BY K.J.C.	DATE 11-4-85	CHECKED BY	DATE		
APPROVED BY J.W.K. / J.A.S.	DATE 11-5-85	APPROVED BY	DATE		
APPROVED BY	DATE	EXXON	DATE		
DRAWING NO 14028-10	SHEET — OF —	REVISION NO			





CROSS-SECTION INDEX

100 50 0 100 200 300
SCALE IN FEET

25 0 50 100
SCALE IN METERS

VERTICAL EXAGGERATION : 5x

LEGEND

- LACUSTRINE
- TILL
- COARSE GRAINED STRATIFIED DRIFT
- FINE GRAINED STRATIFIED DRIFT
- BASAL TILL
- BEDROCK
- WATER LEVEL IN WELL 7-24-85
- GRAVEL PACK
- WELL SCREEN
- EOB — END OF BORING
- K_H = HORIZONTAL FIELD PERMEABILITY (STS, 1984)

NOTE: PROJECTIONS OF SOIL STRATA BASED ON DATA FROM BORING LOCATIONS. SOIL CONDITIONS BETWEEN BORINGS MAY VARY.

PLAN SHEET 11

STS Consultants Ltd.
540 Lambeau St. Green Bay, Wisconsin
ph.414-494-9656

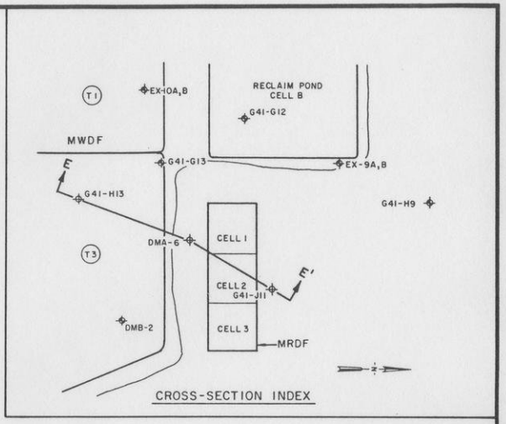
WISCONSIN
WILLIAM M. PERRICONE
E-8801
Green Bay, Wis.
PROFESSIONAL ENGINEER

REVISED	DATE	BY	DESCRIPTION

EXXON MINERALS COMPANY
CRANDON PROJECT

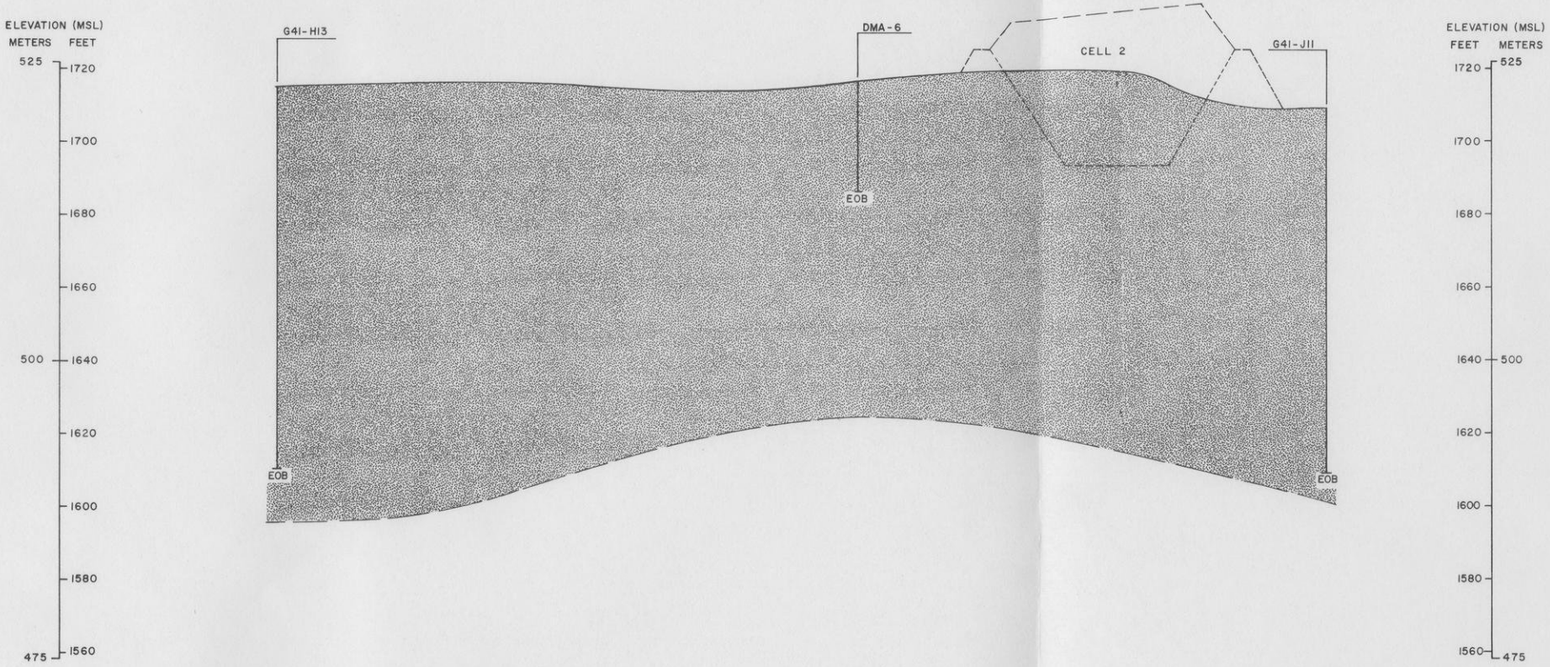
TITLE: GEOLOGIC CROSS-SECTION D-D'

SCALE: AS SHOWN	STATE: WISCONSIN		COUNTY: FOREST		
DRAWN BY: K.J.C.	DATE: 11-4-85	CHECKED BY:	DATE		
APPROVED BY: J.W.K. / J.A.S.	DATE: 11/5/85	APPROVED BY:	DATE		
APPROVED BY:	DATE	EXXON:	DATE		
DRAWING NO: 14028-11	SHEET ___ OF ___		REVISION NO		



CROSS-SECTION INDEX

E



E'

100 50 0 100 200 300
SCALE IN FEET

25 0 50 100
SCALE IN METERS

VERTICAL EXAGGERATION : 5x

LEGEND

- LACUSTRINE
- TILL
- COARSE GRAINED STRATIFIED DRIFT
- FINE GRAINED STRATIFIED DRIFT
- BASAL TILL
- BEDROCK
- WATER LEVEL IN WELL 7-24-85
- GRAVEL PACK
- WELL SCREEN
- EOB — END OF BORING
- K_H = HORIZONTAL FIELD PERMEABILITY (STS, 1984)

NOTE: PROJECTIONS OF SOIL STRATA BASED ON DATA FROM BORING LOCATIONS. SOIL CONDITIONS BETWEEN BORINGS MAY VARY.

PLAN SHEET 12

WILLIAM M. PERPICH E-28651 Green Bay, Wis. PROFESSIONAL ENGINEER WISCONSIN

STS Consultants Ltd.
540 Lambeau St. Green Bay, Wisconsin
ph.414-494-9656

EXXON MINERALS COMPANY
CRANDON PROJECT

TITLE: GEOLOGIC CROSS-SECTION E-E'

REVISED	DATE	BY	DESCRIPTION

SCALE: AS SHOWN	STATE: WISCONSIN		COUNTY: FOREST
DRAWN BY: K.J.C.	DATE: 11-4-85	CHECKED BY:	DATE
APPROVED BY: J.W.K. / J.A.S.	DATE: 11-5-85	APPROVED BY:	DATE
APPROVED BY:	DATE	EXXON:	DATE
DRAWING NO: 14028-12	SHEET ___ OF ___		REVISION NO

N 33.000

N 34.000

N 35.000

N 36.000

E 696.000

E 697.000

DEEP HOLE LAKE

DUCK LAKE

SKUNK LAKE

484

485

486

482

483

EX-16
485.76

G41-B12
486.24

DMB-1
486.04

EX-13
485.30

EX-11
485.89

EX-10
486.13

EX-12
485.68

EX-9
485.92

DMB-4
485.65

RECLAIM POND AREA
(FOR REFERENCE ONLY)

T1

T2

T3

T4

MINE WASTE
DISPOSAL FACILITY
(FOR REFERENCE ONLY)

APPROXIMATE GROUNDWATER DIVIDE

CELL 1

CELL 2

CELL 3

MINE REFUSE
DISPOSAL FACILITY
(MRDF)

G41-K13A
485.67

G41-G21
485.42

EX-14
485.04

EX-7
481.42

EX-8
481.47

DMB-8
485.08

G41-N21
484.72

CREST 528

CREEK

HEMLOCK

LEGEND

485 — GROUNDWATER CONTOURS IN METERS ABOVE MSL 1929 ADJUSTMENT. CONTOURS BASED ON JULY 1985 MEASUREMENTS.

(T2) POND NUMBER

MONITORING WELL

485.92 WATER LEVEL ELEVATION IN WELL (SHALLOW WELL AT NEST LOCATIONS)

GROUNDWATER FLOW DIRECTION

APPROXIMATE LOCATION OF GROUNDWATER DIVIDE

0 200 400 800 1200 1600
SCALE IN FEET

0 50 100 150 200 300 400 500
SCALE IN METERS

GENERAL NOTES

1. ELEVATIONS IN METERS ABOVE MSL BASED ON 1929 ADJUSTMENT.
2. BASE MAP AND AERIAL PHOTOGRAPHY (1976) BY AERO-METRIC ENGINEERING, INC.
3. GRID COORDINATES IN METERS BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM.

PLAN SHEET 13

STS Consultants Ltd.
540 Lambeau St. Green Bay, Wisconsin
ph.414-494-9656

WILLIAM M. BERRIGAN E-2191 Green Bay, Wis. PROFESSIONAL ENGINEER WISCONSIN

EXXON MINERALS COMPANY
CRANDON PROJECT

TITLE
MINE REFUSE DISPOSAL FACILITY AREA
GROUNDWATER POTENTIOMETRIC CONTOURS

SCALE AS SHOWN	STATE WISCONSIN		COUNTY FOREST
DRAWN BY K.J.C.	DATE 11-1-85	CHECKED BY	DATE
APPROVED BY J.W.K. / J.A.S.	DATE 11-15-85	APPROVED BY	DATE
APPROVED BY	DATE	EXXON	DATE
DRAWING NO 14028-13		SHEET — OF —	REVISION NO

REVISED	DATE	BY	DESCRIPTION

E696,300
E696,600
E696,700
E696,800
N35,400
N35,300
N35,200
N35,100

WS-2
(CONSTRUCTION WATER SUPPLY WELL)

APPROXIMATE BOUNDARY OF CONSTRUCTION SUPPORT AREA

TO RETENTION POND

CLEANOUT ACCESS PORT

x 1725 ft. (526 m)

TOP OF DIKE

LEACHATE COLLECTION LYSIMETER

POSSIBLE LYSIMETER

LEACHATE COLLECTION PIPE

1695 ft. (517m)

1695 ft. (526m)

1694

1693

1693 ft. (516m) (BASE GRADE)

1693 ft. (516m)

1694 ft. (516.5m)

1694 ft. (516.2m)

2% SLOPE

MANHOLE

CLEANOUT ACCESS PORT

CELL 1

CELL 2

CELL 3

A

A'

B

B'

C

C'

3:1

4:1

TOE OF SLOPE

7% ACCESS ROAD

CULVERT

APPROXIMATE TOE OF MWDF DIKE

PROPOSED AIR CURTAIN DESTRUCTOR (FOR REFERENCE ONLY)

NOTE: PHASING WILL PROCEED AS FOLLOWS

1) CONSTRUCTION OF CELL 1
2) OPERATION OF CELL 1, CONSTRUCTION OF CELL 2
3) CLOSURE OF CELL 1, OPERATION OF CELL 2, CONSTRUCTION OF CELL 3
4) CLOSURE OF CELL 2, OPERATION OF CELL 3
5) CLOSURE OF CELL 3

NOTES:

1.) ALL 3 CELLS TO BE CONSTRUCTED WITH SIMILAR BASE GRADES, PIPE INVERTS AND SIDESLOPES.

2.) BASE GRADES SHOWN ON THIS DRAWING REFLECT BOTTOM OF LINER.

LEGEND

- LEACHATE MANHOLE
- PERFORATED PVC PIPE
- SURFACE WATER DRAINAGE
- [1693] PROPOSED PIPE INVERT
- CLEANOUT ACCESS PORT
- LYSIMETER MONITORING POINT
- CONSTRUCTION WATER SUPPLY WELL

N

0 50 100 150 200
SCALE IN FEET

0 25 50
SCALE IN METERS

GENERAL NOTES:

1. ELEVATIONS IN METERS ABOVE MSL BASED ON 1929 ADJUSTMENT
2. BASE MAP AND AERIAL PHOTOGRAPHY (1976) BY AERO-METRIC ENGINEERING, INC.
3. GRID COORDINATES IN METERS BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM.

WISCONSIN
WILLIAM M. PERPICH
E-5601
Green Bay, Wis.
PROFESSIONAL ENGINEER

REVISED	DATE	BY

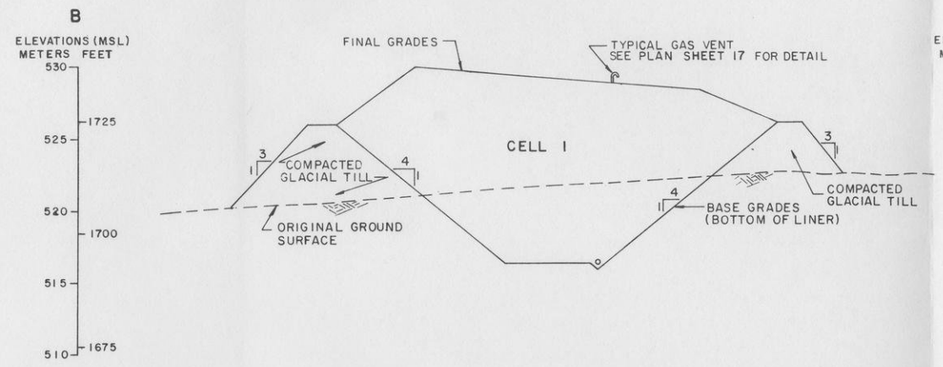
PLAN SHEET 14

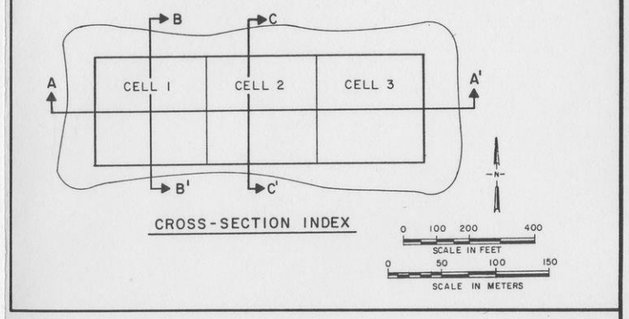
STS Consultants Ltd.
540 Lambeau St. Green Bay, Wisconsin
ph.414-494-9656

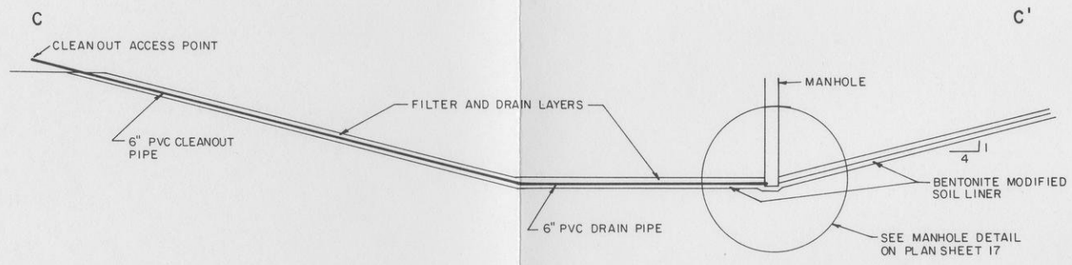
EXXON MINERALS COMPANY
CRANDON PROJECT

TITLE
PROPOSED SITE DEVELOPMENT
MRDF

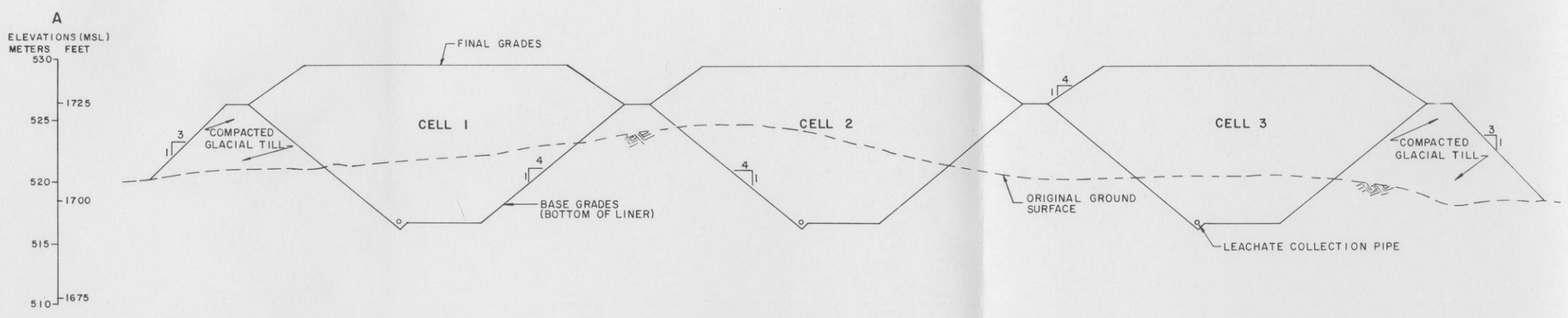
SCALE AS SHOWN	STATE WISCONSIN		COUNTY FOREST
DRAWN BY P.D.P.	DATE 11-18-85	CHECKED BY	DATE
APPROVED BY J.W.K./ J.A.S.	DATE 11-18-85	APPROVED BY	DATE
APPROVED BY	DATE	EXXON	DATE
DRAWING NO 14028-14			SHEET OF REVISION NO







NOT TO SCALE



NOTES AND PRELIMINARY SPECIFICATIONS

1. Glacial till embankment material shall be finer than 6 in. and compacted to 95% maximum dry density, within ±3% of optimum moisture content as determined by ASTM D-698.
2. Liner material shall be glacial till finer than 0.75 in. modified with bentonite. Liner shall be compacted to 95% maximum dry density, at 3% above optimum moisture content, as determined by ASTM D-698.
3. Drain material shall be finer than 2 in. and coarser than No. 40 U.S. Standard Sieve.
4. Filter material shall be glacial till finer than 6 in. and shall not be compacted.

0 50 100 150 200
SCALE IN FEET
0 25 50
SCALE IN METERS
APPROXIMATE VERTICAL EXAGGERATION: 3X

PLAN SHEET 15

WISCONSIN
WILLIAM M. PERPICH
E-4801
Green Bay, Wis.
PROFESSIONAL ENGINEER

REVISED	DATE	BY	DESCRIPTION

STS Consultants Ltd.
540 Lambeau St. Green Bay, Wisconsin
ph.414-494-9656

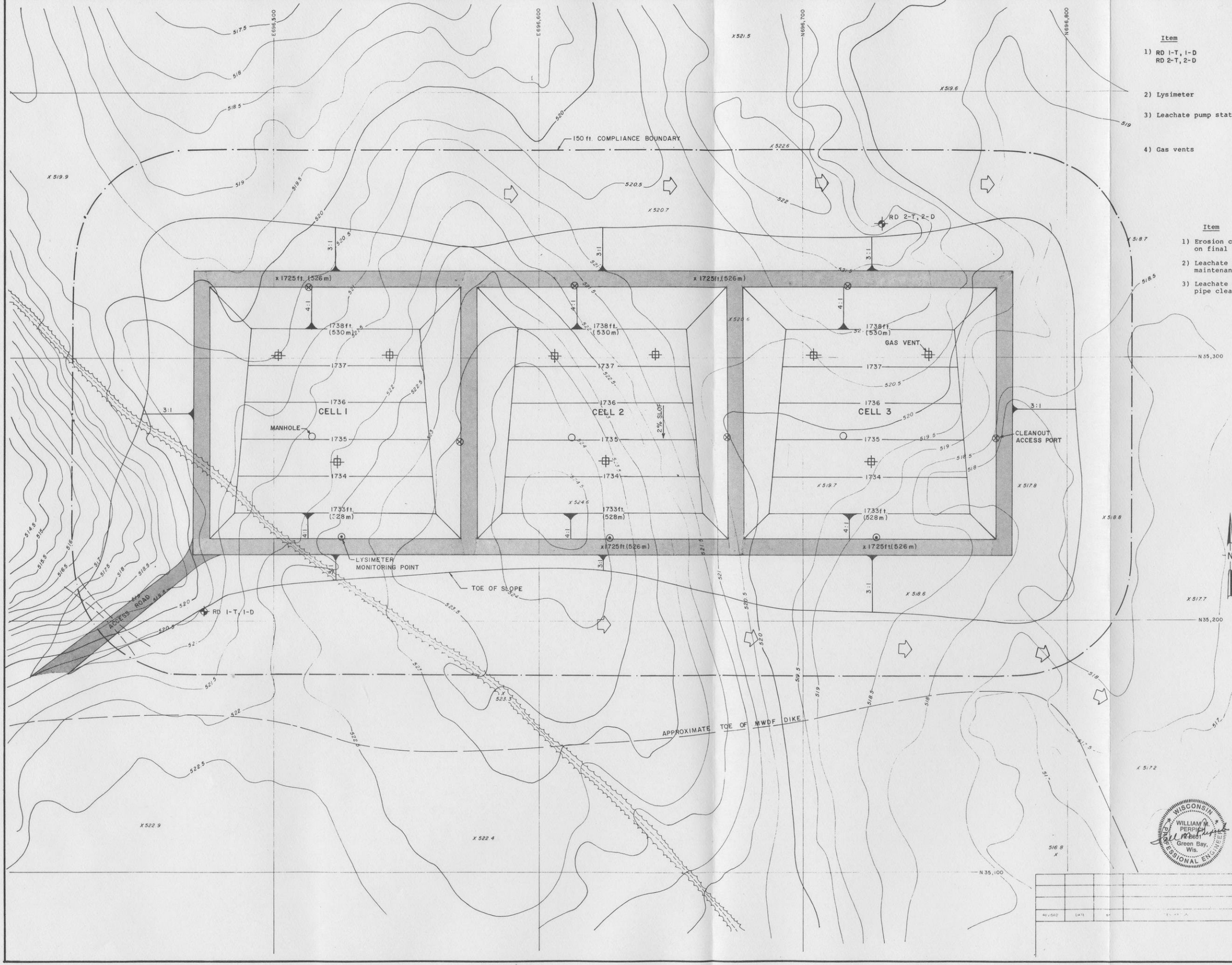
EXXON MINERALS COMPANY
CRANDON PROJECT

TITLE
TYPICAL CROSS-SECTIONS,
A-A', B-B' & C-C'

SCALE	STATE	COUNTY
AS SHOWN	WISCONSIN	FOREST

DRAWN BY	DATE	CHECKED BY	DATE
P.D.P	11-22-85		
APPROVED BY	DATE	APPROVED BY	DATE
J.W.K./J.A.S	11-22-85		
APPROVED BY	DATE	EXXON	DATE

DRAWING NO. 14028-15 | SHEET ___ OF ___ | REVISION NO.



LONG TERM MONITORING SCHEDULE

Item	Sampling Frequency	Parameters
1) RD 1-T, 1-D RD 2-T, 2-D	Quarterly: March 15 June 15 Sept. 15 Dec. 15	Water elevation, field pH, field conductivity, hardness, alkalinity, COD, chloride, iron
2) Lysimeter	Quarterly	Parameters same as above quantity
3) Leachate pump station	Weekly during operations. Monthly after final cover.	Volume pumped to Reclaim Pond, quarterly sample for above parameters
4) Gas vents	Quarterly	Percent methane

LONG TERM MAINTENANCE SCHEDULE

Item	Frequency
1) Erosion control, on final cover	Regrade and reseed as necessary
2) Leachate pump station maintenance in each cell	As necessary - check levels - pump when required monthly
3) Leachate collection pipe clean-out	Annually

LEGEND

- LONG TERM MONITORING WELL
- 150 FOOT COMPLIANCE BOUNDARY
- CLEANOUT ACCESS PORT
- LYSIMETER MONITORING POINT
- GAS VENT
- LEACHATE COLLECTION MANHOLE
- SURFACE WATER DRAINAGE

KEY TO WELL IDENTIFICATION
RD 2-T, 2-D
T- SCREENED IN TILL
D- SCREENED IN DRIFT
2- WELL I.D. NUMBER

N

0 50 100 150 200
SCALE IN FEET
0 25 50
SCALE IN METERS

GENERAL NOTES:

1. ELEVATIONS IN METERS ABOVE MSL BASED ON 1929 ADJUSTMENT.
2. BASE MAP AND AERIAL PHOTOGRAPHY (1976) BY AERO-METRIC ENGINEERING, INC.
3. GRID COORDINATES, IN METERS BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM.

PLAN SHEET 16

STS Consultants Ltd.
540 Lambeau St. Green Bay, Wisconsin
ph.414-494-9656

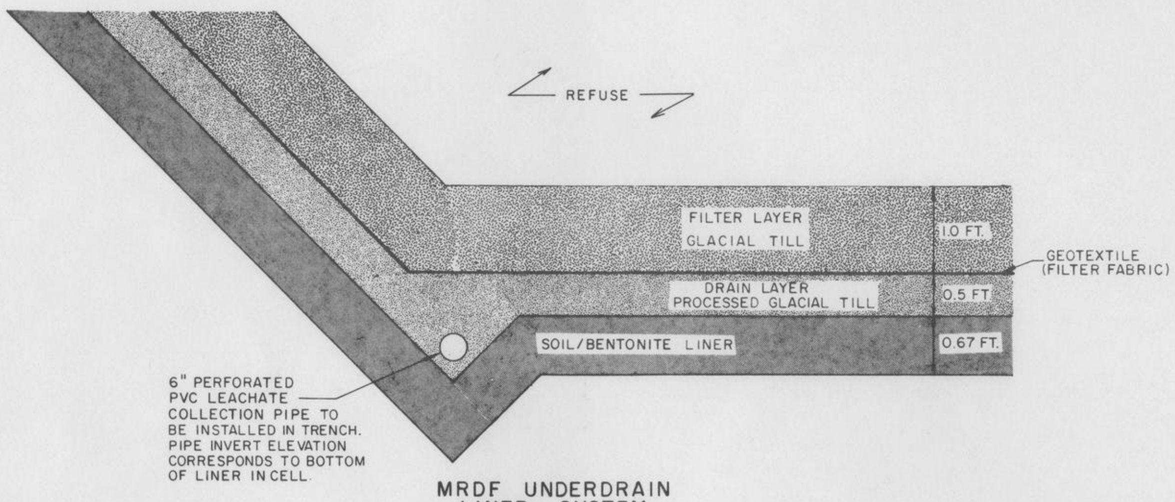
WISCONSIN WILLIAM W. PERPICH E-26611 Green Bay, Wis. PROFESSIONAL ENGINEER

EXXON MINERALS COMPANY
CRANDON PROJECT

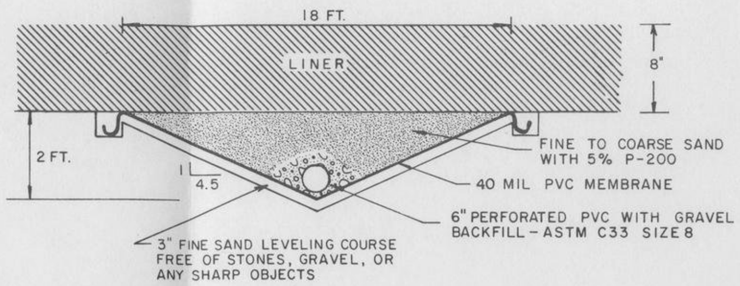
TITLE
PROPOSED FINAL GRADES AND LONG TERM CARE

SCALE: AS SHOWN	STATE: WISCONSIN		COUNTY: FOREST
DRAWN BY: P.D.P.	DATE: 11-18-85	CHECKED BY:	DATE
APPROVED BY: J.W.K. / J.A.S.	DATE: 11-18-85	APPROVED BY:	DATE
APPROVED BY:	DATE	EXXON	DATE
DRAWING NO: 14028-16	SHEET ___ OF ___		REVISION NO

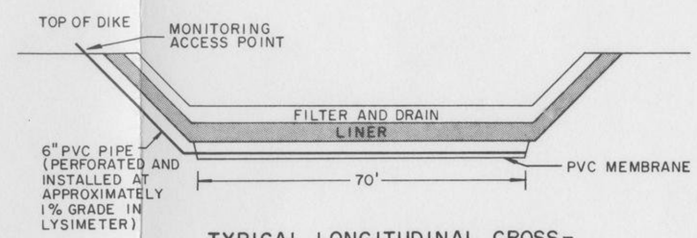
REVISED	DATE	BY



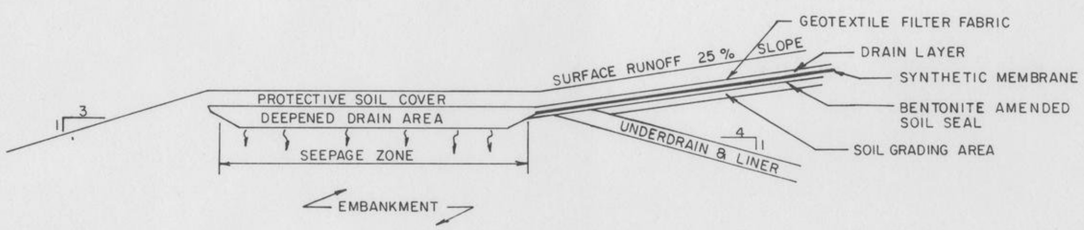
MRDF UNDERDRAIN LINER SYSTEM
NOT TO SCALE



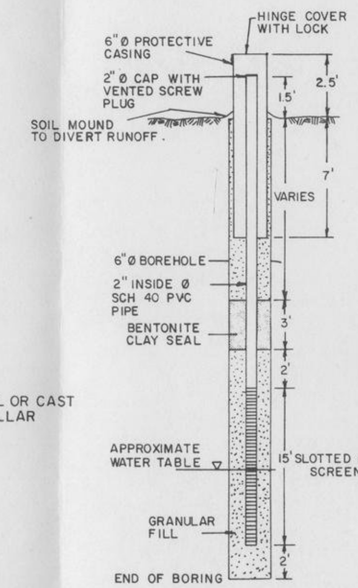
COLLECTION LYSIMETER DETAIL
NOT TO SCALE



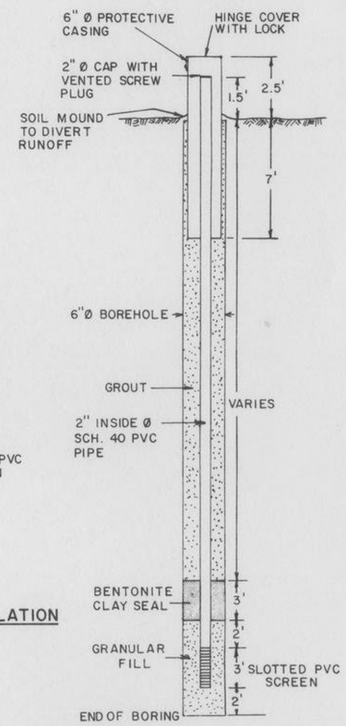
TYPICAL LONGITUDINAL CROSS-SECTION OF LYSIMETER
NOT TO SCALE



TYPICAL RECLAMATION EMBANKMENT DRAINAGE DETAIL
NOT TO SCALE

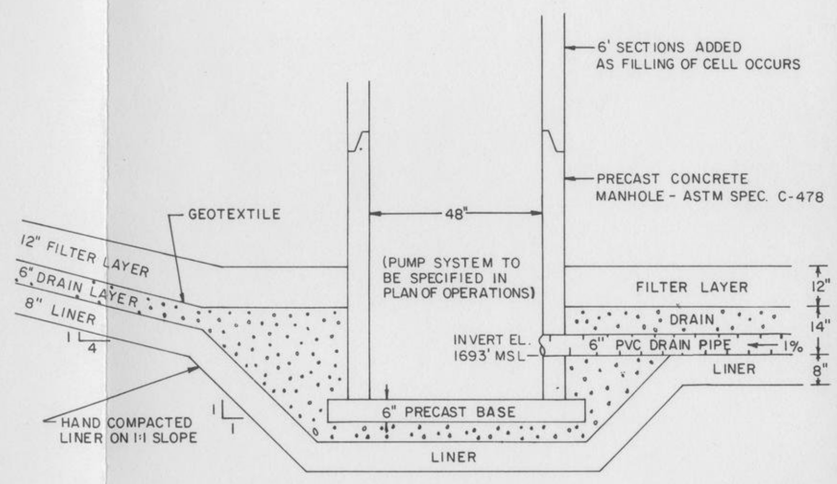


WATER TABLE WELL INSTALLATION

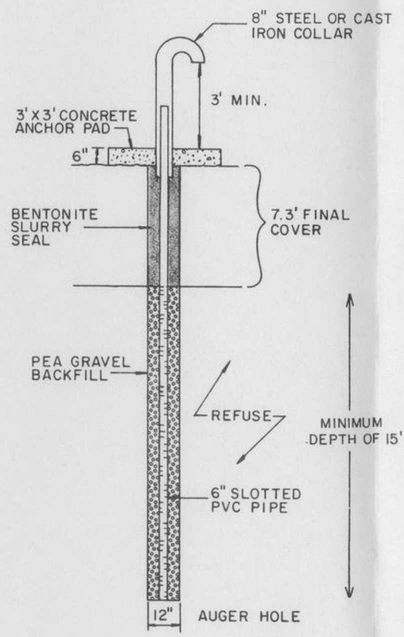


PIEZOMETER INSTALLATION

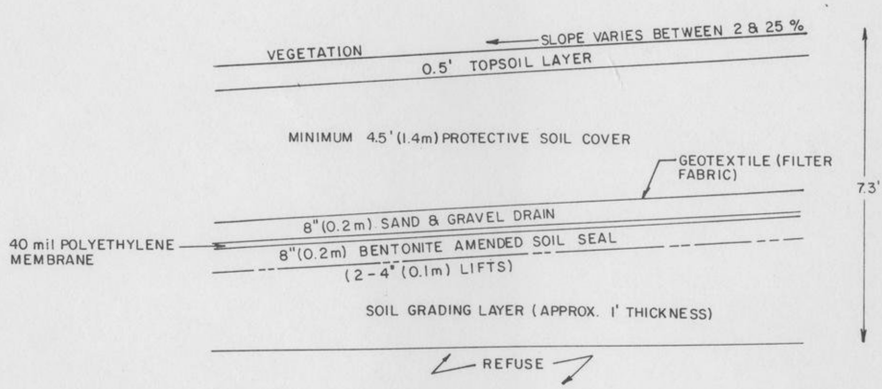
TYPICAL MONITORING WELL INSTALLATIONS
NOT TO SCALE



MANHOLE DETAIL
SCALE 1" = 2'



TYPICAL GAS VENT
NOT TO SCALE



TYPICAL FINAL COVER DETAIL
NOT TO SCALE

PLAN SHEET 17

STS Consultants Ltd.
540 Lambeau St. Green Bay, Wisconsin
ph.414-494-9656

WISCONSIN
WILLIAM M. PERPICH
E-8801
Green Bay, Wis.
PROFESSIONAL ENGINEER

EXXON MINERALS COMPANY
CRANDON PROJECT

TITLE: CONSTRUCTION DETAILS

SCALE: AS SHOWN	STATE: WISCONSIN	COUNTY: FOREST	
DRAWN BY: P.D.P.	DATE: 11-20-85	CHECKED BY	DATE
APPROVED BY: J.W.K./J.A.S.	DATE: 11-21-85	APPROVED BY	DATE
APPROVED BY	DATE	EXXON	DATE
DRAWING NO: 14028-17		SHEET ___ OF ___	REVISION NO

REVISED	DATE	BY	DESCRIPTION

DESIGN PRODUCTS CO.—

10-21-85 DNR LETTER

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES
Carroll D. Besadny
Secretary

BOX 7921
MADISON, WISCONSIN 53707

October 21, 1985

IN REPLY REFER TO: 4400

Mr. Barry Hansen, Permitting Manager
Exxon Minerals Company
P.O. Box 813
Rhinelander, WI 54501

RE: Landfill Design Suggestions; Exxon Crandon Project; Forest County, Wisconsin

Dear Mr. Hansen:

This letter is formal documentation on a number of subjects discussed during a meeting in Madison on August 21, 1985 with Mr. Charlton Schroeder and Mr. Joseph DeMarte. Bob Grefe had requested the meeting in order to provide a summary of preliminary review of your plans for a solid waste landfill for the Exxon-Crandon Project. The meeting was also useful to address some items concerning the Mine Waste Disposal Facility (MWDF) and Reclaim Ponds. Ken Wiesner and David Hantz of the Department's Bureau of Wastewater Management addressed the Reclaim Pond items and have summarized their review in a letter dated August 30, 1985. As source materials, we used previously submitted project documents and available data, supplemented by specific information attached to your letters to the Department dated July 19, 1985, and July 31, 1985. There is sufficient information in these documents to provide initial site review - level response on conceptual engineering and the development of the feasibility study for the solid waste landfill.

Mr. Grefe advised Mr. Schroeder and Mr. DeMarte that a feasibility study for the solid waste landfill should be developed and submitted separately from the MWDF revised feasibility study. He also advised them at that time that development of the site should be proposed under NR 182 rather than NR 180.13, but, after further analysis, it is our best cumulative opinion that a solid waste landfill should be proposed and regulated under NR 180.13 and it is our intention to review and regulate your proposed solid waste landfill under that code. Therefore, the landfill feasibility study should be developed in accordance with NR 180.13.

Discussions with your staff and with your legal consultant on October 3, 1985 revealed concerns with soils and groundwater investigations requirements under NR 180.13 and groundwater standards application. These issues will be addressed below, as well as the applicability of other provisions of the solid waste licensing and siting process.

Sections 144.44(2)(f)6., (n)4., (nm) and (om) relate to the requirement of an applicant to document need and meet certain site design life restrictions. However s. 144.44(2)(nr) specifically exempts any facility which is a part of a mining operation from these requirements. Since the solid waste landfill is a part of the mining operation, the needs and design life requirements of Chapter 144 do not apply.

Section 144.445 relates to the landfill siting negotiation/arbitration process. However, s. 144.445(12)(d) specifies that the process does not apply to waste facilities which are a part of a mining operation. Therefore, the Chapter 144 negotiation/arbitration process does not apply.

The groundwater standards requirements and enforcement process established in NR 140 do not apply to this project. NR 140.03 indicates that facilities on a mining site subject to the groundwater quality requirements of NR 132 and NR 182 are not subject to the requirements of that chapter. NR 132.17(9) indicates that the groundwater standards of NR 182 apply to mine sites. Therefore, the groundwater standards contained in NR 182.075 would apply to the solid waste disposal site.

Section 144.44(2)(f)6. and 7. (Act 426, Laws of 1983) requires that an analysis of alternatives to land disposal be conducted as an element of the feasibility report. This requirement applies to the proposed disposal site. I have attached a copy of a guidance document on this issue for your information. (This requirement is essentially the same as that imposed by NR 182.08(2)(b)3.g. as part of characterization of mining waste.)

Since licensing will take place under the provisions of s. 144.43-.47 and NR 180, the plan review and licensing fees specified in NR 180.05 will apply to the project. The disposal of solid waste will also be subject to various tonnage fees as specified in s. 144.441. Since the waste will be regulated as a "nonmining" solid waste under s. NR 182.02(4), the appropriate tonnage fee is that contained in s. 144.441(4)(a). In addition, a Groundwater Fee will be imposed as specified in s. 144.441(7)(c). An Environmental Repair Fund fee as specified in s. 144.442(1m) and (cm) (from Act 29, the FY '86-87 State Budget Bill) would also be imposed.

The provision of s. 144.441(2) would also be applicable to the solid waste landfill. Since the landfill will be a part of a mining site, it will be an "approved mining facility" as defined in s. 144.441(1) and the 30 year long-term care period will apply.

The financial responsibility standards of s. 144.443 will also be applicable to the solid waste disposal site. The appropriate instruments for assuring closure and long-term care either under NR 132.09(2) and NR 180.15 will be determined at a later date.

NR 180.13(6) has some specific requirements for soils investigation work at proposed landfill sites. The intent behind the requirements is to adequately characterize the geology and hydrogeology of the site. In general, the Department is reluctant to encourage use of less than the minimum number of required borings and wells at a site and, in many cases, has required more.

However, the Department has also accepted less than the minimum number of wells and borings for some sites due to site size, previously defined level of characterization, or other evidence of site definition such as backhoe pits or private well logs.

Our opinion is that the project site and groundwater investigative and modeling work performed to date adequately establishes depth to bedrock, general soil strategraphy, and depth to groundwater for the solid waste landfill as well. However, there are only a few soil sample points within your proposed landfill location (boring G41-J11 and test pits TP-2, -7, -8 and -9) and adjacent groundwater monitoring wells or nests are rather distant (EX-9, EX-10, G41-H9, G41-G13, G41-G12, G41-K13 and DMA-6). It will be necessary to provide adequate definition of soils down to and below site base grades in order to demonstrate soil suitability for liner and drain construction and to illustrate the character or presence of seeps, high permeability soils, or zones of cobbles or boulders.

We recommend that the investigative program emphasize the use of backhoe pits on a frequency of at least one per acre of fill area. Sufficient soil samples should be taken to compare site subbase soils and soils used for constructing liner, drains and final cover. Attention should also be placed on examination of in-field soils as revealed in the pit sidewalls and floor. Backhoe pit locations should be placed along the perimeter as well as within the fill area. Solid waste staff request that they be notified and that arrangements be made to allow them to inspect the backhoe pits and sampling procedures.

A few points should be kept in mind when selecting pit locations and depth. Borings in the project area indicate the existence of an extremely dense soil layer approximately 15 to 25 feet below the present land surface. Department staff consider it important to extend two or more backhoe pits several feet into this dense soil layer, in order to compare soil types and relative frequency of cobbles and boulders. Observation of the composition of these dense soils will aid interpretation of boring logs and should be relevant to other construction decisions, as the MWDF base grades will extend into this dense soil layer. Pit sidewall examination should include detection of permeable, coarse or uniform soil seams, particularly near liner subbase grade. (Placement of liner material on well-graded soil rather than uniform or coarse soil should provide protection against piping of fines from the liner.) Examination of pit sidewalls should also provide data concerning depth, quality and recoverability of soils suitable for topsoil and other reclamation purposes.

Since the solid waste landfill will be considerably smaller than the MWDF, there is flexibility in locating it on available drumlin uplands. Mr. Schroeder and Mr. DeMarte provided some preliminary rationale at the 8/21/85 meeting supporting the proposed location at the MWDF area. The siting analysis for the landfill feasibility study should be explicit and logical concerning reasons for locating the site near the MWDF. The advantage of confining disturbance to the vicinity of the MWDF and for use of the common haul road is evident, but it is only one consideration in landfill siting.

The solid waste characterization presented in your letter dated November 9, 1984 to Mr. Gary Kulibert should satisfy much of the waste characterization requirements of NR 180.13(6)(c)6 and the applicable requirements of NR 180.13(10), as well as the reuse and land disposal alternatives evaluation required by Act 426, Laws of 1983. However, this information should be updated and reevaluated for suitability in addressing those code sections and to demonstrate compatibility between the waste, leachate, and landfill liner.

The landfill liner is proposed to be made of bentonite-amended soils, similar to the liner of the MWDF. This type of liner is not standard when compared to typical requirements for clay-lined sanitary landfills in Wisconsin. However, the Department has approved several landfills in the recent past with reduced liner thicknesses or with nonstandard designs, mainly for industrial waste landfills receiving restricted waste types with defined leaching characteristics. The solid waste landfill feasibility study must explicitly address the relationship between waste leachability and liner type, material, and thickness.

Desirable site operations and liner characteristics indicate that the solid waste landfill should not be used for disposal of sludges, chemical wastes, liquids, oils, solvents, and similar wastes not likely to be compatible with a mill refuse site. We also suggest that food wastes be segregated and containerized or else disposed of separately to minimize animal intrusion and visitation at the landfill.

The Exxon Crandon project as a whole will utilize an air curtain destructor for volume reduction unusable wood wastes. I recommend that this device be located near the landfill to facilitate cooling and transfer of ashes. Procedurally, the air curtain destructor should be described in the discussion of the landfill but will be required to comply with and be licensed under NR 180.12.

It is our understanding that you have selected STS Consultants, Ltd., Green Bay, Wisconsin to develop the solid waste landfill feasibility study. Your consultant and staff should contact Gary Kulibert, North Central District Solid Waste Coordinator, concerning the air curtain destructor design details. We encourage you to review plans of the Marathon and Portage County landfills in the North Central District office for details of conventional landfill sequencing and operations and to discuss these subjects with Mr. Kulibert. The conceptual cross section of the solid waste landfill proposes three separate phases developed as three discontinuous below-ground-level cells. This is not standard design and may involve considerably more excavation than is necessary for a site which does not require daily covering. We recommend use of contiguous cells, sequential liner and final cover placement, and gravity drainage of surface water away from the active fill area of the solid waste landfill. Your consultant should also evaluate site operations in terms of liner thickness and protection details.

It is the opinion of both Solid Waste and Wastewater staff that the proposed location of the solid waste landfill is too close to the Reclaim Ponds. Use of a common berm between the two facilities may not leave enough room for monitoring, reparative actions (if necessary), and normal site operations.

Additional separation distance is needed for compliance boundary placement, as we strongly recommend that the compliance boundaries of the reclaim ponds and the solid waste landfill not overlap. You should be aware that the Department intends to propose a compliance boundary for the solid waste landfill with dimensions of 150 feet from the limits of waste filling.

In addition to other monitoring, the solid waste landfill design should include at least one collection basin lysimeter under each cell. Since the landfill location has not yet been fixed, you should select a location where existing groundwater monitoring wells could be utilized as monitoring points near the limits of waste filling. You may find it advantageous to conduct soil borings and to install monitoring wells near the downgradient side of the landfill as part of the landfill soils investigative program. Monitoring wells for the landfill will be required as part of the overall project monitoring plan.

This project should have versatility in terms of treating the leachate, given the presence of both the water treatment system and the package wastewater treatment plant. Choice of treatment facility will depend on the characteristics of the leachate and its potential to cause plant upset. You may wish to contact the North Central District to obtain data on leachate characteristics from other solid waste sites in order to address potential Bureau of Wastewater Management concerns for leachate treatment. This data would also be useful in terms of addressing waste compatibility with the amended soil liner.

There are some items with regard to the MWDF redesign which I would like to transmit as well.

The MWDF should be designed to contain the maximum surface-disposed volume of tailings expected from the project. If there is a potential need for the "contingency area" mentioned in the attachments to your letters, this should be addressed by explicitly designing a fifth cell in the plans. Making the design of this additional cell explicit would remove potential confusion regarding its effect on site design. (I also suggest that you use another term instead of "contingency area" which may be confused with the contingency plan required for unanticipated events.)

During a meeting with Mr. Charlton Schroeder on September 4, 1985, he suggested that additional fill volume could be generated by simply enlarging the proposed cells somewhat. This appears to be a more practical method of assuring capacity for overall project waste volumes.

We will need some additional information on the proposed 80 acre borrow area, which is evidently needed to provide soil for final cover purposes at the MWDF. At the very least, some of the likely alternative locations for the borrow area should be identified and located. Design changes and input from waste physical characterization may reduce the required soil volumes and necessary borrow area. NR 182.11(1)(m) requires that the MWDF have final slopes between 2% and 33% "unless the site or facility is specifically designed for a final use compatible with other slopes." Drainage from the final cover of the MWDF must be maintained and ponding of water should not be allowed except for minor slope breaks. However, this would not preclude some

reduction in designed MWDF top slope (with consequent savings in grading layer volumes) if you can demonstrate adequate prediction and control of tailings settlement and consolidation.

During the meeting with Mr. Schroeder on September 4, 1985, he discussed two conceptual proposals for addressing the cut and fill imbalance which led to the need for soil borrow. In brief, both final grade and base grade changes can be made to the MWDF design. The final grade design change involves placing the crest of the final cover in each cell over the center of the cell and sloping the final cover to the exterior and interior confining dike crests. This vastly reduces fill requirements in the center of the site. The design change also allows use of infiltration galleries in the interior dike crests, concentrates surface runoff along the interior dikes, reduces slope lengths, and allows complete final cover placement after closure of each cell. The base grade change involves lowering base grades approximately one meter, thus generating enough soil material to eliminate the overall cut and fill imbalance. A relatively small borrow area was proposed near the MWDF to provide soil borrow during periods of temporary imbalance.

Our preliminary opinion was that these changes are advantageous. Directing surface drainage to the interior dikes may cause some difficulties but these should be partially compensated for with reduced slope lengths and drainage areas. Lower base grades would still result in more than 40 feet of unsaturated soil below the MWDF liner. The revised MWDF cell surface should result in a final cover with a more variable outline. We encourage you to incorporate these elements in site design.

It is our understanding that some additional testing of tailings consolidation characteristics is being pursued by Exxon Research and Development. Results of these tests should be included in the MWDF feasibility report. In addition, we would like to discuss any additional tailings characterization tests which you anticipate will be performed on the tailings produced from ore pilot plant testing. It may be necessary to explicitly address whether the revised ore grinds, increased tailings sulfide content, or decreased tailings gradation would have any expected effect on waste leachability or consolidation characteristics.

During the meeting on August 21, 1985, and in the letter dated August 30, 1985, wastewater and solid waste staff stated that water treatment sludge generated during site construction should be stored in a separate facility rather than isolated in a corner of one of the Reclaim Ponds. However, we did not give direction on design or codes applicable to a sludge storage area. It is the opinion of Solid Waste and Wastewater staff that a water treatment sludge storage facility should be designed, described and proposed in the water treatment system revised Preliminary Engineering Plan. This requirement stems from the general conditions of the project WPDES permit described in NR 205.07(3)(f). Sludge storage site design will be required to include a liner which meets or exceeds the minimum requirements of NR 213. Your consultant should carefully consider how long the facility will have to be used. Solid Waste staff are of the opinion that stored sludge solids should not be introduced into the first MWDF cell until a layer of tailings has been placed on the cell base and sufficient tailings are being generated to comingle with the sludge.

Finally, I would encourage you and your technical staff to observe solid waste projects in northern Wisconsin or to discuss aspects of site design and construction with site owners or designers. You may wish to contact the North Central District to determine which projects would be useful for observations. A point I wish to stress is that weather (particularly rain) is a constant factor in landfill liner construction, particularly in the fall months. Site owners and designers would be able to give you valuable input as to the difficulties imposed by weather and necessary adaptations in their construction programs. Our experience is that nonstandard liner designs are at least as sensitive to weather conditions as is clay liner construction and may impose unusual environmental constraints on construction.

If you have any questions concerning this letter, please call Robert Grefe at (608) 266-2178, Nile Ostenso at (608) 267-7571, or Larry Lynch at (608) 267-7553.

Sincerely,
Bureau of Solid Waste Management

for Rich Schuff by Paul Richter

Richard G. Schuff, P.E., Chief
Residuals Management & Land Disposal Section

RGS:cr

cc: Gordon Reinke - SW/3
Paul Didier - SW/3
Archie Wilson - NCD
Gary Kulibert - NCD
Ken Markart - Antigo
Robert Ramharter - EA/6
Ken Wiesner - WW/2
Charles Hammer - LC/5
Linda Bochert - AD/5
Lyman Wible - AD/5
Wally Arts - DOJ
Donald Zuidmulder - Green Bay
Kevin Lyons - Milwaukee
Gene Linehan - Wausau
James Derouin - Madison
Earl Charlton - Milwaukee
Joe Reed - Keshena

6023R

11-9-84 EXXON LETTER

EXXON MINERALS COMPANY

P. O. Box 813, RHINELANDER, WISCONSIN 54501

CRANDON PROJECT

November 9, 1984

Reference 4400
Non-Tailing Mining Wastes

Mr. Gary Kulibert
Department of Natural Resources
North Central District Office
P.O. Box 818
Rhinelander, Wisconsin 54501

Dear Mr. Kulibert:

This letter is written in reply to the questions and information needs identified in the August 22, 1984 letter to Exxon Minerals Company regarding non-tailing mining wastes associated with the Crandon Project. As described in various sections of the EIR we will utilize a combination of waste disposal services or facilities for various Project wastes. The City of Antigo landfill, speciality disposers, recyclers, scrap dealers, and supplies will ultimately dispose of all Project non-tailing mining wastes. The estimates of waste volumes are based on existing data where available, although generally, there is a lack of substantial and detailed historical data available to project waste estimates. When historical data were not available, assumptions were made based on professional experience. Also, based on the planned disposal methods, the absolute waste volume is not critical to the disposal plans. Estimate variances of $\pm$ 25 percent or even higher would not change the disposal plans described in the various Project documents. Information is provided following Section II of the August 22 letter.

Question II.A.1:

What volume and weight of the wastes indicated in Section IA will be generated by the construction activity?

Response:

Clearing and Grubbing Wastes (I.A.1)

Current estimates for the clearing and grubbing construction wastes are presented in Table 1.

TABLE 1

CONSTRUCTION PHASE

Clearing and Grubbing Wastes

Facility	Construction Period Yr(1)	Area For Clear & Grub ha (acres)(1)	Marketable Timber(2)	Brush, Limbs Unmarketable Timber (In the Field)(3)	Brush, Limbs Unmarketable Timber (Chipped)(4) Yd^3	Stumps (In the Field)(5)	Stumps (Chipped)(6) Yd^3
Access Road	1	15 (37)	272 Cord 5,997 Board Ft.	316 S.T.(8) 2,350 Yd^3	1,175	146 S.T. 541 Yd^3	541
Railroad Spur	1	18 (45)	411 Cord 24,755 Board Ft.	497 S.T. 3,681 Yd^3	1,840	229 S.T. 850 Yd^3	850
Tailings/Route Haul Road	1	4 (10)	109 Cord 4,056 Board Ft.	129 S.T. 958 Yd^3	479	60 S.T. 221 Yd^3	221
Mine/Mill Site	1	46 (114)	1,565 Cords 105,943 Board Ft.	1,909 S.T. 14,113 Yd^3	7,071	881 S.T. 3,259 Yd^3	3,259
Excess Water Discharge	1	6 (15)	137 Cords(7) 8,251 Board Ft.	166 S.T. 1,228 Yd^3	613	77 S.T. 283 Yd^3	283
MWDF							
Phase 1 - Waste Rock Area + R1 + Construction Support Area	1	48 (119)	1,667 Cords 107,700 Board Ft.	2,027 S.T. 15,015 Yd^3	7,507	936 S.T. 3,467 Yd^3	3,467
Phase 2 - T1 + R2	4	50 (124)	1,737 Cords 112,230 Board Ft.	2,113 S.T. 15,652 Yd^3	7,826	975 S.T. 3,611 Yd^3	3,611
Phase 3 - T2	9	55 (136)	1,906 Cords 123,090 Board Ft.	2,319 S.T. 17,178 Yd^3	8,589	1,070 S.T. 3,963 Yd^3	3,963
Phase 4 - T3	16	55 (136)	1,906 Cords 123,090 Board Ft.	2,319 S.T. 17,178 Yd^3	8,589	1,070 S.T. 3,963 Yd^3	3,963
Phase 5 - T4	22	50 (124)	1,737 Cords 112,230 Board Ft.	2,113 S.T. 15,652 Yd^3	7,826	975 S.T. 3,611 Yd^3	3,611
TOTALS	-	347 (860)	11,447 Cords 727,342 Board Ft.	13,908 S.T. 103,005 Yd^3	51,515	6,419 S.T. 23,769 Yd^3	23,769

NOTES:
(1) See Table 1.3-1 of EIR.
(2) From Steigerwaldt, 1982. Adjusted on an area basis to current clear and grub area estimates.
(3) Weight estimated at 65% of weight of marketable timber assuming:
a) Cord = 128 Ft^3 with wood volume = 80 ft^3; b) Air dry wood weight = 3500 lb/cord; c) For timber quantities air dry wood weight = 45 lb/ft^3; d) Volume estimate based on 10 lb/ft^3.
(4) Volume estimate based on 20 lb/ft^3.
(5) Weight estimated at 30% of weight of marketable timber. Volume estimate based on 20 lb/ft^3.
(6) Volume estimate based on 20 lb/ft^3.
(7) Tree density/acre assumed same as railroad spur.
(8) S.T. - Short tons; Yd^3 - Cubic yards.

Refuse (I.A.2)

Including:

a. Solid waste from construction crews;
b. Packaging waste; and
c. Scrap metals.

These estimated quantities are presented in EIR Section 1.3.5.1 Solid Waste. The data presented in Table 2 were developed by applying the high end of the range of estimated weekly waste quantities.

Building Materials (I.A.3)

a. Waste rates for construction materials (i.e. concrete, asphalt, etc.) will be kept low through detailed job planning and a high level of construction management. Although normal estimating rules of thumb might project closer to 5% waste for the following materials, with better work management an average waste rate of 3 percent can be assumed, resulting in the following waste quantities:

Item	Approximate Estimated Quantity For Project	Approximate Waste Quantity With 3 Percent Waste
Concrete (includes surface and underground)	46,900 m^3	1407 m^3 (1840 cubic yards)
Base Course (includes access road and in-plant roads)	24,400 m^3	732 m^3 (959 cubic yards)
Subbase (includes access road and in-plant roads	28,800 m^3	864 m^3 (1132 cubic yards)
Asphalt Pavement	7,400 m^3	222 m^3 (291 cubic yards)
Railroad Ballast (includes spur and siding)	37,900 t	1137 t (1251 short tons)
Railroad Subbase	12,400 t	372 t (409 short tons)
Bentonite	7,700 t	231 t (254 short tons)

b. Waste estimates for steel, rebar, metal siding, insulation, etc. and similar building materials can be approximated according to the following table. For concrete form materials a 25% overall waste rate is included based on a 10% waste rate with each use and an average 2.5 uses; other wood wastes are insignificant. Other waste rates are based on a nominal or rule of thumb estimate of 5% waste adjusted for the particular item according to any prefabrication plan or field installation plan. Portions of some of the wastes would be salvageable.

TABLE 2

Construction Phase Refuse Quantities

Construction Year	Period	Weekly Rate (Short Tons)	Total Short Tons	Total Volume* (Yd^3)
1	May-Sept	5	110	220
1	Oct-Dec	1	13	26
2	Jan-Apr	1	17	34
2	May-Sept	5	110	220
2	Oct-Dec	1	13	26
3	Jan-Apr	3	51	102
3	May-Sept	10	220	440
3	Oct-Dec	3	39	78
4	Jan-Apr	3	51	102
4	May-Sept	10	220	440
4	Oct-Dec	3	39	78
		Total	883	1766

* Volume based on 1000 lb/yd^3 density.

Similar refuse quantity estimates based on workforce size and a representative pounds per capita per day (pcd) of waste provide a nearly equal quantity estimate:

Construction Year	Average Workforce	pcd(a)	Total Short Tons(b)	Total Volume(c) (Yd^3)
1	516(d)	1.5	71	142
2	652	1.5	152	305
3	1101	1.5	258	516
4	1206	1.5	282	564
		Total	763	1527

NOTES:
(a) pcd estimate from Handbook of Solid Waste Management, by David Gordon Wilson, Van Nostrand Reinhold, page 553.
(b) 26 work-days per month assumed.
(c) Volume based on 1000 lb/yd^3 density.
(d) Average workforce from EIR Figure 1.1-5. Construction Year 1 for 7 months.

Item	Approximate Estimated Quantity For Project	Approximate Waste Quantity at Waste Rate Noted	
		Assumed Waste Rate (%)	Waste Quantity
Reinforcing Steel (Mostly Shop Bent)	2,000 t	3	60 t (66 Short Ton)
Structural and Building Steel (Shop Fabricated)	5,000 t	1	50 t (55 Short Ton)
Concrete Formwork	63,000 m^2	25	16,000 m^2 (19,100 Square Yards 266 yd^3
Metal Siding and Roofing	60,000 m^2	5	3,000 m^2 (3,600 Square Yards 100 yd^3
Metal Liner Panel	43,000 m^2	5	2,150 m^2 (2,600 Square Yards 72 yd^3
Drywall	9,000 m^2	20	1,800 m^2 (2,200 Square Yards 30 yd^3
Insulation	43,000 m^2	5	2,150 m^2 (2,600 Square Yards 145 yd^3

c. Estimates of waste oils, lubricants, hydraulic fluids and other petroleum products were based on estimated fuel consumptions and an overall waste rate assumed at 1:250. Most waste petroleum products would be recycled or ultimately re-used.

Construction Year	Total Diesel Fuel Consumed (gallons)	Total Gasoline Consumed (gallons)	Total Estimated Petroleum Based Waste (gallons)
1	2,044,000	43,800	8,400
2	414,000	43,100	1,800
3	1,129,000	36,800	4,700
4	1,399,000	40,300	5,800
Totals	4,986,000	164,000	20,700

d. Total painting wastes can be estimated based on an assumed 5 percent waste rate. Based on estimated material takeoffs of 5,000 t of structural steel (at 1.2 gallon/short ton for two coats) and 26,000 m^2 of steel plate and wall (at 1.0 gallon/200 square feet for two coats), a total paint quantity of approximately 8,000 gallons will be required. With a 5 percent waste rate there would be 400 gallons of waste paint.

Other Wastes (I.A.4)

a. Sanitary wastes have been estimated to start at a conservative level of 2,800 gallons per day over the first 6 months of Project construction. During this initial 6-month period the wastes would be removed and disposed off-site by a licensed disposer. Following this 6 month period (after

installation of the sanitary waste disposal system), sanitary wastes would be disposed on-site except for the periodic removal and off-site disposal of septic tank sludge. Over the remainder of the construction phase (approximately 3 years) sanitary sewage volume would increase from the 2,800 gallon per day rate to the approximate 29,000 gallon per day rate expected during the operating period. After the sanitary waste disposal system is in operation a maximum of 2,400 cubic feet per year of sludge will be removed from the system and disposed off-site by a licensed disposer.

b. No significant quantity of hazardous material packaging waste or containers are expected to be generated during Project construction. Disposal of any minor amounts of these materials will be handled similar to the plans during operations, i.e. either by returning them to the vendor or by utilizing a speciality waste disposer licensed to handle and dispose of the particular waste.

Question II.A.2:

At what rate will the wastes be generated during the construction activity?

Response:

Maximum clear and grub rates (Item I.A.1) would occur in construction year 1 with much of the work starting at about the same time. The highest rate for an individual facility is for the first phase of the MWDF construction where 48-ha (119 acres) will be cleared and grubbed in approximately one month.

Refuse quantities (Item I.A.2) are assumed to be generated at constant rates throughout the individual periods shown in Table 2.

Building materials (Item I.A.3) should be assumed to be generated at a constant rate over the approximate 2 1/2 years required for surface facilities construction (the last 2 1/2 years of the construction period). Each individual waste would probably predominate at some time in the schedule but the overall rate would probably be approximately constant.

Sanitary wastes (Item I.A.4) would fluctuate according to the construction workforce and the continually increasing percentage of people with access to complete sanitary facilities as opposed to only portable facilities. An approximate estimate of rate of sanitary sewage generation would be a linear increase from 2,800 gallons per day at the 6 month point in construction to the 29,000 gallon per day volume at the start of operations.

Question II.A.3:

What will be the time frame for the production of wastes?

Response:

The responses to questions II.A.1 and II.A.2 include the approximate Project time frames when the wastes will be generated.

Question II.A.4:

How and where will the wastes be collected and stored prior to disposal?

Response:

Clear and grub tree wastes (Item I.A.1) will be temporarily piled in convenient areas adjacent to the construction area. Storage areas will be located during detailed final construction planning but probably 3 or 4 storage areas would be planned for each major facility (i.e. mill site, MWDF).

Refuse wastes (Item I.A.2) will be stored in dumpsters or similar containers conveniently located around the Project area.

Building materials wastes (Item I.A.3) would be temporarily stored in segregated areas located in the mine/mill area. Waste oils, paints, other toxic fluids or any hazardous solid or liquid wastes would be segregated and isolated in separate secure containers or facilities while being temporarily held.

For the first 6 months of Project construction, sanitary wastes (Item I.A.4) will be removed off-site and disposed by a licensed disposer at an approved location or facility of his choice. From the 6-month period onward (except for twice yearly off-site sludge disposal) sanitary wastes will be disposed on-site through the sanitary waste disposal system.

Question II.A.5:

Where and how will the waste be disposed?

Response:

Clear and grub wastes (Item I.A.1) will be chipped at the temporary storage locations and transported to a stockpile area on the east side of the mine/mill area. Any stumps or other grubbing materials that cannot be chipped will be disposed by burning in an approved air curtain destructor(s).

Refuse wastes (Item I.A.2) will be collected periodically from the dumpsters and transported and disposed at the City of Antigo landfill or another approved facility including potentially an on-site facility.

Building materials wastes (Item I.A.3) will be disposed of differently according to the waste. Concrete, gravel, asphalt pavement and similar wastes will be dumped in an area that either requires fill or else can be worked into the final grading plans for the various facilities. Any wastes with salvage value will be segregated and salvaged. Non-salvageable wastes that can be burned will be burned in the mine/mill area in an approved facility. If a waste cannot be burned or if burning is not allowed, then the waste would be disposed at the City of Antigo landfill or another approved facility including

potentially an on-site facility. Any remaining wastes not allowable in the landfill (potentially hazardous wastes) would be transported to and disposed in a suitable facility such as Waste Research and Reclamation (Eau Claire) or Milwaukee Solvent. Waste oils, hydraulic fluids and other petroleum product wastes would be periodically removed from the temporary holding facilities by a waste oil recycler. Any of these types of waste fluids not recycleable would be disposed at one of the facilities (or a similar one) noted above.

Final disposition of sanitary wastes (Item I.A.4) has been previously described.

Question II.A.6:

What alternatives to disposal were and are being considered for these wastes?

Response:

Significantly different alternative methods of disposal of the various wastes have not been considered. However, variations of the proposed action have been considered:

a) For the wastes proposed for disposal at the City of Antigo landfill several other landfills have been considered, including the Town of Nashville landfill, Ridgeview Landfill in Manitowoc County, and also a new on-site facility developed as part of the Project;

b) For the clear and grub waste, chipping is preferred followed by burning as a second choice. However, burying has also been considered as an alternative; and

c) Other facilities or equipment to better manage the wastes (baler or an incinerator) have also been considered. At this time it is preferable to wait until a firm pattern of waste generation is established (one or two years into operations) to determine if equipment like this would be beneficial.

Question II.A.7:

Are there any other wastes not indicated in Section IA which will be produced during construction activity?

Response:

It is possible that some minor amounts of wastes have not been identified; however, it is assumed that any unidentified waste would conform with one of the existing waste categories identified previously and could be disposed in accordance with an existing plan.

Question II.B.1:

What volume and weight of the wastes identified in I.B. will be generated during operation of the Project?

Response:

Responses are provided for both the mine and mill by item according to the wastes identified in Section I.B. of your letter. The basis for determining the waste estimate is also included with the response. Table 3 summarizes the information for all waste types.

Solid Waste, Refuse (Item I.B.1)

a. Refuse from Exxon employees, cafeteria, office etc.

Quantity of this waste is based on an estimate of 2.3 t (2.5 short tons) per year per employee. Assuming a conservative workforce estimate of 800 employees, the total yearly waste quantity would be 1,815 t (2,000 short tons). Over the 22-year Project operating life the total quantity of this waste would be 39,930 t (44,000 short tons). Assuming a density of 1,000 pounds per cubic yard, the waste volume is 4,000 cubic yards per year and 88,000 cubic yards over the life of the Project. The waste is expected to consist of the following materials and it is all currently planned to be disposed at the City of Antigo landfill or another approved landfill including potentially an on-site facility:

Material	Percentage
Paper and Garbage	75
Plastic	5
Wood	5
Metal	10
Miscellaneous	5

b. Tires

Used or worn out tires will be recycled by periodically returning them to the vendors. Tire life under similar conditions is approximately 1,000 - 3,000 hours with an average life of approximately 2,000 hours. For the approximate 100 mobile vehicle fleet, with a total of approximately 500 tires, and with an average vehicle operation of 3,000 hours per year, approximately 750 tires per year would be worn out and returned to the vendors.

At an average weight of 150 pounds per tire total yearly weight of disposed tires would be approximately 56 short tons. For the 22-year operating

period the total weight of recycled tires would be 1,232 shorts tons. With an approximate volume of 7 cubic feet per tire total waste tire volume would be 195 cubic yards per year and 4,300 cubic yards over the life of the Project.

c. Scrap Metal

Project scrap metal will be returned to vendors or sold to scrap dealers to be recycled or ultimately reused. Based on the Project equipment, operating rates and typical scrap rates, the following estimated scrap metal will be generated annually:

	Short Tons
Mine	
Drill Steel, Pipe, Roof Bolts	7
Hoist Cables	5
Crusher Liners	6
Chutes	6
Mobile Equipment Parts/Buckets	12
Mill	
Crusher Liners	184
Mill Liners	190
Screens	5
Chutes, Piping, etc.	3
Overall contingency (approximately 20%)	82
Total Annual Scrap Metal	500

Assuming a piled or stacked density of 400 pounds per cubic foot approximately 93 cubic yards of scrap metal would be generated per year. Over the 22-year operating period total scrap metal would be 11,000 short tons with a volume of 2,040 cubic yards.

d. Others

Estimates of other scrap or waste material (some with possible reuse) include:

	Annual		Over Project Life	
Item	Short Tons	Cubic Yards	Short Tons	Cubic Yards
Conveyor Belting	4	3	88	66
Plastic Piping	2	3	44	66
Rubber Hose and Pipe	2	4	44	88
Mine Planks and Timber	3	6	66	132
Blasting Supplies Packaging	1	4	22	88
Totals	12	20	264	440

Petroleum Products, Chemical Wastes (Item I.B.2)

a. Waste Oil, Hydraulic Fluids, Lubricants

For equipment oil changes, hydraulic fluid changes, or oil or fluid removal for repairs or preventative maintenance, a total weekly disposal of 500 gallons is estimated. On an annual basis this is 26,000 gallons and over the 22-year operating period this totals approximately 572,000 gallons. Portions of these waste products may be recycled or adapted for secondary use.

b. Solvents, Degreasers

Estimated solvent and degreaser use may amount to 2 gallons per day. Assuming this entire quantity is recycled or handled by a speciality disposer, the yearly quantity would be 730 gallons and the amount over the entire Project life would be 16,060 gallons.

c. Waste Fuels, i.e., Spills

To account for potential fuel spills an allowance or projection of one barrel (55 gallon drum) every 3 months of recoverable spills was assumed. This is equivalent to 220 gallons per year or 4,840 gallons of fuel over the Project life.

d. Waste Chemical Residue Produced as the Result of a Spill or Off-Specification Products and Waste Containers

The practice followed will be to return chemical containers and any off-specification products to the supplier. To provide for potential spills or other circumstances that result in chemicals or containers that must be disposed of an allowance of one barrel (55 gallon drum) every 6 months was assumed. This is equivalent to 110 gallons per year or 2,420 gallons of chemical waste over the Project life. Overall it was assumed that these wastes have a density of approximately 60 pounds per cubic foot.

To the extent they are suitable, all of the petroleum and chemical wastes noted above will be returned to recyclers. Any non-recyclable wastes would be disposed with a specialty disposer such as Waste Research and Reclamation (Eau Claire) or Milwaukee Solvent.

Potential Hazardous Wastes. Wastes which may be classified as hazardous according to NR 181, subchapter II (Item I.B.3).

a. Laboratory Wastes

Ordinary paper wastes, cardboard boxes, and similar waste materials are included in the solid waste refuse projections under item I.B.1.a. Laboratory sink drains will carry liquids for transfer to the reclaim water pond system. To provide allowance for other laboratory wastes that may be potentially hazardous and that require special handling (i.e., broken containers, waste chemicals or material samples) 25 pounds per day or approximately 0.5 cubic foot of laboratory waste per day was assumed. On a yearly basis this is approximately 4.5 short tons or 7 cubic yards. Over the life of the Project it is 100 short tons or 154 cubic yards.

b. Machine, Repair, or Paint Shops Waste

Salvageable scrap metal and recycleable oils or solvents from these operations have been included under Item I.B.2.a. and b. Other wastes might include paint cans with some waste paint, oily, greasy or solvent soaked rags, waste absorbents, and non-salvageable waste machine cuttings. Altogether these wastes are estimated to be generated at the rate of approximately 35 pounds per day with a disposal volume of approximately 2 cubic feet. On a yearly basis this is 6.4 short tons or 27 cubic yards; and 141 short tons or 594 cubic yards for the Project life.

c. Spill Residues

All potential Project spills are included under Items I.B.2.c. and d.

d. Other

All types of potentially hazardous wastes have been included in the categories above. Any minor amounts of other specific wastes would fit into one of the above groups.

Disposal of these types of potentially hazardous wastes (other than the laboratory waste liquids transferred to the reclaim ponds) would be through a specialty disposer. All applicable regulations covering handling, transfer, and disposal of the wastes would be followed.

Sanitary Wastes (Item I.B.4)

All sanitary waste related questions are covered in the response to Question II.B.8. Yearly and total septic tank sludge disposal volumes are included in Table 3.

Question II.B.2:

At what rate (tons or yd^3/day) will these wastes be produced?

Response:

Table 3 represents estimated daily and annual waste generation rates and also a total waste volume and weight for the life of the Project. Most of the wastes will be generated at relatively uniform rates throughout the year and applying a daily average waste generation rate is considered accurate. Some wastes, such as the scrap metal (consisting in large part of the mill liners) will be generated at higher rates over shorter periods of time; however, considering the overall amount of waste generation for the Project applying a uniform daily rate is a reasonable approximation.

Question II.B.3:

How will waste generation rate change during any changes in mine/mill operations, i.e. temporary shutdowns, equipment failure?

Response:

Temporary shutdowns will not immediately affect waste generation because they will not be of sufficient duration. Prolonged shutdowns will obviously reduce waste quantities.

Equipment failure may influence the generation of waste. For instance, crusher and mill liner changeout is a periodic occurrence which will result in generation of several tons of scrap metal. However, liner steel is a valuable scrap and will be salvaged. Rags and shipping carton wastage will also increase for a major repair job. Since there will be numerous pieces of equipment under constant maintenance, even a major repair job will not result in a major increase in the annualized estimates of disposable waste.

TABLE 3
OPERATIONS WASTE SUMMARY

Type	Item	Volume (Yd^3)(1) Daily	Annually	Total	Weight (S.T.)(2) Daily	Annually	Total
Solid Waste, Refuse	General Refuse	11	4,000	88,000	5.5	2,000	44,000
	Tires	0.5	195	4,300	0.15	56	1,232
	Scrap Metal	0.25	93	2,040	1.4	500	11,000
	Others	0.05	20	440	0.03	12	264
Petroleum Products, Chemical Wastes	Waste Oil and Hydraulic Fluid	0.35	129	2,830	0.28	104	2,294
	Solvents and Degreasers	0.01	4	80	0.01	3	58
	Fuel Spills	0.003	1	24	0.003	1	19
	Chemical Residues	0.001	0.5	12	0.001	0.5	10
Potentially Hazardous Wastes	Laboratory Wastes	0.02	7	154	0.01	4.5	100
	Machine and Paint Shop	0.07	27	594	0.02	6.4	141
	Spill Residues	(Included in Fuel Spills and Chemical Residues).					
	Other	(Nothing Else Identified)					
Sanitary Wastes	Sludge	0.24	89	1,955	0.21	75	1,647

Notes:

(1) Yd^3 = cubic yards.
(2) S.T. = short tons.

Question II.B.4:

How will the wastes indicated in I.B be collected and stored on site?

Response:

The following collection and storage procedures will be used:

Item	Collection*	Storage
Refuse	Trash cans, barrel	Dumpsters
Tires	Truck/hoist	Timber & steel storage yard
Scrap Metal	Plant metal bins, truck, recyclers, etc.	Timber & steel storage yard
Others	Trash cans, etc.	Timber & steel storage yard
Oil	Shop storage drums	Lubricant storage on surface
Waste Fuel, Solvents, Chemical Spills	Pump, barrel if needed, truck if needed	Lubricant, cold storage building on surface
Laboratory (Other than ordinary refuse and liquids drained to reclaim ponds.)	Lab trash cans, jars, etc.	Reagent, supply storage area in lab
Machine & Paint	Special dumpsters for paint, solvent cans to be removed by specialty disposer	Cold storage building area on surface
Spill Residues (Potentially hazardous)	Special sumps designed to contain all materials in case of a spill on the property by a delivery truck; spills will be placed in pilot plant tails sump by front end loader.	Secure area such as pilot plant tails sump until removed by specialty disposer

* Underground collection procedures which apply will be similar. Transportation to the ultimate surface waste storage locations will employ the main shaft service cage. Drums, bins, etc. will be either caged by forklift or carried on-board a suitable mine vehicle of cageable dimensions.

Question II.B.5:

What alternatives to disposal such as recycling/reuse were and are being considered?

Response:

Except for the solid waste refuse from the Exxon employees, cafeteria, office and other facilities to be disposed of at the City of Antigo Landfill or another approved landfill and the potentially hazardous wastes to be handled by special disposer, nearly all wastes are recycled:

1) Tire casings will be returned to the supplier for recapping or disposal.

2) Scrap metal will be recycled. This is common practice in the mining industry today. Mill liners are returned to vendors in most cases, while scrap angle iron and other common scrap metal is sold to scrap dealers.

3) Common scrap metal will be segregated in a storage area for a period of time and then proposals from scrap dealers will be accepted with the scrap going to the highest bidder.

4) To the extent possible, chemicals and reagents will be purchased in returnable containers. Cyanide, for instance, will be purchased in "Flo-bins" which are returnable and minimize the handling of the chemical.

5) The laboratory will follow common industry practice of keeping glass wastage (empty bottles, broken glassware) in separate trash cans. This will enable the Crandon Project to offer this glass to recyclers.

6) The chemicals used in the analytical laboratory will consist of small quantities of acids, bases, and very small amounts of organics. The present plan includes piping the laboratory sinks to drain into the reclaim ponds. Accordingly, there will be virtually no need to discard toxic chemicals from the laboratory.

7) The reagents used in the laboratory are not significantly different than those used in the mill and, in quantity, they are very low in comparison to the total flow through the reclaim ponds. These ponds are routinely used for recycling mill water and disposal of these small quantities of waste reagents will not affect the chemical composition of the ponds.

8) Paper waste could be recycled to the local mills if sufficient quantities of different paper types are generated.

Question II.B.6:

Due to the large volume of petroleum products, waste oil, hydraulic fluids, chemical reagents, a spill plan for all storage areas will be needed. The spill plan must address the prevention, containment, clean-up and disposal of spilled materials.

Response:

Chapter 1.0 of the Crandon Project EIR addresses this concern in several sections. All storage tanks have been designed with containment berms and

sumps which will contain the entire contents of the storage tank. Blind sumps, which are part of the spill containment design, do not contain drains or automatic pumps which might inadvertently displace a spill into some unsafe location. Such sumps would contain the entire spill.

In most instances, spills will not preclude the reuse of the chemical in the plant since the sumps avoid contamination of the chemical and the environment. Should a spill occur during transport of a chemical to the storage area while on the property, it would be reclaimed by pumps, front-end loaders, shovels or by whatever means is appropriate. If a spill should contaminate soils, the contaminated soil would be removed immediately by front-end loader and truck and stored in the pilot plant tailings sump or other safe storage until a licensed disposal firm could remove it to an appropriate disposal facility.

Question II.B.7:

A number of industrial processes located at the project have the potential for generating a hazardous waste (as defined by NR 181), i.e., machine shop, laboratory, maintenance areas, etc. What areas will generate hazadous waste? What type and volume of hazardous waste will be generated? How will the material be handled, stored and disposed?

Response:

a. Surface and Underground Repair/Machine Shops

Hazardous wastes will be restricted to solvents and solvent soaked rags. These will be held in an approved fire resistant container for recycle/disposal by licensed hazardous waste handlers.

Used batteries will be stored prior to recycle in the covered area near the timber and steel storage compound. they will be offered as part of metal recycle to the scrap dealers.

b. Laboratory

Hazardous wastes would consist of empty containers which previously contained chemicals. These chemicals consist of mostly acids, alkalies and occasionally some organics.

The chemicals themselves are consumed in the assaying and experimental procedures. Since they are similar to reagents used in the mill processes, they will be disposed in the mill streams and end up in the mill recycle water where they are decomposed and/or eliminated in the water treatment plant. They represent a negligible part of the mill water system (less than 1 gpm of the 6,000 gpm recycle).

The empty bottles from the chemicals will be rinsed, segregated and stored according to chemical type and held for disposal or recycle by a licensed handler (4 - 5 one-gallon bottles per day). Laboratory drains flow to the reclaim ponds and the water is recycled in the mill.

c. Reagent Handling and Storage Facility

The reagent handling and storage facility in the mill has a possibility for accidental generation of hazardous wastes. The reagents used in the processes consist of sodium cyanide, sodium dichromate, sulfuric acid, sulfur dioxide, lime, xanthates, and various organic chemicals. For normal circumstances, it is not anticipated that this facility will generate hazardous wastes. All containers for these chemicals will be returned to the vendors. All storage areas are protected by retaining walls and sumps. Accidental spills in these areas will normally be returned to the process as they would not harm the reagents.

In the event that a reagent was spilled outside the storage area, it could get contaminated in such a way as to make it unusable. This spill could possibly be a liquid and could saturate a limited amount of soil. This spill residue would be cleaned up by removing the affected soil. The pilot plant tailings sump is a concrete sump with vehicle access so that it might be used to store the residue until a licensed handler could remove it.

Question II.B.8:

What volume of septic tank sludge and/or chemical toilet waste will be produced? At what rate will the waste be produced? How will it be disposed? Will the chemical toilet waste be compatible with the proposed septic system? Can the chemical toilet waste be disposed with the septic sludge or will it require special handling?

Response:

The total Project sanitary wastewater flow is estimated at 109 m^3 (28,750 gallons) per day during the 22-year operating period. These waste generation rates are assumed to remain constant over the 22-year operating period. This estimate is conservatively based on an 800 person employee and visitor population and a 0.13 m^3 (35 gallon) per person per day waste generation rate. By DILHR code a 2.84 m^3 (750 gallon) base flow is added to the total daily volume.

This estimate is also conservative because approximately one-third of the work force will utilize chemical toilets in the mine. They will have access to full sanitary facilities before and after their shift but will occassionally utilize

the chemical toilets. This will tend to reduce their total waste contribution.

The chemical toilets will generate less than 0.004 m^3 (1 gallon) per person per day of sanitary waste. Waste from these chemical toilets will be flushed into the surface sanitary sewer system for disposal in the permanent surface sanitary waste disposal facility. Flush to waste rates of 5:1 would still only yield a total waste quantity from the chemical toilets of 0.02 m^3 (5 gallons) per person per day.

The chemical toilets are normally charged with a small volume of formaldehyde and perfume when they are emptied, cleaned, and prepared for reuse. Based on the dilution that these chemical toilet wastes ultimately receive from the flushing when they are dumped into the surface sewage system and also when they are combined with the other sewage normally handled in the permanent facilities, these chemicals are not expected to affect the operation of the sanitary waste disposal system septic tanks.

The quantity of sanitary sewage solids has been approximated based on a per capita contribution of 0.07 kg (0.15 pound) total suspended solids per day. For the 800 person population this is equivalent to approximately 120 pounds per day. Assuming a specific gravity of 1.0, a solids volume of approximately 2.0 cubic feet would be generated per day. On a yearly basis this would amount to approximately 730 cubic feet.

To provide a conservative projection of sludge disposal, it has been assumed that one-fourth of the total septic tank system storage capacity is pumped and removed for disposal twice a year. Based on this approximation a total yearly sludge disposal volume of 2,400 cubic feet has been estimated. At this yearly rate, over the 22-year operating period, a total of 52,800 cubic feet of sludge will be disposed of off-site.

Question II.C.1:

What volume of demolition material will be disposed on site at the end of the Project?

Response:

Assuming no other use is determined for any of the Project facilities and all facilities are either demolished or dismantled, the following waste materials and quanities would be disposed on-site during final Project reclamation. Where disposal options are noted as (1) and (2) options are given in order of preference. However, if the preferable options are not available at the time of disposal, all listed wastes will be disposed on-site.

The waste quantities estimated for on-site disposal include all items with significant volumes. Other minor amounts of building wastes (e.g., masonary walls, drywall) may be buried on-site in a legal and environmentally acceptable manner.

Facility	Item	Quantity	Disposal
Access Road	Asphalt Pavement	7,216 t	(1) Recycled and used elsewhere. (2) Buried within roadway right-of-way or in mine/mill area and worked into the final grading plan.
	Stone Base	56,700 t	(1) Recovered and reused elsewhere. (2) Buried within roadway right-of-way or in mine/mill area and worked into the final grading plan.
	Bridge Girders	194 m	(1) Salvaged and reused elsewhere. (2) Demolished and buried within roadway right-of-way and worked into the final grading plan.
	Other Bridge Concrete	247 m^3	(1) Demolished and buried within roadway right-of-way and worked into the final grading plan.
Railroad Spur	Ballast	25,820 t	(1) Recovered and reused elsewhere. (2) Buried within railroad right-of-way or in mine/mill area and worked into the final grading plan.
	Subballast	12,430 t	(1) Same as for ballast. (2) Same as for ballast.

Facility	Item	Quantity	Disposal
	Bridge Girders	61 m	(1) Salvaged and reused elsewhere. (2) Demolished and buried within railroad right-of-way and worked into the final gradng plan.
	Other Bridge Concrete	191 m^3	(1) Demolished and buried within railroad right-of-way and worked into the final grading plan.
Mine/Mill Area	Asphalt Pavement	5,075 t	(1) Recycled and used elsewhere. (2) Buried within mine/mill area and worked into the final grading plan.
	Stone Base	35,130 m^3	(1) Recovered and reused elsewhere. (2) Buried within mine/mill area and worked into the final grading plan.
	Railroad Ballast	6,625 m^3	(1) Same as for stone base.
	Concrete*	13,900 m^3	(1) Demolished and buried within mine/mill area and worked into the final grading plan.

---

* Concrete for on-site disposal estimated to include all suspended slabs, all walls, one-half the volume of all grade beams, one-half the volume of all slabs on grade, all tunnel roofs, and one-half the volume of all tunnel walls.

Question II.C.2:

What material will be removed from the Project for reuse or off-site disposal?

Response:

Assuming the Project site is completely reclaimed, the following materials will be removed from the site for reuse, scrap, or waste disposal elsewhere. The following list includes all major items; however, there may be other minor

amounts of similar materials that will also be removed for reuse or scrap or actual disposal.

Facility	Item	Quantity	Disposal
Access Road	Fencing	2,650 m	Reuse or scrap
	Guardrail	325 m	Reuse or scrap
Railroad Spur	Track (2 rails)	8,116 m	Relayer or scrap
	Ties	14,500	Reuse
	Wood Plank	4,200 Bd. Ft.	Reuse
Mine/Mill Area	Structural and Building Steel	5,000 t	Reuse or scrap
	Metal Siding and Roofing	60,000 m^2	Reuse or scrap
	Metal Liner Panel	43,000 m^2	Reuse or scrap
	Prefabricated Buildings	5 2900 m^2	Reuse or scrap
(DRYWALL 12543)	Insulation	43,000 m^2	Waste
	Process Equipment	Lump Sum	Reuse or scrap
	Above Ground Mechanical Systems	Lump Sum	Reuse or scrap
	Above Ground Electrical Systems	Lump Sum	Reuse or scrap
	Other Above Ground Utility Systems	Lump Sum	Reuse or scrap
	Track (2 rails)	3,310 m	Relayer or scrap
	Ties	6,000	Reuse
	Fencing	5,635 m	Reuse or scrap
	Doors and Windows	Lump Sum	Reuse or scrap
MWDF Area	Above Ground Mechanical Systems	Lump Sum	Reuse or scrap
	Above Ground Electrical Systems	Lump Sum	Reuse or scrap
Mine	Mine Hoisting Equipment and Conveyances	Lump Sum	Reuse or scrap
	Salvageable Mine Electrical, Mechanical, and Processing Equipment		

Facility	Item	Quantity	Disposal
	i.e. Crushers, Main Fans, Pumps, Transformers etc.	Lump Sum	Reuse of scrap
	Salvageable Mine Mobile and Portable Equipment i.e. LHD's, Blasthole Drills, Compressors, Diamond Drills, Utilities, etc.	Lump Sum	Reuse or scrap

Question II.C.3:

What structures, etc., will remain on site after closure?

Response:

The portions or items of the various Project facilities noted below will remain in place in the final reclamation work. Building floor slabs, pit floors, or other larger concrete areas left in place would be broken up to allow normal rainfall infiltration.

Within the mine/mill area all concrete, pipes, conduits, or other facility components or materials will be removed to 0.5 m below the final reclamation grades and disposed either on-site (in the case of concrete) or off-site.

Facility	Item	Quantity
Project Area Monitoring System	Piezometers, lysimeters, etc.	Lump Sum
Access Road	Culverts	200 m
	Bridge Piling	213 m
Railroad Spur	Culverts	213 m
	Bridge Piling	234 m
Tailings Slurry Lines & Haul Road	Tailings Slurry Pipe	1.0 km
	Water Pipe	2.0 km
	Stone Roadway Base	19,000 Mt
	Culverts	150 m
Excess Water Discharge Line	Pipe	9.8 km

Facility	Item	Quantity
Mine/Mill Area	Concrete*	14,700 m^3
	Underground Pipe and Conduit	14,000 m
	Culverts	975 m
MWDF	Essentially entire MWDF plus reclamation cap remains in place. Additional information is included in MWDF Feasibility Report and Reclamation Plan.	
Mine	Essentially entire underground portion of mine remains in place. Additional information is included in Reclamation Plan.	

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* Concrete left in place estimated to include all building and equipment foundations, one-half the volume of all grade beams, one-half the volume of all slabs on grade, all tunnel floors, and one-half the volume of all tunnel walls.

Question II.D.

Have any other wastes of concern been identified since the original submittal of the EIR?

Response:

The information presented in this letter represents our current waste information and estimates. This information will also be included in the final EIR.

Please contact me or Carlton Schroeder if you have any questions or comments regarding the information provided in these responses.

Sincerely,

EXXON MINERALS COMPANY

B. J. Hansen
Permitting Manager

BJH:CCS:sjq

xc/R. Ramharter

D.B. Achttien
J.A. DeMarte
J.G. Derouin
B.J. Hansen
H.G. Hoskins
J.R. Klauser
H.S. Lewis
D.E. Moe
J.D. Patton

Comment No. 20:

What volumes of general refuse, hazardous waste, petroleum wastes, and construction wastes would be generated during the various phases of the project? Is an onsite landfill feasible? In particular please indicate what changes may occur to page 1.1-38 and Table 1.3.2 and Section 1.4.8.3.

Response:

The volume estimates for general refuse, hazardous waste, petroleum wastes and construction wastes presented in the November 9, 1984 letter to the DNR will not change substantially in the revised Project plan. Also the types and nature of the wastes will not change.

During the operation phase, the annual rate of waste generation for most types of waste will be reduced because of a reduction in workforce and a lower operating rate. However, the extended mine operating life will offset the annual reduction in waste volume caused by a lower operating rate and a reduction in the estimated workforce from 800 to 650 employees.

There will be marginal reductions in waste volume during construction and reclamation phases due to the reduced size of facilities. However, these reductions are negligible compared with the total Project waste volume, and therefore do not significantly affect the totals.

There are several reasons for the change from off-site disposal in the previous plan to development and use of an on-site facility in the revised Project plan:

1) Current and future availability of off-site disposal facilities is not a certainty.

2) Based on economics alone, an on-site facility is more cost effective than hauling to an off-site facility, and with expected increasingly higher off-site disposal costs it probably will improve further in the future.

The attached preliminary design information provides a description of an on-site facility and the basis for its design. The facility will be designed to accommodate the revised waste volume of 1,625 short tons annually.

EMC will proceed with preparation of a feasibility report for this facility under NR 182 regulation and will submit a permit application at a later date. The attached preliminary design package should provide the necessary details for DEIS preparation.

For the revised EIR the specific changes on page 1.1-38 will include:

1) Disposal on-site, in an EMC mine waste landfill, of non-hazardous wastes and refuse. Plans for disposal at special off-site facilities for potentially hazardous wastes, petroleum, chemical and other related specialty wastes, as identified in the November 9, 1984 letter, will not change.

2) With a 650 employee allowance, the annual waste volume will be reduced to 1,625 short tons from the previous estimate of 2,000 short tons.

There will be no change in Table 1.3-2.

The changes for subsection 1.4.8.3 will include:

1. All references to the off-site landfill for disposal of the non-potentially hazardous wastes and refuse will be revised and disposal operations associated with the proposed on-site EMC mine waste landfill will be substituted.

2. The annual waste quantity will be reduced from 2,000 to 1,625 short tons.

GENERAL NOTES

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS : Split Spoon – 1 3/8" I.D., 2" O.D., unless otherwise noted
ST : Shelby Tube – 2" O.D., unless otherwise noted
PA : Power Auger
DB : Diamond Bit – NX: BX: AX
AS : Auger Sample
JS : Jar Sample
VS : Vane Shear
OS : Osterberg Sampler – 3" Shelby Tube
HS : Hollow Stem Auger
WS : Wash Sample
FT : Fish Tail
RB : Rock Bit
BS : Bulk Sample
PM : Pressuremeter test - in situ

Standard "N" Penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2 inch OD split spoon, except where noted.

WATER LEVEL MEASUREMENT SYMBOLS:

WL : Water Level
WCI : Wet Cave In
DCI : Dry Cave In
WS : While Sampling
WD : While Drilling
BCR : Before Casing Removal
ACR : After Casing Removal
AB : After Boring

Geologic Units:

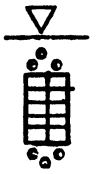
FD: Fine-grained stratified drift
CD: Coarse-grained stratified drift
BT: Basal till
T: Glacial till
L: Lacustrine

Water levels indicated on the boring logs are the levels measured in the boring at the times indicated. In pervious soils, the indicated elevations are considered reliable ground water levels. In impervious soils, the accurate determination of ground water elevations is not possible in even several days observation, and additional evidence of ground water elevations must be sought.

GRADATION DESCRIPTION & TERMINOLOGY:

Coarse Grained or Granular Soils have more than 50% of their dry weight retained on a #200 sieve; they are described as: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are described as: clays or clayey silts if they are cohesive, and silts if they are non-cohesive. In addition to gradation, granular soils are defined on the basis of their relative in-place density and fine grained soils on the basis of their strength or consistency, and their plasticity.

Major Component Of Sample	Size Range	Descriptive Term(s) (Of Components Also Present in Sample)	Percent of Dry Weight
Boulders	Over 8 in. (200mm)	Trace	1 – 9
Cobbles	8 in. to 3 in. (200mm to 75mm)	Little	10 – 19
Gravel	3 in. to #4 sieve (75mm to 2mm)	Some	20 – 34
Sand	#4 to #200 sieve (2mm to .074mm)	And	35 – 50
Silt	Passing #200 sieve (0.074mm to 0.005mm)		
Clay	Smaller than 0.005mm		



groundwater level 5-24-84

well screen with pea gravel backfill.

CONSISTENCY OF COHESIVE SOILS:

Unconfined Comp. Strength, Qu, tsf	Consistency
< 0.25	Very Soft
0.25 – 0.49	Soft
0.50 – 0.99	Medium (Firm)
1.00 – 1.99	Stiff
2.00 – 3.99	Very Stiff
4.00 – 8.00	Hard
>8.00	Very Hard

RELATIVE DENSITY OF GRANULAR SOILS:

N – Blows/ft.	Relative Density
0 – 3	Very Loose
4 – 9	Loose
10 – 29	Medium Dense
30 – 49	Dense
50 – 80	Very Dense
80+	Extremely Dense

SOIL BORING LOGS

STS Consultants Ltd.

OWNER Exxon Minerals Company

LOG OF BORING NUMBER EX-9

PROJECT NAME Piezometer Installations

Feet: N-116461 E-2284725 Meters: N-35497 E-696386

SITE LOCATION Crandon Project

WELL INSTALLATION TOP STANDPIPE EL. + _____

SURFACE ELEVATION 1708.86-ft. 520.862-m

DEPTH FEET / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	PIEZOMETER ID	GEOLOGIC UNIT	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
	A	SS			Brown fine to coarse sand (SP) - coarse drift		CD	5			3	
10	1	SS										
					Reddish brown silty fine to coarse sand (SM) - some gravel, glacial till		T	6			13	
20	2	SS										
	3	SS						4			17	
30												
	4	SS						6			--	
40	4A	SS										
	5	SS						6			11	
50					Brown slightly silty fine to coarse sand (SM-SP)- some gravel - coarse drift		T					
	6	SS						9			--	
60												
	7	SS						11			6	
70												
	8	SS						5			--	
80												
90					Brown fine to coarse gravel (GP) and fine to coarse sand (SP) - coarse drift							

Continued

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED 3-16-84
BORING COMPLETED 3-21-84
RIG Denny's Drilling
FOREMAN Denny

STS OFFICE 540 Lambeau Green Bay, WI 54303
DRAWN BY SMD SHEET 1 OF 4
APP'D. BY JAS STS JOB NO. 12959

BL: 5-983

STS Consultants Ltd.

OWNER Exxon Minerals Company

PROJECT NAME Piezometer Installations

LOG OF BORING NUMBER EX-9

Feet: N-116461 E-2284725 Meters: N-35497 E-696386

SITE LOCATION Crandon Project

WELL INSTALLATION
TOP STANDPIPE EL. +

SURFACE ELEVATION 1708.86-ft. 520.862-m

DEPTH FEET / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	PIEZOMETER ID	GEOLOGIC UNIT	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
	A	SS			Brown fine to coarse sand (SP) - coarse drift		CD	5			3	
10	1	SS			Reddish brown silty fine to coarse sand (SM) - some gravel, glacial till		T	6			13	
20	2	SS						4			17	
30	3	SS						6			--	
40	4	SS										
	4A	SS										
50	5	SS			Brown slightly silty fine to coarse sand (SM-SP)- some gravel - coarse drift		T	6			11	
60	6	SS						9			--	
70	7	SS						11			6	
80	8	SS						5			--	
90					Brown fine to coarse gravel (GP) and fine to coarse sand (SP) - coarse drift							

Continued

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL	BCR		ACR		
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED 3-16-84
BORING COMPLETED 3-21-84
RIG Denny's Drilling
FOREMAN Denny

STS OFFICE 540 Lambeau Green Bay, WI 54303
DRAWN BY SMD SHEET 1 OF 4
APP'D. BY JAS STS JOB NO. 12959

BL: 5-983

STS Consultants Ltd.

OWNER
Exxon Minerals Company

PROJECT NAME
Piezometer Installations

LOG OF BORING NUMBER
EX-9 Continued

Feet N-116461 E-2284725 Meters N-35497 E-696386

SITE LOCATION
Crandon Project

WELL INSTALLATION
TOP STANDPIPE EL. +_____

DESCRIPTION OF MATERIAL

SURFACE ELEVATION 1708.86-ft. 520.862-m

DEPTH FEET ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	PIEZOMETER ID	GEOLOGIC UNIT	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
90												
	9	SS			Brown fine to coarse gravel (GP) and fine to coarse sand (SP) - coarse drift			8			4	
100												
	10	SS			Reddish brown silty fine to coarse sand (SM) - some gravel - glacial till		T	8			20	
110	11	SS			5-24-84 ▽			7			--	
120												
	12	SS				BU		9			19	
130												
	13	SS			Brown slightly silty fine to coarse sand (SM-SP)- some gravel - waterbearing - coarse drift			11			6	
140							CD					
	14	SS						13			9	
150												
	15	SS						9			--	
160												
	16	SS			Reddish brown silty fine to coarse sand (SM) - a little gravel - glacial till		T	9			21	
170												
					Continued							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED 3-16-84
BORING COMPLETED 3-21-84
RIG Denny's Drilling
FOREMAN Denny

STS OFFICE 540 Lambeau Green Bay, WI 54303
DRAWN BY SMD SHEET 2 OF 4
APP'D. BY JAS STS JOB NO. 12959

BL: 5-983

STS Consultants Ltd.

OWNER: Exxon Minerals Company	LOG OF BORING NUMBER: EX-9
PROJECT NAME: Piezometer Installations	Feet: N-116461 E-2284725 / Meters: N-35497 E-696386
SITE LOCATION: Crandon Project	

WELL INSTALLATION
TOP STANDPIPE EL. +_____

SURFACE ELEVATION 1708.86-ft. 520.862-m

DEPTH FEET / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	PIEZOMETER ID	GEOLOGIC UNIT	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
170												
	17	SS		LS	Reddish brown silty fine to coarse sand (SM) - a little gravel - glacial till		T	10			--	
180	17A	SS										
	18	SS			Dark reddish brown slightly silty fine to coarse sand (SM-SP) - some gravel - coarse drift	BL	CD	10			11	$2x10^{-6}$
190	19	SS						14			--	
200					Brown silty fine to coarse sand (SM) - trace gravel - coarse drift		CD	14			13	
	20	SS										
210												
	21	SS			Brown silty fine to medium sand (SM) - fine drift		FD	21			--	
220												
	22	SS						20			--	
230												
	23	SS						18			--	
240												
	24	SS				AU		20			--	$6x10^{-3}$
250												

Continued

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED	3-16-84
BORING COMPLETED	3-21-84
RIG	Denny's Drilling
FOREMAN	Denny
STS OFFICE	540 Lambeau Green Bay, WI 54303
DRAWN BY	SMD
SHEET	3 OF 4
APP'D. BY	JAS
STS JOB NO.	12959

BL: 5-983

STS Consultants Ltd.

OWNER
Exxon Minerals Company

PROJECT NAME
Piezometer Installations

SITE LOCATION
Crandon Project

LOG OF BORING NUMBER
EX-9 Continued

Feet: N-116461 E-2284725
Meters: N-35497 E-696386

WELL INSTALLATION
TOP STANDPIPE EL. +

SURFACE ELEVATION 1708.86-ft. 520.862-m

DEPTH FEET / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	PIEZOMETER ID	GEOLOGIC UNIT	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
250												
	25	SS			Brown silty fine to medium sand (SM) - fine drift		FD	17			17	
260					Reddish brown fine to coarse sandy silt (ML) - trace gravel - basal till		BT	13			--	
	26	SS										
270					Bedrock	AL						$2x10^{-8}$
280					End of Boring in Bedrock Boring advanced to 280.0 feet with rock bit and bentonite mud							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED 3-16-84
BORING COMPLETED 3-21-84
RIG Denny's Drilling
FOREMAN Denny

STS OFFICE 540 Lambeau, Green Bay, WI 54303
DRAWN BY SMD
SHEET 4 OF 4
APP'D. BY JAS
STS JOB NO. 12959

BL: 5-983

STS Consultants Ltd.

OWNER Exxon Minerals Company

PROJECT NAME Piezometer Installations

LOG OF BORING NUMBER EX-10

Feet: N-115111 E-2284239 Meters: N-35086 E-696237

SITE LOCATION Crandon Project

WELL INSTALLATION TOP STANDPIPE EL. + _____

SURFACE ELEVATION 1674.93-ft. 510.520-m

DEPTH FEET / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	PIEZOMETER ID	GEOLOGIC UNIT	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
10	1	SS			Brown silty fine to medium sand (SM) - trace gravel		CD	19			-	
20	2	SS			Reddish brown fine to coarse sand (SP) - little gravel - coarse drift		CD	15			37	
30	3	SS						8			4	
40	4	SS			Brown slightly silty fine to coarse sand (SM-SP)- some gravel - coarse drift		CD	5			6	
50	5	SS			Reddish brown silty fine to coarse sand (SM) - trace to little gravel - glacial till		T	9			24	
60	6	SS						10			24	
70	7	SS						9			-	
80	8	SS			5-24-84 ▽		BU	12			-	
90					Continued							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL			BCR		ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED 3-13-84
BORING COMPLETED 3-15-84
RIG Lusiers
FOREMAN Keith

STS OFFICE 540 Lambeau Street Green Bay, WI. 414-494-9656
DRAWN BY SD
SHEET 1 OF 4
APP'D. BY JAS
STS JOB NO. 12959

BL: 5-983

STS Consultants Ltd.

OWNER: Exxon Minerals Company

PROJECT NAME: Piezometer Installations

SITE LOCATION: Crandon Project

LOG OF BORING NUMBER: EX-10

Feet: N-115111 E-2284239 Meters: N-35086 E-696237

WELL INSTALLATION
TOP STANDPIPE EL. +

SURFACE ELEVATION 1674.93-ft. 510.520-m

DEPTH FEET / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	PIEZOMETER ID	GEOLOGIC UNIT	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
					Continued							
90												
	9	SS			Reddish brown silty fine to coarse sand (SM) - trace to little gravel - glacial till	BU	T	14			25	
100												
	10	SS						9			14	
110												
	11	SS						8			-	
120												
	12	SS						10			-	
130												
	13	SS						11			20	
140						BL						$2x10^{-5}$
	14	SS						10			-	
150												
	15	SS						10			-	
160												
	16	SS						7			-	
170					Continued							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED 3-13-84
BORING COMPLETED 3-15-84
RIG Lusiers
FOREMAN Keith

STS OFFICE 540 Lambeau Street, Green Bay, WI. 414-494-9656
DRAWN BY SD
SHEET 2 OF 4
APP'D. BY JAS
STS JOB NO. 12959

BL: 5-983

STS Consultants Ltd.

OWNER Exxon Minerals Company

PROJECT NAME Piezometer Installations

LOG OF BORING NUMBER EX-10

Feet: N-115111 E-2284239 Meters: N-35086 E-696237

SITE LOCATION Crandon Project

SURFACE ELEVATION 1674.93-ft. 510.520-m

DEPTH FEET / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	WELL INSTALLATION TOP STANDPIPE EL. +	PIEZOMETER ID	GEOLOGIC UNIT	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
170					Continued								
180	17	SS			Brown slightly silty fine to medium sand (SM-SP) - trace gravel - fine drift			FD	13			6	
	18	SS							19			6	
190	19	SS					AU		18			-	$1x10^{-3}$
200	20	SS							17			-	
210	21	SS			Brown silty fine sand (SM) - with thin silt seams - lacustrine			L	17			38	
220	22	SS			Brown silt (ML) - lacustrine			L	22			93	
230	23	SS			Reddish brown silty clay (CL) - with varves of gray very fine sandy silt (ML) - lacustrine			L	21			92	
240	24	SS			Brown slightly silty fine to medium sand (SM-SP) with thin seams of coarse sand - lacustrine			L	14			9	
250					Continued								

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED 3-13-84
BORING COMPLETED 3-15-84
RIG Lusiers
FOREMAN Keith

STS OFFICE 540 Lambeau Street, Green Bay, WI. 414-494-9656
DRAWN BY SD
SHEET 3 OF 4
APP'D. BY JAS
STS JOB NO. 12959

BL: 5-983

STS Consultants Ltd.

OWNER: Exxon Minerals Company

PROJECT NAME: Piezometer Installations

LOG OF BORING NUMBER: EX-10

Feet: N-115111 E-2284239 Meters: N-35086 E-696237

SITE LOCATION: Crandon Project

WELL INSTALLATION
TOP STANDPIPE EL. +_____

SURFACE ELEVATION 1674.93-ft. 510.520-m

DEPTH FEET / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	PIEZOMETER ID	GEOLOGIC UNIT	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
250					Continued	AL						1×10^{-5}
256					Weathered bedrock							
					End of boring Boring advanced to 256' with rock bit and bentonite mud							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED 3-13-84
BORING COMPLETED 3-15-84
RIG Lusiers
FOREMAN Keith

STS OFFICE 540 Lambeau Street Green Bay, WI. 414-494-9656
DRAWN BY SD
SHEET 4 OF 4
APP'D. BY JAS
STS JOB NO. 12959

BL: 5-983

COOR. N115825 ft. (E35303m)
E2284430 ft. (E696296m)

BORING LOG G41-G12

SHEET 1 OF 1

SURFACE ELEV. 1675.7 ft. (510.76m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 3/31/79 DATE COMPLETED 3/31/79

DRILL RIG CME 45 DRILLING METHOD Solid Stem Auger and Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6 IN. (Note 1)	SAMPLES REC./ATT. (ins.)	GROUNDWATER OBSERVATION WELL
0.0		Loose, red-brown, SILT, some fine to medium sand, trace clay	ML	5	1	DO	1-3-2	15/18	(Note 2) Grout
1.07									
3.5		Compact, red-brown, fine to coarse SAND, some silt, trace fine gravel, trace clay	SM	24	2	DO	7-12-12	10/18	▼2.77 4/18/79
2.93									9.1 3.05
9.6		Dense, red-brown, fine to coarse gravelly, fine to coarse SAND, some silt, trace clay	SM	30	3	DO	8-14-16	8/18	10.0 Bentonite Clay Seal 3.96
				36	4	DO	14-20-16	12/18	13.0 Pea Gravel 4.42
									14.5 Pea Gravel 5.94
6.40				167	5	DO	45-92-75	18/18	19.5
21.0		END OF BORING							

2" Solid PVC Pipe

2" Slotted PVC Pipe

NOTES

1. Standard Penetration Test - Driving 3" O.D. sampler with 140 lb. hammer freely falling 30". (All samples)
2. Water ponded on ground surface, 3/31/79.
3. Elevation of top of protector pipe, 1678.6 ft. (511.64m).

Table of Water Level Readings by Date. Readings Indicate Depth Below Ground Surface.

DATE	4/18/79	11/12/79*	9/10/80*				
DEPTH (m)	2.77	4.15	3.63				
DEPTH (ft.)	9.1	13.6	11.9				

*Pump Test and Recovery Period Between these Dates. For Pump Test Data, Refer to PUMP TEST AND ANALYSIS, Project Report No. 4.

Job No. 786085
Scale 1"=5'

Golder Associates

Drawn jls
Checked DB

COOR. N115260 ft. (N35131m)
E2284725 ft. (E696386m)

BORING LOG G41-G13

SHEET 1 OF 11

SURFACE ELEV. 1709.6 ft. (521.08m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/27/81 DATE COMPLETED 6/4/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
0.0		Compact to very dense, brown to red brown, fine to coarse gravelly fine to coarse SAND, some silt to silty fine to coarse SAND, some fine to coarse gravel, occasional to frequent cobbles	SM	-	1	DO	Hydraulic Push	24/24	
							Hydraulic Push		
				-	2	DO		10/13	
				-	3	DO	Air Hammer	17/17	
				-	4	DO	Air Hammer	24/24	
11.13									
36.5		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N115260 ft. (N35131m)
E2284725 ft. (E696386m)

BORING LOG G41-G13

SURFACE ELEV. 1709.6 ft. (521.08m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/27/81 DATE COMPLETED 6/4/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS/FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
11.13 / 36.5		CONTINUED							
		Compact to very dense, brown to red brown, fine to coarse gravelly fine to coarse SAND, some silt to silty fine to coarse SAND, some fine to coarse gravel, occasional to frequent cobbles	SM	-	5	DO	Air Hammer	24/24	
				-	6	DO	Air Hammer	12/18	
16.76 / 55.0		Very dense, multi-colored, fine to coarse sandy fine to coarse GRAVEL, frequent cobbles	GP	-	7	DO	Air Hammer	23/23	
21.03 / 69.0		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N115260 ft. (N35131m)
E2284725 ft. (E696386m)

BORING LOG G41-G13

SURFACE ELEV. 1709.6 ft. (521.08m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/27/81 DATE COMPLETED 6/4/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS/FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
21.03		CONTINUED							
69.0		Very dense, multi-colored, fine to coarse sandy fine to coarse GRAVEL, frequent cobbles	GP	-	8	DO	Air Hammer	27/27	
23.62									
77.5		Very dense, light brown to multi-colored, fine to coarse SAND, trace fine gravel to fine to coarse gravelly fine to coarse SAND, frequent cobbles	SP	-	9	DO	Air Hammer	9/9	
				-	10	DO	Air Hammer	24/24	
30.94				-	11	DO	Air Hammer	12/16	
101.5		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N115260 ft. (N35131m)
E2284725 ft. (E696386m)

BORING LOG G41-G13

SHEET 4 OF 11

SURFACE ELEV. 1709.6 ft. (521.08m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/27/81 DATE COMPLETED 6/4/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
30.94		CONTINUED							
101.5		Very dense, light brown to multi-colored, fine to coarse SAND, trace fine gravel to fine to coarse gravelly fine to coarse SAND, frequent cobbles	SP	-	12	DO	Air Hammer	12/21	
35.05									▼ 6/10/81 35.79
115.0		Very dense, brown to red-brown, silty, fine to coarse SAND, some fine to coarse gravel, occasional cobbles	SM	-	13	DO	Air Hammer	12/21	≈ 117.4
				-	14	DO	Air Hammer	18/24	
40.84									
134.0		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N115260 ft. (N35131m)
E2284725 ft. (E696386m)
SURFACE ELEV. 1709.6 ft. (521.08m)
DATUM USGS MSL
DRILL RIG Schramm Rotadrill T64HP

BORING LOG G41-G13

SHEET 5 OF 11
PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM
DATE STARTED 5/27/81 DATE COMPLETED 6/4/81
DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6 IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
40.84		CONTINUED							
134.0		Very dense, brown to red-brown, silty, fine to coarse SAND, some fine to coarse gravel, occasional cobbles	SM	-	15	DO	Air Hammer	21/21	
				-	16	DO	Air Hammer	18/18	
47.24									
155.0		Very dense, light brown, fine to coarse SAND, some fine to coarse gravel, trace silt	SP	-	17	DO	Air Hammer	10/12	
49.07									
161.0		Very dense, brown to red-brown, silty fine to coarse SAND, some fine to coarse gravel, trace clay to fine to coarse gravelly silty fine to coarse SAND, trace clay, frequent cobbles and occasional boulders	SM						
50.75									
166.5		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N115260 ft. (N35131m)
E2284725 ft. (E696386m)

BORING LOG G41-G13

SHEET 6 OF 11

SURFACE ELEV. 1709.6 ft. (521.08m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/27/81 DATE COMPLETED 6/4/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
50.75		CONTINUED							
166.5				-	18	DO	Air Hammer	10/10	
		Very dense, brown to red-brown, silty fine to coarse SAND, some fine to coarse gravel, trace clay to fine to coarse gravelly silty fine to coarse SAND, trace clay, frequent cobbles and occasional boulders	SM	-	19	DO	Air Hammer	9/9	
				-	20	DO	Air Hammer	6/9	
60.66									2" Solid PVC Pipe; Grout (to surface)
199.0		CONTINUED							CONTINUED

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N115260 ft. (N35131m)
E2284725 ft. (E696386m)

BORING LOG G4i-G13

SHEET 7 OF 11

SURFACE ELEV. 1709.6 ft. (521.08m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/27/81 DATE COMPLETED 6/4/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6 IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
60.66		CONTINUED							CONTINUED
199.0					21	DO	Air Hammer	2/2	
					22	DO	Air Hammer	7/8	
		Very dense, brown to red-brown, silty fine to coarse SAND, some fine to coarse gravel, trace clay to fine to coarse gravelly silty fine to coarse SAND, trace clay, frequent cobbles and occasional boulders	SM		23	DO	Air Hammer	6/8	2" Solid PVC Pipe; Grout (to surface); 67.67; 222.0; Bentonite Clay Seal; 68.58; 225.0; Pea Gravel
69.80									
229.0		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N115260 ft. (N35131m)
E2284725 ft. (E696386m)

BORING LOG G41-G13

SHEET 8 OF 11

SURFACE ELEV. 1709.6 ft. (521.08m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/27/81 DATE COMPLETED 6/4/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
69.80		CONTINUED							CONTINUED
229.0		Very dense, brown to red-brown, silty fine to coarse SAND, some fine to coarse gravel, trace clay to fine to coarse gravelly silty fine to coarse SAND, trace clay, frequent cobbles and occasional boulders	SM	-	24	DO	Air Hammer	5/9	2" Solid PVC Pipe; Pea Gravel
71.32									
234.0									
				-	25	DO	Air Hammer	15/21	
		Very dense, brown to tan, fine to medium SAND, trace silt to fine to coarse SAND, trace fine gravel	SP	-	26	DO	Air Hammer	21/21	75.29; 247.0; 2" Slotted PVC Pipe; Pea Gravel (to bottom of boring); 77.72; 255.0
				-	27	DO	Air Hammer	24/24	
80.47									
264.0		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N115260 ft. (N35131m)
E2284725 ft. (E696386m)

BORING LOG G41-G13

SURFACE ELEV. 1709.6 ft. (521.08m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/27/81 DATE COMPLETED 6/4/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
80.47		CONTINUED							
264.0		Very dense, brown to tan, fine to medium SAND, trace silt to fine to coarse SAND, trace fine gravel	SP	-	28	DO	Air Hammer	21/21	
83.82									
275.0		Very dense, light brown, fine SAND, trace silt to SILT, some fine sand (very poorly graded, above are extremes of materials that occur in random layers)	SP to ML	-	29	DO	Air Hammer	10/12	
88.09									
289.0		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N115260 ft. (N35131m)
E2284725 ft. (E696386m)

BORING LOG G41-G13

SURFACE ELEV. 1709.6 ft. (521.08m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/27/81 DATE COMPLETED 6/4/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
88.09		CONTINUED							
289.0		Very dense, light brown, fine SAND, trace silt to SILT, some fine sand (very poorly graded, above are extremes of materials that occur in random layers)	SP to ML	-	30	DO	Air Hammer	6/9	
89.92									
295.0		Very dense, brown SILT, trace fine sand	ML	-	31	DO	Air Hammer	12/12	
92.96									
305.0		Very dense, light brown, fine to medium SAND, trace silt with occasional layers of red-brown silt and multi-colored fine gravel	SP with ML and GP	-	32	DO	Air Hammer	12/15	
96.32									
316.0		Hard, green, metavolcanic TUFF							
97.23									
319.0		END OF BORING							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N115260 ft. (N35131m)
E2284725 ft. (E696386m)

BORING LOG G41-G13

SHEET 11 OF 11

SURFACE ELEV. 1709.6 ft. (521.08m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/27/81 DATE COMPLETED 6/4/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

NOTES

Elevation of top of protector pipe, 1712.4 ft. (521.95m)

Table of Water Level Readings by Date. Readings Indicate Depth Below Ground Surface.

DATE	6/10/81						
DEPTH (m)	35.79						
DEPTH (ft.)	117.4						

Job No. 786085
Scale 1"=5'

Golder Associates

Drawn JEF
Checked

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)

BORING LOG G41-H9

SHEET 1 OF 10

SURFACE ELEV. 1702.0 ft. (518.78m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/14/81 DATE COMPLETED 5/26/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
0.0									
				-	1	DO	Hydraulic Push	12/24	
		Compact to very dense, brown, fine to coarse SAND, some fine to coarse gravel, some silt, occasional cobbles	SM	-	2	DO	Hydraulic Push	12/24	
				-	3	DO	Air Hammer	18/18	
7.92 / 26.0		Very dense, brown, fine to coarse SAND, trace fine to coarse gravel, trace to some silt to fine to coarse gravelly fine to coarse SAND, trace silt	SP-SM	-	4	DO	Air Hammer	18/18	
10.4 / 34.0		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)

BORING LOG G41-H9

SURFACE ELEV. 1702.0 ft. (518.78m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/14/81 DATE COMPLETED 5/26/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
10.4		CONTINUED							
34.0		Very dense, brown, fine to coarse SAND, trace fine to coarse gravel, trace to some silt to fine to coarse gravelly fine to coarse SAND, trace silt	SP-SM	-	5	DO	Air Hammer	12/12	
				-	6	DO	Air Hammer	8/8	
16.76									
55.0		Very dense, brown, silty fine to coarse SAND, some fine to coarse gravel to fine to coarse gravelly fine to coarse SAND, some silt, occasional cobbles	SM	-	7	DO	Air Hammer	16/16	
20.3									
66.5		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)

BORING LOG G41-H9

SURFACE ELEV. 1702.0 ft. (518.78m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/14/81 DATE COMPLETED 5/26/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
		CONTINUED							
20.3 / 66.5		Very dense, brown, silty fine to coarse SAND, some fine to coarse gravel to fine to coarse gravelly fine to coarse SAND, some silt, occasional cobbles	SM	-	8	DO	Air Hammer	21/21	
				-	9	DO	Air Hammer	24/24	
25.91 / 85.0		Very dense, multi-colored, fine to coarse sandy fine to coarse GRAVEL, trace silt	GP	-	10	DO	Air Hammer	12/12	
28.96 / 95.0		Very dense, brown, fine to coarse SAND, some fine to coarse gravel, trace to some silt	SP to SM						
30.18 / 99.0		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)

BORING LOG G41-H9

SURFACE ELEV. 1702.0 ft. (518.78m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/14/81 DATE COMPLETED 5/26/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6 IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
30.18		CONTINUED							
99.0		Very dense, brown, fine to coarse SAND, some fine to coarse gravel, trace to some silt	SP to SM	-	11	DO	Air Hammer	24/24	▼ 5/26/81 33.69
				-	12	DO	Air Hammer	24/24	110.5
35.05									
115.0		Very dense, gray-brown to red-brown, silty, fine to coarse SAND, some fine to coarse gravel, trace clay to fine to coarse gravelly fine to coarse SAND, some silt, frequent cobbles and occasional boulders	SM	-	13	DO	Air Hammer	24/24	
40.08				-	14	DO	Air Hammer	16/16	
131.5		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)
SURFACE ELEV. 1702.0 ft. (518.78m)
DATUM USGS MSL
DRILL RIG Schramm Rotadrill T64HP

BORING LOG G41-H9

SHEET 5 OF 10
PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM
DATE STARTED 5/14/81 DATE COMPLETED 5/26/81
DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6 IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
40.08		CONTINUED							
131.5		Very dense, gray-brown to red-brown, silty fine to coarse SAND, some fine to coarse gravel, trace clay to fine to coarse gravelly fine to coarse SAND, some silt, frequent cobbles and occasional boulders	SM	-	15	DO	Air Hammer	6/18	
				-	16	DO	Air Hammer	15/15	
				-	17	DO	Air Hammer	7/7	
50.75									
166.5		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)

BORING LOG G41-H9

SURFACE ELEV. 1702.0 ft. (518.78m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/14/81 DATE COMPLETED 5/26/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
50.75 / 166.5		CONTINUED							
		Very dense, gray-brown to red-brown, silty fine to coarse SAND, some fine to coarse gravel, trace clay to fine to coarse gravelly fine to coarse SAND, some silt, frequent cobbles and occasional boulders	SM	-	18	DO	Air Hammer	6/6	
				-	19	DO	Air Hammer	12/12	
				-	20	DO	Air Hammer	12/12	
59.42 / 195.0		Very dense, orange-brown, fine to medium SAND, trace silt	SP-SM	-	21	DO	Air Hammer	9/9	2" Solid PVC Pipe (to surface) Grout (to surface)
61.42 / 201.5		CONTINUED							CONTINUED

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)

BORING LOG G41-H9

SHEET 7 OF 10

SURFACE ELEV. 1702.0 ft. (518.78m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/14/81 DATE COMPLETED 5/26/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
61.42		CONTINUED							CONTINUED
201.5		Very dense, orange-brown, fine to medium SAND, trace silt	SP-SM						
62.48									Grout
205.0		Very dense, red-brown, silty fine to coarse SAND, some fine to coarse gravel	SM	-	22	DO	Air Hammer	11/11	63.03 / 207.0 Bentonite Clay Seal 64.01 / 210.0
65.53									
215.0		Very dense, brown to red-brown, fine to coarse SAND, trace silt to fine to coarse SAND, some fine to coarse gravel, trace silt	SP	-	23	DO	Air Hammer	18/18	2" Solid PVC Pipe; Pea Gravel
				-	24	DO	Air Hammer	18/18	70.10 / 230.0 2" Slotted PVC Pipe; Pea Gravel (to bottom of boring)
72.09									
236.5		CONTINUED							CONTINUED

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)

BORING LOG G41-H9

SURFACE ELEV. 1702.0 ft. (518.78m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/14/81 DATE COMPLETED 5/26/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
72.09		CONTINUED							CONTINUED
236.5		Very dense, brown to red-brown, fine to coarse SAND, trace silt to fine to coarse SAND, some fine to coarse gravel, trace silt	SP	-	25	DO	Air Hammer	18/18	Pea Gravel 73.15 240.0 Pea Gravel (to bottom of boring)
74.67									
245.0				-	26	DO	Air Hammer	18/18	
		Very dense, brown, fine to coarse SAND, trace fine to coarse gravel, trace silt	SP-SM	-	27	DO	Air Hammer	18/18	
80.77									
265.0		Very dense to hard, dark brown to red-brown, fine sandy SILT, trace clay to silty fine SAND (very poorly graded, some stratification evident)	SM to ML	-	28	DO	Air Hammer	18/18	
82.75									
271.5		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)

BORING LOG G41-H9

SURFACE ELEV. 1702.0 ft. (518.78m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/14/81 DATE COMPLETED 5/26/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
82.75		CONTINUED							
271.5				-	29	DO	Air Hammer	18/18	
		Very dense to hard, dark brown to red-brown, fine sandy SILT, trace clay to silty fine SAND (very poorly graded, some stratification evident)	SM to ML	-	30	DO	Air Hammer	18/18	
89.92									
295.0		Very dense, brown, fine to coarse gravelly fine to coarse SAND, some silt	SM	-	31	DO	Air Hammer	18/18	
92.66									
304.0		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)

BORING LOG G41-H9

SHEET 10 OF 10

SURFACE ELEV. 1702.0 ft. (518.78m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/14/81 DATE COMPLETED 5/26/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6 IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
92.66		CONTINUED							
304.0		Very dense, brown, fine to coarse gravelly fine to coarse SAND, some silt	SM						
94.64									
310.5		Weathered to sound, green, metavolcanic TUFF		-	32	Cuttings			
96.01									
315.0		END OF BORING							

NOTES

1. Elevation of top of protector pipe, 1704.8 ft. (519.63m).

Table of Water Level Readings by Date. Readings Indicate Depth Below Ground Surface.

DATE	5/26/81	6/10/81					
DEPTH (m)	33.69	33.67					
DEPTH (ft.)	110.5	110.5					

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N114700 ft. (N34960m)
E2284975 ft. (E696462m)

BORING LOG G41-H13

SHEET 1 OF 4

SURFACE ELEV. 1715.2 ft. (522.80m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 3/6/79 DATE COMPLETED 3/7/79

DRILL RIG CME 75 DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6 IN. (Note 1)	SAMPLES REC./ATT. (ins.)	REMARKS
0.24		Topsoil and rootmat		15	1	DO	6-11-4	10/18	
0.3		Compact, brown to dark brown, silty, fine to coarse SAND, some fine to coarse gravel, trace organic matter	SM	27	2	DO	10-13-14	12/18	
				15	3	DO	6-7-8	2/18	
3.81									
12.5		Very dense, brown, fine to coarse SAND, some fine to coarse gravel, trace silt Cobbles noted at 27.0'-28.0'	SP-SM to SM	99	4	DO	25-65-34	12/18	
				172	5	DO	65-84-88	14/18	
				110	6	DO	55-55	12/12	
8.38									
27.5		Very dense, brown, silty, fine to coarse SAND, some fine to coarse gravel, trace clay	SM	160 8"	7	DO	110-50/2"	8/8	
9.60									
31.5		CONTINUED							

Job No. 786085
Scale 1"=5'

Golder Associates

Drawn jls
Checked JCB

COOR. N114700 ft. (N34960m)
E2284975 ft. (E696462m)

BORING LOG G41-H13

SURFACE ELEV. 1715.2 ft. (522.80m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 3/6/79 DATE COMPLETED 3/7/79

DRILL RIG CME 75 DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN. (Note 1)	SAMPLES REC./ATT. (ins.)	REMARKS
9.60		CONTINUED							
31.5		Very dense, brown, silty, fine to coarse SAND, some fine to coarse gravel, trace clay Cobbles noted at 32.0'-32.5', 34.0'-34.4' and 38.0'-38.5'	SM	135/6"	8	DO	135/6"	5/6	
				200/9"	9	DO	135-65/3"	8/9	
12.95									
42.5		Very dense, red-brown to brown, fine to coarse SAND, some silt, trace to some fine to coarse gravel Cobble and boulders noted at 46.5'-47.0' and 48.0'-54.0'	SM	149/8"	10	DO	105-44/2"	7/8	
				155/8"	11	DO	105-50/2"	6/8	
16.00									
52.5		Very dense, brown to red-brown and gray, silty, fine to coarse SAND, some fine to coarse gravel	SM	200/5.5"	12	DO	200/5.5"	4.5/5.5	
16.76									
55.0		Very dense, light brown to red-brown, fine to coarse SAND, some fine to coarse gravel, some silt, frequent cobbles and boulders	SP-SM to SM	150/0"	13	DO	150/0"	0/0	
18.29									
60.0		CONTINUED							

Job No. 786085
Scale 1"=5'

Golder Associates

Drawn jls
Checked JCB

COOR. N114700 ft. (N34960m)
E2284975 ft. (E696462m)

BORING LOG G41-H13

SURFACE ELEV. 1715.2 ft. (522.80m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 3/6/79 DATE COMPLETED 3/9/79

DRILL RIG CME 75 DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6 IN. (Note 1)	SAMPLES REC. / ATT. (ins.)	REMARKS
18.29		CONTINUED							
60.0				150 / 0"	14	DO	150/0"	0/0	
		Very dense, light brown to red-brown, fine to coarse SAND, some fine to coarse gravel, some silt, frequent cobbles and boulders	SP-SM to SM	150 / 8"	15	DO	85-95-55/2"	11/14	
				140 / 9"	16	DO	90-50/3"	7/9	
				210 / 9"	17	DO	120-90/3"	6/9	
				185 / 5"	18	DO	185/5"	4/5	
26.67									
87.5				150 / 4"	19	DO	150/4"	3/4	
		Very dense, brown fine to coarse SAND and fine to coarse GRAVEL, some silt to fine to coarse gravelly, fine to coarse SAND, some silt, trace clay	GM to SM						
28.19									
92.5		CONTINUED							

Job No. 786085
Scale 1"=5'

Golder Associates

Drawn jls
Checked 203

COOR. N114700 ft. (N34960m)
E2284975 ft. (E696462m)

BORING LOG G41-H13

SHEET 4 OF 4

SURFACE ELEV. 1715.2 ft. (522.80m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 3/6/79 DATE COMPLETED 3/9/79

DRILL RIG CME 75 DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6 IN. (Note 1)	SAMPLES REC./ATT. (ins.)	REMARKS
28.19 / 92.0		CONTINUED							
				167/10"	20	DO	62-105/4"	9/10	
		Very dense, brown fine to coarse SAND and fine to coarse GRAVEL, some silt to fine to coarse gravelly, fine to coarse SAND, some silt, trace clay	GM to SM	174/10"	21	DO	45-50-124/4"	9/16	
				158/10"	22	DO	58-100/4"	8/10	
31.94 / 104.8		END OF BORING HOLE GROUTED AT COMPLETION							

NOTES

1. Standard Penetration Test - Driving 2" O.D. sampler with 140 lb. hammer freely falling 30". (Samples 1 - 6)

   Penetration Test - Driving 2" O.D. sampler with 300 lb. hammer freely falling 30". (Samples 7 - 22)

Job No. 786085
Scale 1"=5'

Golder Associates

Drawn jls
Checked 003

COOR. N116010 ft. (N35360m)
E2285580 ft. (E696646m)

BORING LOG G41-J11

SHEET 1 OF 3

SURFACE ELEV. 1709.0 ft. (520.89m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 3/7/79 DATE COMPLETED 3/9/79

DRILL RIG CME-75 DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN. (Note 1)	SAMPLES REC./ATT. (ins.)	REMARKS
0.15 / 0.5		Firm, dark brown SILT, some fine sand, trace organic matter (topsoil)	ML	5	1	DO	1-2-3	7/8	
				18	2	DO	5-9-9	18/18	
				11	3	DO	4-5-6	18/18	
		Compact to very dense, red-brown, fine to coarse SAND, some fine to coarse gravel, trace to some silt Occasional cobbles noted at 24.0'-29.0'	SP-SM to SM	39	4	DO	11-20-19	18/18	
				159	5	DO	15-75-84	18/18	
				155 / 8"	6	DO	55-100/2"	8/8	
				120 / 5"	7	DO	120/5"	5/5	
9.75 / 32.0		CONTINUED							

Job No. 786085
Scale 1"=5'

Golder Associates

Drawn jls
Checked

COOR. N116010 ft. (N35360m)
E2285580 ft. (E696646m)

BORING LOG G41-111

SURFACE ELEV. 1709.0 ft. (520.89m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 3/7/79 DATE COMPLETED 3/9/79

DRILL RIG CME-75 DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS.	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN. (Note 1)	SAMPLES REC./ATT. (ins.)	REMARKS
9.75		CONTINUED							
32.0				100 / 4"	8	DO	100/4"	4/4	
		Compact to very dense, red-brown, fine to coarse SAND, some fine to coarse gravel, trace to some silt	SP-SM to SM	115 / 4.5"	9	DO	115/4.5"	2/4.5	
		Occasional cobbles noted at 36.0-39.0'		150 / 5"	10	DO	150/5"	5/5	
12.95									
42.5				120 / 0"	11	DO	120/0"	0/0	
		Very dense, brown, fine to coarse SAND and fine to coarse GRAVEL, trace silt	GM to SM	150 / 7"	12	DO	125-50/1"	5/7	
		Occasional cobbles noted at 46.0'-49.0' Scattered boulders noted at 49.0'-54.0' and 56.0'-57.0'		150 / 6"	13	DO	150/6"	6/6	
18.59									
61.0		Very dense, brown to gray-brown, fine to coarse SAND, some fine to coarse gravel, trace to some silt	SP-SM to SM	200 / 2"	14	DO	200/2"	0.5/2	
19.96									
65.5		CONTINUED							

Job No. 786085
Scale 1"=5'

Golder Associates

Drawn jls
Checked

COOR. N116010 ft. (N35360m)
E2285580 ft. (E696646m)

BORING LOG G41-J11

SURFACE ELEV. 1709.0 ft. (520.89m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS -MSL DATE STARTED 3/7/79 DATE COMPLETED 3/9/79

DRILL RIG CME-75 DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6 IN. (Note 1)	SAMPLES REC/ATT. (ins.)	REMARKS
19.96		CONTINUED							
65.5				150/1"	15	DO	150/1"	0/1	
				200/3.5"	16	DO	200/3.5"	1.0/3.5	
		Very dense, brown to gray-brown, fine to coarse SAND, some fine to coarse gravel, trace to some silt	SP-SM to SM	150/4"	17	DO	150/4"	0/4	
		Cobbles and boulders noted at: 64.5'-69.0' 69.0'-72.0' 75.0'-78.0' 91.0'-96.0'		150/8"	18	DO	105-145/2"	2/8	
				150/5"	19	DO	150/5"	3/5	
				150/4"	20	DO	150/4"	0/4	
				200/7"	21	DO	150-50/1"	3/7	
30.39									
99.7		END OF BORING HOLE GROUTED AT COMPLETION							

NOTES

1. Penetration Test Driving 3" O.D. sampler with 300 lb. hammer freely falling 30". (All samples)

Job No. 786085
Scale 1"=5'

Golder Associates

Drawn jls
Checked JCB

BORING DMB-2

SURFACE ELEVATION 1706.28
COORDINATES N 114,995 E 2,285,000

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH PSF	ATTERBERG LIMITS: LIQUID LIMIT %	ATTERBERG LIMITS: PLASTIC LIMIT %	ATTERBERG LIMITS: PLASTICITY INDEX %	FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	RQD
0									
5	P.C.								
10	SA, HA					10.4			
15	X-RAY					9.4	123		
20									
25									
30	P.C.								
35	SA, pH COLOR					9.7			
40									
45									
50									
55									
60	P.C.								
65									
70									
75									

BLOW COUNTS SAMPLES	SYMBOLS	DESCRIPTIONS	ELEVATION (FEET)
21 B	SM	BROWN FINE GRAINED, SUBROUNDED QUARTZ SAND, SOME SILT, TRACE SUBANGULAR GRAVEL, MEDIUM DENSE, NONCALCAREOUS, MOIST	— 1705
13 B		GRADES WITH THIN LAYERS OF COARSE SAND, VERY MOIST	— 1700
7 B		GRADES WITH MORE GRAVEL, TRACE CLAY	— 1695
46 B		GRADES SOME SUBANGULAR METAMORPHIC GRAVEL, DENSE	— 1690
		GRADES WITH COBBLES	
56 B		GRADES SLIGHTLY CALCAREOUS	— 1685
83 B		GRADES WITH LESS GRAVEL AND COBBLES, NONCALCAREOUS	— 1680
140/10" B	SP	LIGHT BROWN FINE TO MEDIUM SUBROUNDED QUARTZ SAND, TRACE TO SOME GRAVEL AND COBBLES, VERY DENSE, CALCAREOUS, MOIST	— 1675
125/9" B		GRADES WITH MORE GRAVEL TO 3" IN DIAMETER	— 1670
130/3" B	SP GP	BROWN MEDIUM ROUNDED QUARTZ SAND AND SUBANGULAR METAMORPHIC GRAVEL, TRACE SILT, VERY DENSE, VERY MOIST, NONCALCAREOUS	— 1665
135/10" B	SP	BROWN MEDIUM GRAINED ROUNDED QUARTZ SAND, TRACE SILT, VERY DENSE, MOIST, SLIGHTLY CALCAREOUS	— 1660
140/4" B	SP GP	BROWN MEDIUM TO COARSE ROUNDED QUARTZ SAND, SOME GRAVEL, TRACE SILT, SLIGHTLY CALCAREOUS, SOME COBBLES, DAMP	— 1655
200/2" D			— 1650
100/5" D *200/3" B		GRADES SAND AND ROUNDED METAMORPHIC GRAVEL AND BOULDERS LARGE PEBBLES IN GRAVEL CALCAREOUS	— 1645
125/5" B	SP	LIGHT BROWN FINE TO MEDIUM ROUNDED QUARTZ SAND, TRACE SILT, TRACE GRAVEL, VERY DENSE, WET, CALCAREOUS	— 1640
127/5" B	SP GP	BROWN MEDIUM TO COARSE GRAINED SUBROUNDED QUARTZ SAND AND SUBROUNDED METAMORPHIC GRAVEL TO 1 INCH DIAMETER, TRACE SILT, VERY DENSE, SLIGHTLY CALCAREOUS, WET.	— 1635

EXXON MINERALS COMPANY, U.S.A.
CRANDON PROJECT

LOG OF BORING DMB-2
SHEET 1 OF 2

DAMES & MOORE

FIGURE B-41.1

1/79

8837-044-07

EXXON (URANIUM, WIS.) AND NUMBER 8837-0 -07
DRAWING TITLE: LOG OF BORINGS —
DRAWING NUMBER:
REV 0 1 2 3 4
ISSUE DATE
ILLUSTRATOR (INITIALS / DATE)
SR. ILLUSTRATOR (INITIALS / DATE)
P.I.C. / P.M. (INITIALS / DATE)

BORING DMB-2 (CONT'D)

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH PSF	ATTERBERG LIMITS: LIQUID LIMIT %	ATTERBERG LIMITS: PLASTIC LIMIT %	ATTERBERG LIMITS: PLASTICITY INDEX %	FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	RQD
75	P.C.								
80									
85									
90									
95									
100									
105									

BLOW COUNTS & SAMPLES

125/4" B

144/4" B

*119/6" B

125/4" B

169/6" B

150/4" B

SYMBOLS

SP
GP

DESCRIPTIONS

GRADES WITH MORE GRAVELS AND COBBLES TO 3 INCHES IN DIAMETER

GRADES FINE TO MEDIUM SAND, TRACE SILT

ELEVATION (FEET)

1630

1625

1620

1615

1610

1605

BORING COMPLETED AT 100.3 FEET ON 5-17-78.
4 INCH CASING USED TO A DEPTH OF 45.0 FEET.
PIEZOMETER INSTALLED ON 5-17-78.
2 INCH PVC SLOTTED FROM 90.2 TO 100.2 FEET.
GRAVEL PACK: 68.2 TO 100.2 FEET.
SAND: 45.2 TO 68.2 FEET.
BENTONITE: 45.0 TO 45.2 FEET.
GROUT: 0.0 TO 45.0 FEET.
PIEZOMETER DRY ON 6-21-78.

EXXON (CRANDON, WIS.) JOB NUMBER 8837-0 -07

TITLE: LOG OF BORINGS

REV. 0 1 2 3 4

ISSUE DATE

8837-044-07

1/79

EXXON MINERALS COMPANY, U.S.A.
CRANDON PROJECT

LOG OF BORING DMB-2
SHEET 2 OF 2

DAMES & MOORE

FIGURE B-41.2

BORING DMA-6

SURFACE ELEVATION

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH PSF	ATTERBERG LIMITS: LIQUID LIMIT %	ATTERBERG LIMITS: PLASTIC LIMIT %	ATTERBERG LIMITS: PLASTICITY INDEX %	FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	ROD
0						9.8	123		
5						5.7	125		
						8.1			
10						7.2	134		
15									
20	SA, HA					7.0	126		
25									
30						8.9	143		

BLOW COUNTS SAMPLES	SYMBOLS	DESCRIPTIONS
18	ML	ORANGISH-BROWN TO BROWN CLAYEY SILT WITH SOME FINE SAND, COARSE GRAVEL AND COBBLES; MEDIUM STIFF
22		ORANGISH-BROWN TO BROWN FINE TO MEDIUM SILTY SAND; WITH TRACE FINE TO COARSE GRAVEL AND SOME COBBLES; MEDIUM DENSE
		CLAYEY SILT POCKET AT 7.0 FEET
75/6"		GRADING TO REDDISH-BROWN FINE SILTY SAND WITH TRACE FINE TO COARSE GRAVEL; VERY DENSE
125/9"		GRADES WITH COBBLES
	SM	
80		
50/0"□		NUMEROUS COARSE GRAVEL AND COBBLES
150/6"		

ELEVATION (FEET)

BORING COMPLETED AND GROUTED TO 30.0 FEET ON 3-25-77.
CASING USED TO A DEPTH OF 8.0 FEET.
GROUNDWATER LEVEL NOT RECORDED.

LOG OF BORINGS

FIGURE B-5

TEST PIT LOGS

STS Consultants Ltd.

OWNER Exxon Minerals Company	**LOG OF TEST PIT NUMBER** TP-85-1
PROJECT NAME MRDF Test Pits	**ENGINEER**
SITE LOCATION Crandon Project	

WELL INSTALLATION
TOP STANDPIPE EL. +_____

SURFACE ELEVATION

DEPTH / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, N (B/FT)	UNCONFINED COMPRESSIVE STRENGTH, Qp (TONS/FT²)	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
					Boulder							
2					Brown fine sandy silt (ML) - trace gravel - mottling - seep at 1.5 feet							
4					Brown silty fine to medium sand (SM) - trace gravel							
6												
8					Brown fine to medium sand (SP) - trace coarse sand and gravel							
10												
12					Brown silty fine to medium sand (SM) - trace gravel and cobbles							
12.5					End of Test Pit Test pit advanced by backhoe Backfilled							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL			BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME	

BORING STARTED	10-23-85
BORING COMPLETED	10-23-85
RIG	
FOREMAN	DK

STS OFFICE	540 Lambeau Street Green Bay, WI 54303
DRAWN BY	JJT
SHEET	1 OF 1
APP'D. BY	JWK
STS JOB NO.	14028

BL: 5-983

STS Consultants Ltd.

OWNER: Exxon Minerals Company	LOG OF TEST PIT NUMBER: TP-85-2
PROJECT NAME: MRDF Test Pits	ENGINEER:
SITE LOCATION: Crandon Project	

WELL INSTALLATION
TOP STANDPIPE EL. + _____

DEPTH / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, N (B/FT)	UNCONFINED COMPRESSIVE STRENGTH, Qp (TONS/FT²)	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
					SURFACE ELEVATION							
					Topsoil with cobbles							
2					Brown sandy silt (ML) - little cobbles - trace gravel - mottled-seep at 2.5 ft							
4					Brown silty fine to coarse sand (SM) - trace cobbles and gravel - Till							
6												
8												
10												
12					End of test pit Test pit advanced by backhoe Backfilled							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED	10-23-85
BORING COMPLETED	10-23-85
RIG	
FOREMAN	DK

STS OFFICE	540 Lambeau Street Green Bay, WI 54303
DRAWN BY	JJT
SHEET	1 OF 1
APP'D. BY	JWK
STS JOB NO.	14028

BL: 5-983

STS Consultants Ltd.

OWNER: Exxon Minerals Company	LOG OF TEST PIT NUMBER: TP-85-3
PROJECT NAME: MRDF Test Pits	ENGINEER:
SITE LOCATION: Crandon Project	

WELL INSTALLATION
TOP STANDPIPE EL. +

SURFACE ELEVATION

DEPTH / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, N (B/FT)	UNCONFINED COMPRESSIVE STRENGTH, Qp (TONS/FT²)	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
					Boulder							
2					Brown sandy silt (ML) - trace clay and gravel - roots - mottling							
4					Brown silty fine to medium sand (SM) - trace gravel and cobbles - Till							
6					Brown silty fine to coarse sand (SM) - little cobbles and gravel - Till - seep at 6.0 feet							
8												
10												
12												
13					End of test pit Test pit advanced by backhoe Backfilled							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED	10-23-85
BORING COMPLETED	10-23-85
RIG	
FOREMAN	DK

STS OFFICE 540 Lambeau Street, Green Bay, WI 54303

DRAWN BY JJT | SHEET 1 OF 1

APP'D. BY JWK | STS JOB NO. 14028

BL: 5-983

STS Consultants Ltd.

OWNER: Exxon Minerals Company	LOG OF TEST PIT NUMBER: TP-85-4
PROJECT NAME: MRDF Test Pits	ENGINEER:
SITE LOCATION: Crandon Project	

DEPTH / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, N (B/FT)	UNCONFINED COMPRESSIVE STRENGTH, Qp (TONS/FT²)	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
					WELL INSTALLATION TOP STANDPIPE EL. + _____							
					SURFACE ELEVATION							
0.75					Topsoil - boulder							
2					Brown sandy silt (ML) - trace gravel - mottled							
4					Brown fine to coarse sand (SM) - little gravel - trace cobbles - Till - seep at 4.0 feet							
6												
8												
10												
12												
13.5					End of test pit Test pit advanced by backhoe Backfilled							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED	10-23-85
BORING COMPLETED	10-23-85
RIG	
FOREMAN	DK

STS OFFICE	540 Lambeau Street Green Bay, WI 54303
DRAWN BY	JJT
SHEET	1 OF 1
APP'D. BY	JWK
STS JOB NO.	14028

BL: 5-983

STS Consultants Ltd.

OWNER: Exxon Minerals Company	LOG OF TEST PIT NUMBER: TP -85-5
PROJECT NAME: MRDF Test Pits	ENGINEER:
SITE LOCATION: Crandon Project	

WELL INSTALLATION
TOP STANDPIPE EL. +

DEPTH / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, N (B/FT)	UNCONFINED COMPRESSIVE STRENGTH, Qp (TONS/FT²)	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K * (CM/SEC)
					SURFACE ELEVATION							
					Topsoil - boulder							
2					Brown sandy silt (ML) - trace gravel and cobbles - mottled - seep at 2.5 feet							
4					Brown silty fine to coarse sand (SM) - trace clay, gravel and cobbles - Till							
6												
8												
10												
12												
12.5					End of test pit Test pit advanced by backhoe Backfilled							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED	10-23-85
BORING COMPLETED	10-23-85
RIG	
FOREMAN	DK

STS OFFICE 540 Lambeau Street
Green Bay, WI 54303

DRAWN BY	JJT	SHEET 1	OF 1
APP'D. BY	JWK	STS JOB NO.	14028

BL: 5-983

STS Consultants Ltd.

OWNER Exxon Minerals Company	**LOG OF TEST PIT NUMBER** TP-85-6
PROJECT NAME MRDF Test Pits	**ENGINEER**
SITE LOCATION Crandon Project	

WELL INSTALLATION
TOP STANDPIPE EL. +_____

DEPTH / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, N (B/FT)	UNCONFINED COMPRESSIVE STRENGTH, Qp (TONS/FT²)	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
					SURFACE ELEVATION							
					Topsoil							
2					Brown sandy silt (ML) - trace gravel and cobbles							
4					Brown silty fine to medium sand (SM) - trace gravel and cobbles - seep at 3.5 feet							
6												
8					Brown silty fine to coarse sand (SM) - little gravel, trace cobbles - Till							
10												
12												
13.5					End of test pit Test pit advanced by backhoe Backfilled							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED	10-23-85
BORING COMPLETED	10-23-85
RIG	
FOREMAN	DK

STS OFFICE	540 Lambeau Street Green Bay, WI 54303
DRAWN BY	JJT
SHEET	1 OF 1
APP'D. BY	JWK
STS JOB NO.	14028

BL: 5-983

STS Consultants Ltd.

OWNER: Exxon Minerals Company	LOG OF TEST PIT NUMBER: TP-85-7
PROJECT NAME: MRDF Test Pits	ENGINEER:
SITE LOCATION: Crandon Project	

WELL INSTALLATION
TOP STANDPIPE EL. + _____

DEPTH / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, N (B/FT)	UNCONFINED COMPRESSIVE STRENGTH, Qp (TONS/FT²)	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
					SURFACE ELEVATION							
					Topsoil - boulder							
					Brown sandy silt (ML) - trace cobbles and boulders							
2					Brown silty fine to coarse sand (SM) - trace gravel and cobbles - Till - seep at 3.0 feet							
4												
6					Brown silty fine to coarse sand (SM) - trace gravel, cobbles and boulders - very dense - Till							
8												
10												
12												
13					End of test pit Test pit advanced by backhoe Backfilled							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED	10-23-85
BORING COMPLETED	10-23-85
RIG	
FOREMAN	DK

STS OFFICE	540 Lambeau Street Green Bay, WI 54303
DRAWN BY	JJT
SHEET	1 OF 1
APP'D. BY	JWK
STS JOB NO.	14028

BL: 5-983

STS Consultants Ltd.

OWNER: Exxon Minerals Company	LOG OF TEST PIT NUMBER: TP-85-8
PROJECT NAME: MRDF Test Pits	ENGINEER:
SITE LOCATION: Crandon Project	

DEPTH / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	WELL INSTALLATION / TOP STANDPIPE EL. + / DESCRIPTION OF MATERIAL / SURFACE ELEVATION	STANDARD PENETRATION TEST, N (B/FT)	UNCONFINED COMPRESSIVE STRENGTH, Qp (TONS/FT²)	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
					Topsoil							
					Brown sandy silt (ML) - trace gravel							
2					Brown silty fine to coarse sand (SM) - trace cobbles and boulders - Till - seep at 5.0 feet							
4												
6												
8												
10					Brown silty fine to coarse sand (SM) - very dense - Till							
12												
					End of test pit Test pit advanced by backhoe Backfilled							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED	10-23-85
BORING COMPLETED	10-23-85
RIG	
FOREMAN	DK

STS OFFICE: 540 Lambeau Street, Green Bay, WI 54303

DRAWN BY: JJT | SHEET: 1 OF 1

APP'D. BY: JWK | STS JOB NO.: 14028

BL: 5-983

STS Consultants Ltd.

OWNER: Exxon Minerals Company	LOG OF TEST PIT NUMBER: TP-85-9
PROJECT NAME: MRDF Test Pits	ENGINEER:
SITE LOCATION: Crandon Project	

DEPTH / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, N (B/FT)	UNCONFINED COMPRESSIVE STRENGTH, Qp (TONS/FT²)	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
					WELL INSTALLATION TOP STANDPIPE EL. + _____							
					SURFACE ELEVATION							
					Topsoil - boulder							
2					Brown silty fine to coarse sand (SM) - trace gravel, cobbles and boulders - Till - seep at 5.0 feet							
4												
6												
8												
10												
12					Brown silty fine to coarse sand (SM) - trace gravel, cobbles and boulders - very dense - Till							
					End of test pit Test pit advanced by backhoe Backfilled							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED	10-23-85
BORING COMPLETED	10-23-85
RIG	
FOREMAN	DK

STS OFFICE	540 Lambeau Street Green Bay, WI 54303
DRAWN BY	JJT
SHEET	1 OF 1
APP'D. BY	JWK
STS JOB NO.	14028

BL: 5-983

STS Consultants Ltd.

OWNER: Exxon Minerals Company	LOG OF TEST PIT NUMBER: TP-85-10
PROJECT NAME: MRDF Test Pits	ENGINEER:
SITE LOCATION: Crandon Project	

WELL INSTALLATION
TOP STANDPIPE EL. +

DEPTH / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, N (B/FT)	UNCONFINED COMPRESSIVE STRENGTH, Qp (TONS/FT²)	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
					SURFACE ELEVATION							
					Topsoil							
					Brown sandy silt(ML) - trace cobbles							
2					Brown silty fine to coarse sand (SM) - trace gravel, cobbles and boulders - Till - seep at 4.0 feet - very dense at 13.0 feet							
4												
6												
8												
10												
12												
14					End of test pit Test pit advanced by backhoe Backfilled							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED	10-23-85
BORING COMPLETED	10-23-85
RIG	
FOREMAN	DK

STS OFFICE	540 Lambeau Street Green Bay, WI 54303
DRAWN BY	JJT
SHEET	1 OF 1
APP'D. BY	JWK
STS JOB NO.	14028

BL: 5-983

STS Consultants Ltd.

OWNER: Exxon Minerals Company	LOG OF TEST PIT NUMBER: TP-85-14
PROJECT NAME: MRDF Test Pits	ENGINEER:
SITE LOCATION: Crandon Project	

WELL INSTALLATION
TOP STANDPIPE EL. +_____

DEPTH / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, N (B/FT)	UNCONFINED COMPRESSIVE STRENGTH, Qp (TONS/FT²)	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
					SURFACE ELEVATION							
					Topsoil - boulder							
					Brown silty fine to coarse sand (SM)							
2												
4												
6					Brown silty fine to coarse sand (SM) - trace of gravel, cobbles and boulders - seep at 11.0 feet							
8												
10												
12												
13					End of Test Pit Test Pit advanced by backhoe Backfilled							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED	10-30-85
BORING COMPLETED	10-30-85
RIG	Backhoe
FOREMAN	DK

STS OFFICE	540 Lambeau Street Green Bay, WI. 54303
DRAWN BY	KJC
SHEET	1 OF 1
APP'D. BY	JWK
STS JOB NO.	14028

BL: 5-983

STS Consultants Ltd.

OWNER: Exxon Minerals Company	LOG OF TEST PIT NUMBER: TP-85-15
PROJECT NAME: MRDF Test Pits	ENGINEER:
SITE LOCATION: Crandon Project	

DEPTH / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST, N (B/FT)	UNCONFINED COMPRESSIVE STRENGTH, Qp (TONS/FT²)	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
					WELL INSTALLATION TOP STANDPIPE EL. + _____							
					SURFACE ELEVATION							
					Topsoil							
					Brown silty fine to medium sand (SM)-trace gravel							
2												
4												
6					Brown silty fine to coarse sand (SM) - trace of gravel and cobbles - little to some cobbles and boulders at 6.0 to 7.0 feet - seeps at 5.0 and 11.0 feet							
8												
10												
12												
13					End of Test Pit Test Pit advanced by backhoe Backfilled							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED	10-30-85
BORING COMPLETED	10-30-85
RIG	Backhoe
FOREMAN	DK

STS OFFICE	540 Lambeau Street Green Bay, WI. 54303
DRAWN BY KJC	SHEET 1 OF 1
APP'D. BY JWK	STS JOB NO. 14028

BL: 5-983

STS Consultants Ltd.

OWNER: Exxon Minerals Company	LOG OF TEST PIT NUMBER: TP-85-16
PROJECT NAME: MRDF Test Pits	ENGINEER:
SITE LOCATION: Crandon Project	

DEPTH / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	WELL INSTALLATION / TOP STANDPIPE EL. + / DESCRIPTION OF MATERIAL / SURFACE ELEVATION	STANDARD PENETRATION TEST, N (B/FT)	UNCONFINED COMPRESSIVE STRENGTH, Qp (TONS/FT²)	WATER CONTENT, %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY, K (CM/SEC)
					Topsoil							
					Brown sandy silt (ML) - trace of gravel and cobbles							
1												
2												
3												
4					Brown silty fine to coarse sand (SM) - trace of gravel and cobbles - seep at 4.0 feet							
5												
6												
					End of Test Pit Test Pit advanced by backhoe Backfilled							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED	10-30-85
BORING COMPLETED	10-30-85
RIG	Backhoe
FOREMAN	DK

STS OFFICE	540 Lambeau Street Green Bay, WI. 54303
DRAWN BY KJC	SHEET 1 OF 1
APP'D. BY JWK	STS JOB NO. 14028

BL: 5-983

STS Consultants Ltd.

OWNER: Exxon Minerals Company	LOG OF TEST PIT NUMBER: TP-85-17
PROJECT NAME: MRDF Test Pits	ENGINEER:
SITE LOCATION: Crandon Project	

WELL INSTALLATION
TOP STANDPIPE EL. +_____

DEPTH / ELEVATION	SAMPLE NO.	SAMPLE TYPE	SAMPLE DISTANCE	RECOVERY	DESCRIPTION OF MATERIAL	STANDARD PENETRATION TEST. N (B/FT)	UNCONFINED COMPRESSIVE STRENGTH. Qp (TONS/FT²)	WATER CONTENT. %	UNIT DRY WEIGHT (LBS/FT³)	LIQUID/PLASTIC LIMIT LL/PL	PERCENT PASSING #200 SIEVE	PERMEABILITY. K (CM/SEC)
SURFACE ELEVATION					Topsoil							
2					Brown sandy silt (ML) - trace of gravel and cobbles							
4												
6												
8					Brown silty fine to coarse sand (SM) - trace of gravel, cobbles and boulders - seep at 7.5 feet							
10												
12												
12.5					End of Test Pit Test Pit advanced by backhoe Backfilled							

The stratification lines represent the approximate boundary between soil types. In situ, the transition may be gradual. Water levels were measured at the times indicated. Water levels may vary seasonally.

WL		BCR			ACR
WL-T. PIPE	DATE	TIME	WL-T. PIPE	DATE	TIME

BORING STARTED	10-30-85
BORING COMPLETED	10-30-85
RIG	Backhoe
FOREMAN	DK

STS OFFICE	540 Lambeau Street Green Bay, WI. 54303
DRAWN BY KJC	SHEET 1 OF 1
APP'D. BY JWK	STS JOB NO. 14028

BL: 5-983

APPROX. N116000 ft. (N35356m)
COOR. E2285600 ft. (E696650m)

TEST PIT LOG TP-2

SHEET 1 OF 1

SURFACE ELEV. Approx. 1715 ft. (522.73m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SITE

DATUM USGS MSL DATE STARTED 11/16/79 DATE COMPLETED 11/16/79

EQUIPMENT John Deere 690 Backhoe

DEPTH METER / FEET	DESCRIPTION	UNIFIED CLASS.	REMARKS
.305	Topsoil and rootmat	PT	
1.0	Brown, fine to coarse SAND, trace fine to coarse gravel, trace silt, occasional cobbles and boulders	SP to SP-SM	
2.13			Seep at 7.0' (2.13m)
7.0	Red-brown, fine to coarse SAND, some fine to coarse gravel, some silt, trace clay to fine to coarse gravelly, fine to coarse SAND, some silt, occasional cobbles and boulders	SM	Sand cone density at 8.5' (2.59m) γ_d=122.4 pcf (1961 kg/m^3) w%= 14.6
4.57			
15.0	END OF PIT		

Job No. 786085
Scale 1"=2.5'

Golder Associates

Drawn jls
Checked MKB

APPROX. N115980 ft. (N35351m)
COOR. E2285270 ft. (E696550m)

TEST PIT LOG TP-7

SHEET 1 OF 1

SURFACE ELEV. *Approx. 1710 ft. (521.21m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 3/12/81 DATE COMPLETED 3/12/81

EQUIPMENT John Deere 410 Backhoe

DEPTH METER / FEET	DESCRIPTION	UNIFIED CLASS.	REMARKS
.15 / 0.5	Brown, silty fine to coarse SAND, trace fine to coarse gravel, trace organics	SM	
.46 / 1.5	Brown, silty, fine to coarse SAND, some fine to coarse gravel	SM	
	Brown, fine to coarse SAND, some silt, trace clay, occasional cobbles	SP-SM to SM	
1.22 / 4.0			Slow seep at 4.0' (1.22m)
	Brown to red-brown, fine to coarse SAND, some silt, trace clay, trace fine to coarse gravel, occasional cobbles and boulders	SM	SA-1, 7.5'-8.5' (2.29m-2.59m): % finer than #200 sieve=20.3% (By field sieve analysis)
3.05 / 10.0	END OF PIT		
	*Estimated from topographic map		

Job No. 786085
Scale 1" = 2.5'

Golder Associates

Drawn MRB
Checked

APPROX. N116100 ft. (N35387m)
COOR. I2285570 ft. (E696642m)
1709 ft.

TEST PIT LOG TP-8

SHEET 1 OF 1

SURFACE ELEV. *Approx. (520.90m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 3/12/81 DATE COMPLETED 3/12/81

EQUIPMENT John Deere 410 Backhoe

DEPTH METER FEET	DESCRIPTION	UNIFIED CLASS.	REMARKS
.30	Brown, silty fine to coarse SAND, trace fine to coarse gravel	SM	
1.0			
	Brown, fine to coarse SAND, some fine to coarse gravel, some silt, occasional cobbles and boulders	SM	Moderate seep at 8.0' (2.44m)
			SA-1, 9.0'-10.0' (2.74m-3.05m): % finer than #200 sieve=17.4%
3.66			SA-2, 11.0'-12.0' (3.35m-3.66m): % finer than #200 sieve=17.1% (Both results by field sieve analyses)
12.0	END OF PIT		
	*Estimated from elevation of adjacent boring G41-J11		

Job No. 786085
Scale 1" = 2.5'

Golder Associates

Drawn MRB
Checked

APPROX. N115960 ft. (N35345m)
COOR. E2284920 ft. (E696444m)

TEST PIT LOG TP-9

SHEET 1 OF 1

SURFACE ELEV. *Approx. 1707 ft. (520.29m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 3/12/81 DATE COMPLETED 3/12/81

EQUIPMENT John Deere 410 Backhoe

DEPTH METER / FEET	DESCRIPTION	UNIFIED CLASS.	REMARKS
.30	Brown, silty fine to coarse SAND, trace fine to coarse gravel, trace organics	SM	
1.0			
	Brown, fine to coarse SAND, some fine to coarse gravel, some silt, trace organics, occasional cobbles and boulders	SM	
1.07			
3.5	Cobbles and fine to coarse gravel	GP	Heavy seep starting at 4.0' (1.22m) forced abandonment of test pit
1.52			
5.0	END OF PIT		
	*Estimated from topographic map		

Job No. 786085
Scale 1" = 2.5'

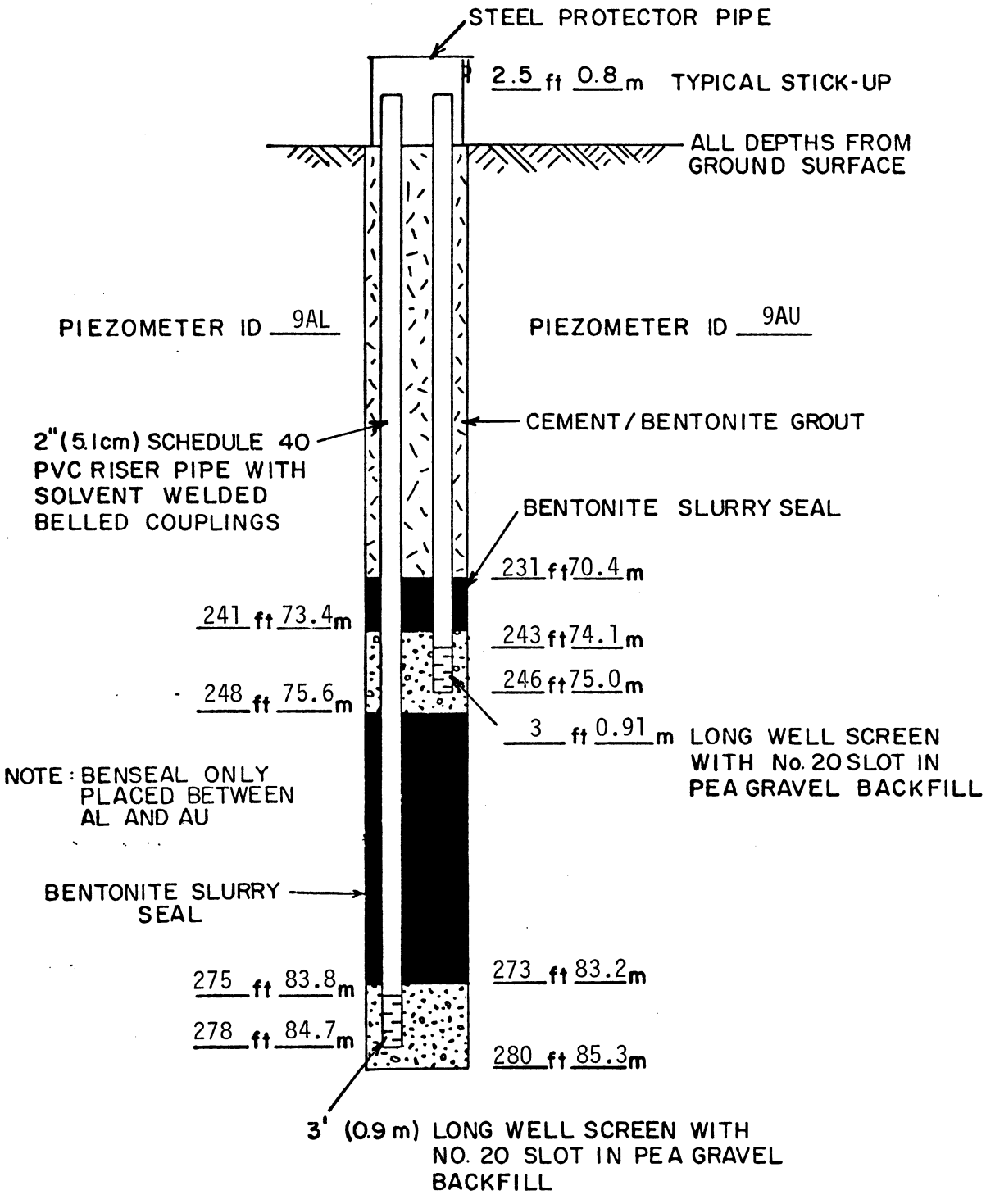
Golder Associates

Drawn MRB
Checked

WELL INSTALLATION DIAGRAM

STS Consultants Ltd.

FIELD WELL INSTALLATION DIAGRAM



Well No. EX-9AL & AU DATE INSTALLED 3-21-84 DRILL RIG Schramm

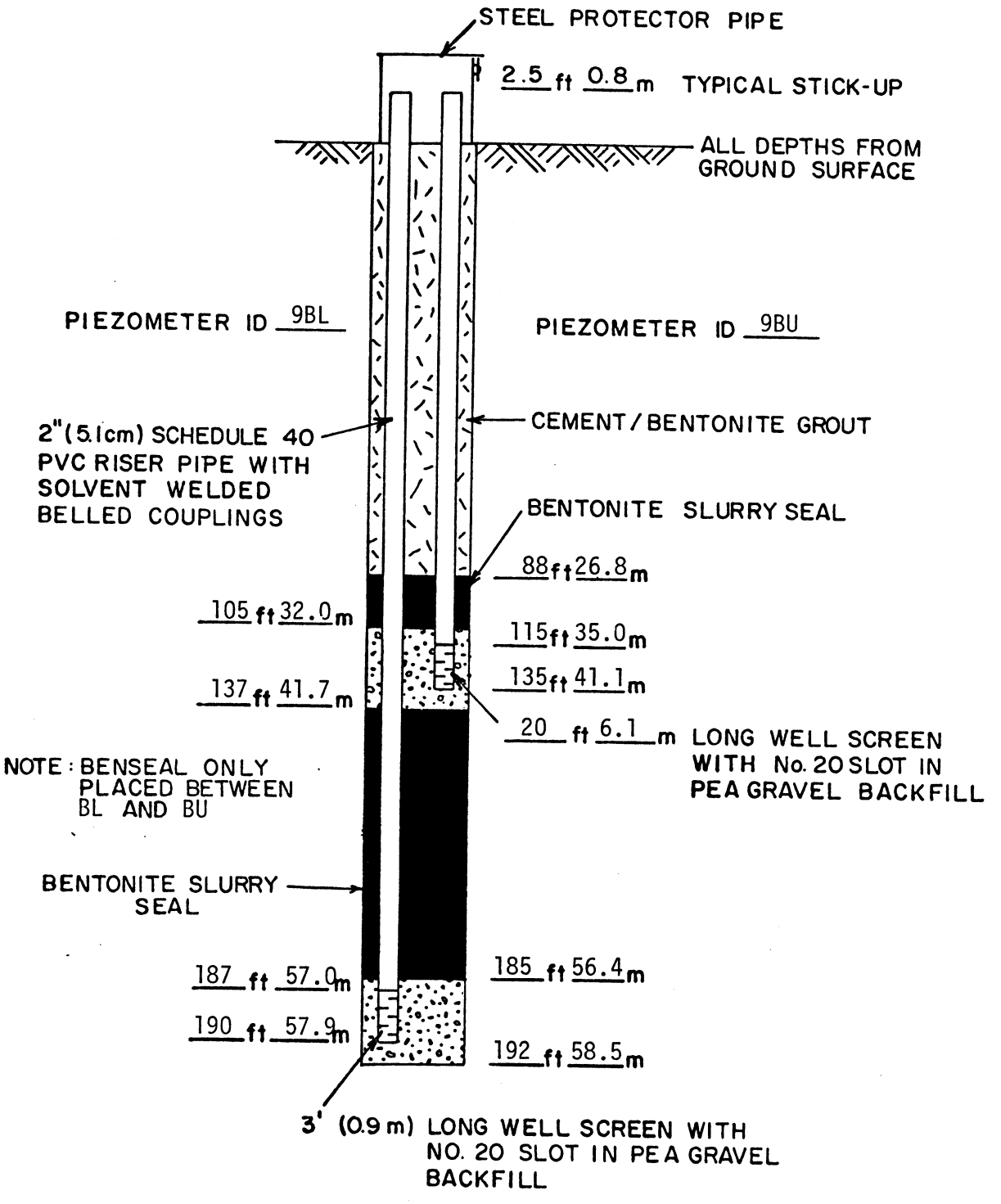
DRILLER Denny's Drilling DRILL CREW Denny

JOB/CLIENT Exxon - Crandon STS JOB No. 12959

FW: 1-983

STS Consultants Ltd.

FIELD WELL INSTALLATION DIAGRAM



Well No. EX-9BL & BU DATE INSTALLED 3-30-84 DRILL RIG Schramm

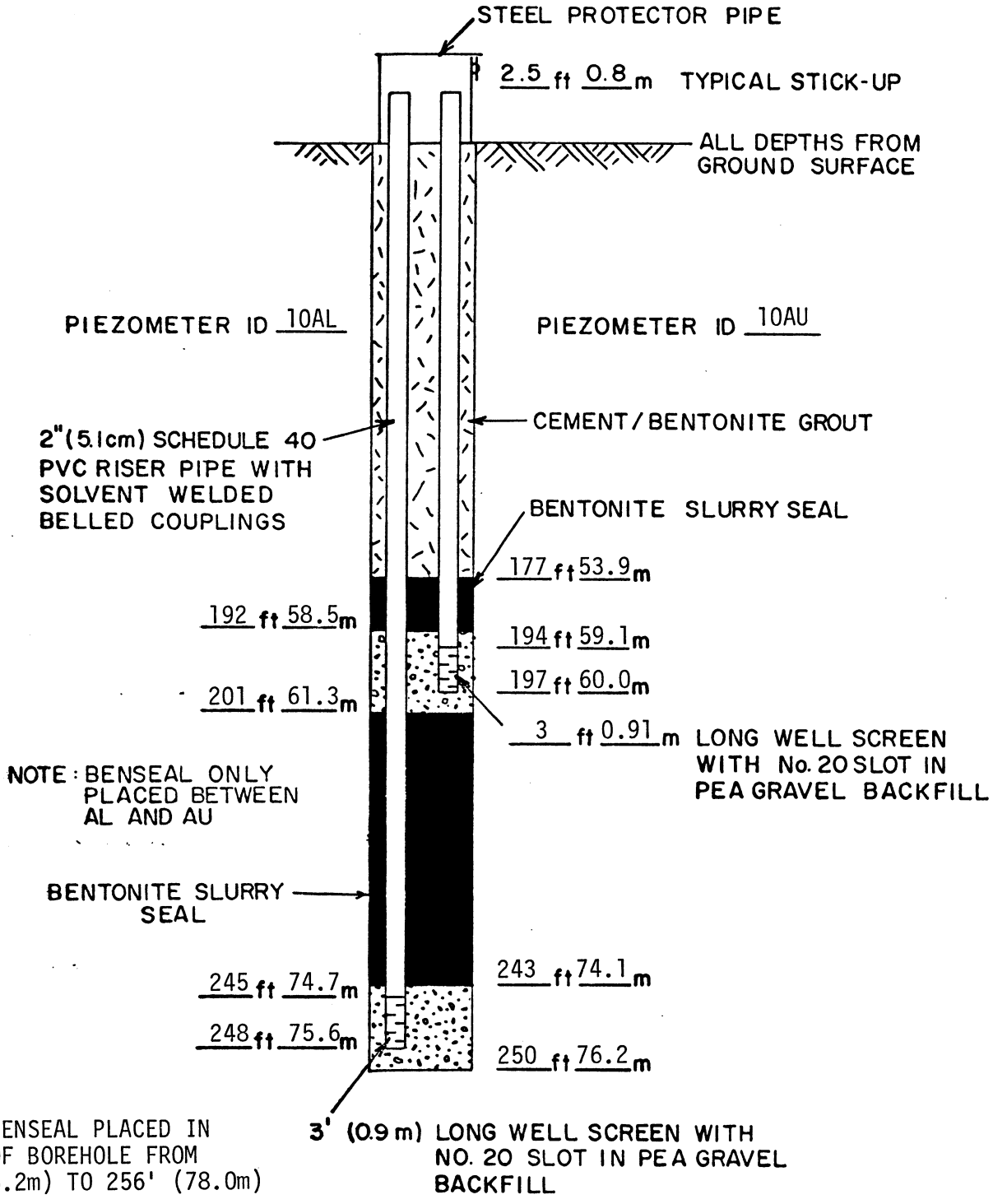
DRILLER Denny's Drilling DRILL CREW Denny

JOB/CLIENT Exxon - Crandon STS JOB No. 12959

FW: 1-983

STS Consultants Ltd.

FIELD WELL INSTALLATION DIAGRAM



NOTE: BENSEAL PLACED IN BOTTOM OF BOREHOLE FROM 250' (76.2m) TO 256' (78.0m)

Well No. EX-10AL & AU DATE INSTALLED 3-16-84 DRILL RIG Schramm

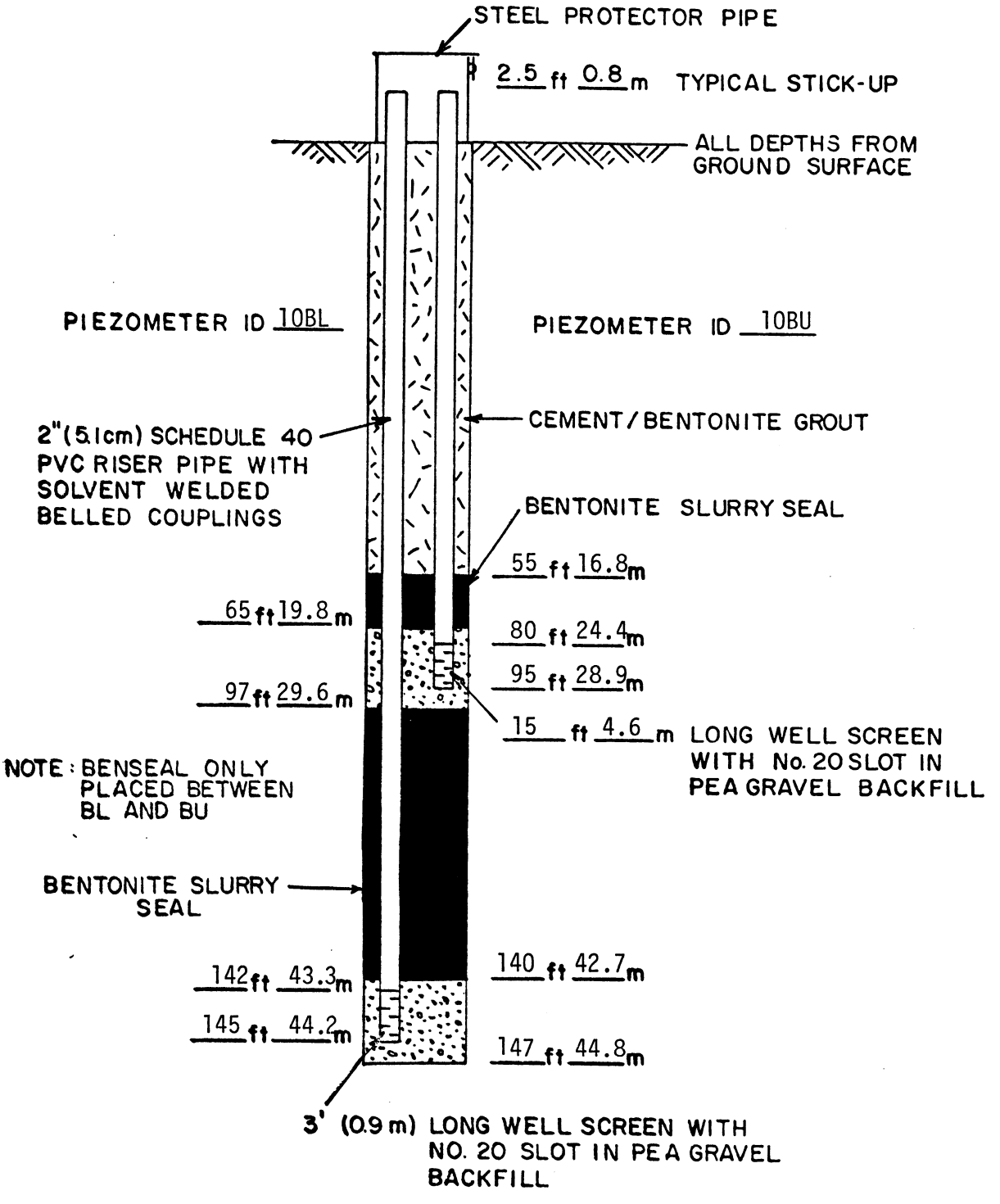
DRILLER Lusiers DRILL CREW Keith

JOB/CLIENT Exxon - Crandon STS JOB No. 12959

FW: 1-983

STS Consultants Ltd.

FIELD WELL INSTALLATION DIAGRAM



Well No. EX-10BL & BU DATE INSTALLED 3-16-84 DRILL RIG Schramm

DRILLER Lusiers DRILL CREW Keith

JOB/CLIENT Exxon - Crandon STS JOB No. 12959

FW: 1-983

UNIFIED SOIL CLASSIFICATION CHART

UNIFIED SOIL CLASSIFICATION SYSTEM

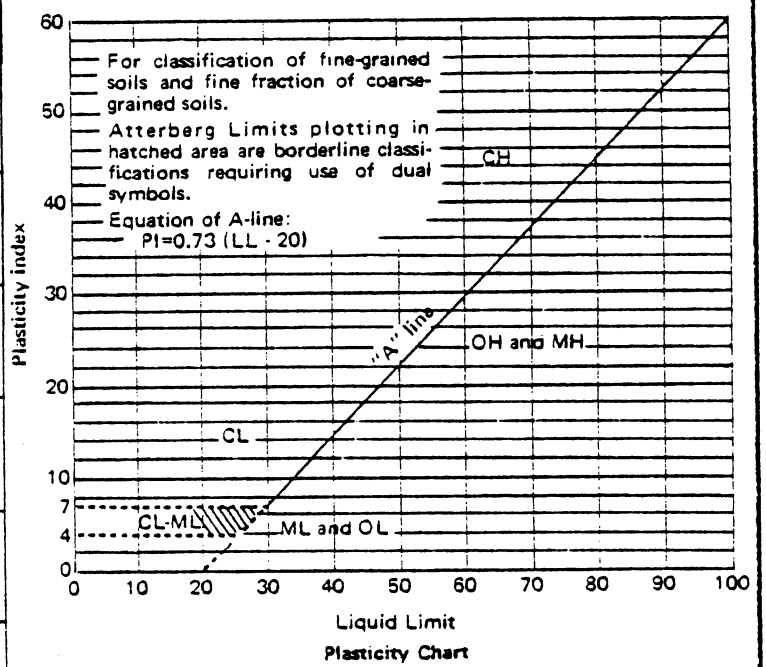
Major divisions			Group symbols	Typical names	Laboratory classification criteria
Coarse-grained soils (More than half of material is *larger* than No. 200 sieve size)	Gravels (More than half of coarse fraction larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines	Not meeting all gradation requirements for GW
		Gravels with fines (Appreciable amount of fines)	GM d / u	Silty gravels, gravel-sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4
			GC	Clayey gravels, gravel-sand-clay mixtures	Atterberg limits above "A" line with P.I. greater than 7
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines	$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
			SP	Poorly graded sands, gravelly sands, little or no fines	Not meeting all gradation requirements for SW
		Sands with fines (Appreciable amount of fines)	SM d / u	Silty sands, sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4
			SC	Clayey sands, sand-clay mixtures	Atterberg limits above "A" line with P.I. greater than 7
Fine grained soils (More than half of material is *smaller* than No. 200 sieve)	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 sandy or silty soils, elastic silts	
			CH	Inorganic clays of high plasticity, fat clays	
			OH	Organic clays of medium to high plasticity, organic silts	
	Highly organic soils		Pt	Peat and other highly organic soils	

Determine percentages of sand and gravel from grain-size curve.
Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

Less than 5 per cent	GW, GP, SW, SP
More than 12 per cent	GM, GC, SM, SC
5 to 12 per cent	*Borderline* cases requiring dual symbols

Above "A" line with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols

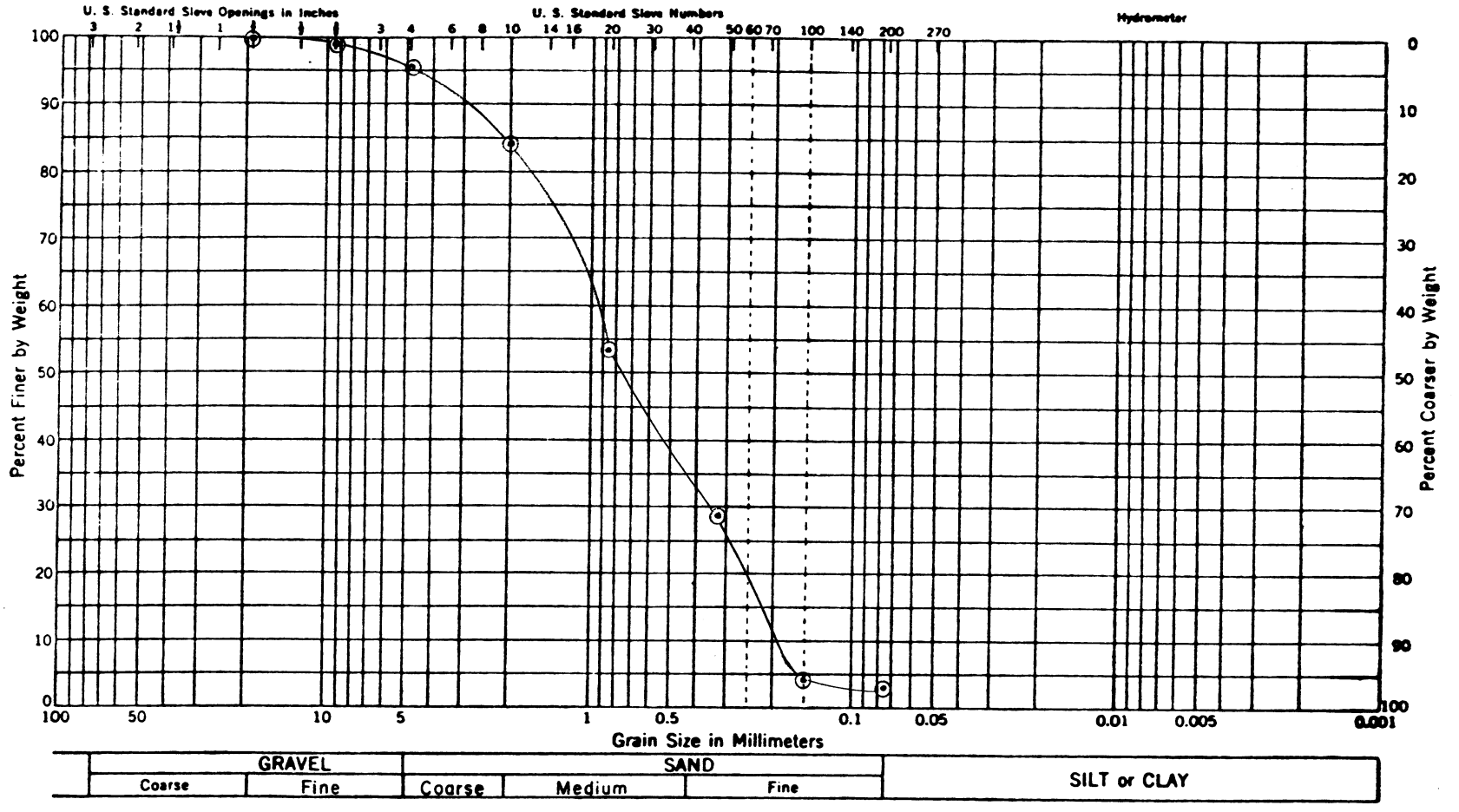
Limits plotting in hatched zone with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols.



Plasticity Chart

GRADATION CURVES - EX BORINGS

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-9	4.9				Fine to coarse sand (SP)
S-A					
4.0-6.0'					

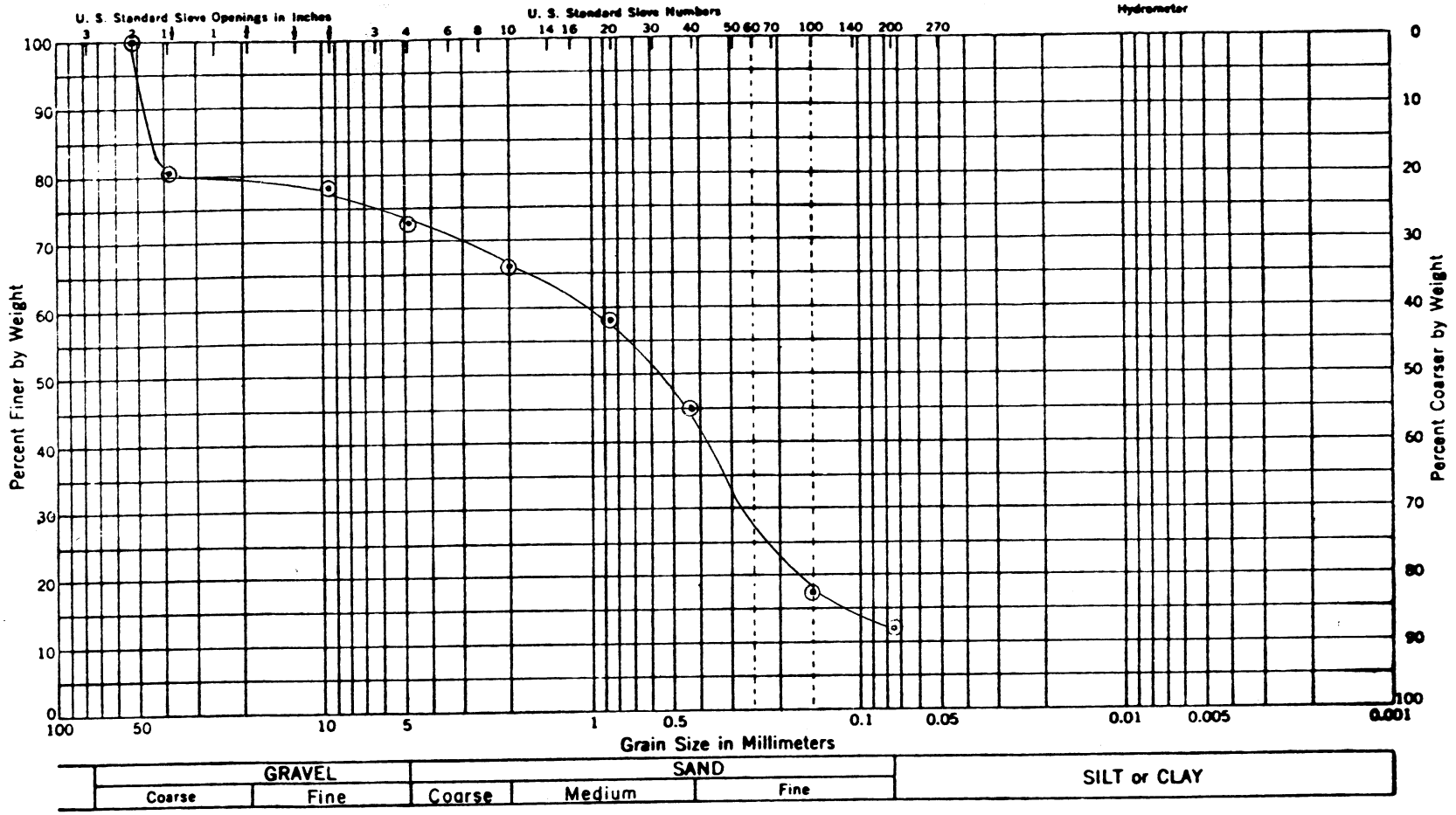
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-9	5.7				silty fine to coarse sand (SM)
S-2					
20.0-22.0'					

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

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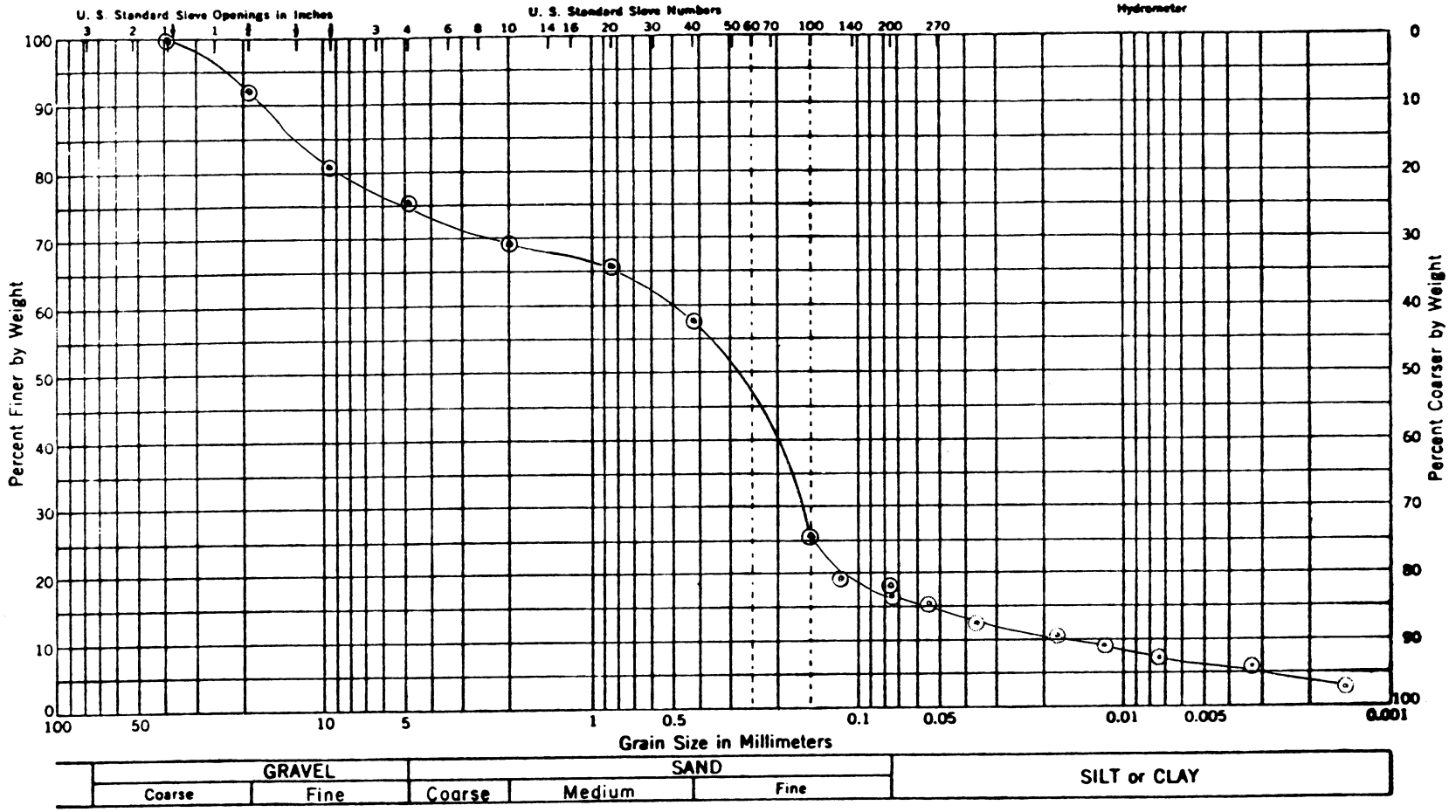
UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-9	4.1				Silty fine to coarse sand (SM)
S-3					
30.1-	31.5'				

EXXON MINERALS COMPANY
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CRANDON PROJECT

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GREEN BAY, WIS. 54303

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JJT	JAS	4-2-84	12959

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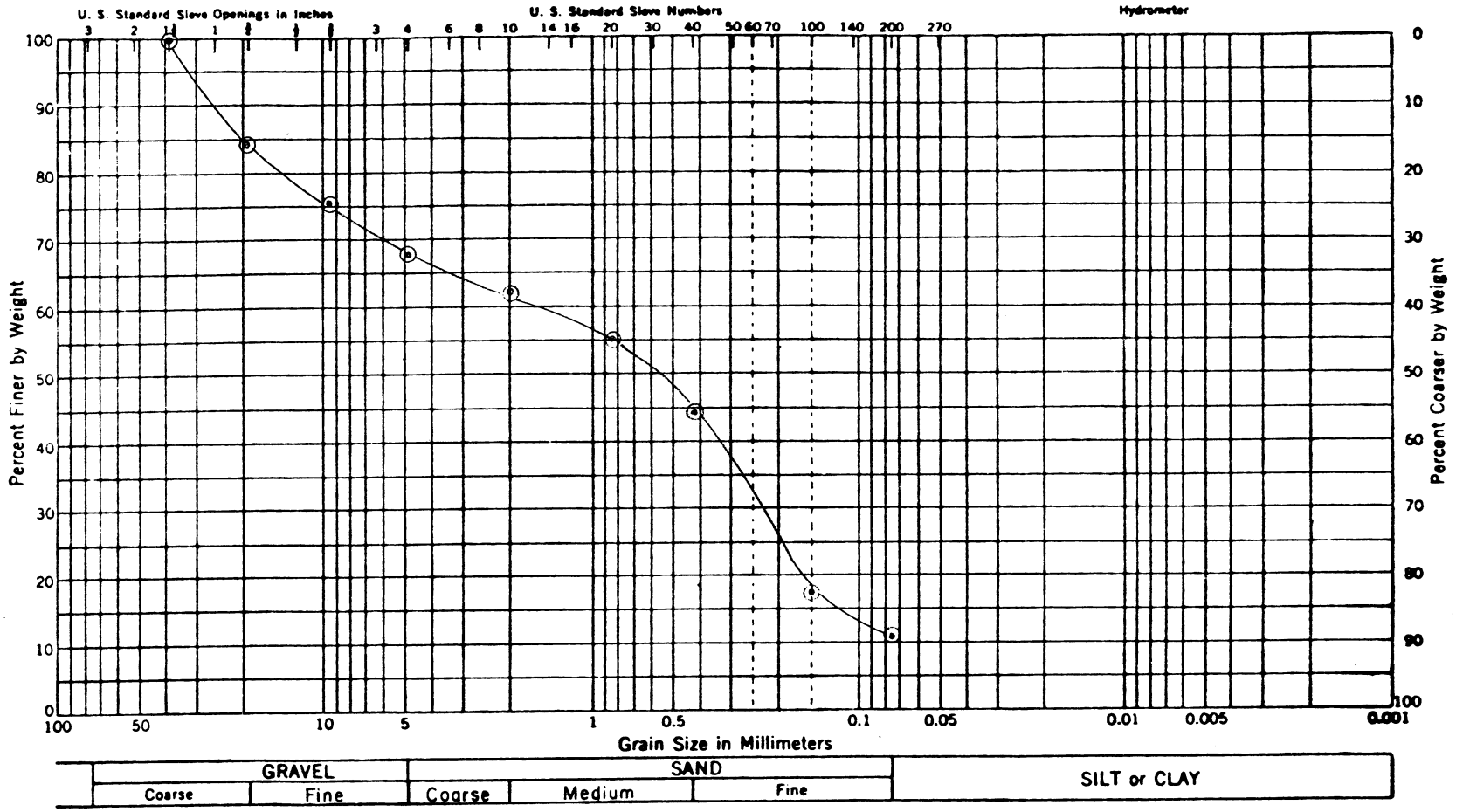
UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-9	5.7				Slightly silty fine to coarse sand (SM-SP)
S-5					
50.5-52.0'					

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

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540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

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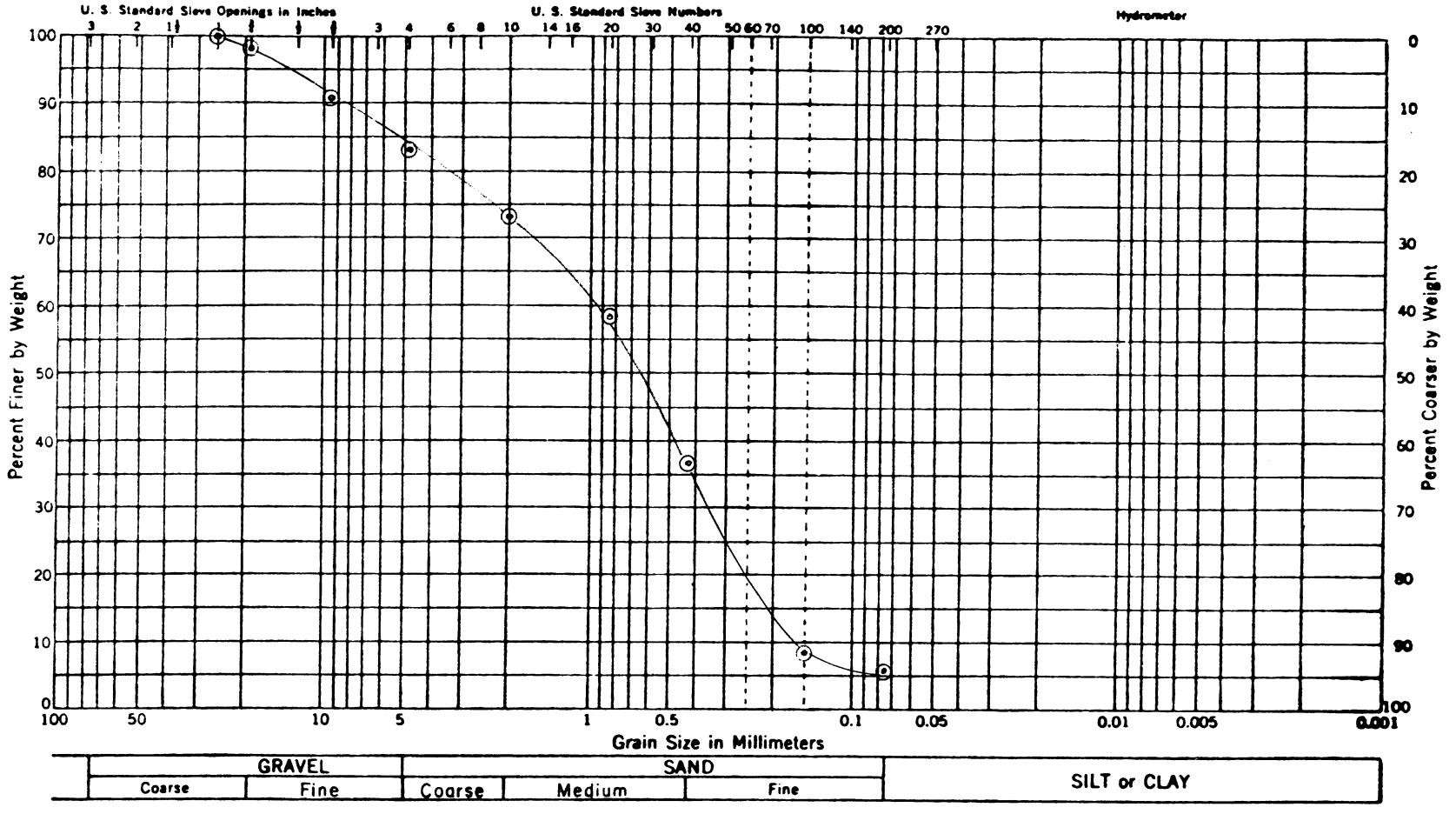
UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-9	11.3				Slightly silty fine to coarse sand (SM-SP)
S-7					
70.5-	72.0'				

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

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540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

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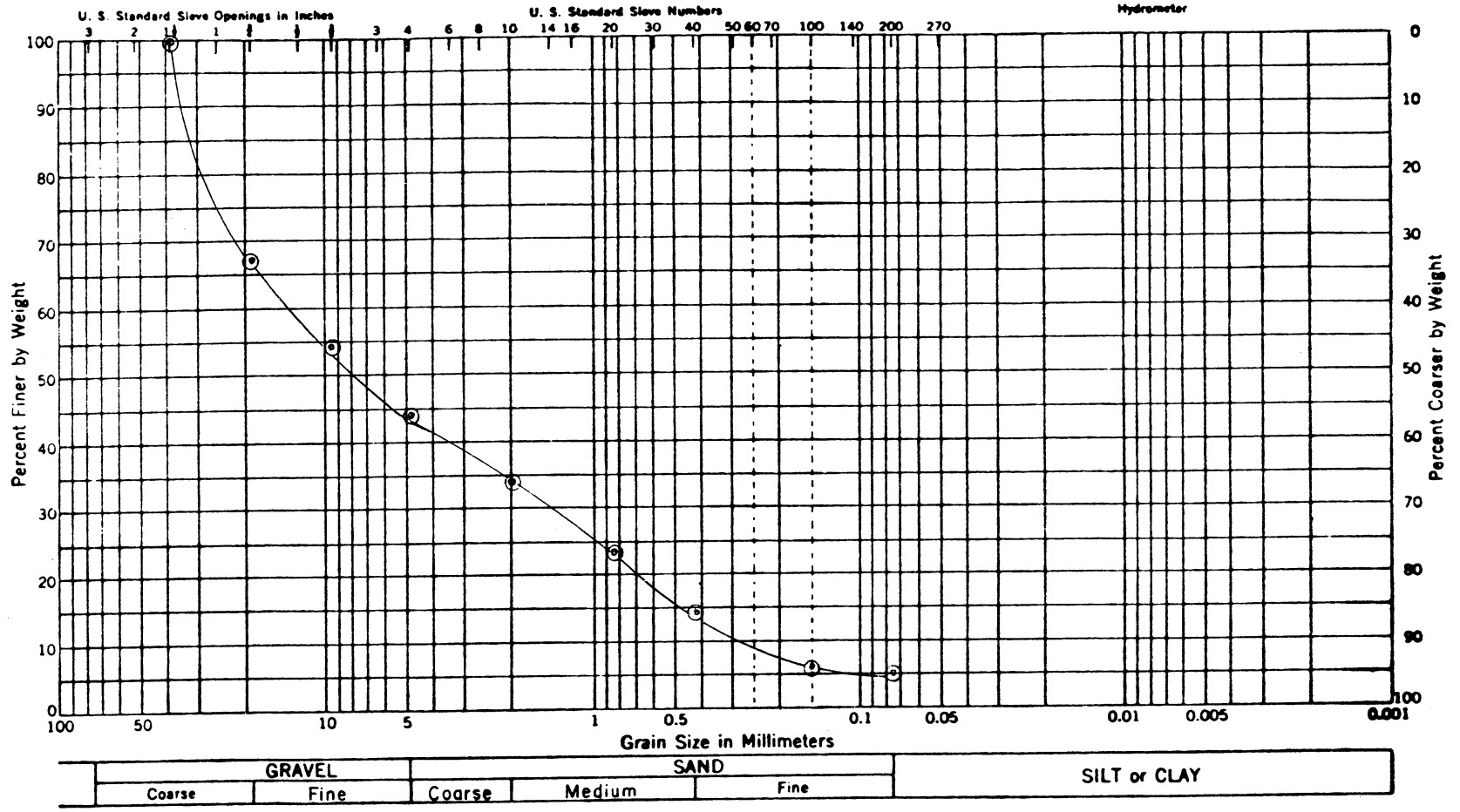
UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-9	7.7				Fine to coarse gravel (GP)
S-9					
91.0-	93.0'				

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

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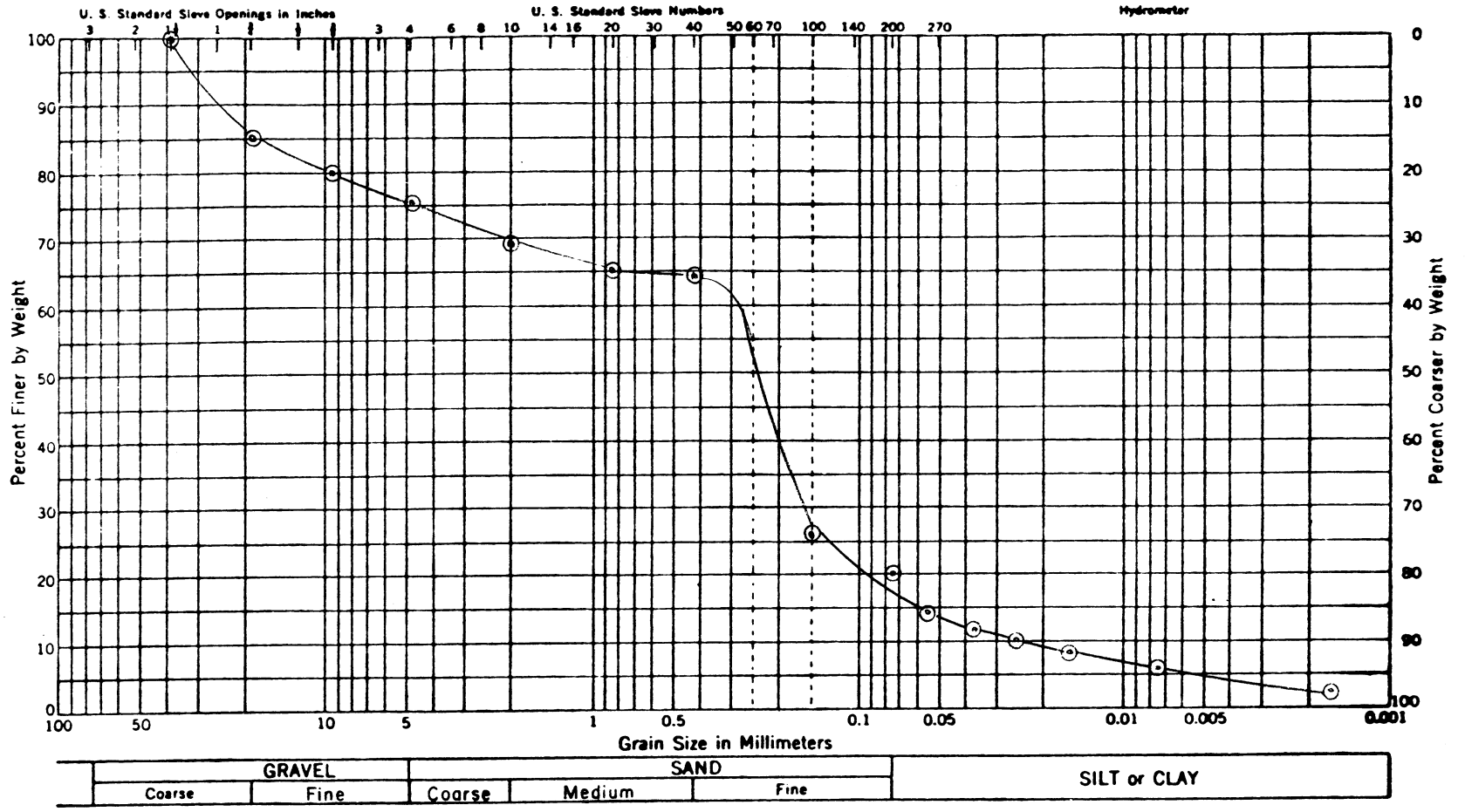
UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-9	8.5				Silty fine to coarse sand (SM)
S-10					
101.5-103.5'					

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

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540 LAMBEAU STREET
GREEN BAY, WIS. 54303

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JJT	JAS	4-2-84	12959

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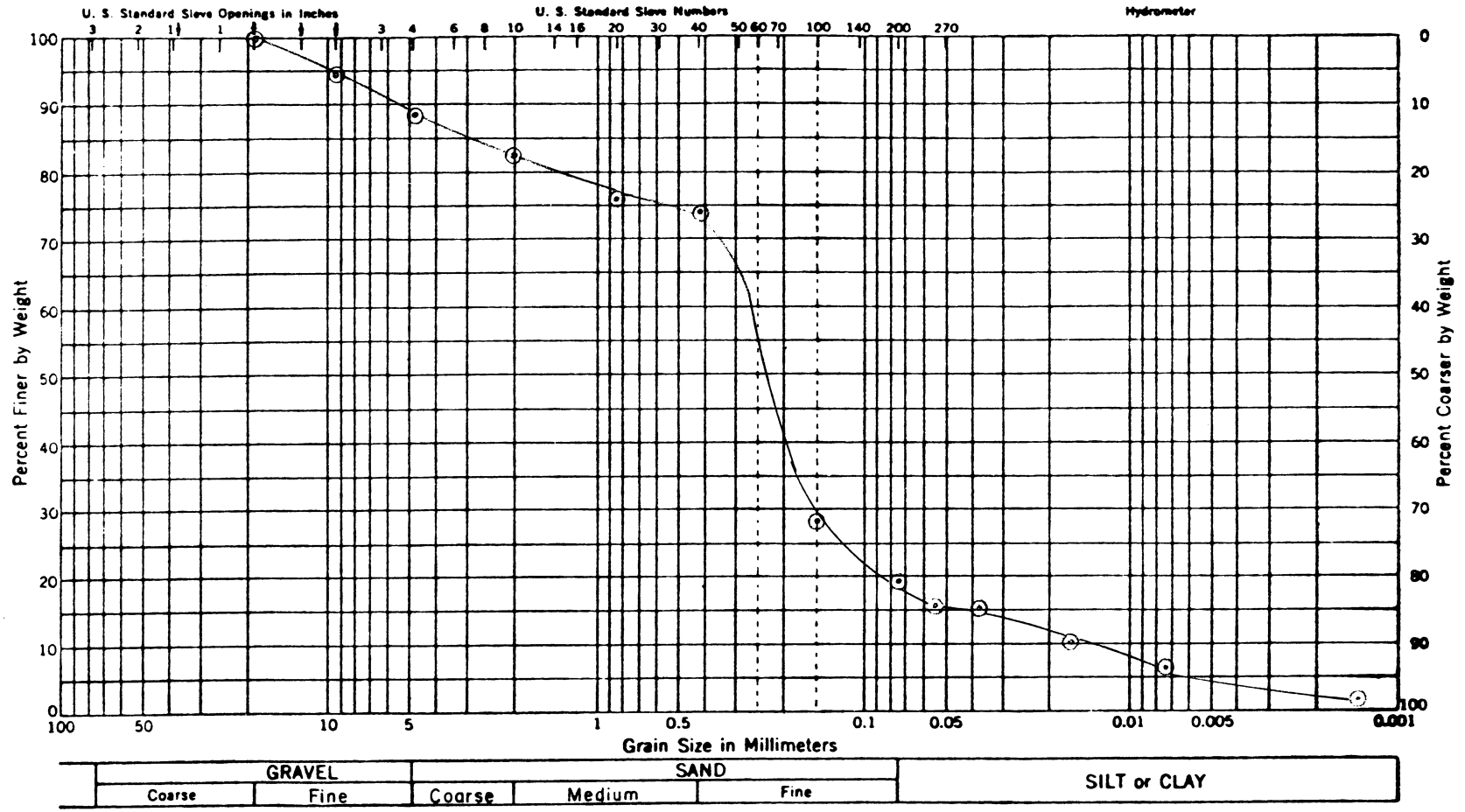

SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-9	8.7				Silty fine to coarse sand (SM)
S-12					
123.0-124.5'					

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

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540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

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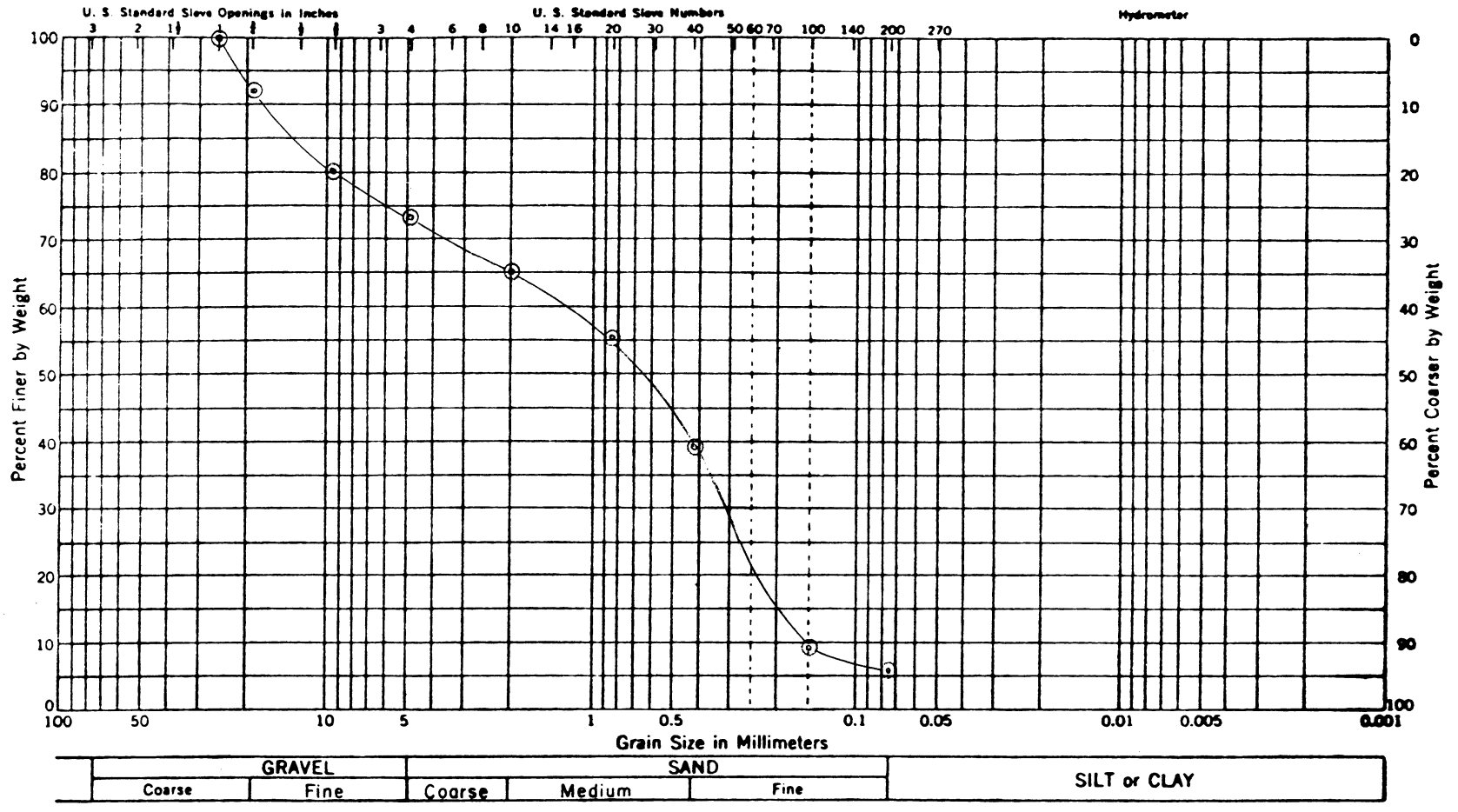

SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-9	10.9				Slightly silty fine to coarse sand (SM-SP)
S-13					
133.5-135.0'					

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

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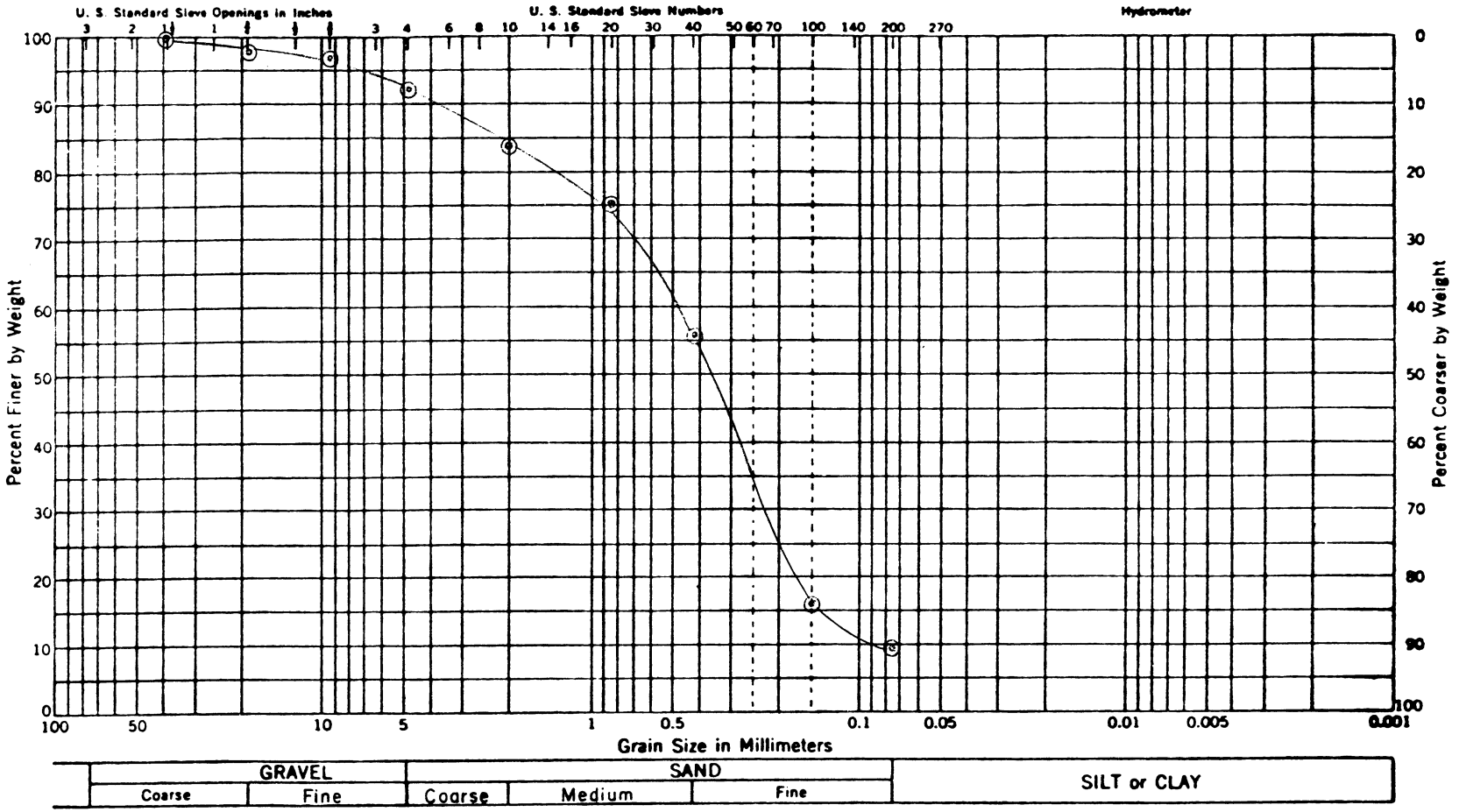
UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-9	13.5				Slightly silty fine to coarse sand (SM-SP)
S-14					
142.5-144.5'					

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

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540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

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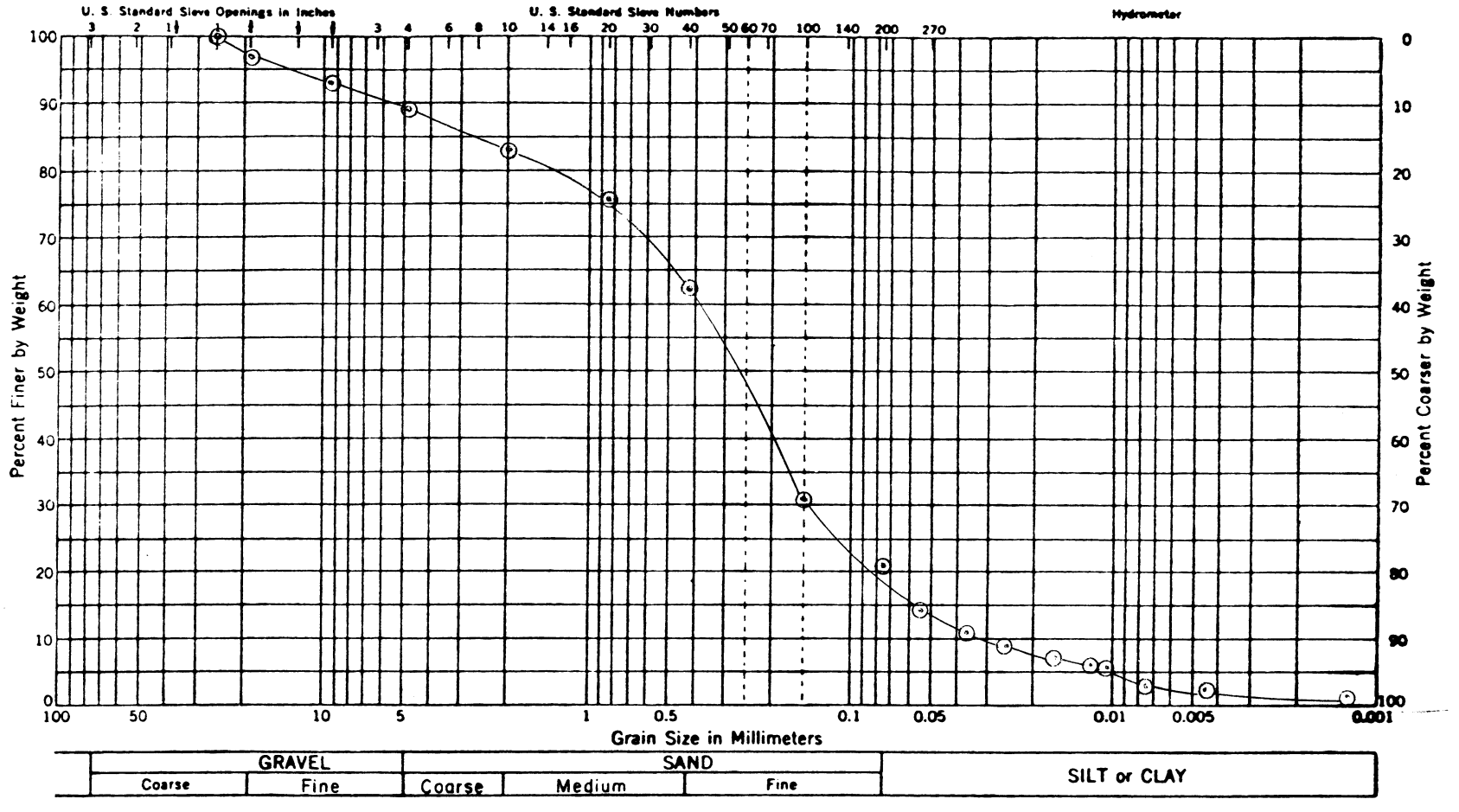

SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-9	9.3				Silty fine to coarse sand (SM)
S-16					
163.0-165.0'					

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

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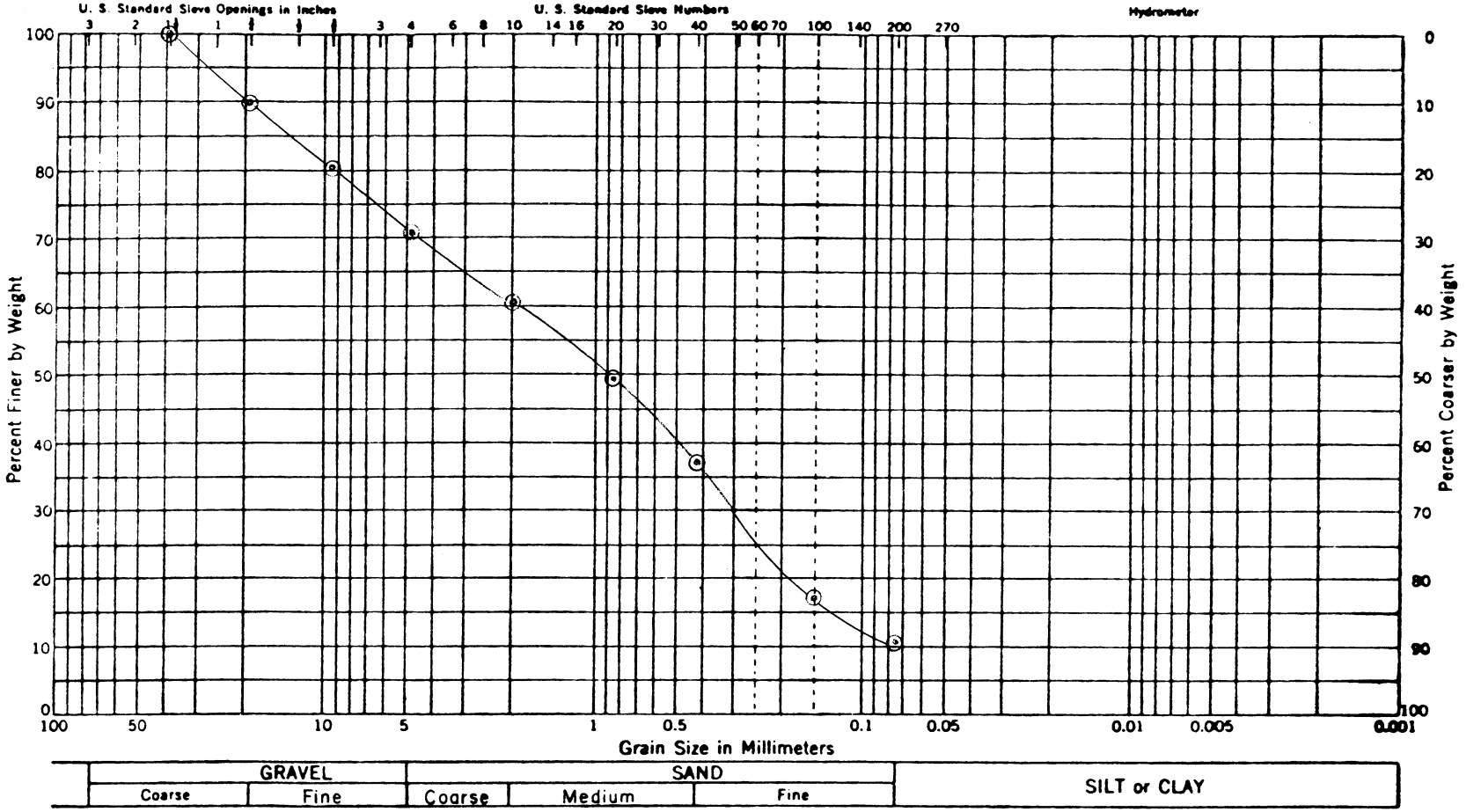
UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-9	9.8				Slightly silty fine to coarse sand (SM-SP)
S-18					
185.0-186.5'					

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

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540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

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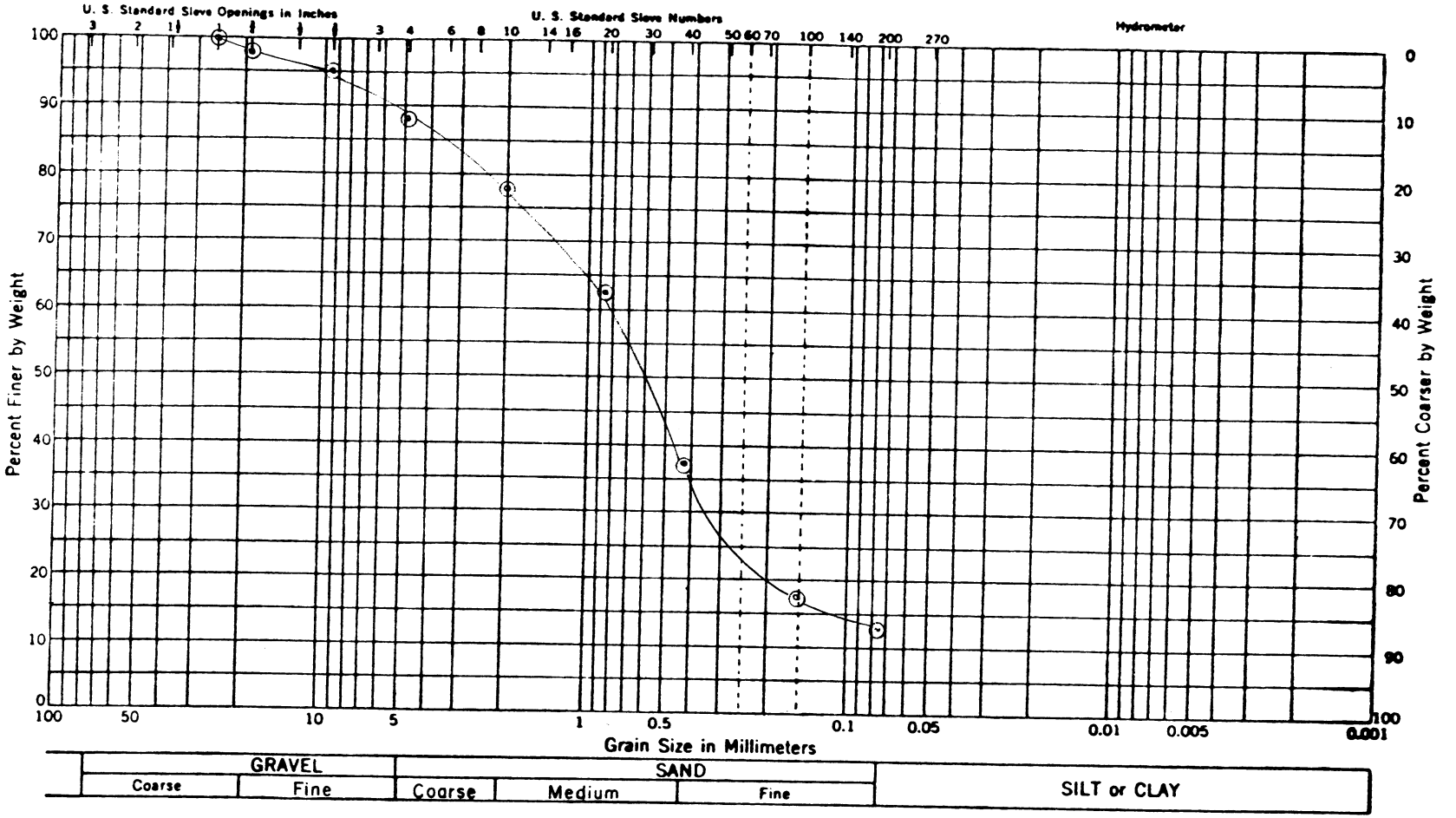

SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-9	13.7				Silty fine to coarse sand (SM)
S-20					
203.0-205.0'					

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

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540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

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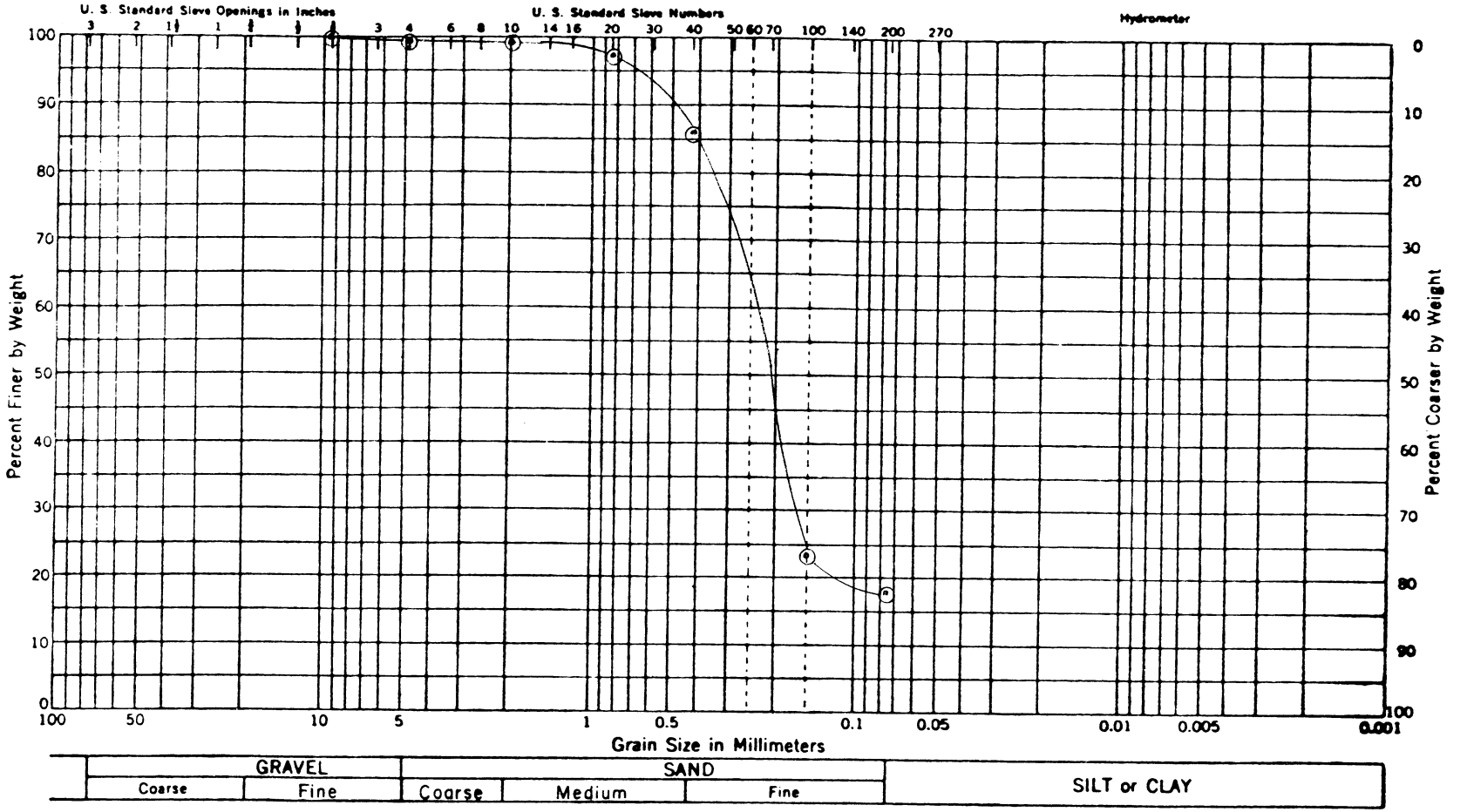
UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-9	17.5				Silty fine to medium sand (SM)
S-25					
255.0-256.0'					

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

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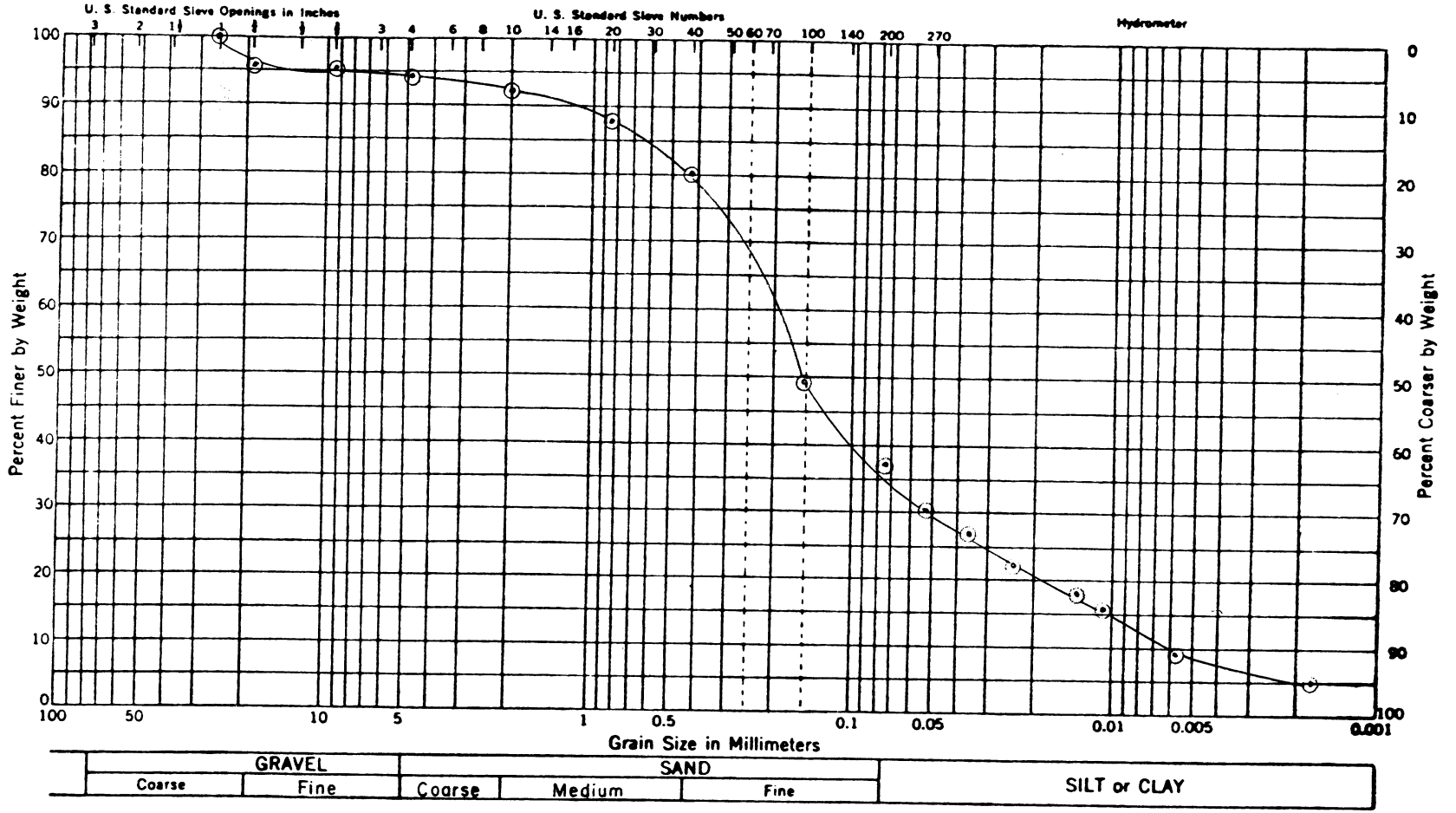
UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-10	14.6				Silty fine to medium sand (SM)
S-1					
10.5-12.5'					

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

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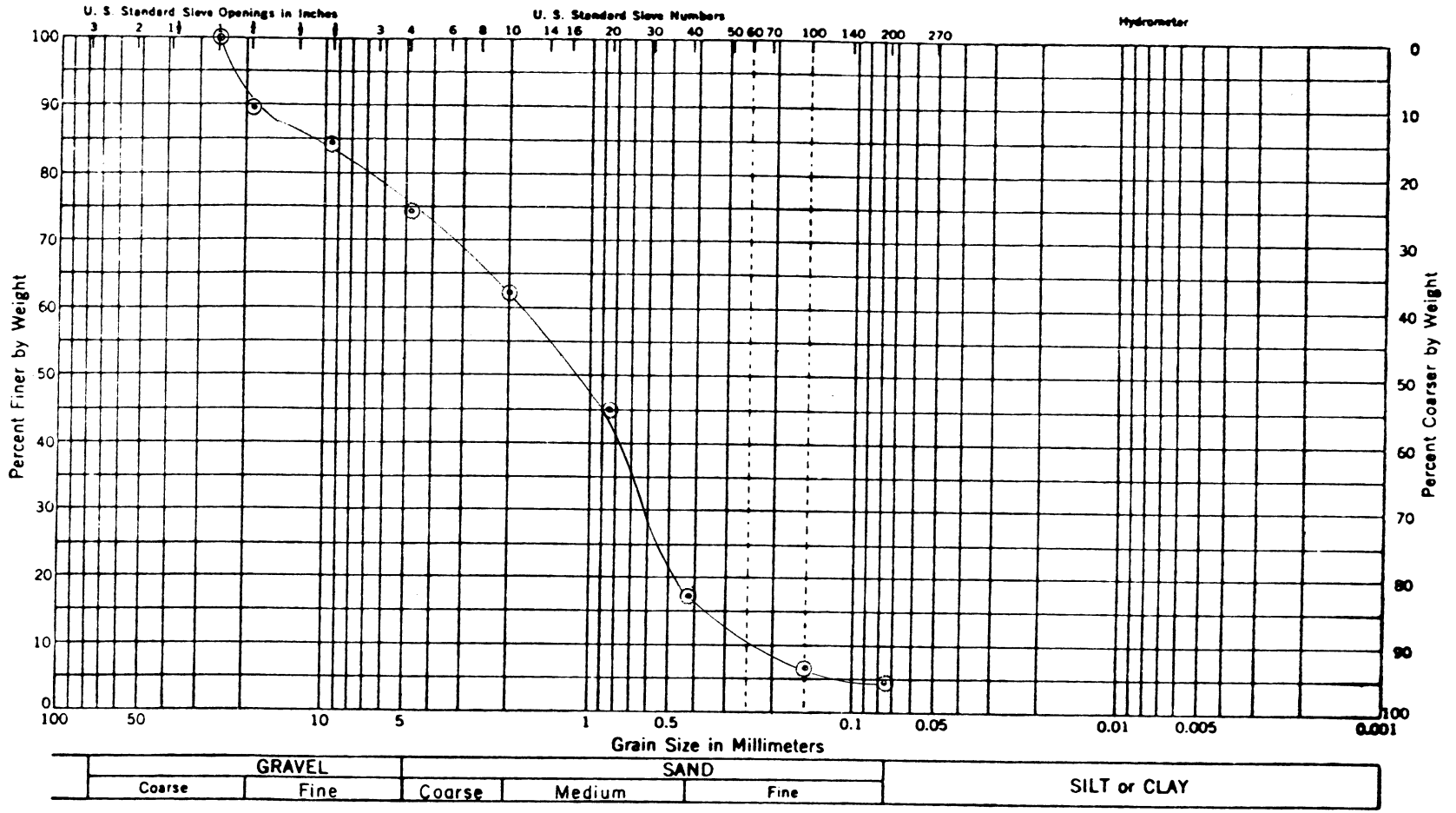
UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-10	3.7				Fine to coarse sand (SP)
S-2					
20.5-22.5'					

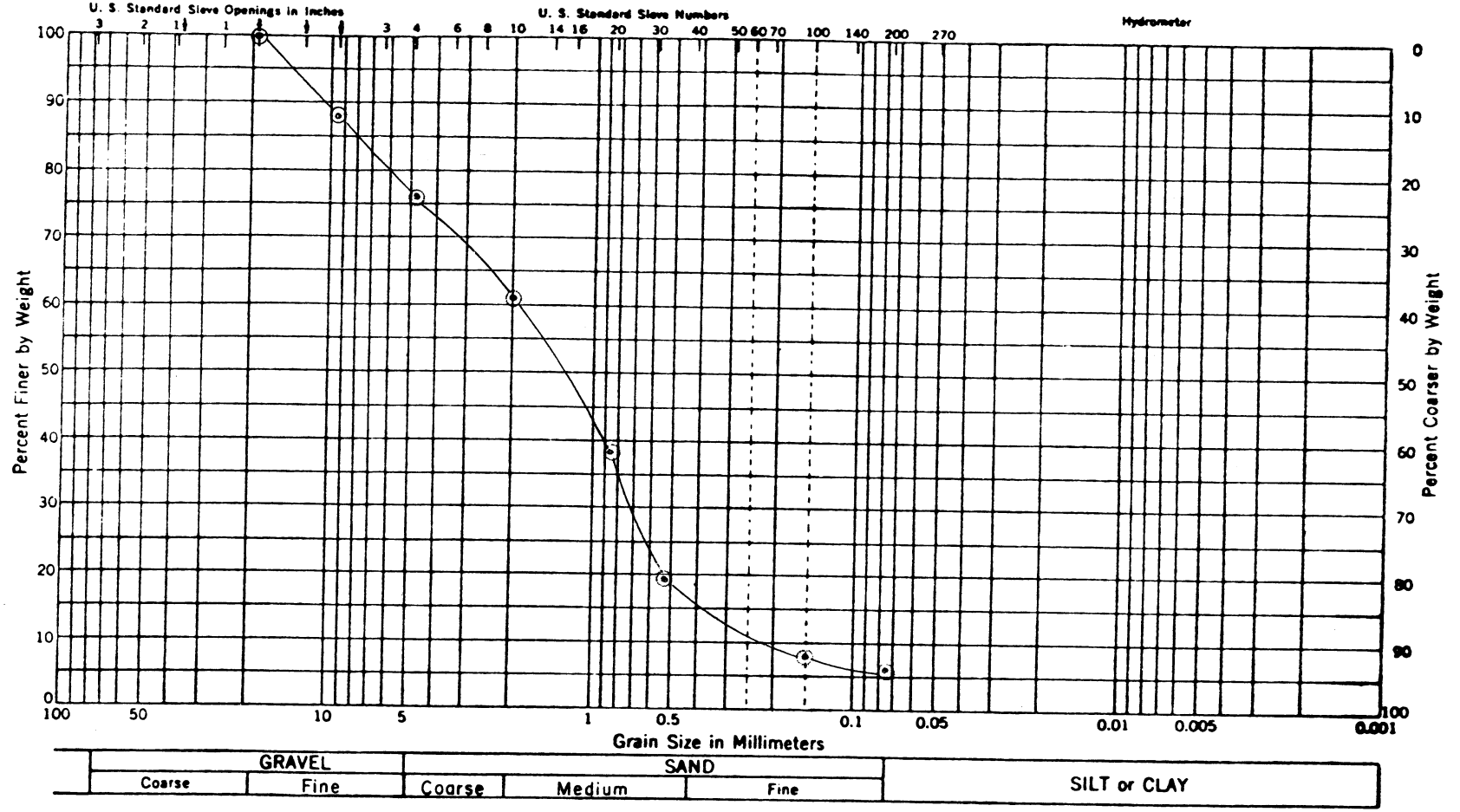
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-10	4.8				Slightly silty fine to coarse sand (SM-SP)
S-4					
41.5-	43.5'				

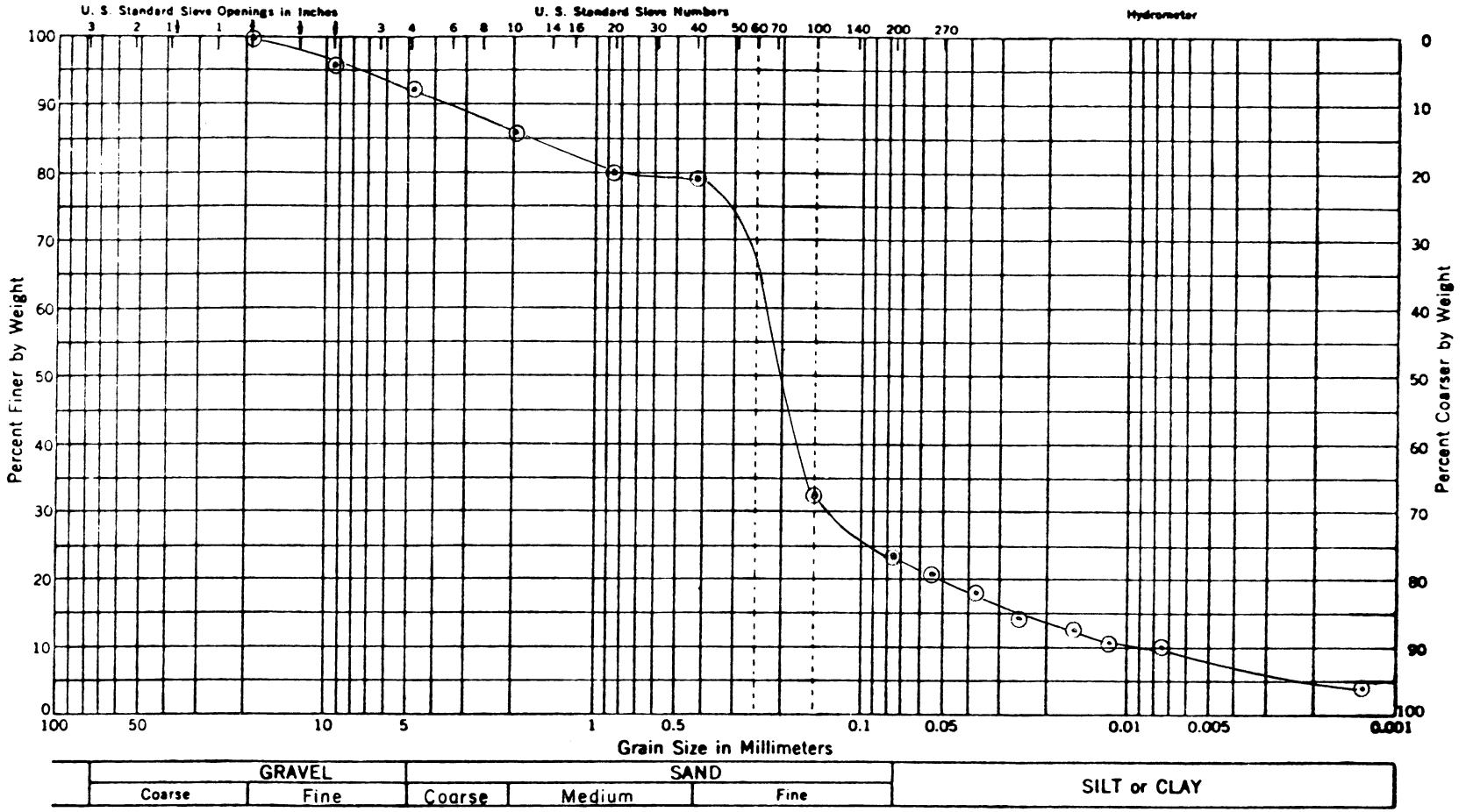
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-10	9.2				Silty fine to medium sand (SM)
S-5					
51.5-	53.5'				

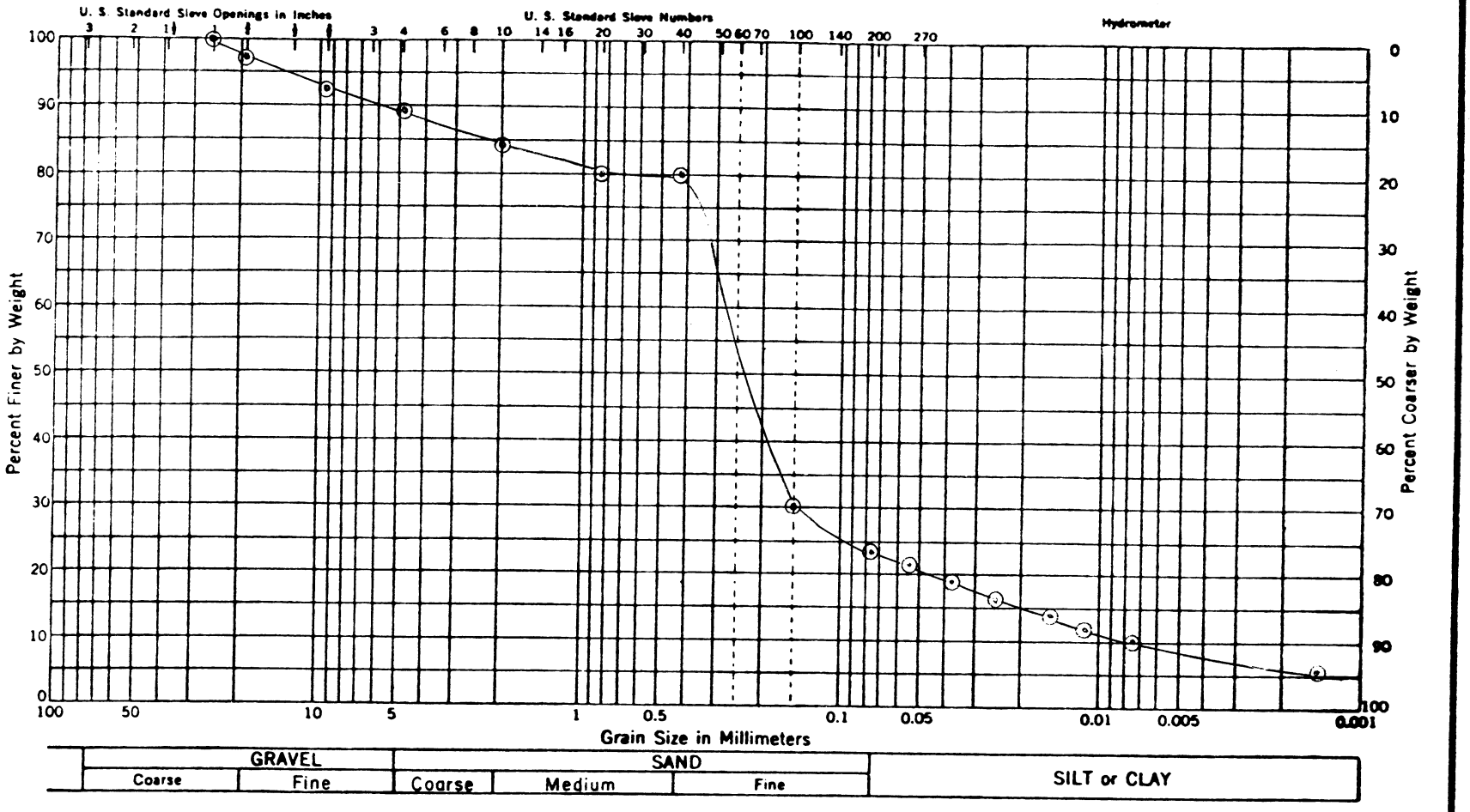
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-10	9.6				Silty fine to medium sand (SM)
S-6					
62.0-	64.0'				

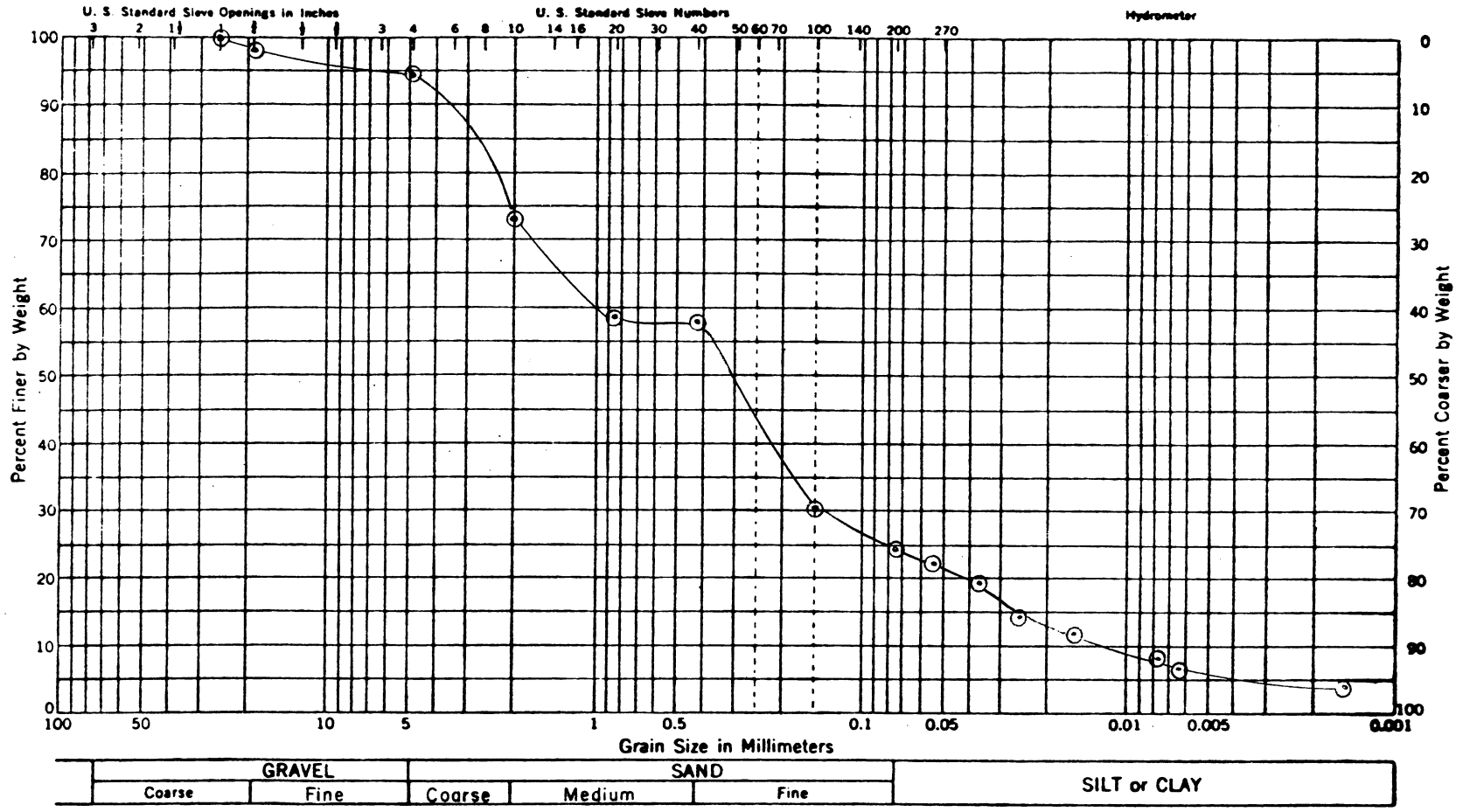
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-10	13.9				Silty fine to coarse sand (SM)
S-9					
92.5-	94.5'				

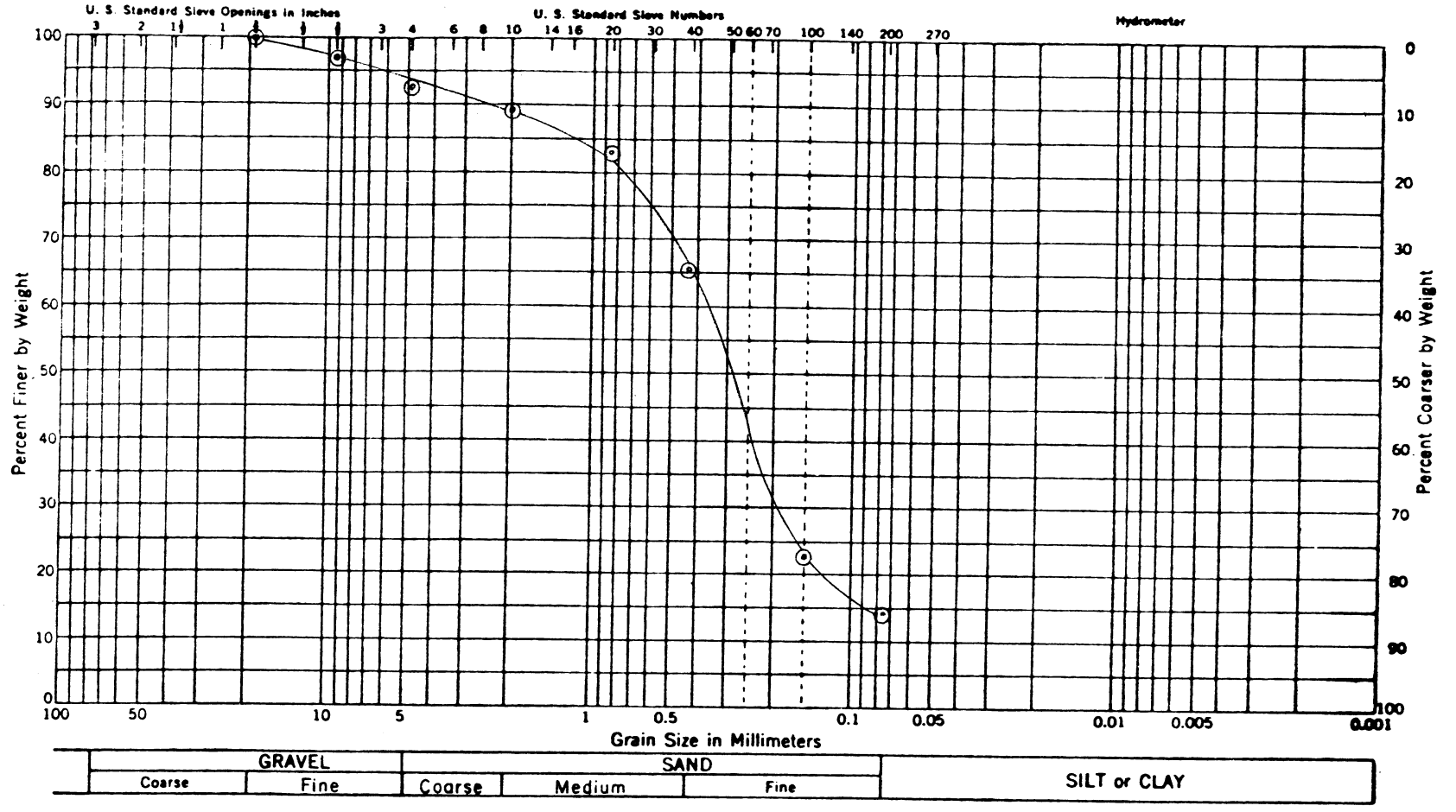
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-10	8.7				Silty fine to coarse sand (SM)
S-10					
103.0-105.0'					

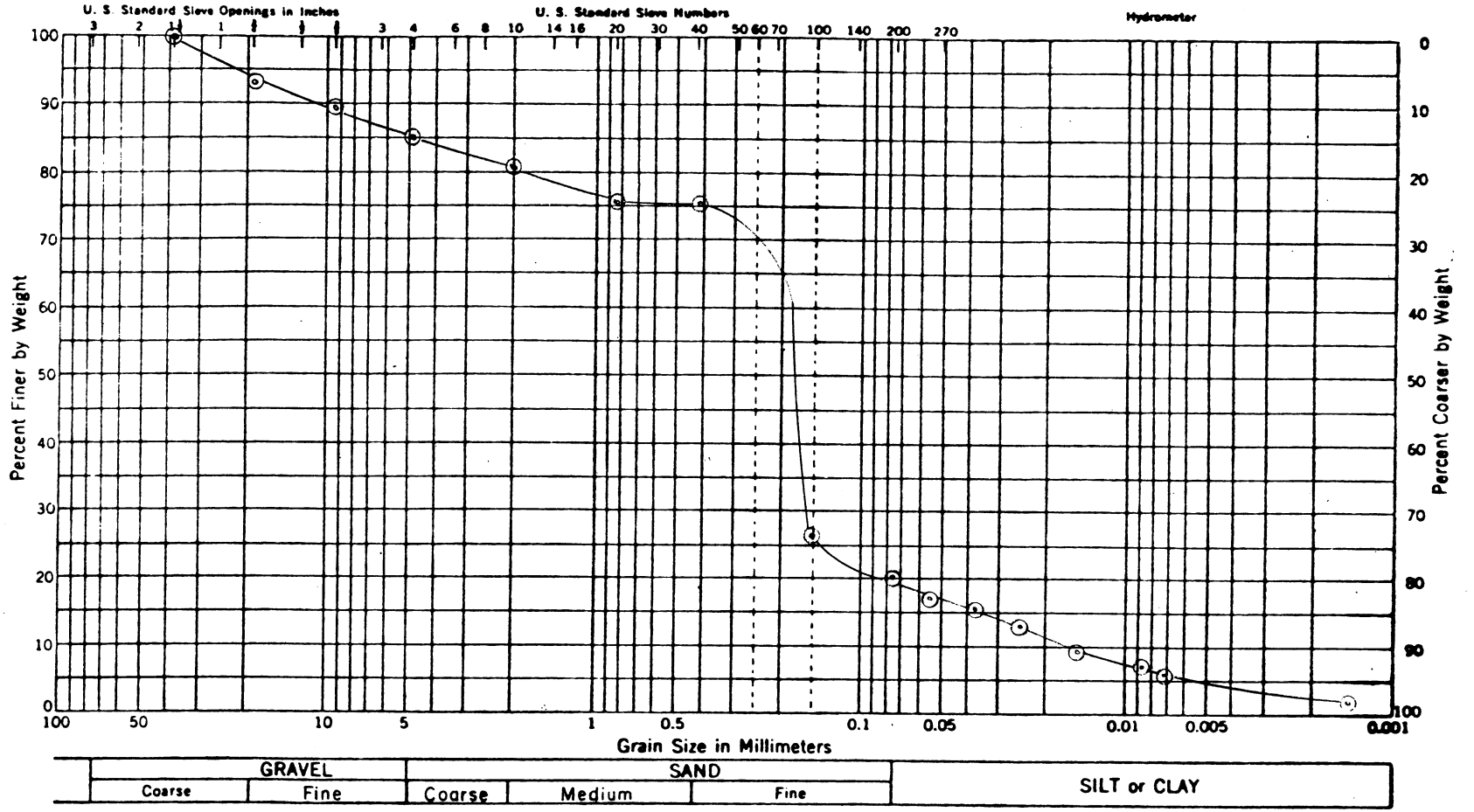
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-10	11.5				Silty fine to coarse sand (SM)
S-13					
133.5-135.5'					

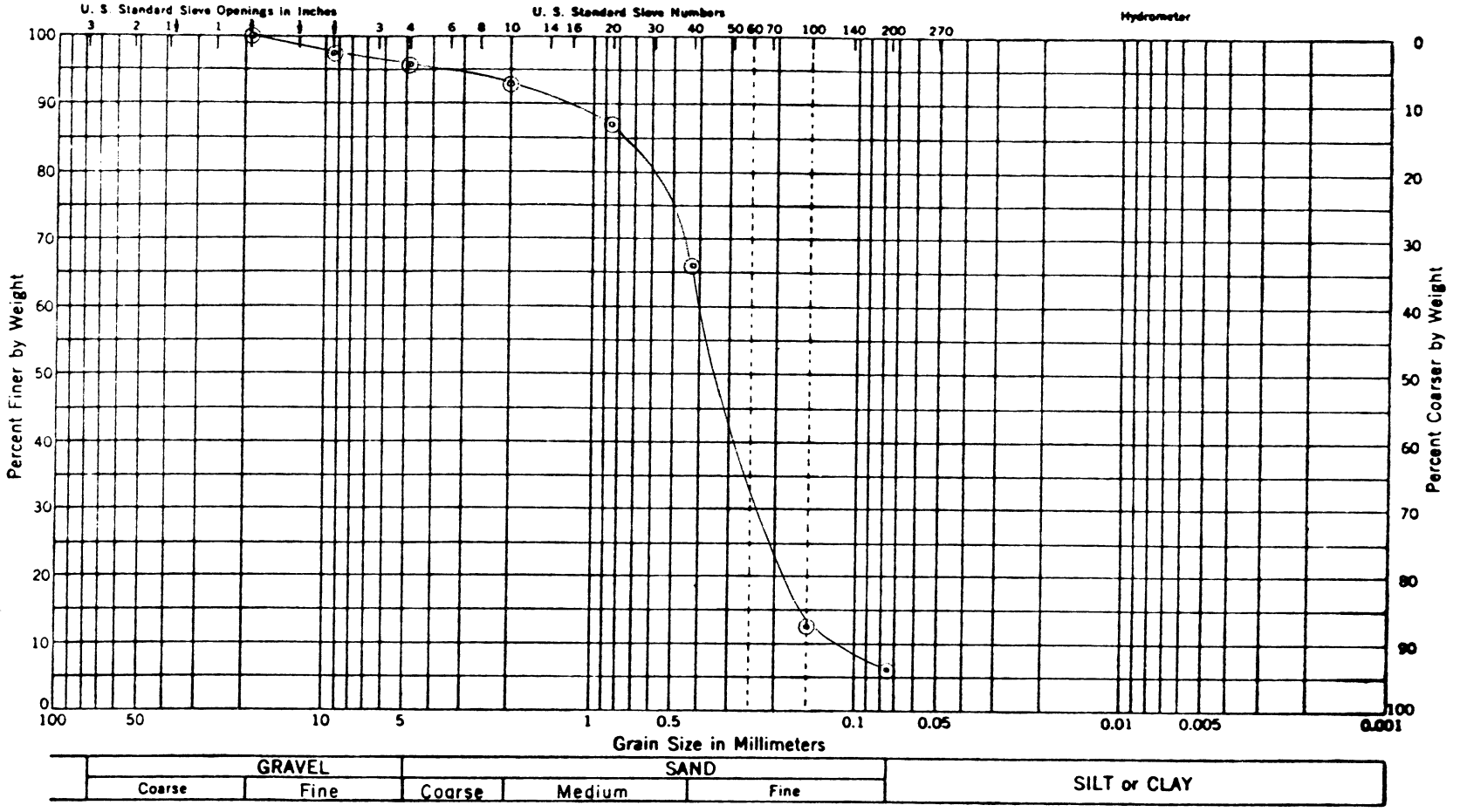
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-10	13.2				Slightly silty fine to medium sand (SM-SP)
S-17					
174.5-176.5'					

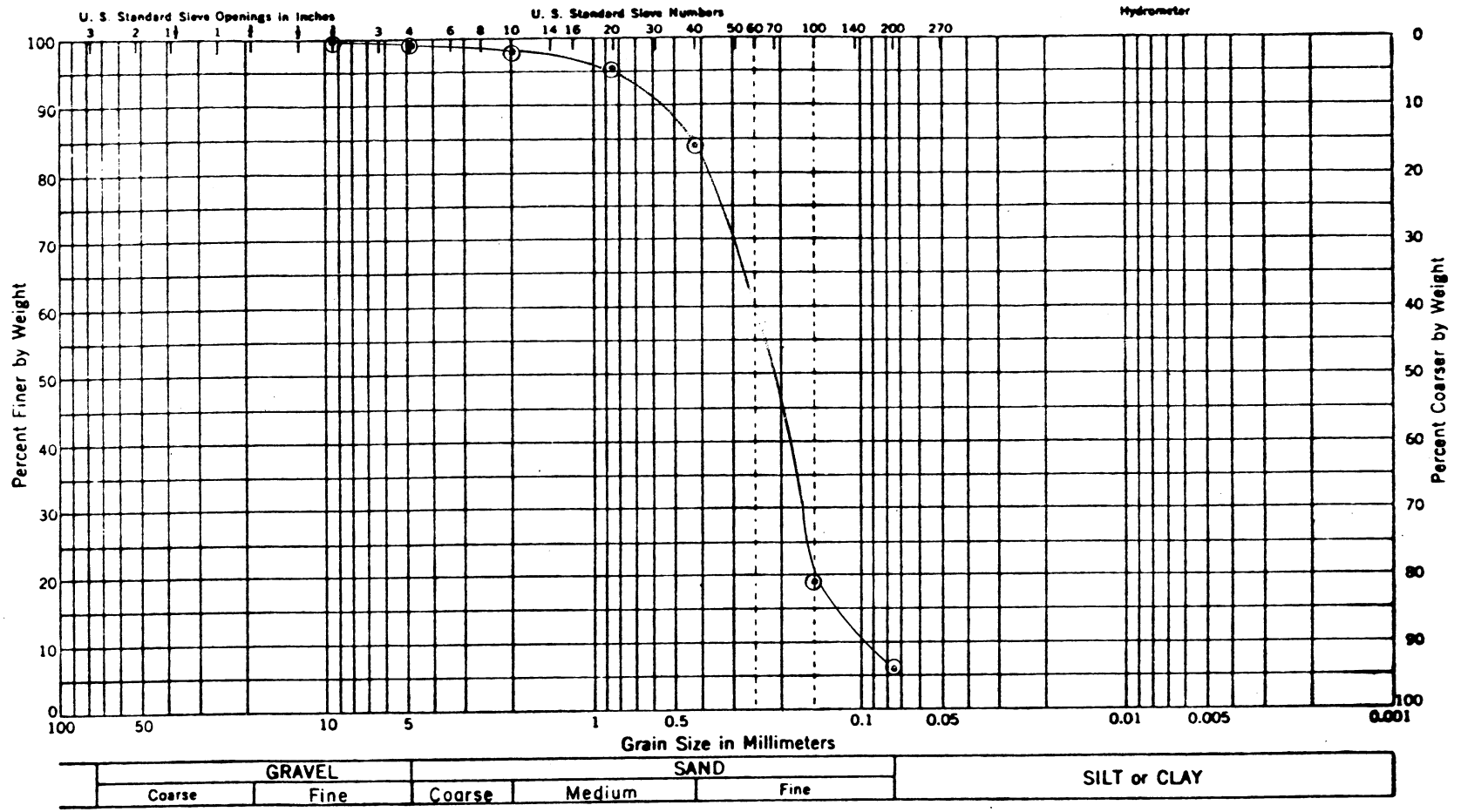
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-10	18.7				Slightly silty fine sand (SM-SP)
S-18					
185.0-186.5'					

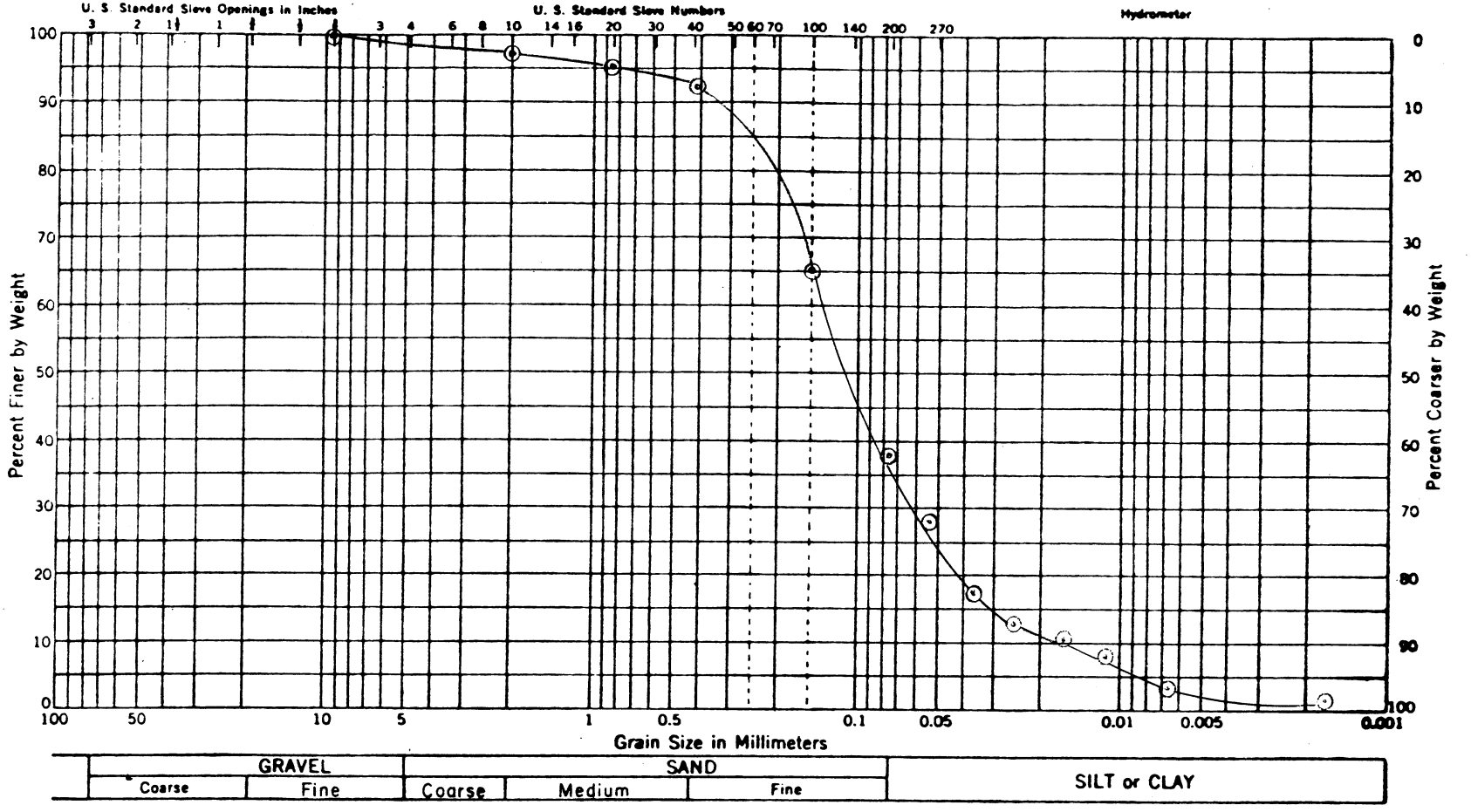
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-10	17.3				Silty fine sand (SM)
S-21					
215.5-217.0					

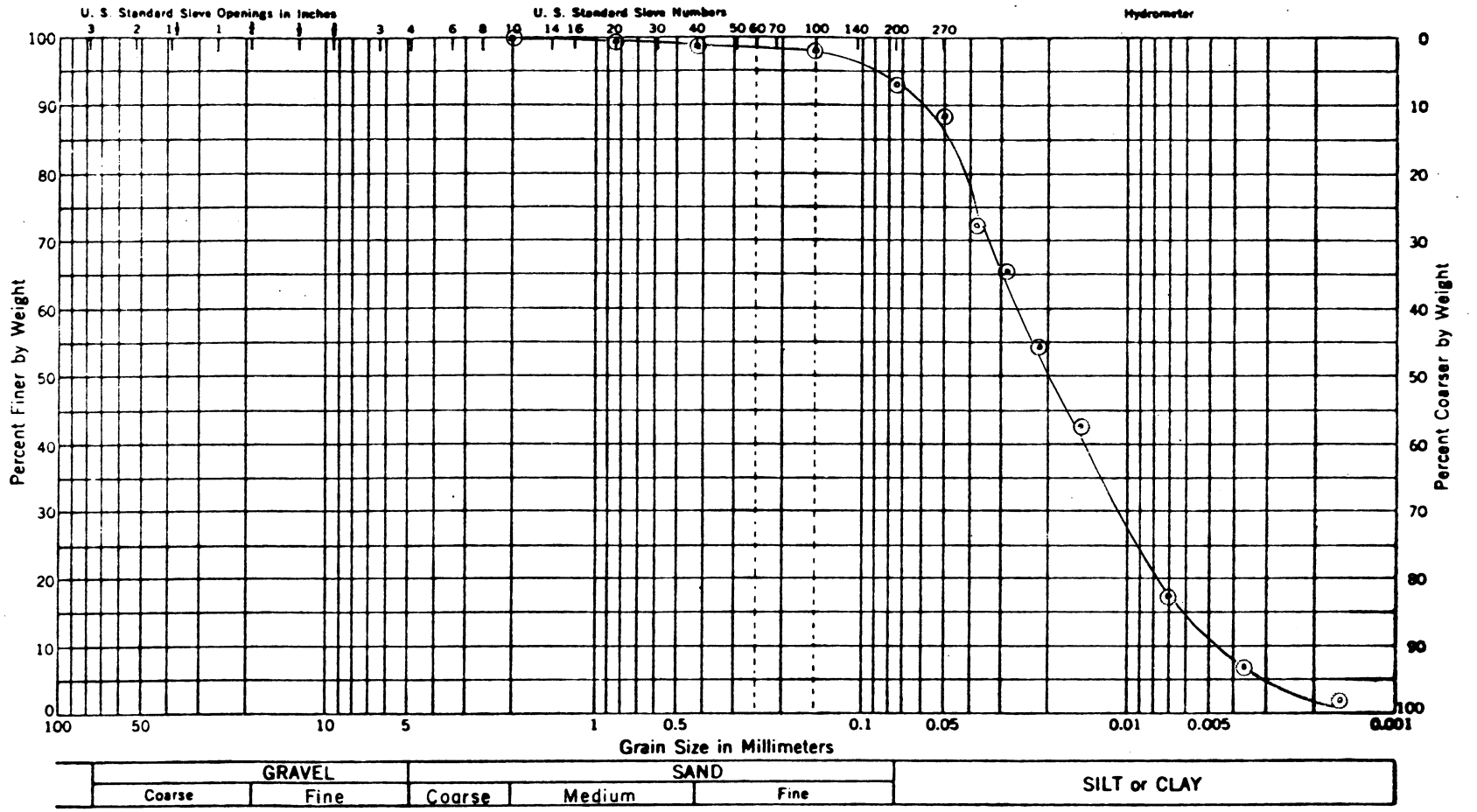
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-10	19.7				Silt (ML)
S-22					
228.0-229.0'					

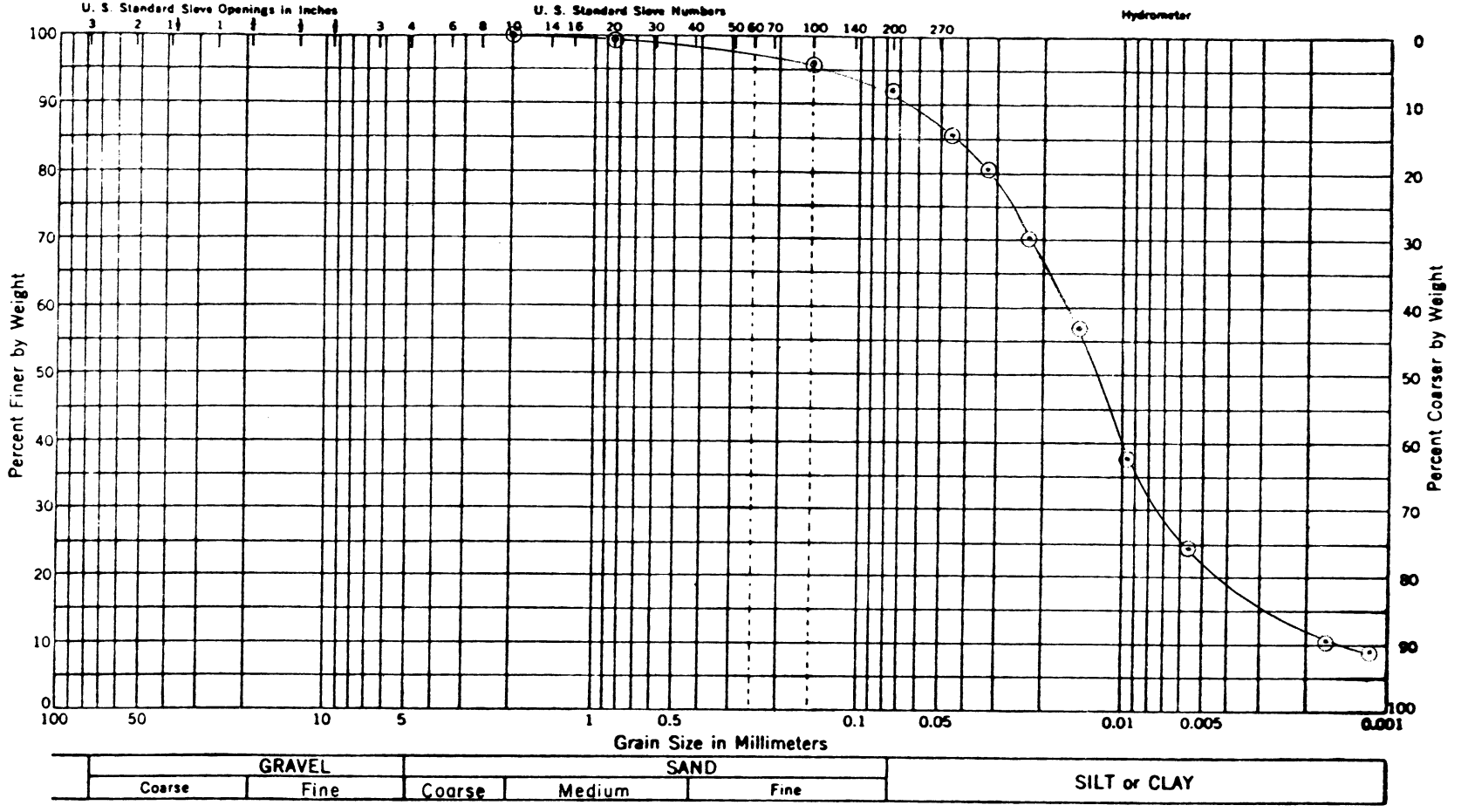
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-10	20.8				Silty clay (CL)
S-23					
236.0-237.0					

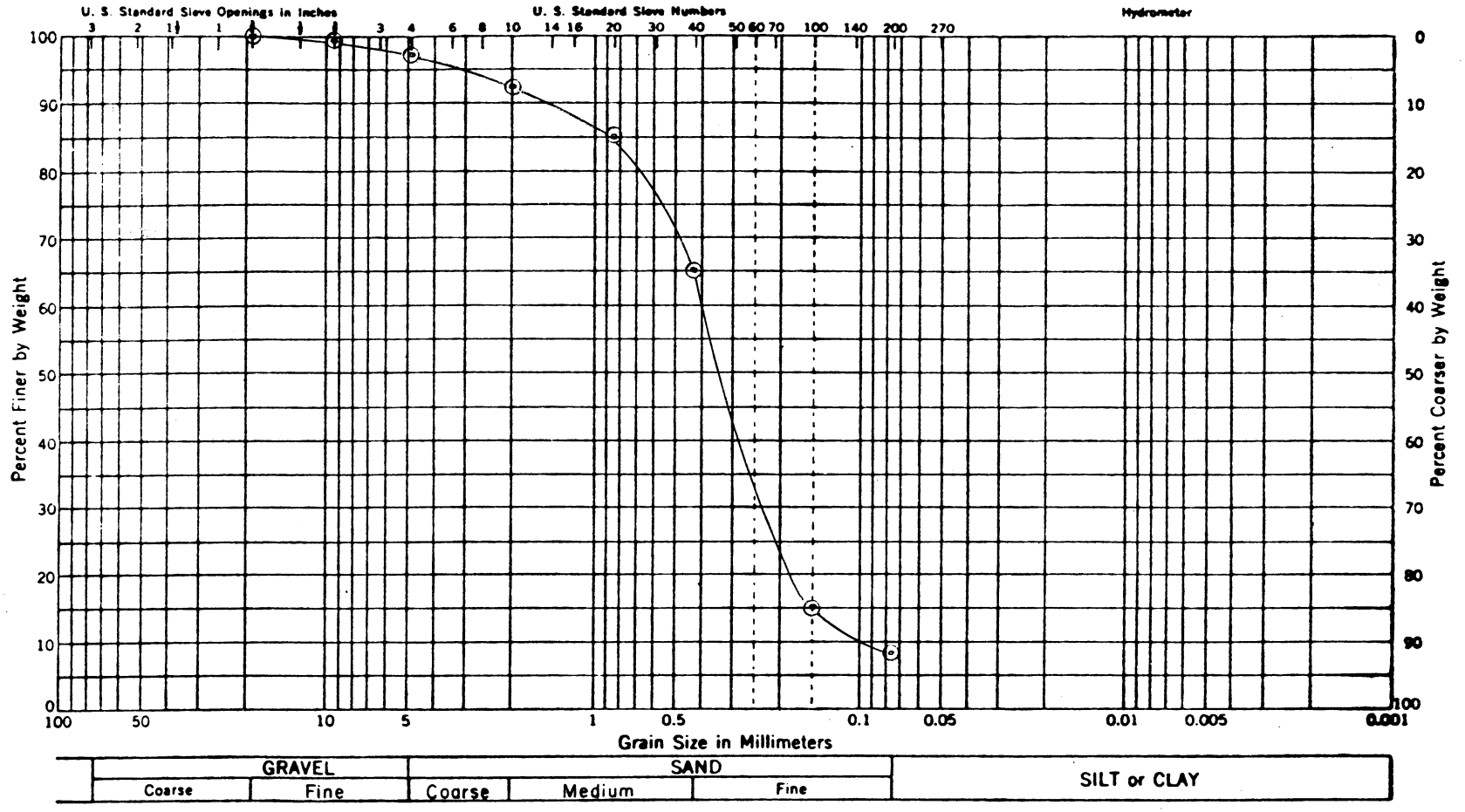
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
EX-10	14.5				Slightly silty fine to medium sand (SM-SP)
S-24					
246.5-250.5'					

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

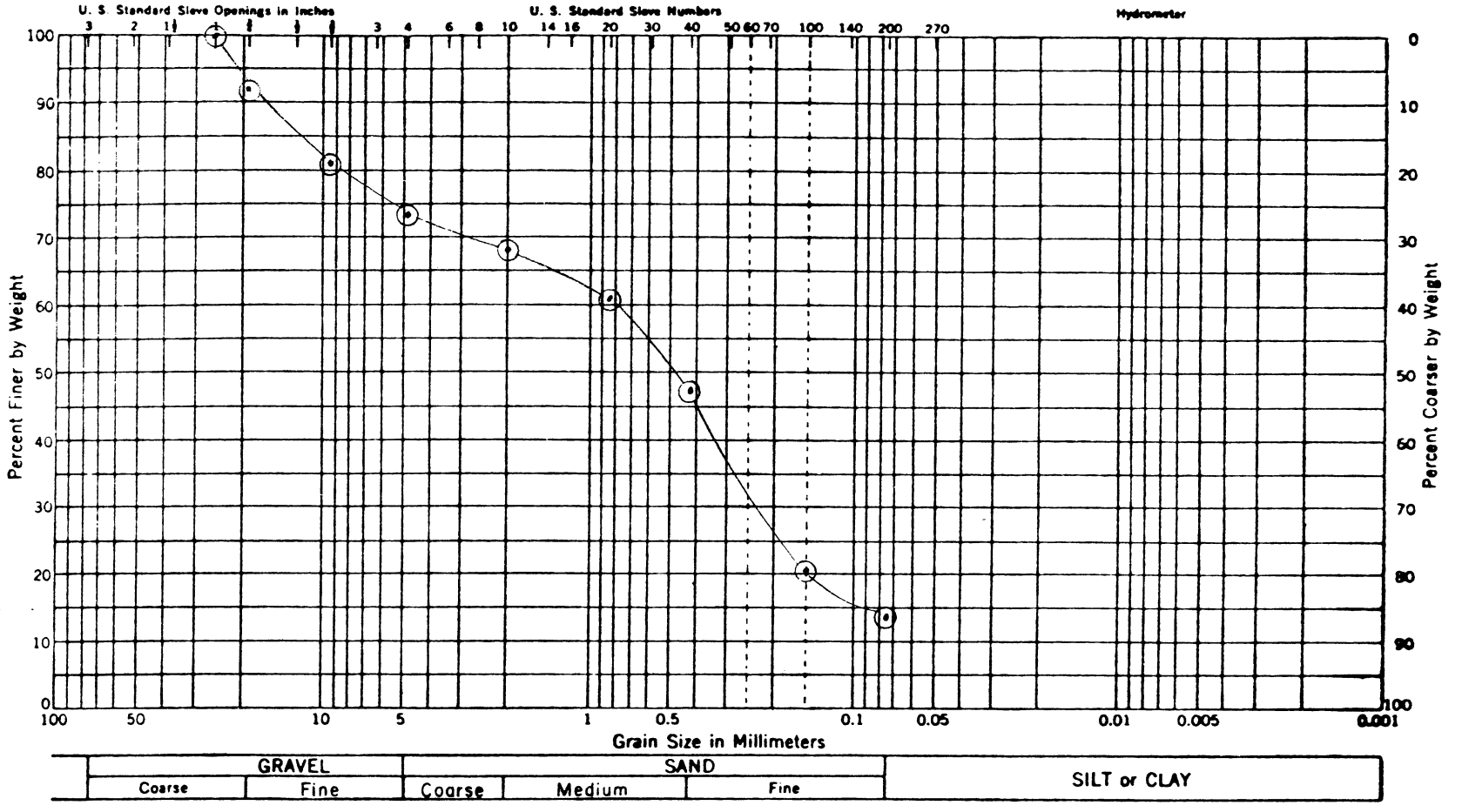
STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
JJT	JAS	4-2-84	12959

BBS09302

GRADATION CURVES - G-41 SERIES

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
G41 G13					Silty fine to coarse sand (SM)
S-5					
43-45'					

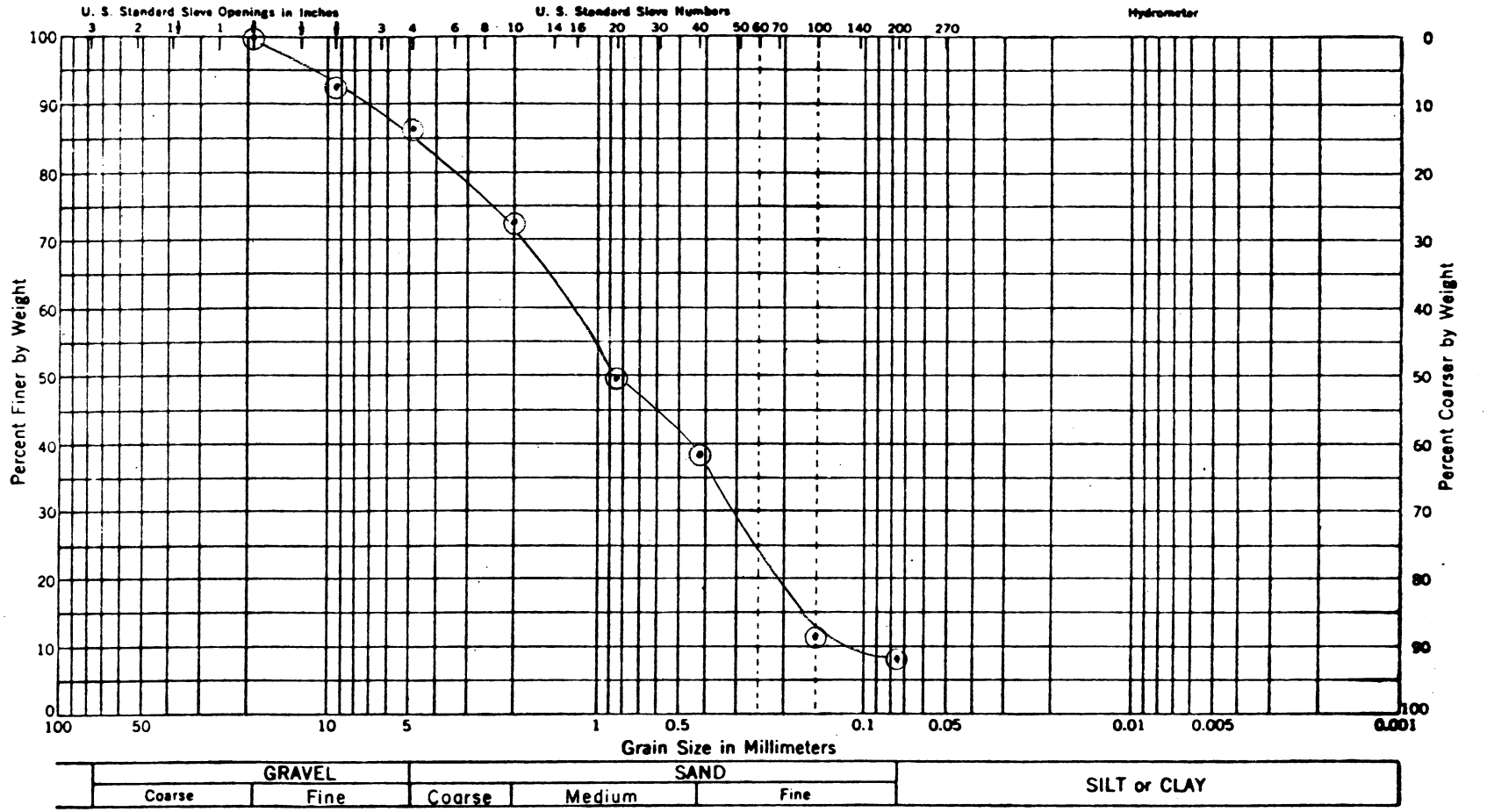
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	5-18-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
G41 G13					Slightly silty fine to coarse sand (SM-SP)
S-12					
110-111.8'					

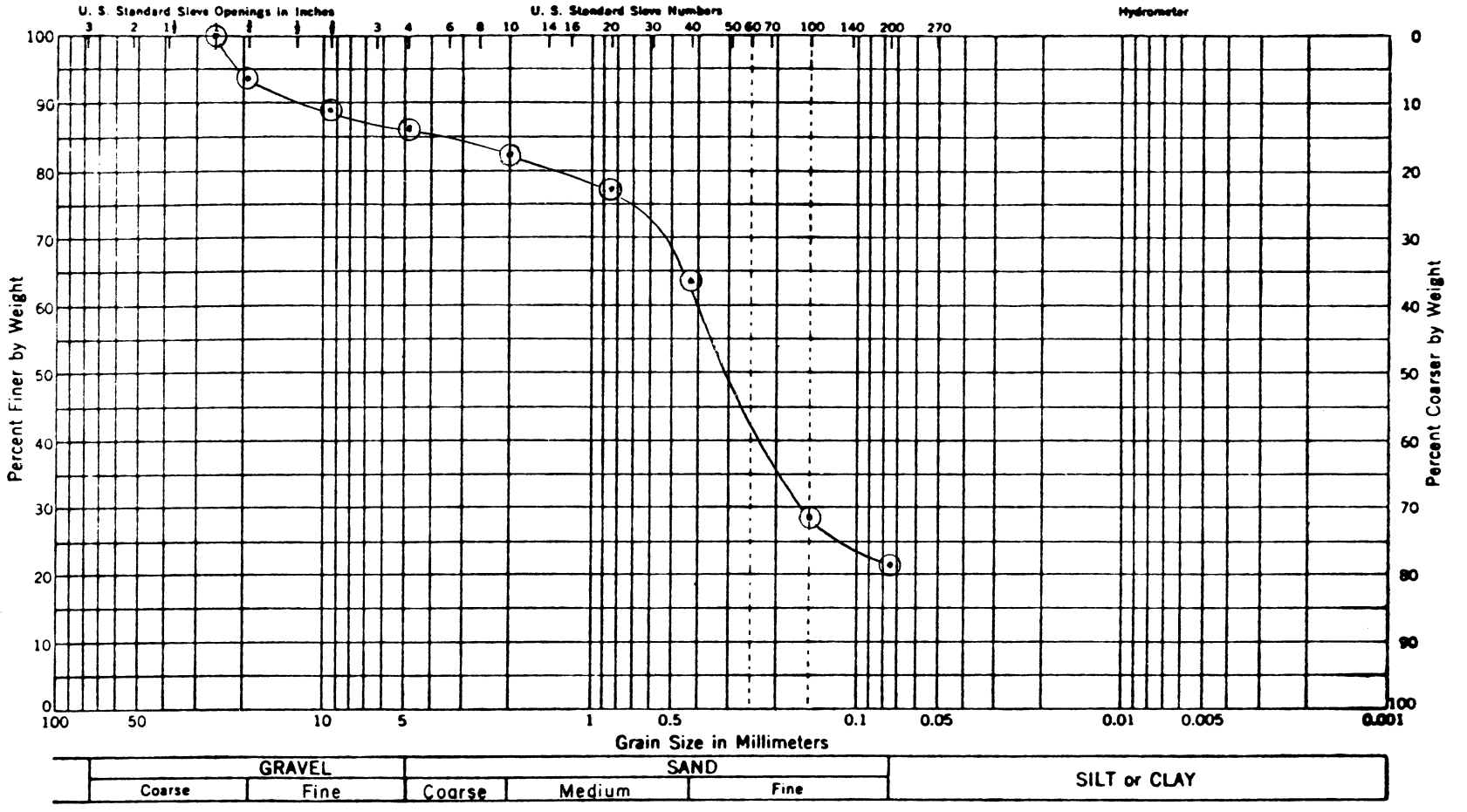
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	5-18-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
G41 G13					Silty fine to coarse sand (SM)
S-13					
120-122'					

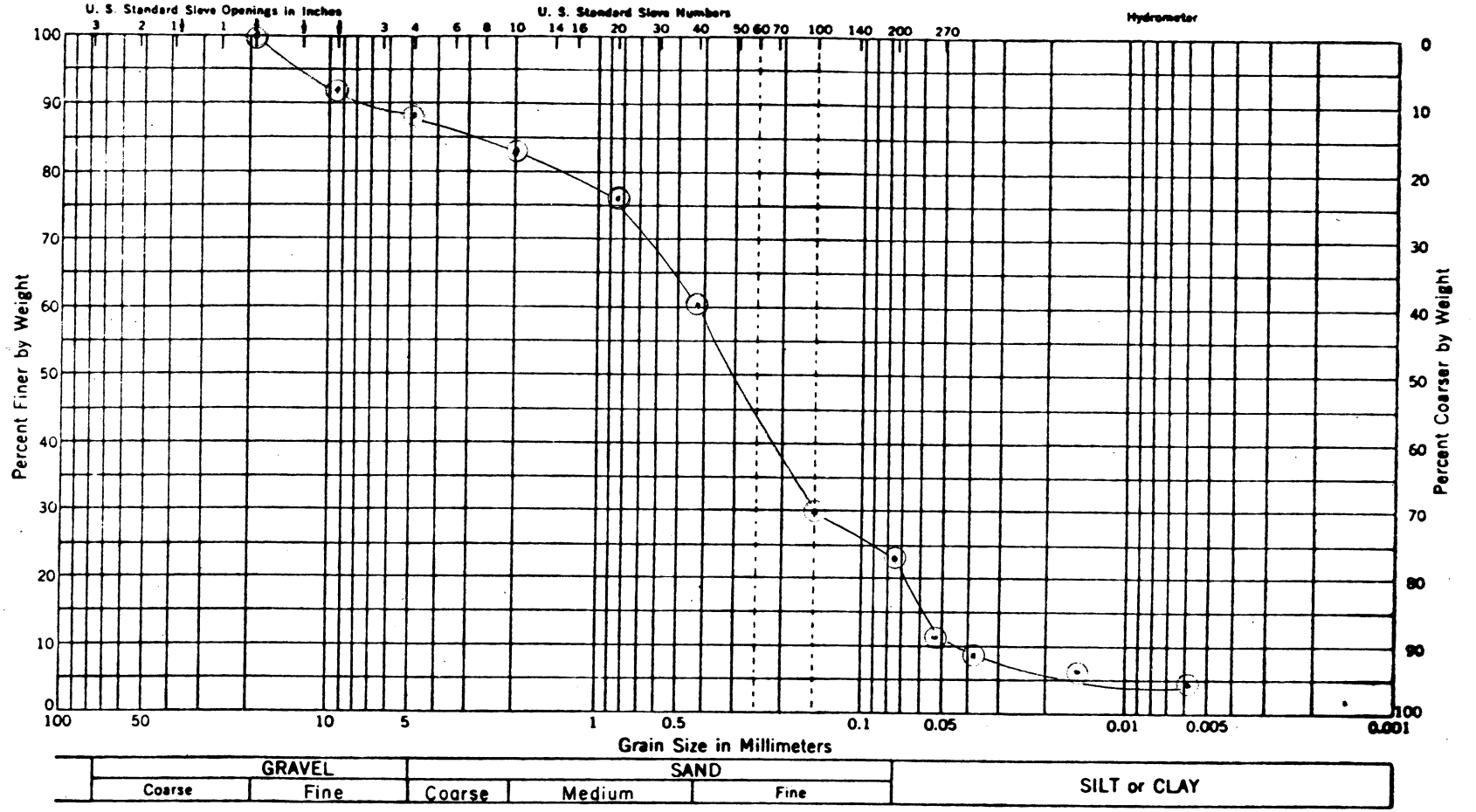
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	5-18-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
G41 G13					Silty fine to coarse sand (SM)
S18					
170-170.9'					

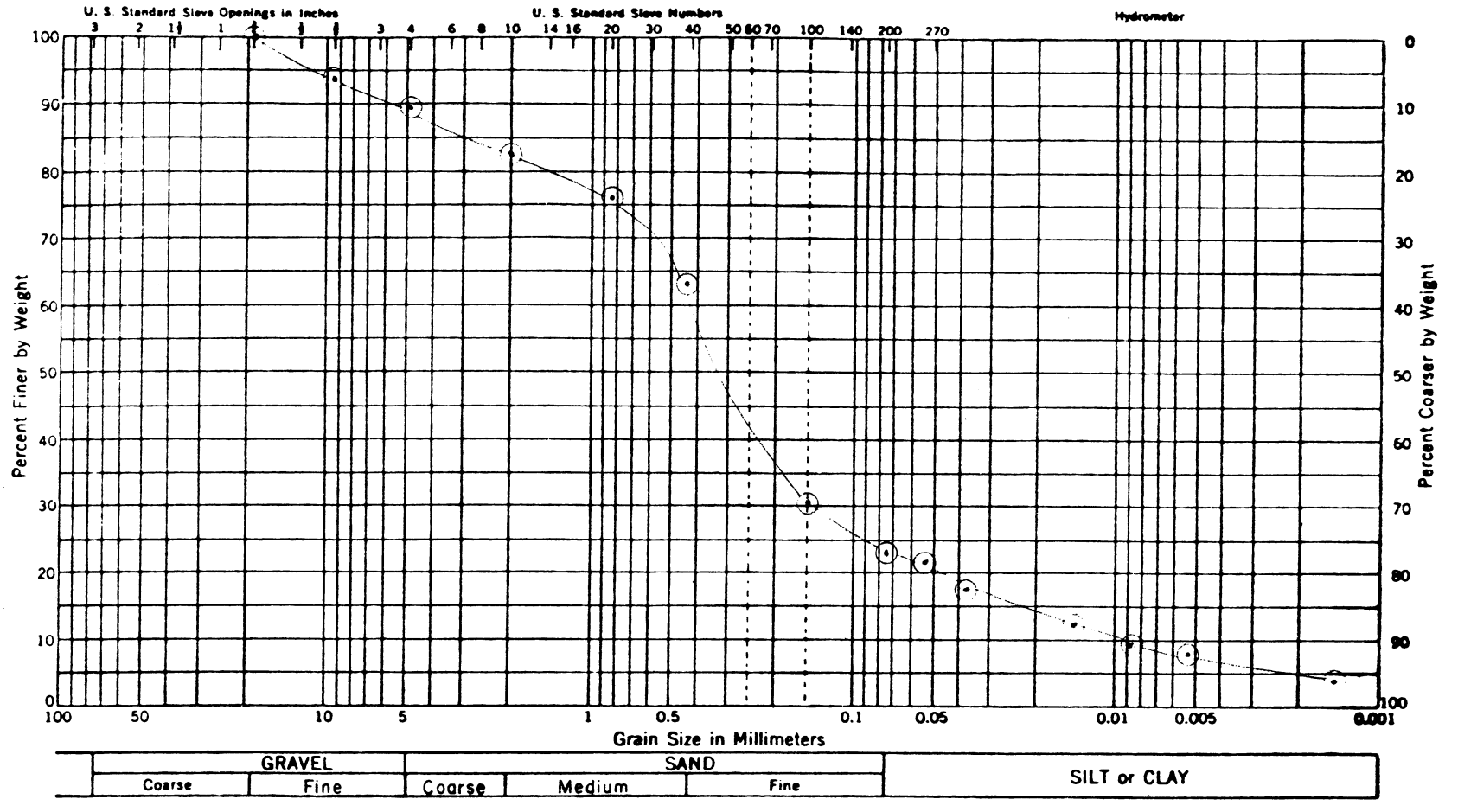
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	6-10-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
G41 G13					Silty fine to coarse sand (SM)
S23					
220-220.7'					

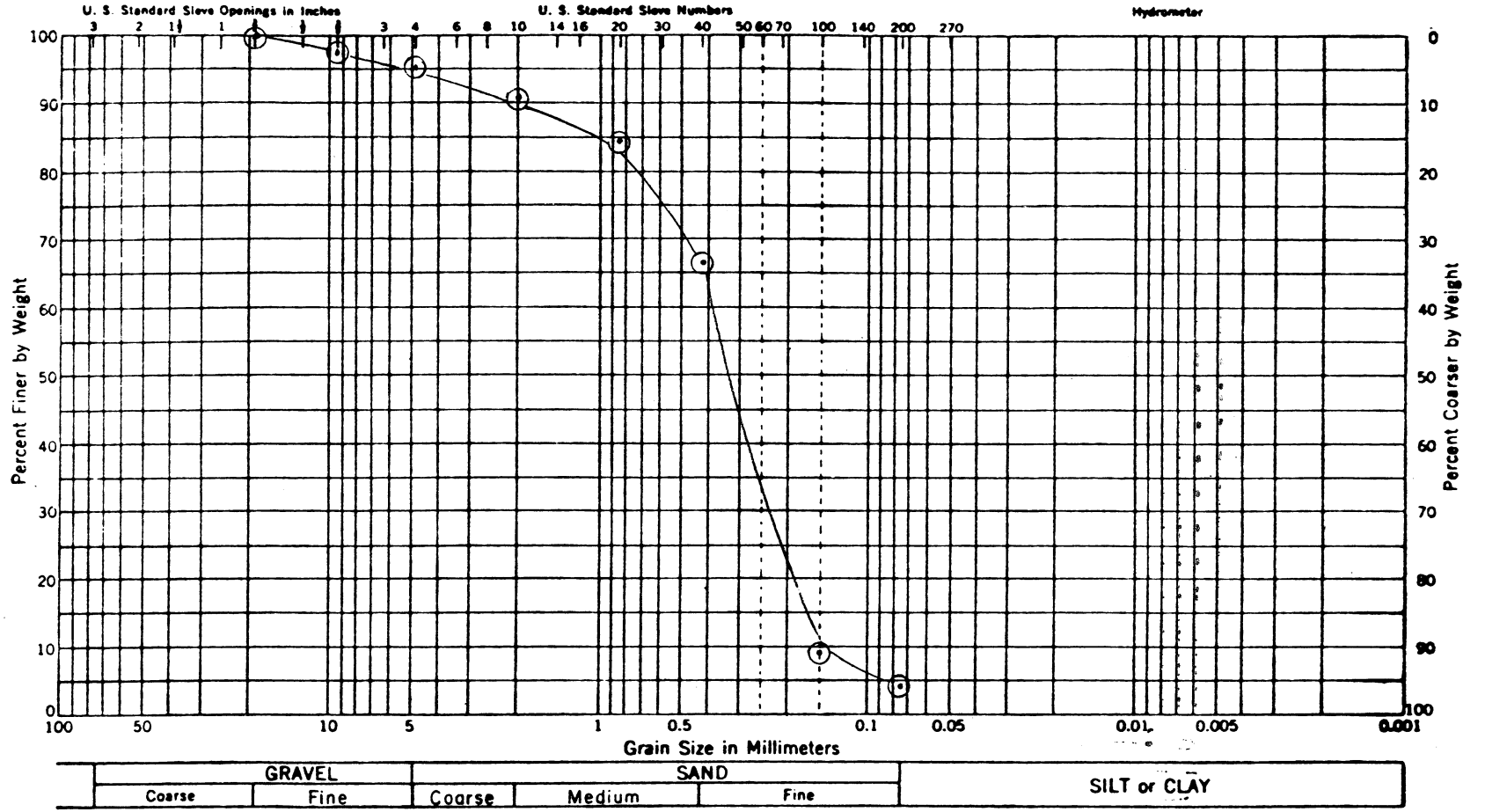
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	6-10-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
G41 G13					Fine to medium sand (SP)
S-25					
240-241.5'					

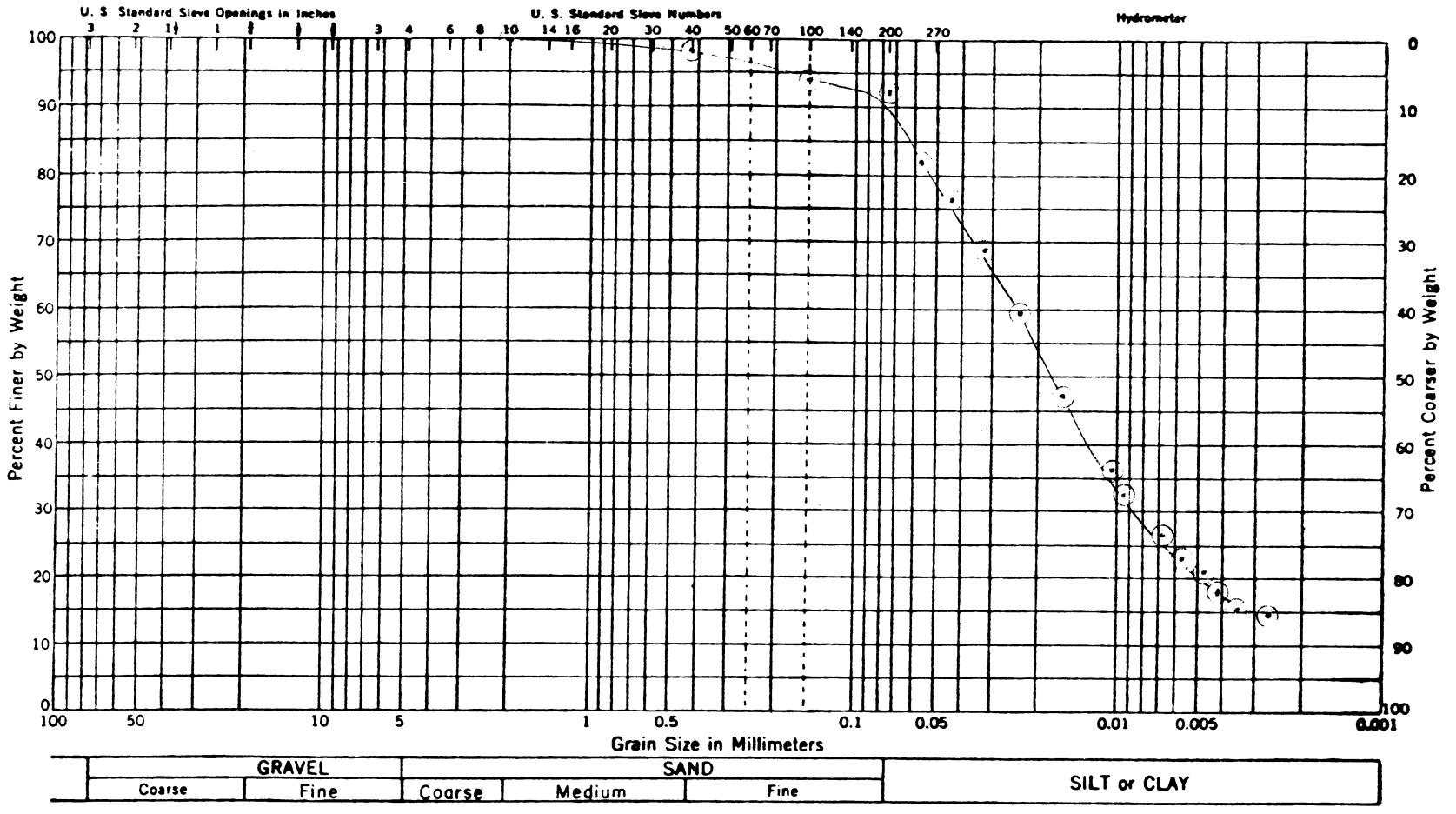
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	5-18-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
G41 G13					Silty clay (CL)
S31					
300-301'					

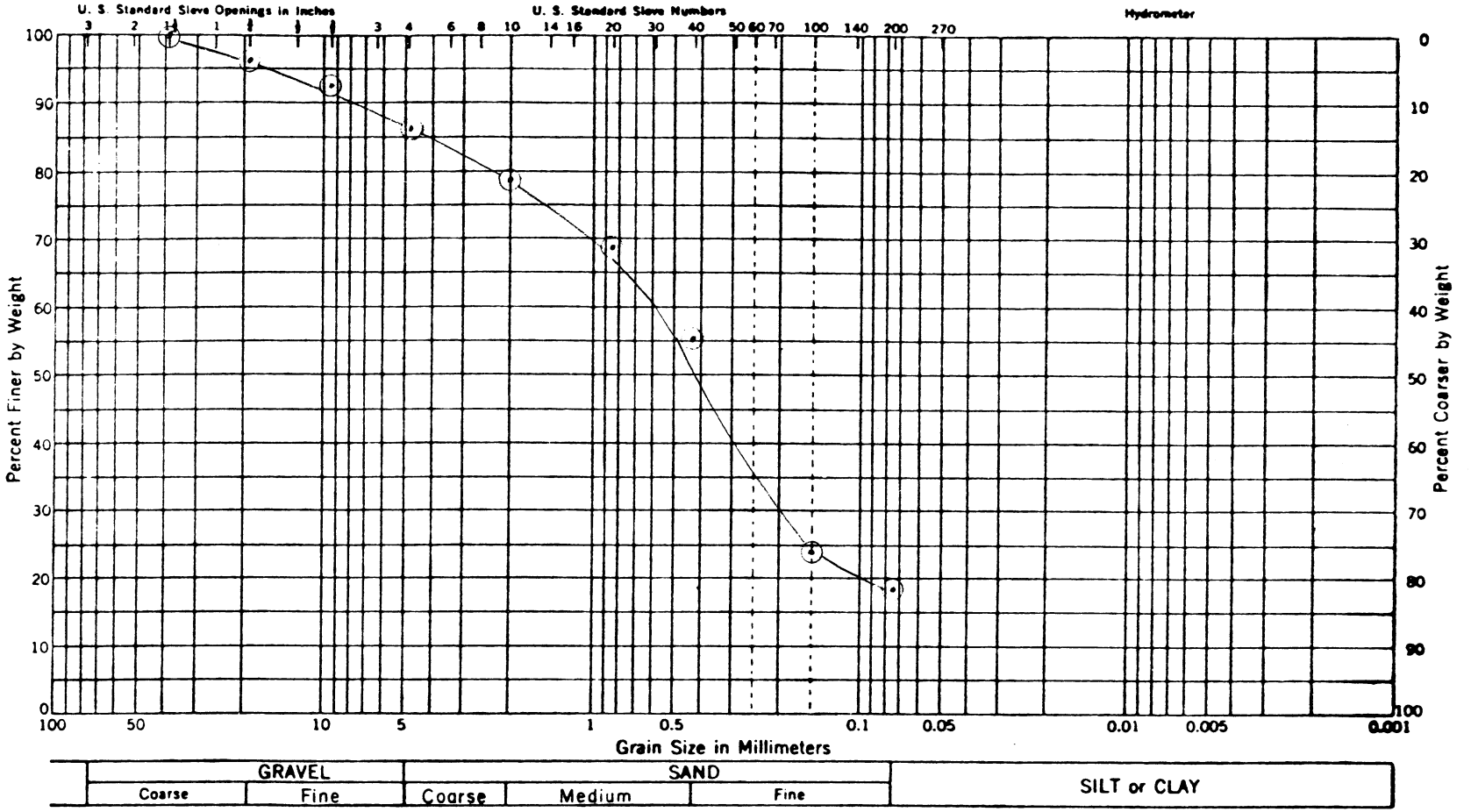
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	6-10-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
G41 H9					Silty fine to coarse sand (SM)
SA-3					
21-22.5'					

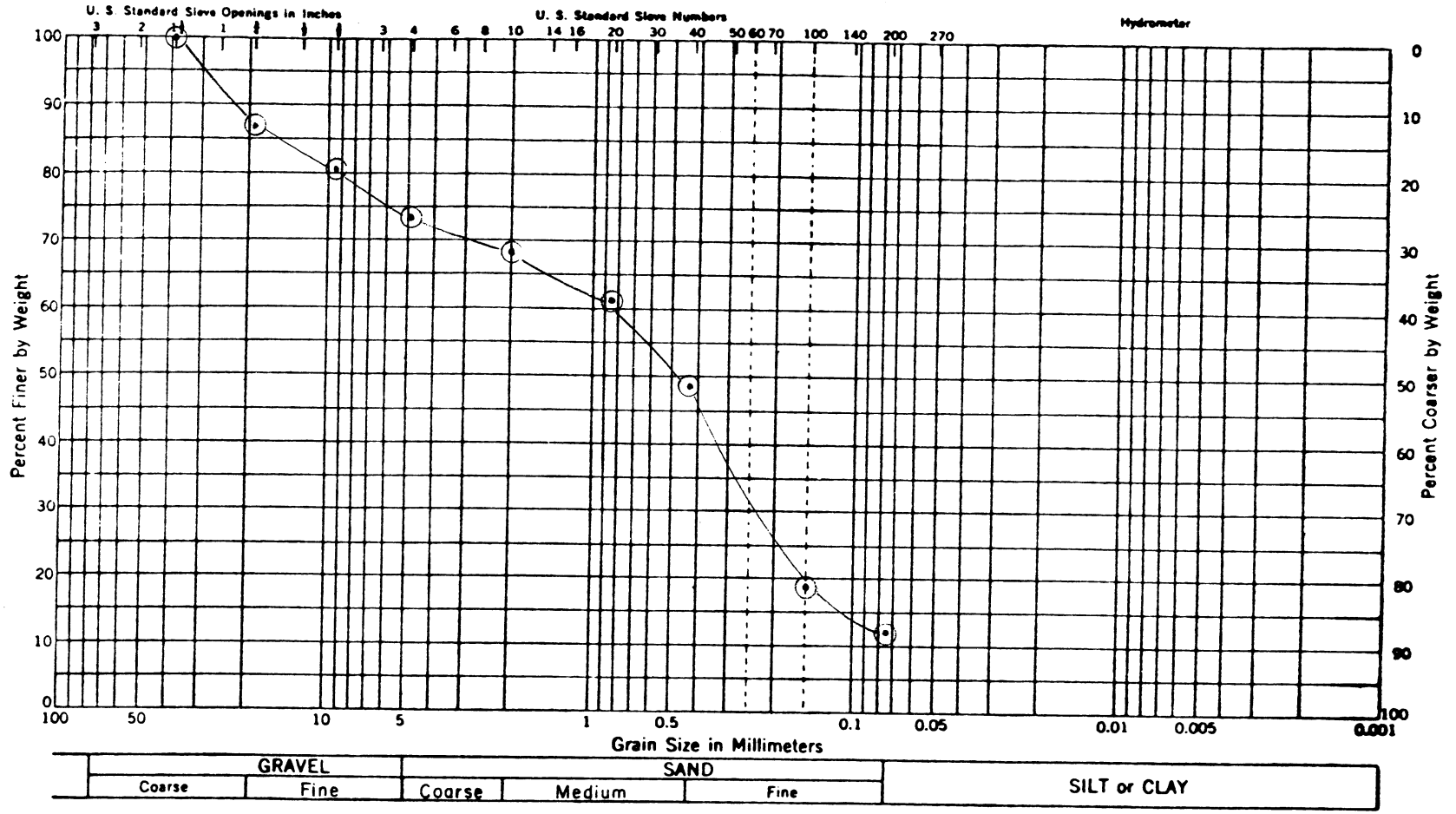
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	5-18-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
G41 H9					Silty fine to coarse sand (SM)
SA-5					
40-41'					

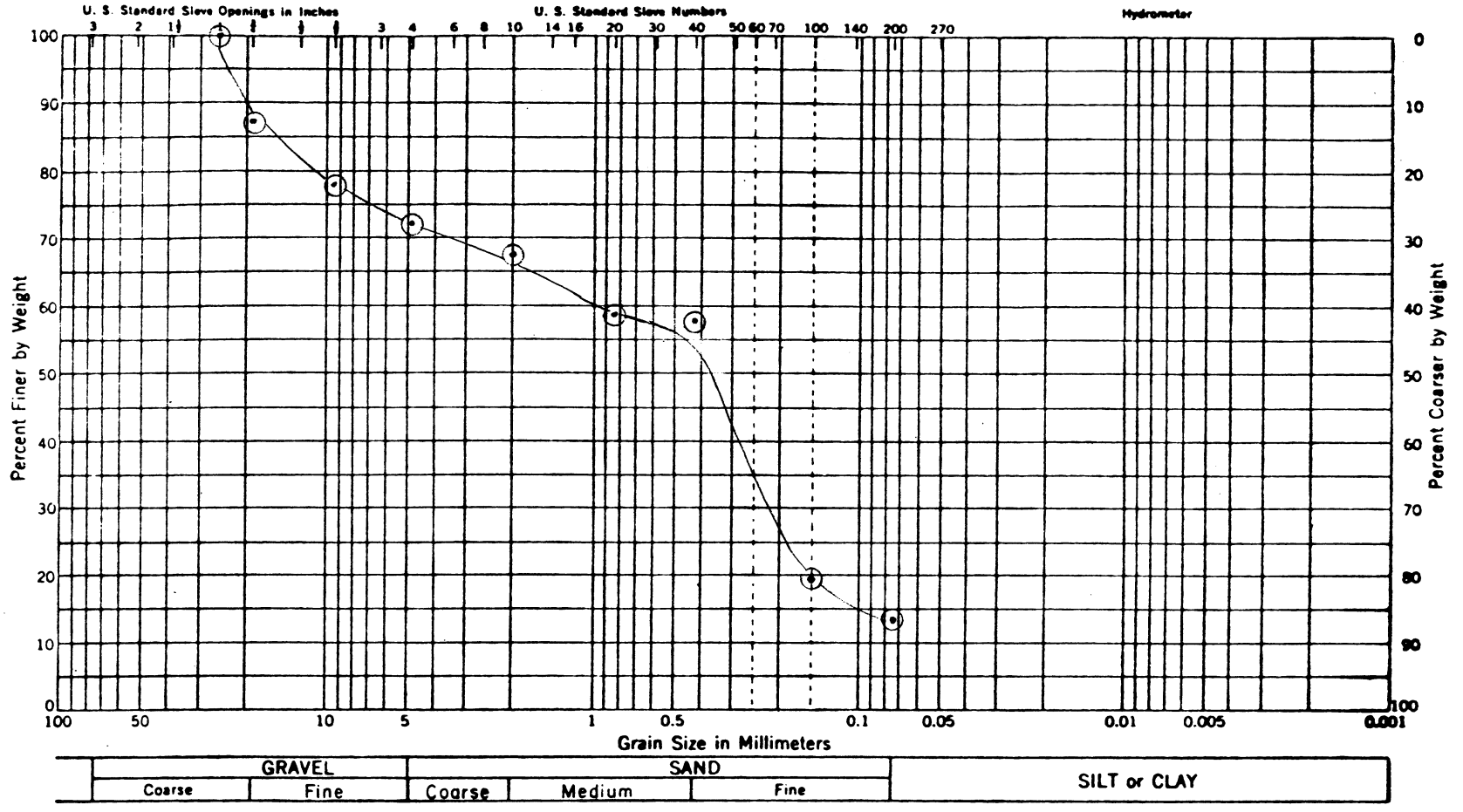
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	5-18-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
G41 H9					Silty fine to coarse sand (SM)
SA-8					
70-71.8'					

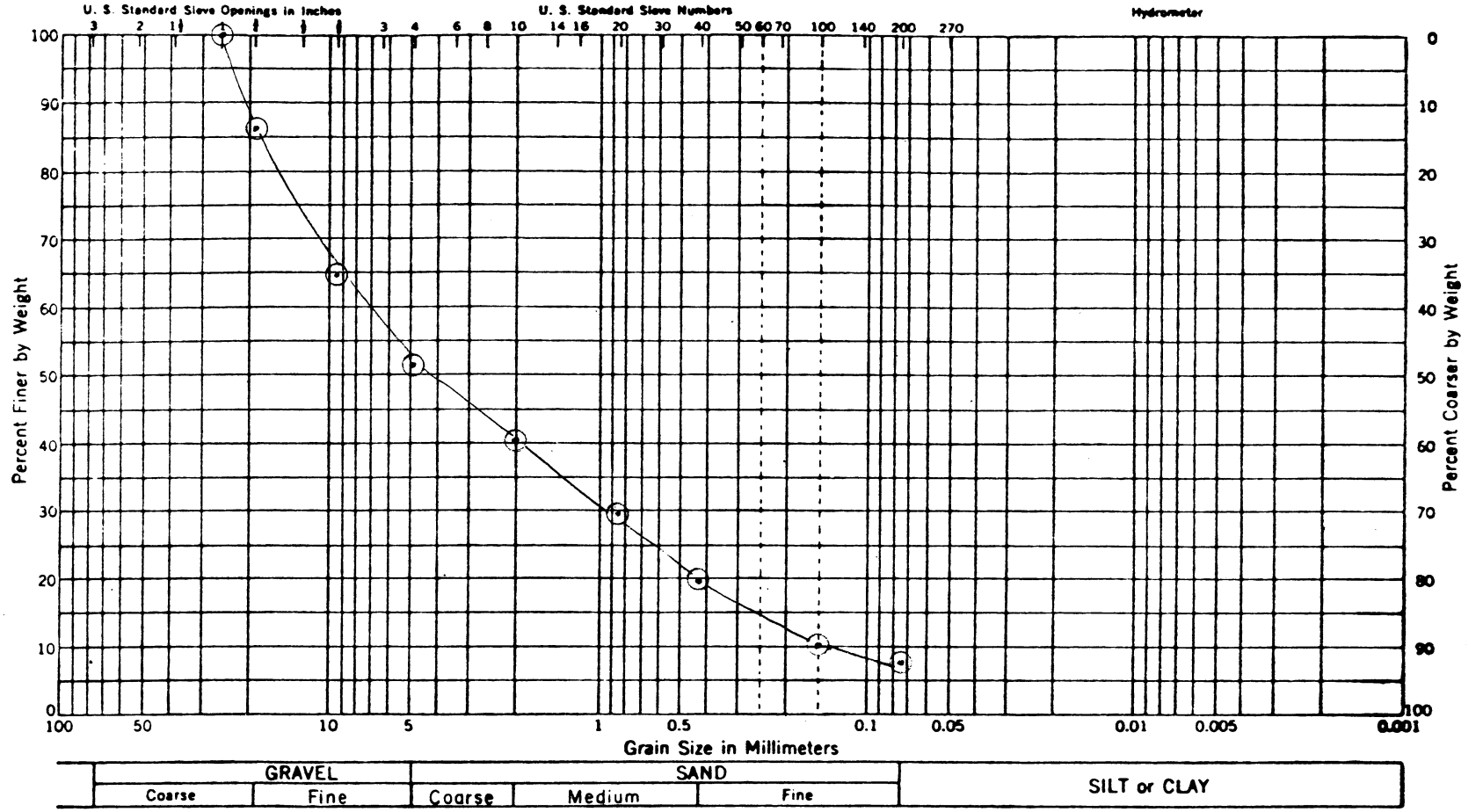
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	5-18-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
G41 H9					Slightly silty fine to coarse sand (SM-SP)
SA-10					
90-91'					

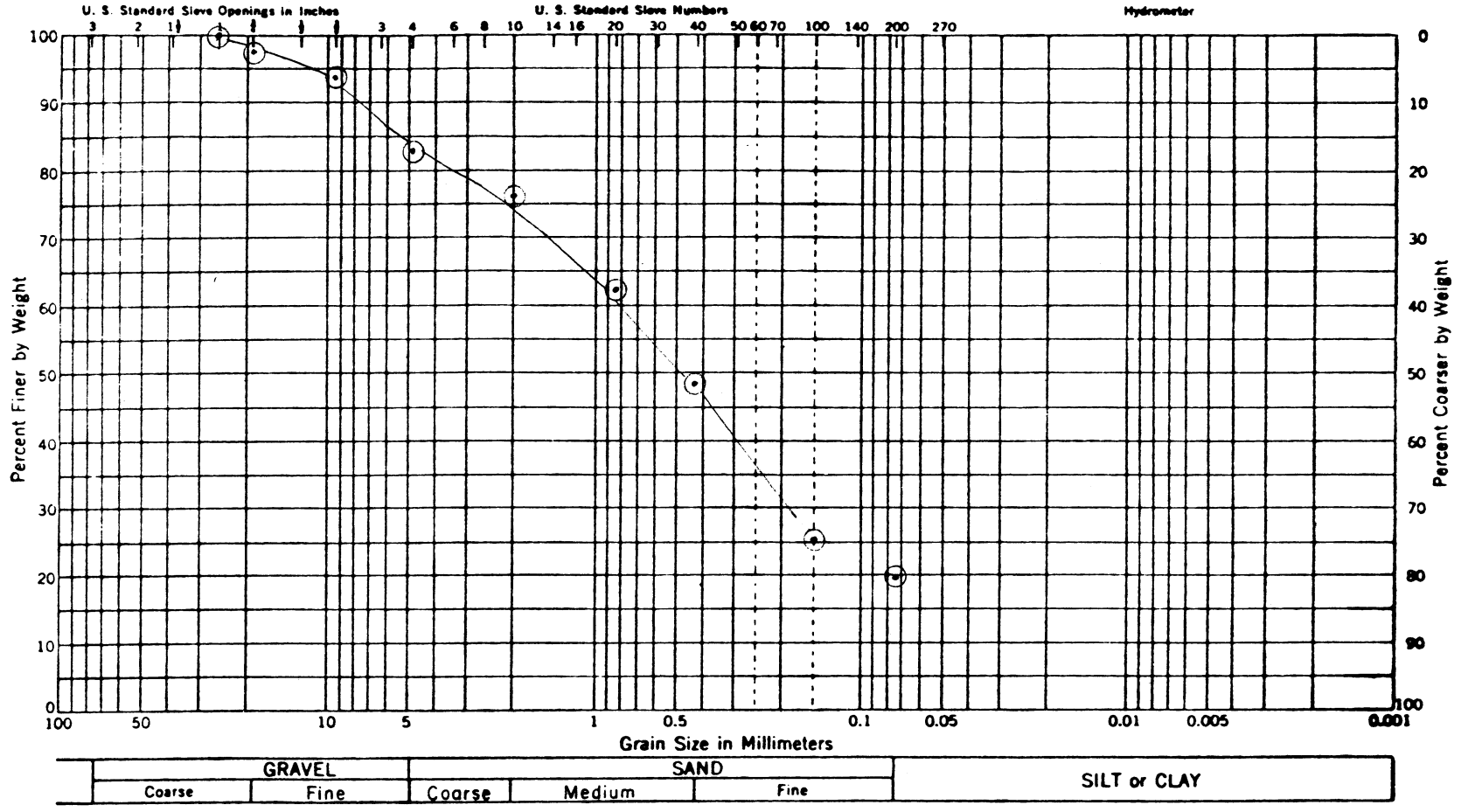
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	5-18-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
G41 H9					Silty fine to coarse sand (SM)
SA-15					
140-141.5'					

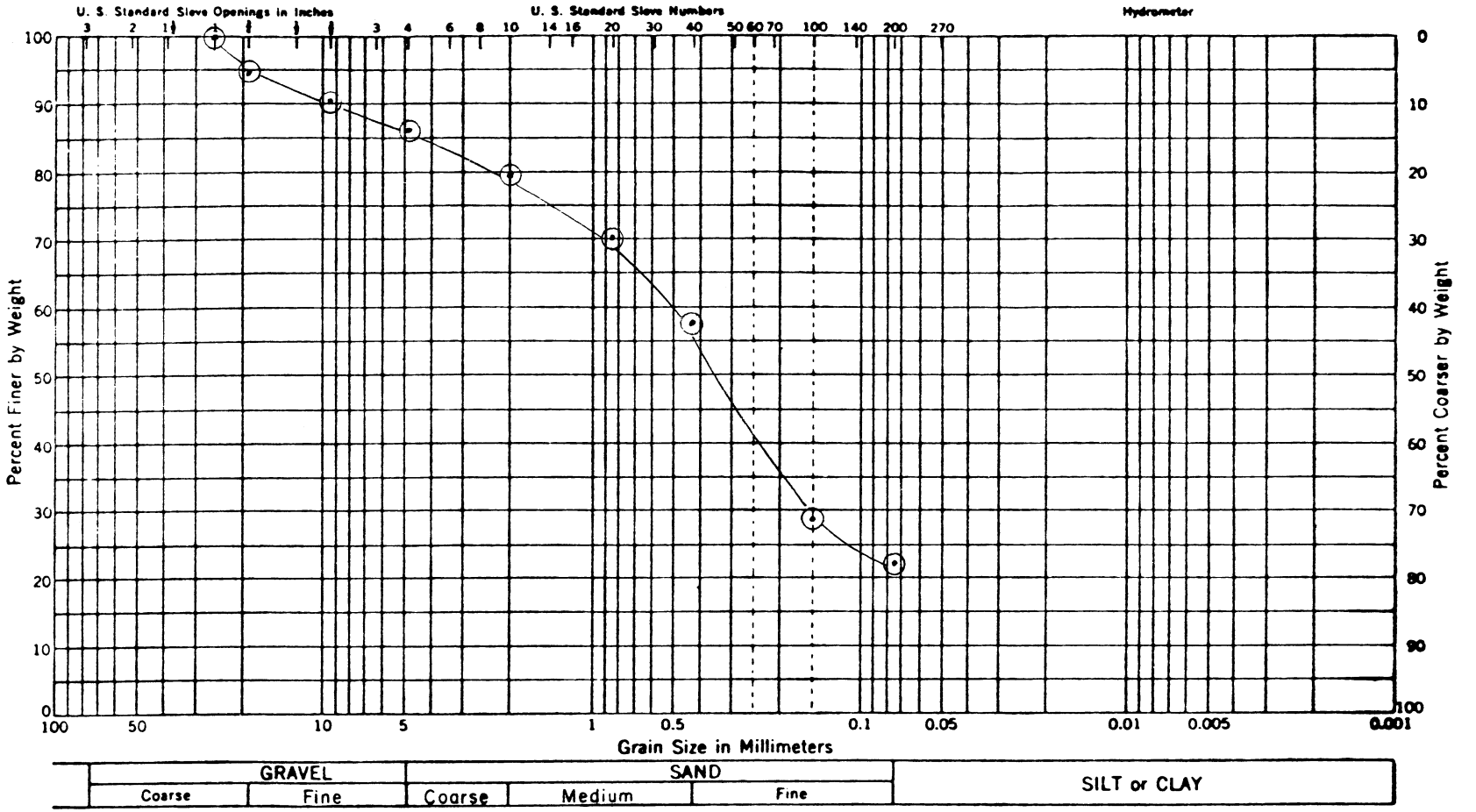
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	5-18-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
G41 H9					Silty fine to coarse sand (SM)
SA-16					
150-151.3'					

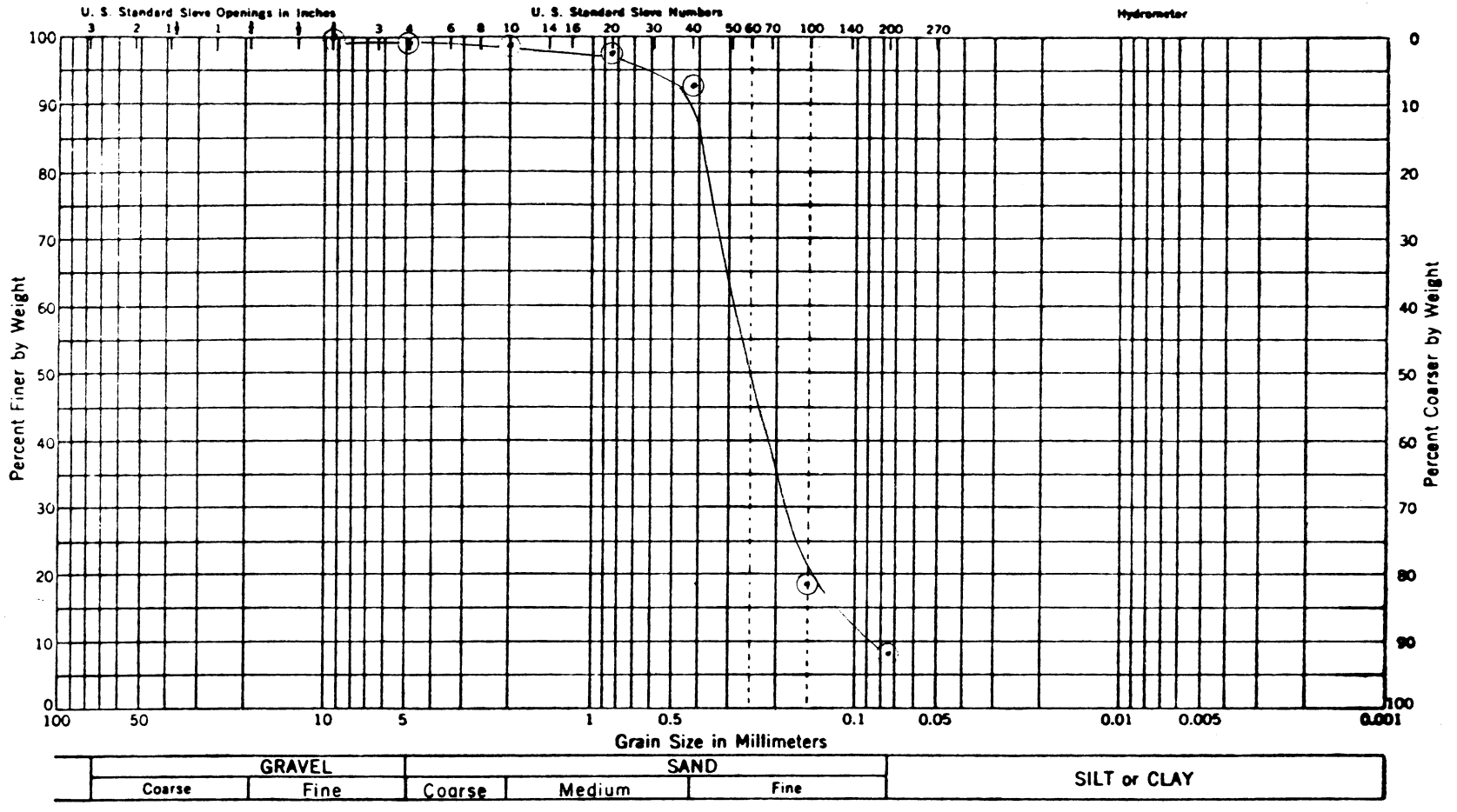
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	5-18-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
G41 H9					Slightly silty fine sand (SM-SP)
SA-21					
200-200.8'					

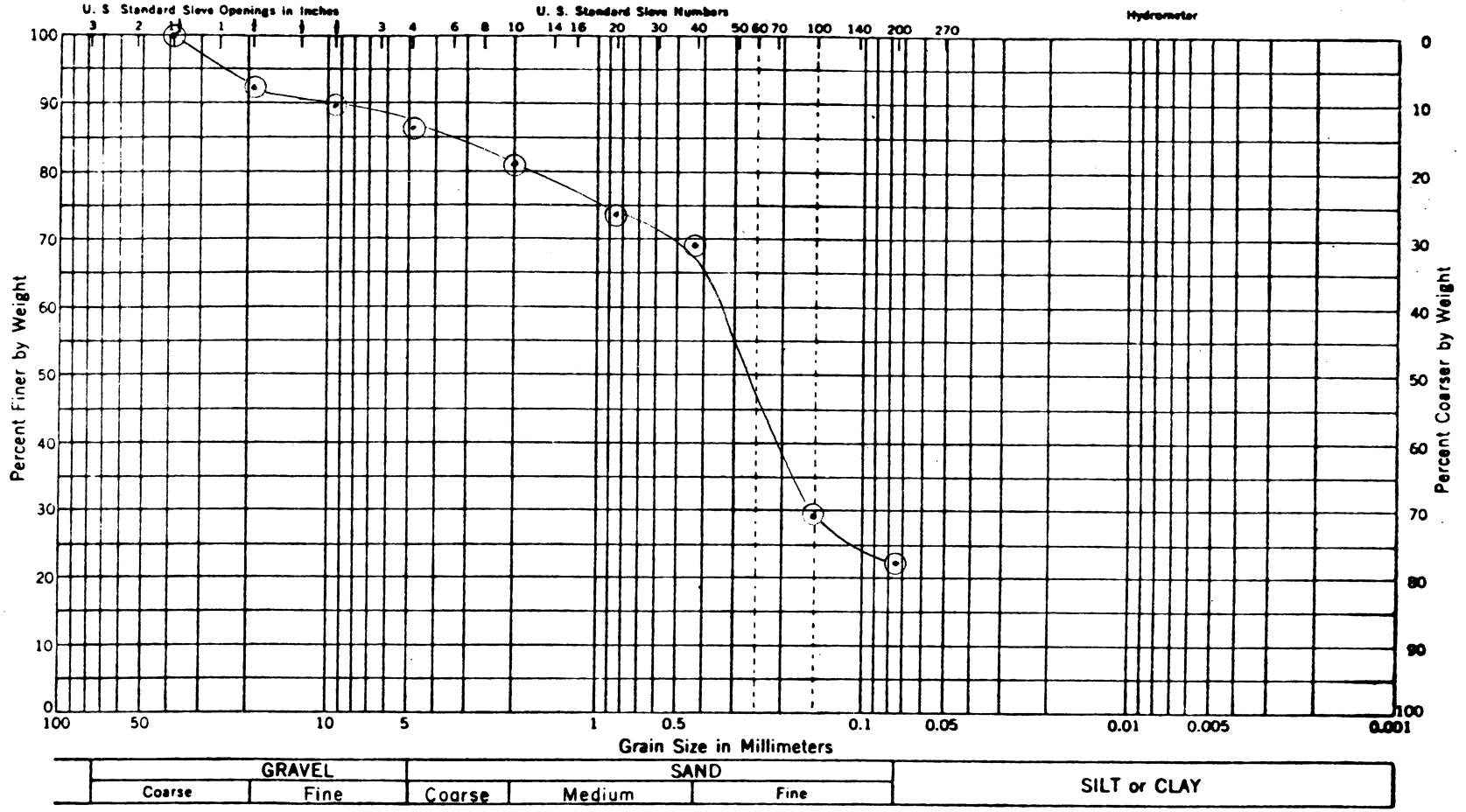
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	5-18-84	12959

BBS09302

UNIFIED CLASSIFICATION SYSTEM



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
G41 H9					Silty fine to coarse sand (SM)
SA-22					
210.5-211.4'					

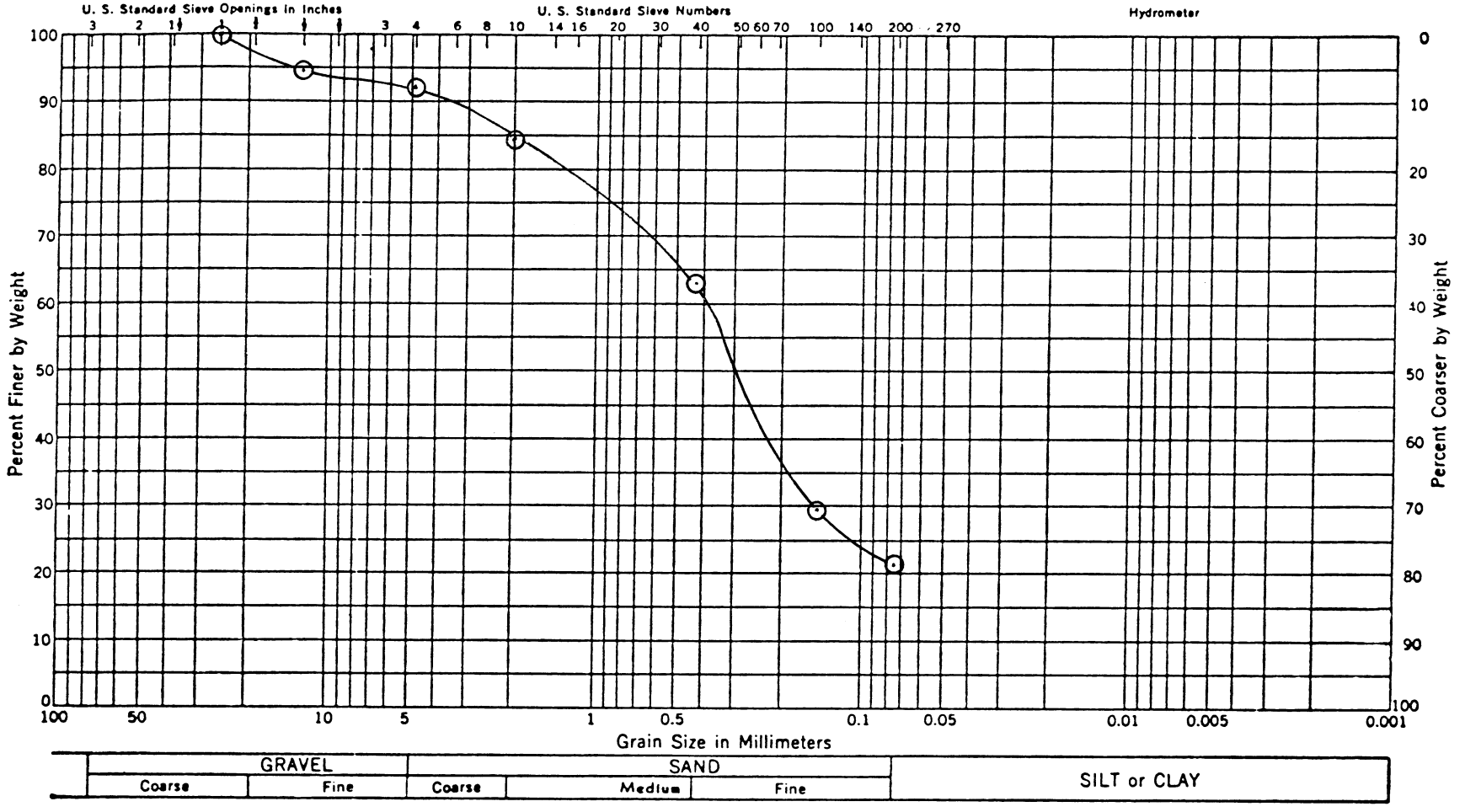
EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
SMD	JAS	5-18-84	12959

BBS09302

GRADATION CURVES - TEST PITS



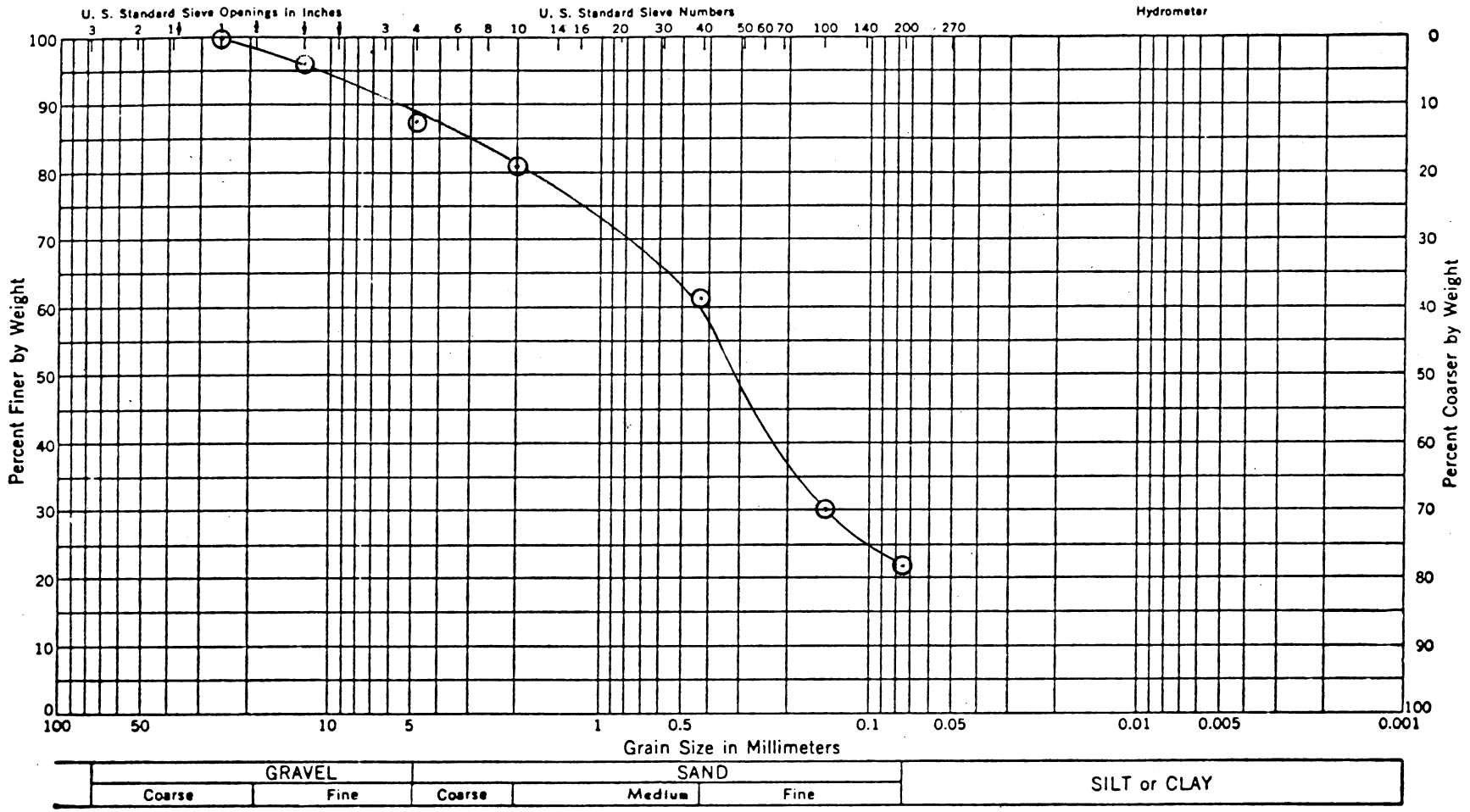
BORING	SAMPLE	DEPTH	SYMBOL	D_{10}	D_{30}	D_{60}	C_u	C_c	CLASSIFICATION
TP-85-8		2 - 8							SM

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
KJC	JWK	11-11-85	14025

BBS12478



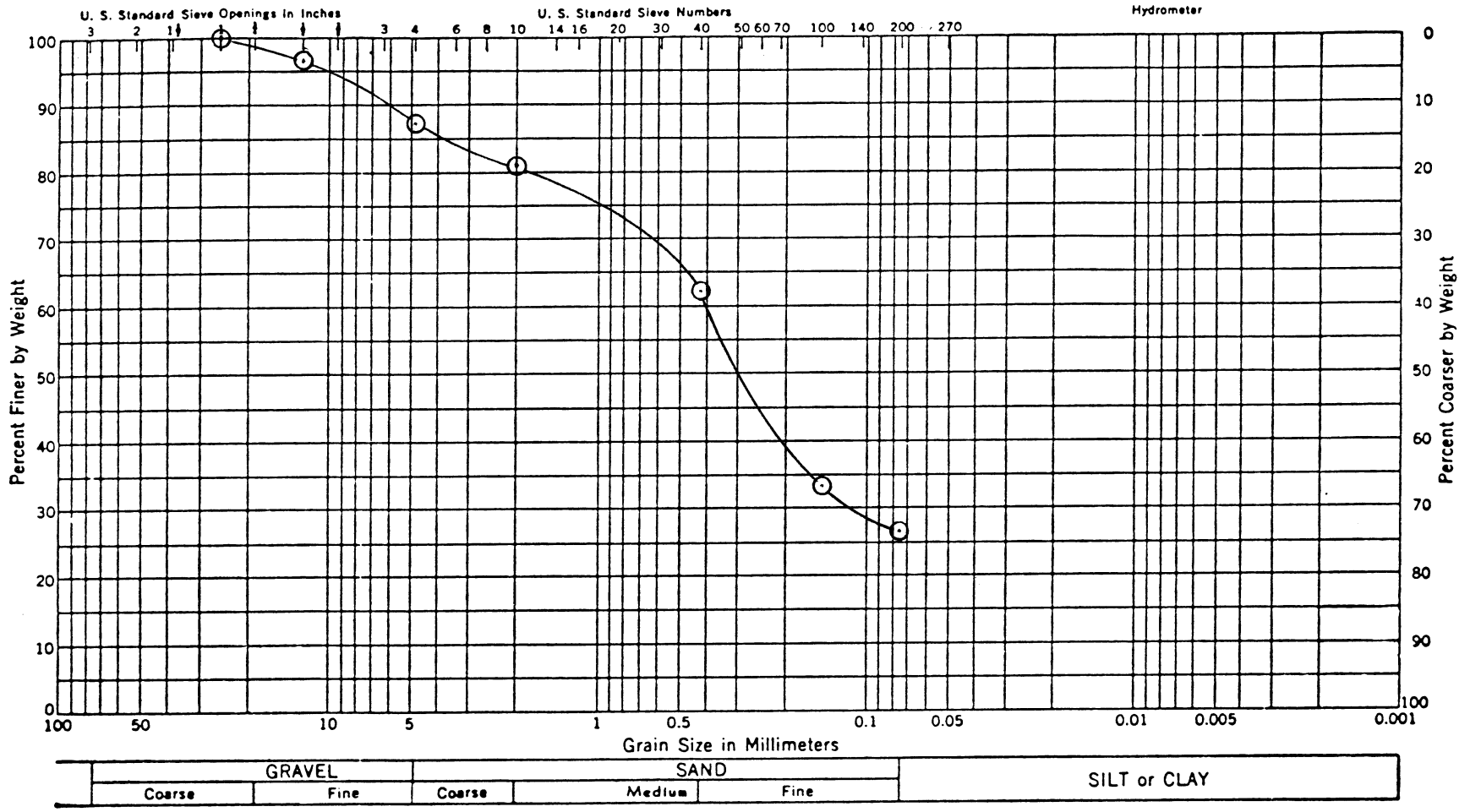
BORING	SAMPLE	DEPTH	SYMBOL	D_{10}	D_{30}	D_{60}	C_u	C_c	CLASSIFICATION
TP-85-9		2-8							SM

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
KJC	JWK	11-11-85	1402S

BBS12478



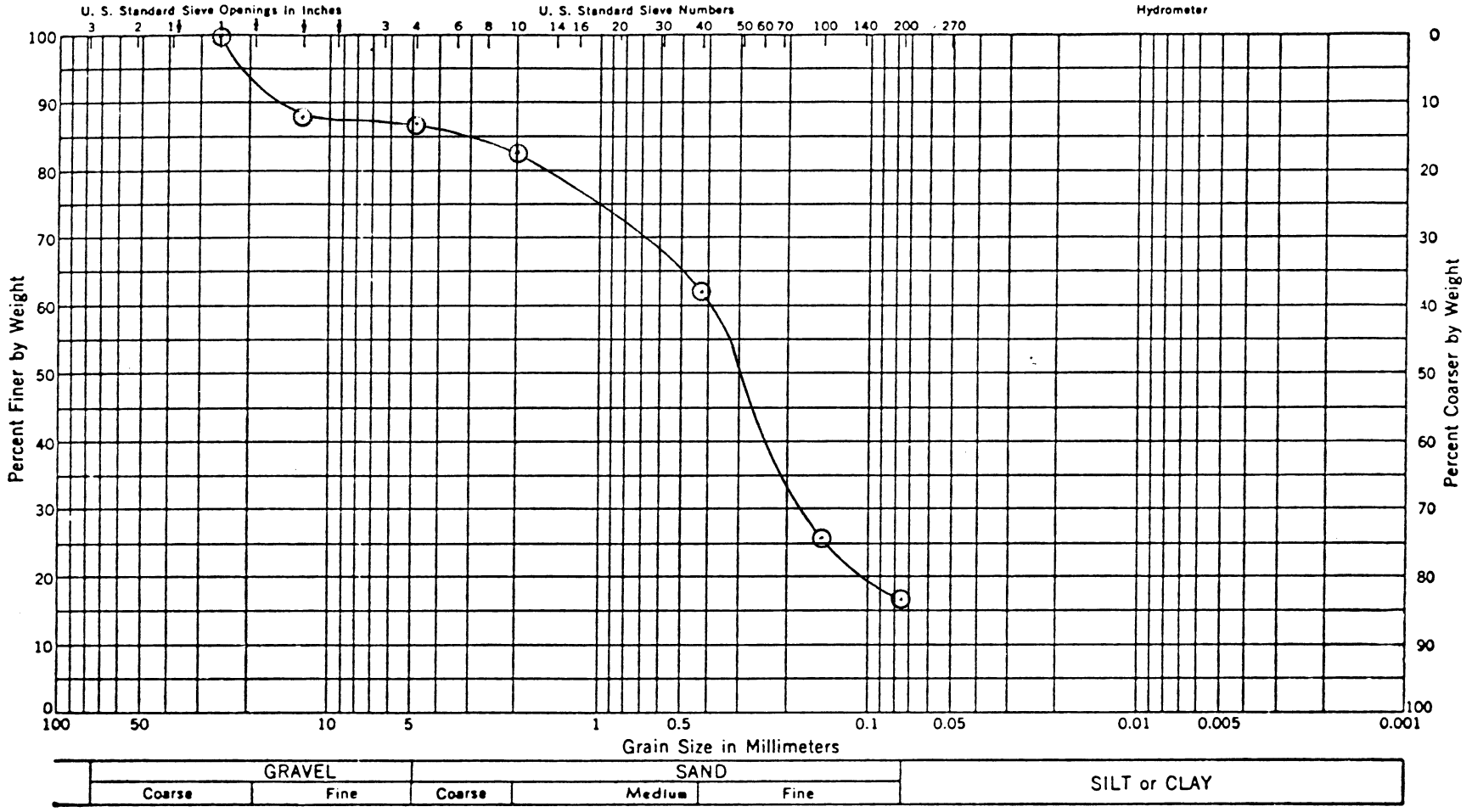
BORING	SAMPLE	DEPTH	SYMBOL	D_{10}	D_{30}	D_{60}	C_u	C_c	CLASSIFICATION
TP-85-	10	13-14							SM

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
KJC	JWK	11-11-85	1[illegible]5

BBS12478



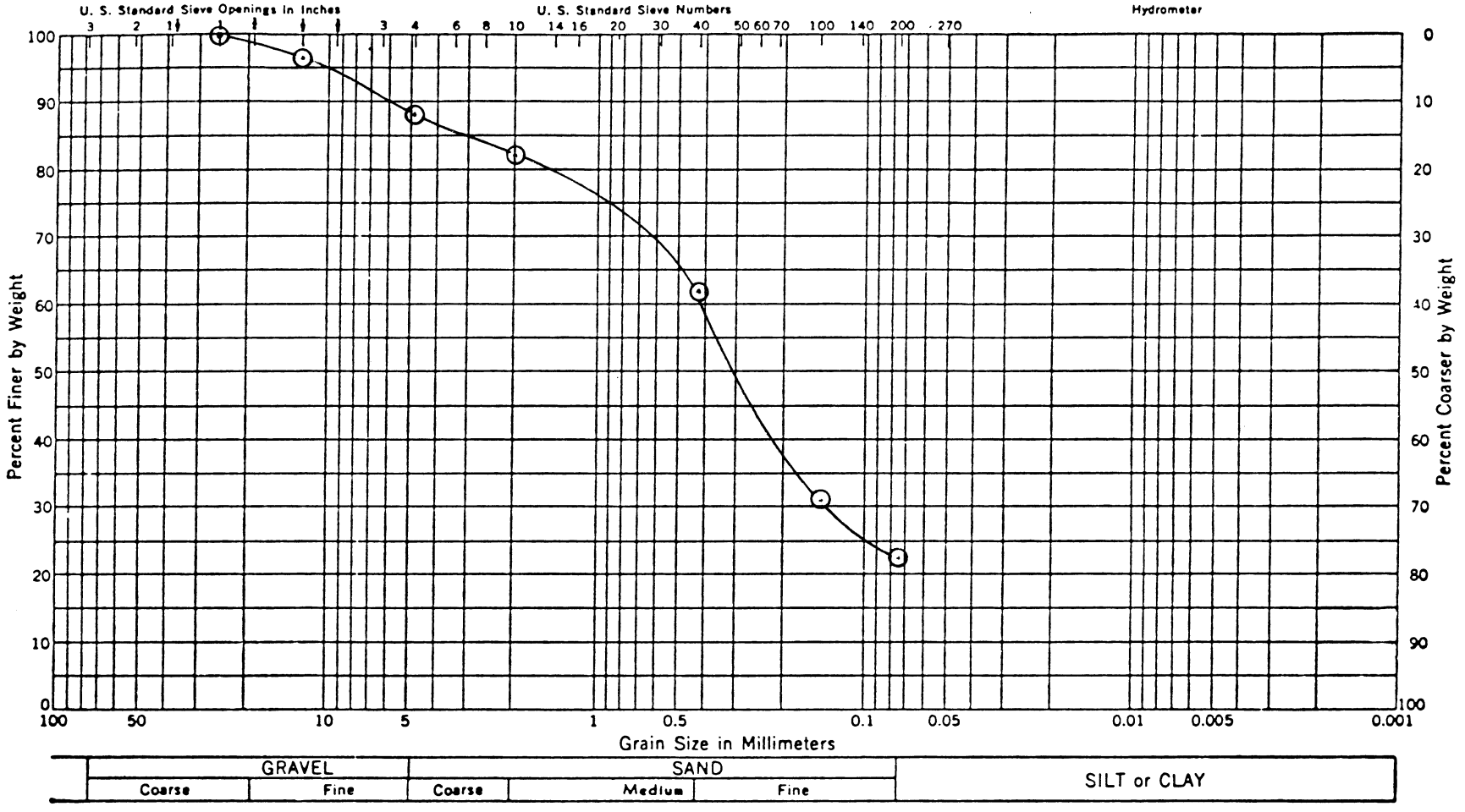
BORING	SAMPLE	DEPTH	SYMBOL	D_{10}	D_{30}	D_{60}	C_u	C_c	CLASSIFICATION
TP-85	-14	10-12							SM

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
AJC	JWK	11-11-85	14028

BBS12478



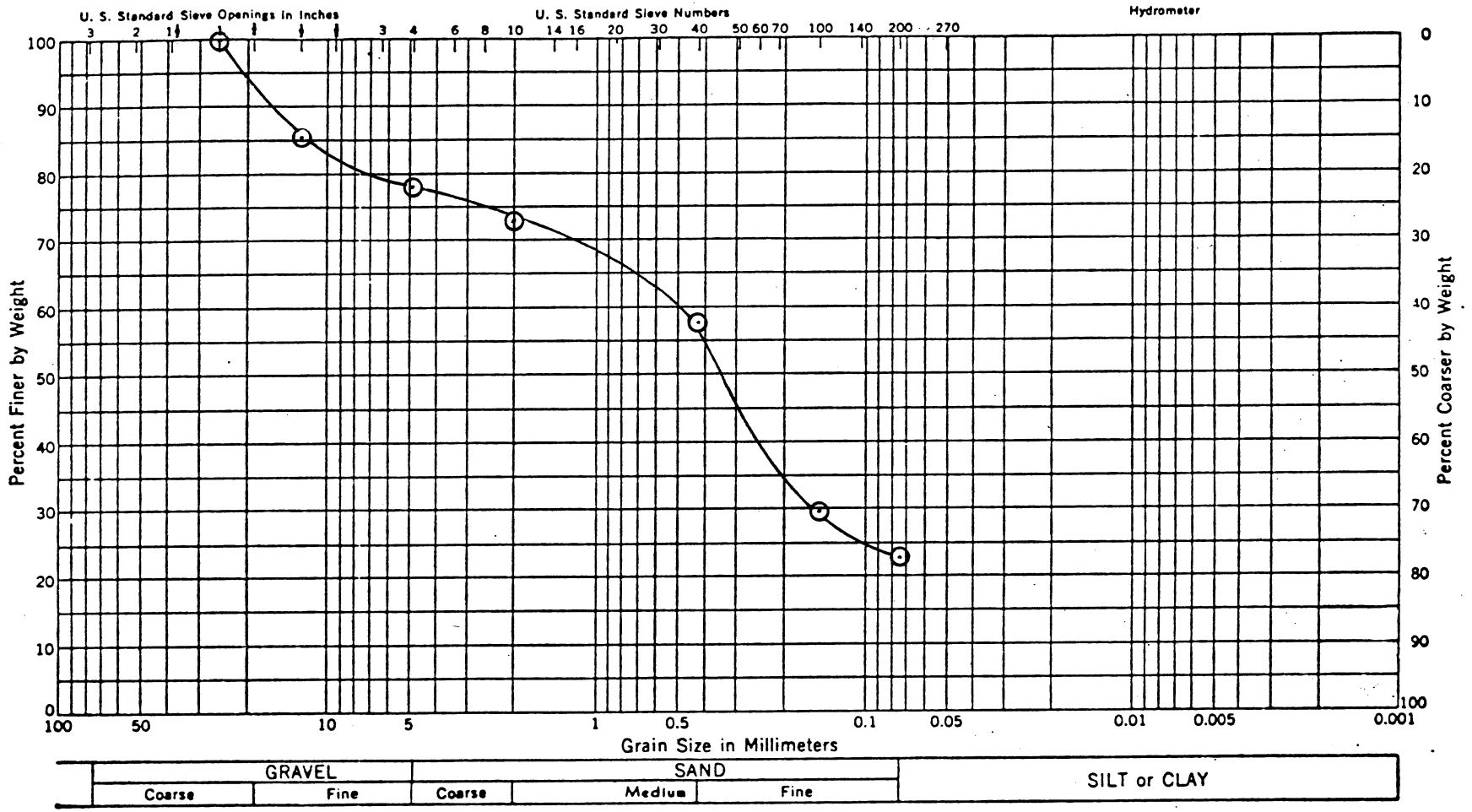
BORING	SAMPLE	DEPTH	SYMBOL	D_{10}	D_{30}	D_{60}	C_u	C_c	CLASSIFICATION
TP-85-15		5-7							SM

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
KJL	JWK	11-11-85	14028

RBS12478



BORING	SAMPLE	DEPTH	SYMBOL	D_{10}	D_{30}	D_{60}	C_u	C_c	CLASSIFICATION
TP-85-17		10-12							SM

EXXON MINERALS COMPANY
GRAIN SIZE ANALYSIS
CRANDON PROJECT

STS Consultants Ltd.
540 LAMBEAU STREET
GREEN BAY, WIS. 54303

DRAWN	APPROVED	DATE	JOB No.
KJC	JWK	11-11-85	14028

BBS12478

COMPACTION CONTROL REPORTS

STS Consultants Ltd.
540 LAMBEAU ST., GREEN BAY, WIS. 54303
PHONE (414) 494-9656

Date 11-8-85 Job Name Exxon - Crandon Project Job No. 14028

COMPACTION CONTROL REPORT

1. Laboratory Compaction Test Data

A. Description of Soil: Brown silty fine to coarse sand - with some gravel

Material Mark Lower till Classification SM AASHO BPR

Source of Material Test pits at proposed MRDF
depth range 8 - 13'

Natural Water Content ____ % Natural Dry Density ____ PCF Specific Gravity ____

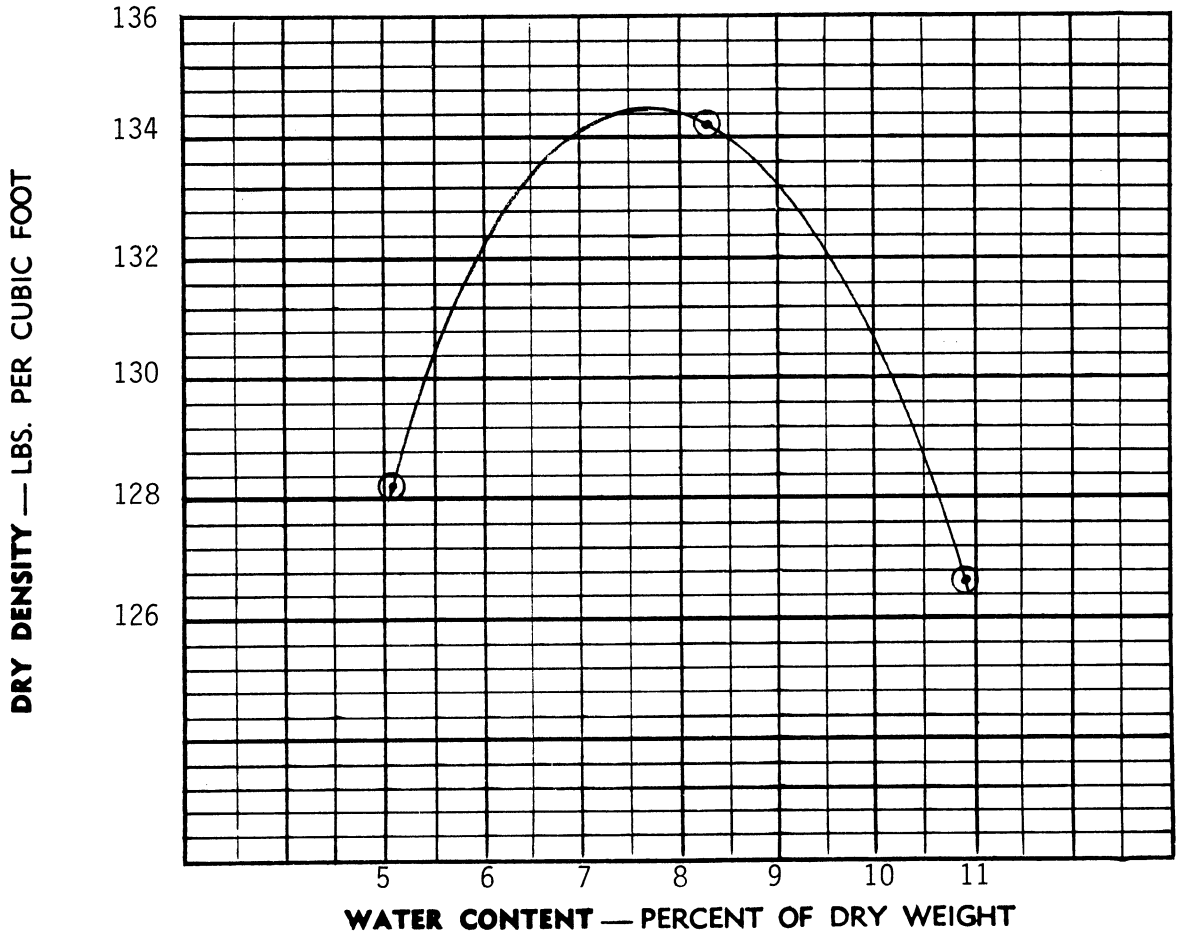
Liquid Limit ____ % Plastic Limit ____ % Plasticity Index ____

B. Test Procedure Used: ASTM D-698-78 Method "C"

C. Test Results:

Optimum Water Content 7.7 %

Maximum Dry Density 134.5 PCF (at a Wet Density of ____ PCF)



STS Consultants Ltd.
540 LAMBEAU ST., GREEN BAY, WIS. 54303
PHONE (414) 494-9656

Date 11-8-85 Job Name Exxon - Crandon Project Job No. 14028

COMPACTION CONTROL REPORT

1. Laboratory Compaction Test Data

A. Description of Soil: Reddish brown silty fine to coarse sand - trace of clay and with some gravel

Material Mark Upper till Classification SM AASHO BPR

Source of Material Test pits at proposed MRDF depth range 2-8'

Natural Water Content _____ % Natural Dry Density _____ PCF Specific Gravity _____

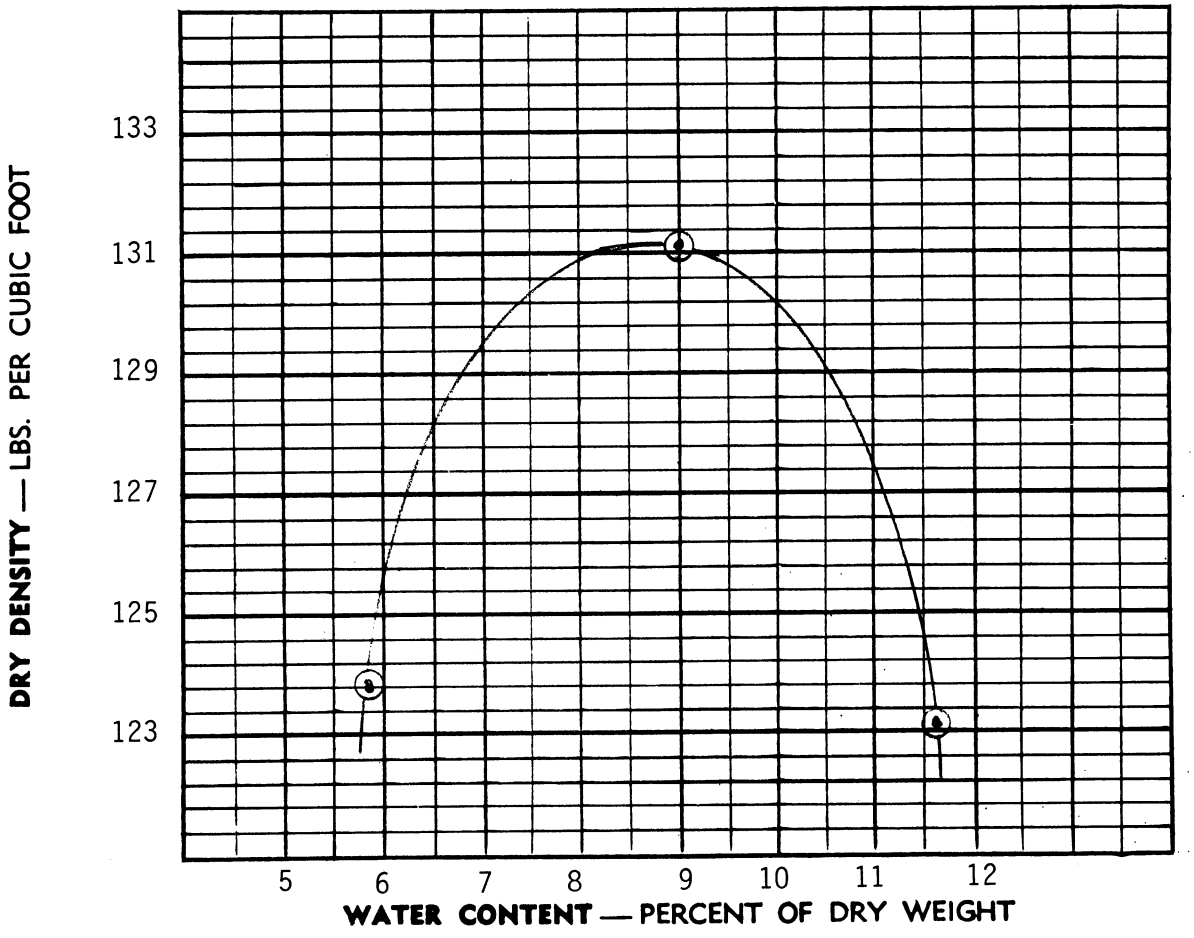
Liquid Limit _____ % Plastic Limit _____ % Plasticity Index _____

B. Test Procedure Used: ASTM D-698-78 Method "C"

C. Test Results:

Maximum Dry Density 131.3 PCF (at a Wet Density of _____ PCF)

Optimum Water Content 8.7 %



92268

WATER LEVEL DATA

WATER LEVEL DATA

7-24-85

WELL	WATER ELEVATION (Meters Above MSL)
DMB-1	486.04
DMB-4	485.65
DMB-8	485.08
EX-7	481.42
EX-8	481.47
EX-9	485.92
EX-10	486.13
EX-11	485.69
EX-12	485.68
EX-13	485.30
EX-14	485.04
EX-16	485.76
G41-B12	486.24
G41-G21	485.42
G41-K13A	485.67
G41-N21	484.72

FIELD PERMEABILITY TEST

TEST DATE
4/16/84

STS CONSULTANTS LTD. - FIELD ENGINEERING SERVICES
SINGLE WELL HYDRAULIC CONDUCTIVITY TEST

STS JOB NO.: 12959
PROJECT/LOCATION: EXXON/CRANDON
PROJECT MANAGER: JAS
TEST TECHNICIAN: JCG
DATA ANALYST: PMB

TEST INFORMATION

TYPE: FALLING HEAD METHOD: SLUG

PIEZOMETER ID: EX9AL
SCREEN LENGTH: 3.0000 feet
SLOT SIZE (est.): 0.0200 inches
STANDPIPE RADIUS: 1.0000 inches

BOREHOLE RADIUS: 3.1250 inches
GRAVEL PACK LENGTH: 7.0000 feet
GRAVEL PACK PERM.: 0.35E-01 ft./sec.
SCREEN PERMEABILITY: 0.35E-02 ft./sec.

LENGTH USED FOR CALCULATION: 7.00 ft.

THE GRAVEL LENGTH WILL BE USED FOR CALC.

SLUG LENGTH: 20.00 feet

SLUG RADIUS: 0.50 inches

TRANSDUCER USED: 25.00 psi

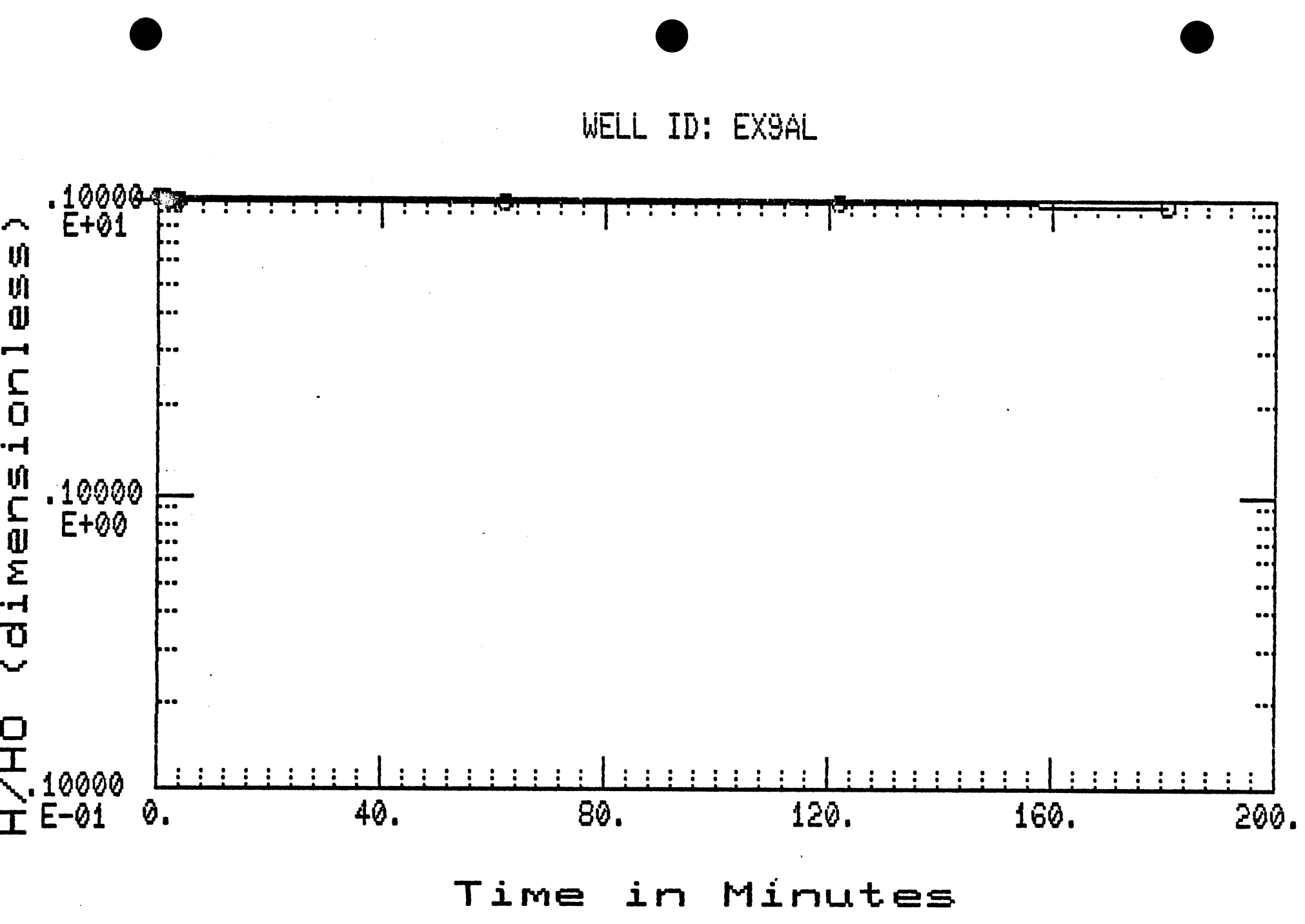
INITIAL READING: 52.32% of 25.00 psi

DATA POINTS SELECTED

1. TIME: 62.00 minutes HEAD: 56.30 % of 25.00 psi
2. TIME: 180.75 minutes HEAD: 56.29 % of 25.00 psi

HYDRAULIC CONDUCTIVITY OF TEST INTERVAL:

0.18E-07 cm/sec 0.58E-09 ft/sec 0.18E-09 m/sec


WELL ID: EX9AL
.10000 E+01
.10000 E+00
.10000 E-01
H/HO (dimensionless)
0.
40.
80.
120.
160.
200.
Time in Minutes

WELL ID: EX9AL

TEST DATA:

MEASUREMENT NUMBER	TIME (HH:MM:SS)	TRANSDUCER READING (% of 25.00 psi)	HEAD RATIO (H/HO)
1	10:28: 0	56.50	1.0000
2	10:28:30	56.48	0.9952
3	10:28:45	56.46	0.9904
4	10:29:15	56.42	0.9809
5	10:30: 0	56.40	0.9761
6	10:30:30	56.32	0.9569
7	10:32: 0	56.30	0.9522
8	11:30: 0	56.30	0.9522
9	12:30: 0	56.30	0.9522
10	13:28:45	56.29	0.9498

STS CONSULTANTS LTD. - FIELD ENGINEERING SERVICES
SINGLE WELL HYDRAULIC CONDUCTIVITY TEST

STS JOB NO.: 12959
PROJECT/LOCATION: EXXON CRANDON
PROJECT MANAGER: JAS
TEST TECHNICIAN: JLG
DATA ANALYST: JAS

TEST INFORMATION

TYPE: FALLING HEAD METHOD: SLUG

PIEZOMETER ID: EX 9AU
SCREEN LENGTH: 3.0000 feet
SLOT SIZE (est.): 0.0200 inches
STANDPIPE RADIUS: 1.0000 inches
BOREHOLE RADIUS: 3.1250 inches
GRAVEL PACK LENGTH: 7.0000 feet
GRAVEL PACK PERM.: 0.35E-01 ft./sec.
SCREEN PERMEABILITY: 0.35E-02 ft./sec.

LENGTH USED FOR CALCULATION: 7.00 ft.

THE GRAVEL LENGTH WILL BE USED FOR CALC.

SLUG LENGTH: 15.00 feet
SLUG RADIUS: 0.50 inches

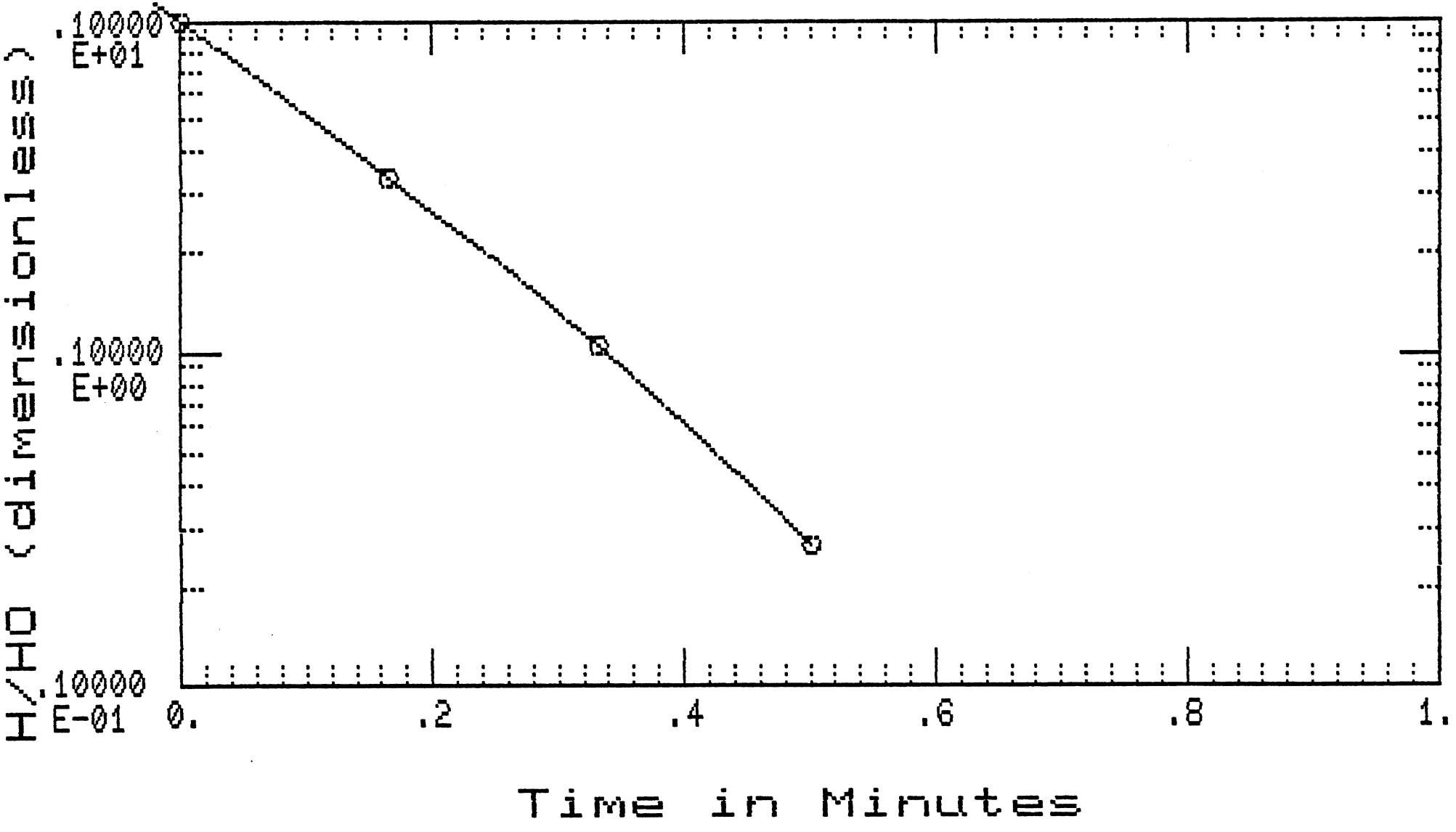
TRANSDUCER USED: 25.00 psi
INITIAL READING: 39.90% of 25.00 psi

DATA POINTS SELECTED

1. TIME: 0.17 minutes HEAD: 40.77 % of 25.00 psi
2. TIME: 0.50 minutes HEAD: 39.97 % of 25.00 psi

HYDRAULIC CONDUCTIVITY OF TEST INTERVAL:

0.63E-02 cm/sec 0.21E-03 ft/sec 0.63E-04 m/sec


WELL ID: EX 9AU
.10000 E+01
.10000 E+00
.10000 E-01
H/HO (dimensionless)
0.
.2
.4
.6
.8
1.
Time in Minutes

WELL ID: EX 9AU

TEST DATA:

MEASUREMENT NUMBER	TIME (HH:MM:SS)	TRANSDUCER READING (% of 25.00 psi)	HEAD RATIO (H/HO)
1	12: 8: 0	42.50	1.0000
2	12: 8:10	40.77	0.3346
3	12: 8:19	40.17	0.1038
4	12: 8:30	39.97	0.0269

STS CONSULTANTS LTD. - FIELD ENGINEERING SERVICES
SINGLE WELL HYDRAULIC CONDUCTIVITY TEST

STS JOB NO.: 12959
PROJECT/LOCATION: EXXON CRANDON
PROJECT MANAGER: JAS
TEST TECHNICIAN: JLG
DATA ANALYST: JAS

TEST INFORMATION

TYPE: RISING HEAD METHOD: SLUG

PIEZOMETER ID: EX 9AU
SCREEN LENGTH: 3.0000 feet
SLOT SIZE (est.): 0.0200 inches
STANDPIPE RADIUS: 1.0000 inches
BOREHOLE RADIUS: 3.1250 inches
GRAVEL PACK LENGTH: 7.0000 feet
GRAVEL PACK PERM.: 0.35E-01 ft./sec.
SCREEN PERMEABILITY: 0.35E-02 ft./sec.

LENGTH USED FOR CALCULATION: 7.00 ft.

THE GRAVEL LENGTH WILL BE USED FOR CALC.

SLUG LENGTH: 15.00 feet
SLUG RADIUS: 0.50 inches

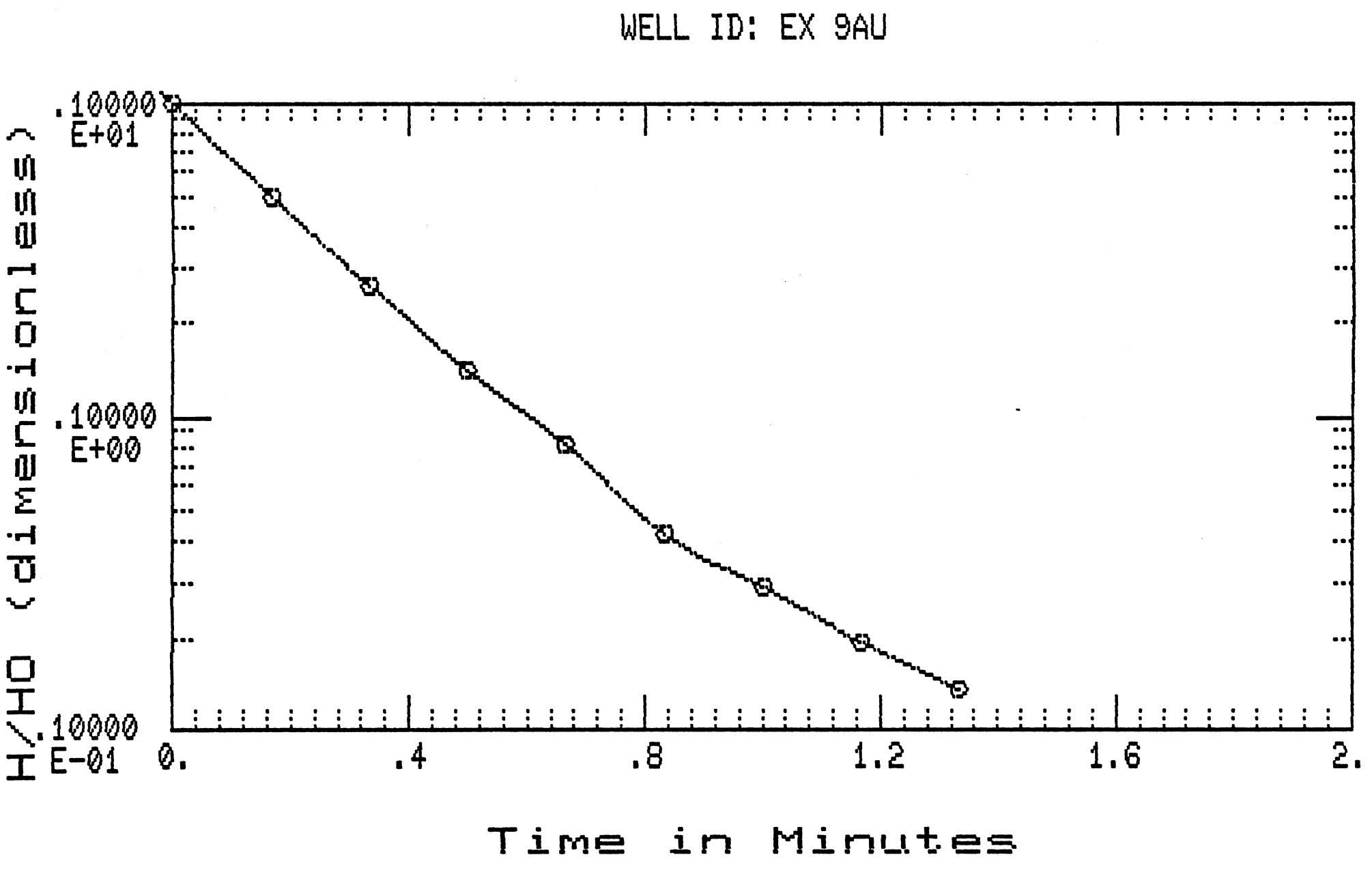
TRANSDUCER USED: 25.00 psi
INITIAL READING: 48.22% of 25.00 psi

DATA POINTS SELECTED

1. TIME: 0.17 minutes HEAD: 45.60 % of 25.00 psi
2. TIME: 0.67 minutes HEAD: 47.80 % of 25.00 psi

HYDRAULIC CONDUCTIVITY OF TEST INTERVAL:

0.30E-02 cm/sec 0.10E-03 ft/sec 0.30E-04 m/sec


WELL ID: EX 9AU
.10000
E+01
.10000
E+00
.10000
E-01
H/HO (dimensionless)
0.
.4
.8
1.2
1.6
2.
Time in Minutes

WELL ID: EX 9AU

TEST DATA:

MEASUREMENT NUMBER	TIME (HH:MM:SS)	TRANSDUCER READING (% of 25.00 psi)	HEAD RATIO (H/HO)
1	14:13: 0	43.07	1.0000
2	14:13:10	45.60	0.5087
3	14:13:19	46.87	0.2621
4	14:13:30	47.50	0.1398
5	14:13:40	47.80	0.0816
6	14:13:49	48.00	0.0427
7	14:14: 0	48.07	0.0291
8	14:14:10	48.12	0.0194
9	14:14:19	48.15	0.0136

STS CONSULTANTS LTD. - FIELD ENGINEERING SERVICES

SINGLE WELL HYDRAULIC CONDUCTIVITY TEST

STS JOB NO.: 12959
PROJECT/LOCATION: EXXON/CRANDON
PROJECT MANAGER: JAS
TEST TECHNICIAN: JCG
DATA ANALYST: PMB/JRT

TEST INFORMATION

TYPE: FALLING HEAD METHOD: SLUG

PIEZOMETER ID: EX9BL
SCREEN LENGTH: 3.0000 feet
SLOT SIZE (est.): 0.0200 inches
STANDPIPE RADIUS: 1.0000 inches
BOREHOLE RADIUS: 3.1250 inches
GRAVEL PACK LENGTH: 7.0000 feet
GRAVEL PACK PERM.: 0.35E-01 ft./sec.
SCREEN PERMEABILITY: 0.35E-02 ft./sec.

LENGTH USED FOR CALCULATION: 7.00 ft.

THE GRAVEL LENGTH WILL BE USED FOR CALC.

SLUG LENGTH: 20.00 feet
SLUG RADIUS: 0.50 inches

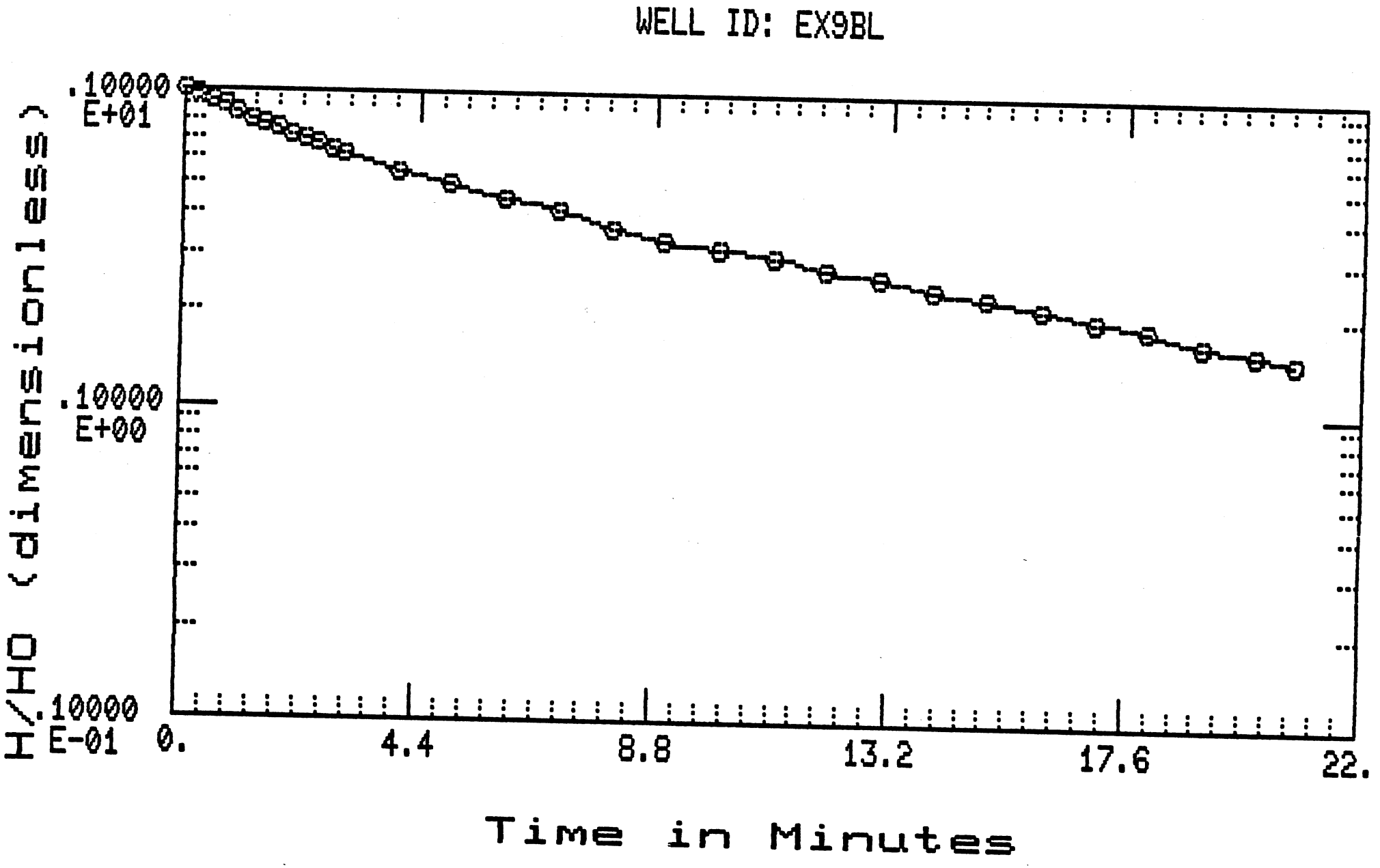
TRANSDUCER USED: 25.00 psi
INITIAL READING: 54.00% of 25.00 psi

DATA POINTS SELECTED

1. TIME: 0.00 minutes HEAD: 60.15 % of 25.00 psi
2. TIME: 2.75 minutes HEAD: 58.00 % of 25.00 psi

HYDRAULIC CONDUCTIVITY OF TEST INTERVAL:

0.13E-03 cm/sec 0.43E-05 ft/sec 0.13E-05 m/sec


WELL ID: EX9BL
.10000 E+01
.10000 E+00
.10000 E-01
H/HO (dimensionless)
0.
4.4
8.8
13.2
17.6
22.
Time in Minutes

WELL ID: EX9BL

TEST DATA:

MEASUREMENT NUMBER	TIME (HH:MM:SS)	TRANSDUCER READING (% of 25.00 psi)	HEAD RATIO (H/HO)
1	9:10: 0	60.15	1.0000
2	9:10:15	59.92	0.9626
3	9:10:30	59.62	0.9138
4	9:10:45	59.40	0.8780
5	9:11: 0	59.17	0.8406
6	9:11:15	58.95	0.8049
7	9:11:30	58.77	0.7756
8	9:11:45	58.60	0.7480
9	9:12: 0	58.45	0.7236
10	9:12:15	58.30	0.6992
11	9:12:30	58.15	0.6748
12	9:12:45	58.00	0.6504
13	9:13: 0	57.87	0.6293
14	9:14: 0	57.37	0.5480
15	9:15: 0	57.07	0.4992
16	9:16: 0	56.80	0.4553
17	9:17: 0	56.57	0.4179
18	9:18: 0	56.25	0.3659
19	9:19: 0	56.05	0.3333
20	9:20: 0	55.95	0.3171
21	9:21: 0	55.85	0.3008
22	9:22: 0	55.70	0.2764
23	9:23: 0	55.60	0.2602
24	9:24: 0	55.47	0.2390
25	9:25: 0	55.40	0.2276
26	9:26: 0	55.30	0.2114
27	9:27: 0	55.20	0.1951
28	9:28: 0	55.12	0.1821
29	9:29: 0	55.02	0.1659
30	9:30: 0	54.97	0.1577
31	9:30:45	54.92	0.1496

STS CONSULTANTS LTD. - FIELD ENGINEERING SERVICES
SINGLE WELL HYDRAULIC CONDUCTIVITY TEST

STS JOB NO.: 12959
PROJECT/LOCATION: EXXON/CRANDON
PROJECT MANAGER: JAS
TEST TECHNICIAN: JCG
DATA ANALYST: PMB/JRT

TEST INFORMATION

TYPE: RISING HEAD METHOD: SLUG

PIEZOMETER ID: EX9BL
SCREEN LENGTH: 3.0000 feet
SLOT SIZE (est.): 0.0200 inches
STANDPIPE RADIUS: 1.0000 inches
BOREHOLE RADIUS: 3.1250 inches
GRAVEL PACK LENGTH: 7.0000 feet
GRAVEL PACK PERM.: 0.35E-01 ft./sec.
SCREEN PERMEABILITY: 0.35E-02 ft./sec.

LENGTH USED FOR CALCULATION: 7.00 ft.

THE GRAVEL LENGTH WILL BE USED FOR CALC.

SLUG LENGTH: 20.00 feet
SLUG RADIUS: 0.30 inches

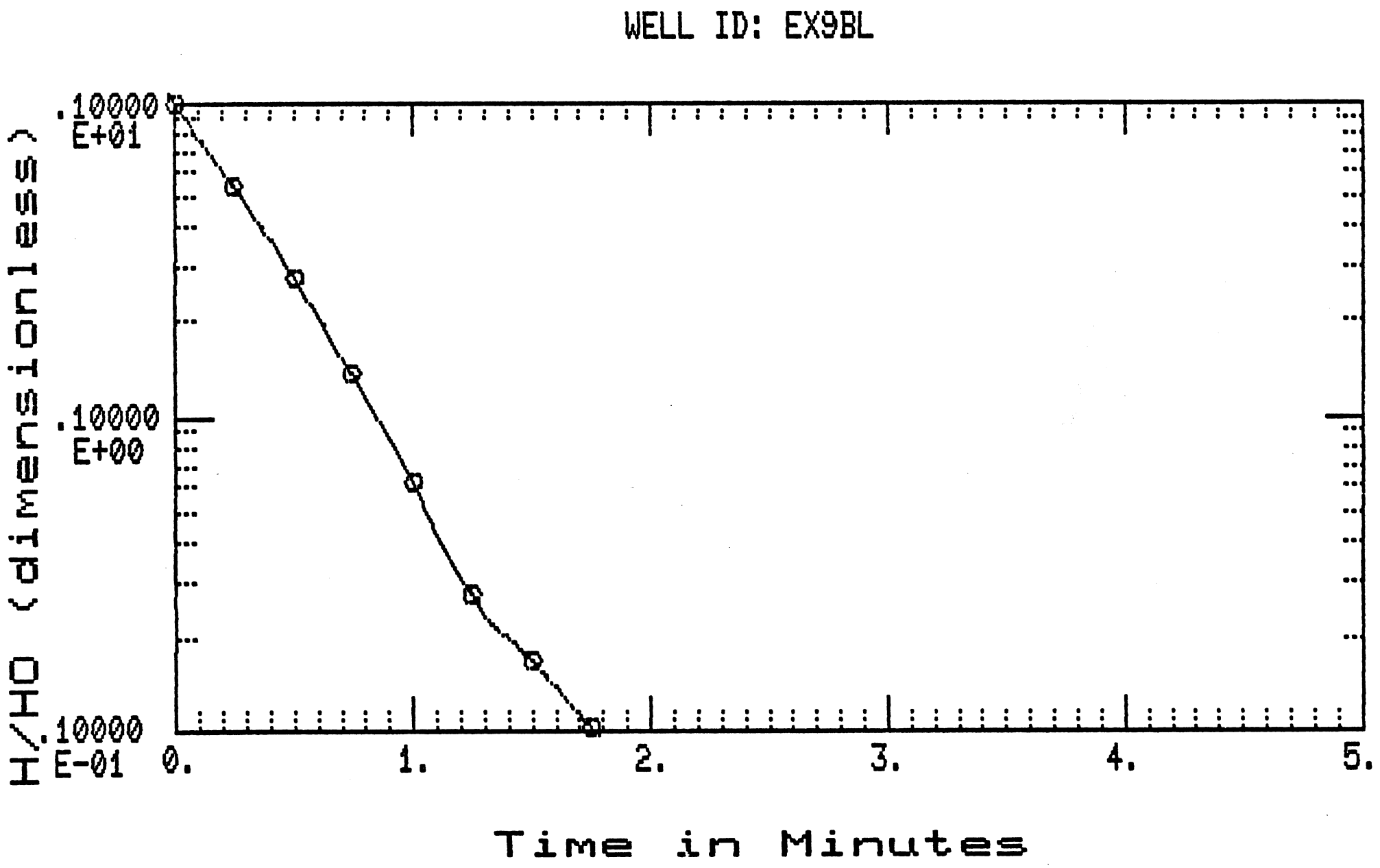
TRANSDUCER USED: 25.00 psi
INITIAL READING: 54.00% of 25.00 psi

DATA POINTS SELECTED

1. TIME: 0.25 minutes HEAD: 51.42 % of 25.00 psi
2. TIME: 1.50 minutes HEAD: 53.92 % of 25.00 psi

HYDRAULIC CONDUCTIVITY OF TEST INTERVAL:

0.23E-02 cm/sec 0.76E-04 ft/sec 0.23E-04 m/sec


WELL ID: EX9BL
.10000 E+01
.10000 E+00
.10000 E-01
H/HO (dimensionless)
0.
1.
2.
3.
4.
5.
Time in Minutes

WELL ID: EX9BL

TEST DATA:

MEASUREMENT NUMBER	TIME (HH:MM:SS)	TRANSDUCER READING (% of 25.00 psi)	HEAD RATIO (H/HO)
1	9:31: 0	49.22	1.0000
2	9:31:15	51.42	0.5397
3	9:31:30	52.67	0.2782
4	9:31:45	53.35	0.1360
5	9:32: 0	53.70	0.0628
6	9:32:15	53.87	0.0272
7	9:32:30	53.92	0.0167
8	9:32:45	53.95	0.0105
9	9:33: 0	53.97	0.0063
10	9:33:15	53.97	0.0063
11	9:33:30	53.97	0.0063
12	9:33:45	53.97	0.0063
13	9:34: 0	53.97	0.0063
14	9:35: 0	54.00	0.0010

STS CONSULTANTS LTD. - FIELD ENGINEERING SERVICES
SINGLE WELL HYDRAULIC CONDUCTIVITY TEST

STS JOB NO.: 12959
PROJECT/LOCATION: EXXON CRANDON
PROJECT MANAGER: JAS
TEST TECHNICIAN: RP
DATA ANALYST: JAS

TEST INFORMATION

TYPE: FALLING HEAD METHOD: SLUG

PIEZOMETER ID: EX 10AL
SCREEN LENGTH: 3.000 feet
SLOT SIZE (est.): 0.0200 inches
STANDPIPE RADIUS: 1.0000 inches
BOREHOLE RADIUS: 3.1250 inches
GRAVEL PACK LENGTH: 6.000 feet
GRAVEL PACK PERM.: 0.35E-02 ft./sec.
SCREEN PERMEABILITY: 0.35E-02 ft./sec.

LENGTH USED FOR CALCULATION: 6.00 ft.

GRAVEL LENGTH WILL BE USED

SLUG LENGTH: 15.00 feet
SLUG RADIUS: 0.50 inches

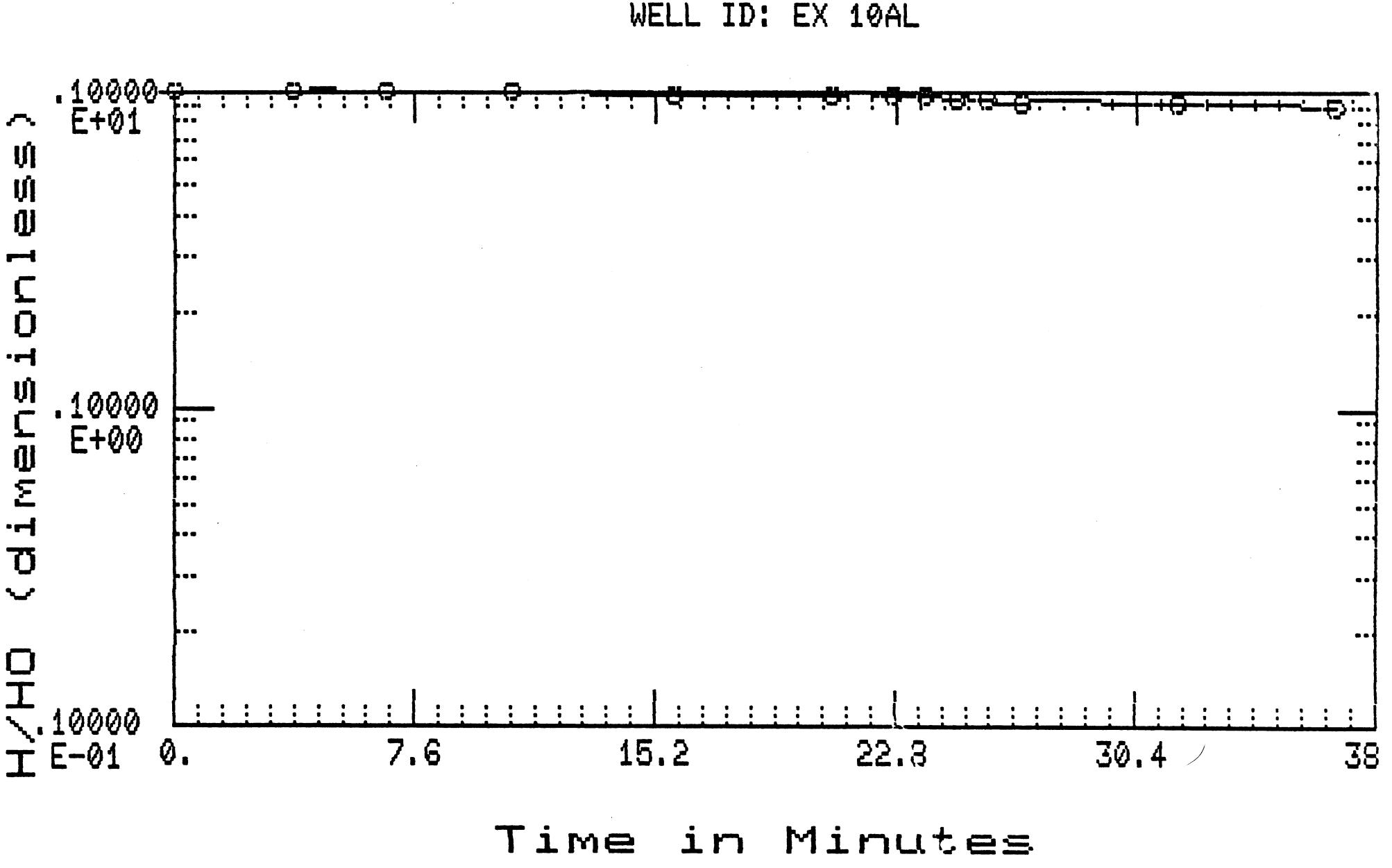
TRANSDUCER USED: 25.00 psi
INITIAL READING: 27.50% of 25.00 psi

DATA POINTS SELECTED

1. TIME: 15.75 minutes HEAD: 31.35 % of 25.00 psi
2. TIME: 23.75 minutes HEAD: 31.27 % of 25.00 psi

HYDRAULIC CONDUCTIVITY OF TEST INTERVAL:

0.24E-05 cm/sec 0.79E-07 ft/sec 0.24E-07 m/sec


WELL ID: EX 10AL
.10000 E+01
.10000 E+00
.10000 E-01
H/HO (dimensionless)
0.
7.6
15.2
22.8
30.4
38
Time in Minutes

WELL ID: EX 10AL

TEST DATA:

MEASUREMENT NUMBER	TIME (HH:MM:SS)	TRANSDUCER READING (% of 25.00 psi)	HEAD RATIO (H/HO)
1	14:13:15	31.45	1.0000
2	14:17: 0	31.42	0.9924
3	14:20: 0	31.40	0.9873
4	14:24: 0	31.37	0.9797
5	14:29: 0	31.35	0.9747
6	14:34: 0	31.32	0.9671
7	14:36: 0	31.30	0.9620
8	14:37: 0	31.27	0.9544
9	14:38: 0	31.22	0.9418
10	14:39: 0	31.17	0.9291
11	14:40: 0	31.15	0.9241
12	14:45: 0	31.07	0.9038
13	14:50: 0	31.00	0.8861

STS CONSULTANTS LTD. - FIELD ENGINEERING SERVICES
SINGLE WELL HYDRAULIC CONDUCTIVITY TEST

STS JOB NO.: 12959
PROJECT/LOCATION: EXXON/CRANDON
PROJECT MANAGER: JAS
TEST TECHNICIAN: JCG
DATA ANALYST: PMB

TEST INFORMATION

TYPE: RISING HEAD METHOD: SLUG

PIEZOMETER ID: EX10AL
SCREEN LENGTH: 3.0000 feet
SLOT SIZE (est.): 0.0200 inches
STANDPIPE RADIUS: 1.0000 inches
BOREHOLE RADIUS: 3.1250 inches
GRAVEL PACK LENGTH: 6.0000 feet
GRAVEL PACK PERM.: 0.35E-01 ft./sec.
SCREEN PERMEABILITY: 0.35E-02 ft./sec.

LENGTH USED FOR CALCULATION: 6.00 ft.

THE GRAVEL LENGTH WILL BE USED FOR CALC.

SLUG LENGTH: 15.00 feet
SLUG RADIUS: 0.50 inches

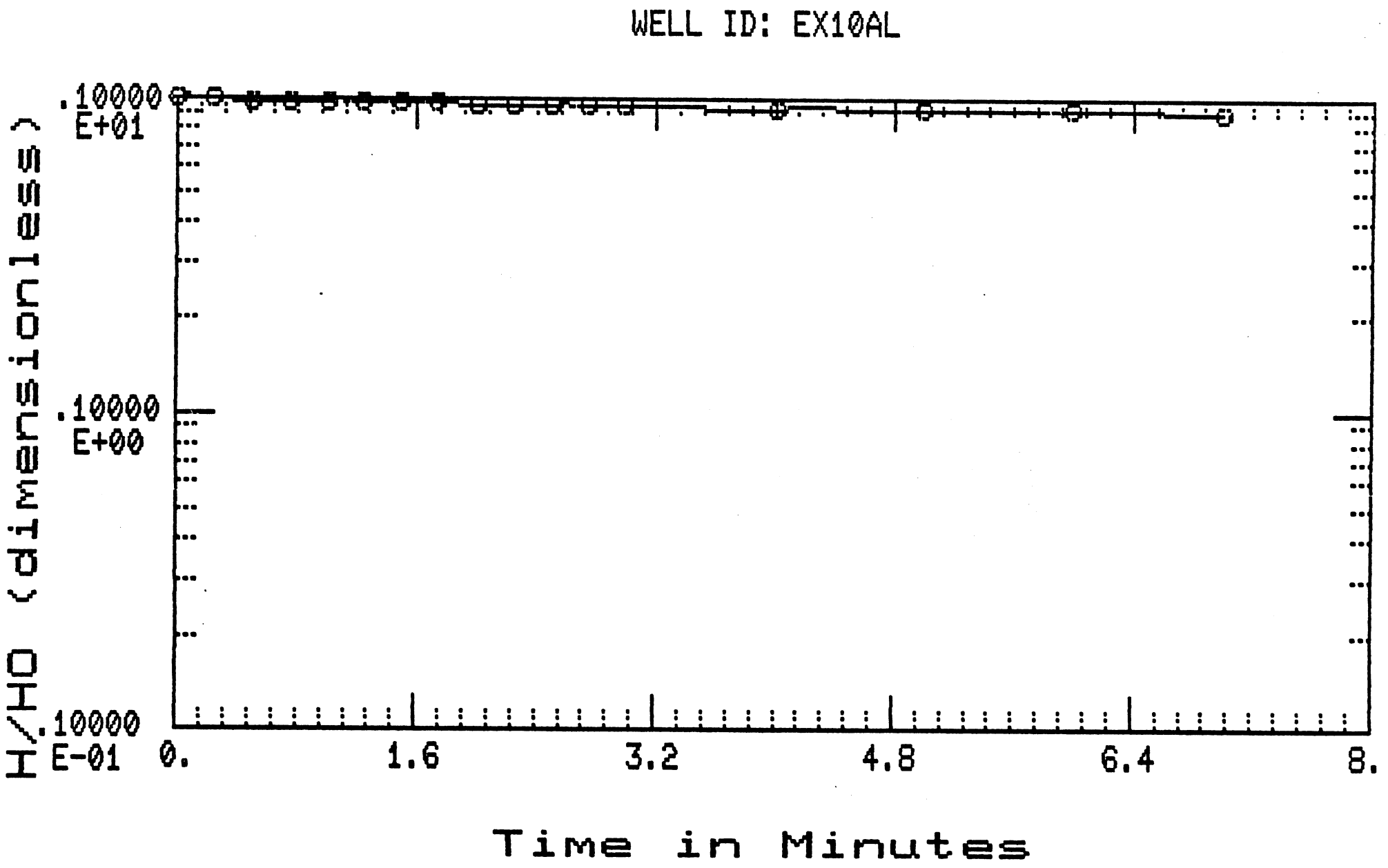
TRANSDUCER USED: 25.00 psi
INITIAL READING: 60.92% of 25.00 psi

DATA POINTS SELECTED

1. TIME: 0.00 minutes HEAD: 52.47 % of 25.00 psi
2. TIME: 7.00 minutes HEAD: 53.37 % of 25.00 psi

HYDRAULIC CONDUCTIVITY OF TEST INTERVAL:

0.15E-04 cm/sec 0.49E-06 ft/sec 0.15E-06 m/sec


WELL ID: EX10AL
.10000 E+01
.10000 E+00
.10000 E-01
H/HO (dimensionless)
0.
1.6
3.2
4.8
6.4
8.
Time in Minutes

WELL ID: EX10AL

TEST DATA:

MEASUREMENT NUMBER	TIME (HH:MM:SS)	TRANSDUCER READING (% of 25.00 psi)	HEAD RATIO (H/HO)
1	11:46: 0	52.47	1.0000
2	11:46:15	52.62	0.9822
3	11:46:30	52.67	0.9763
4	11:46:45	52.70	0.9728
5	11:47: 0	52.75	0.9669
6	11:47:15	52.80	0.9609
7	11:47:30	52.82	0.9586
8	11:47:45	52.87	0.9527
9	11:48: 0	52.90	0.9491
10	11:48:15	52.95	0.9432
11	11:48:30	52.97	0.9408
12	11:48:45	53.00	0.9373
13	11:49: 0	53.05	0.9314
14	11:50: 0	53.15	0.9195
15	11:51: 0	53.22	0.9112
16	11:52: 0	53.30	0.9018
17	11:53: 0	53.37	0.8935

STS CONSULTANTS LTD. - FIELD ENGINEERING SERVICES

SINGLE WELL HYDRAULIC CONDUCTIVITY TEST

STS JOB NO.: 12959
PROJECT/LOCATION: EXXON CRANDON
PROJECT MANAGER: JAS
TEST TECHNICIAN: JLG
DATA ANALYST: JAS

TEST INFORMATION

TYPE: FALLING HEAD METHOD: SLUG

PIEZOMETER ID:	EX 10AU	BOREHOLE RADIUS:	3.1250 inches
SCREEN LENGTH:	3.0000 feet	GRAVEL PACK LENGTH:	9.0000 feet
SLOT SIZE (est.):	0.0200 inches	GRAVEL PACK PERM.:	0.35E-01 ft./sec.
STANDPIPE RADIUS:	1.0000 inches	SCREEN PERMEABILITY:	0.35E-02 ft./sec.

LENGTH USED FOR CALCULATION: 9.00 ft.

THE GRAVEL LENGTH WILL BE USED FOR CALC.

SLUG LENGTH: 15.00 feet SLUG RADIUS: 0.50 inches

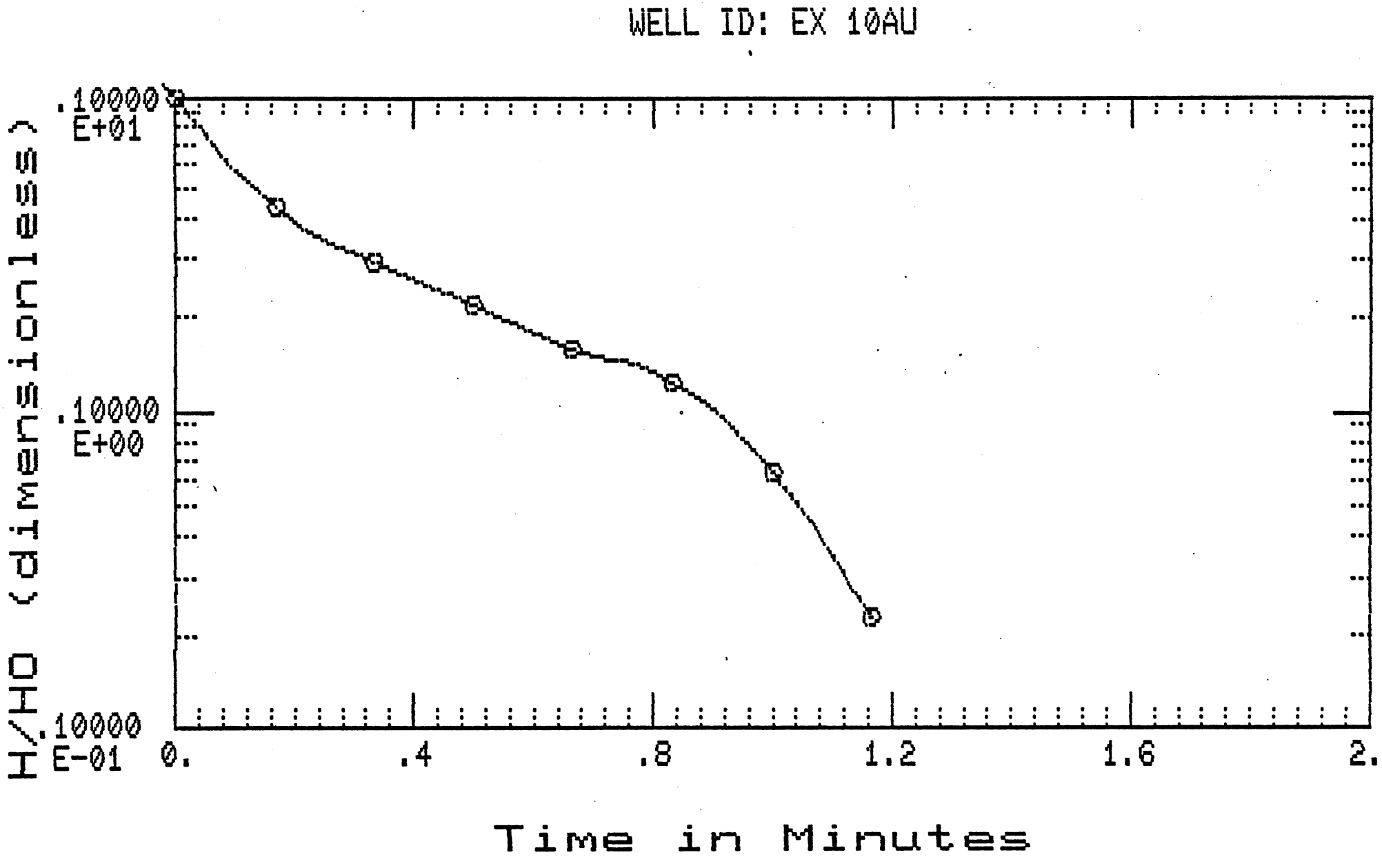
TRANSDUCER USED: 25.00 psi INITIAL READING: 50.00% of 25.00 psi

DATA POINTS SELECTED

1. TIME: 0.17 minutes HEAD: 52.93 % of 25.00 psi
2. TIME: 0.67 minutes HEAD: 51.02 % of 25.00 psi

HYDRAULIC CONDUCTIVITY OF TEST INTERVAL:

0.15E-02 cm/sec 0.48E-04 ft/sec 0.15E-04 m/sec


WELL ID: EX 10AU
.10000 E+01
.10000 E+00
.10000 E-01
H/HO (dimensionless)
0.
.4
.8
1.2
1.6
2.
Time in Minutes

WELL ID: EX 10AU

TEST DATA:

MEASUREMENT NUMBER	TIME (HH:MM:SS)	TRANSDUCER READING (% of 25.00 Psi)	HEAD RATIO (H/HO)
1	15:46: 0	56.60	1.0000
2	15:46:10	52.93	0.4439
3	15:46:19	51.95	0.2955
4	15:46:30	51.42	0.2152
5	15:46:40	51.02	0.1545
6	15:46:49	50.80	0.1212
7	15:47: 0	50.42	0.0636
8	15:47:10	50.15	0.0227

TEST DATE
4/11/84

STS CONSULTANTS LTD. - FIELD ENGINEERING SERVICES
SINGLE WELL HYDRAULIC CONDUCTIVITY TEST

STS JOB NO.: 12959
PROJECT/LOCATION: EXXON/CRANDON
PROJECT MANAGER: JAS
TEST TECHNICIAN: JCG
DATA ANALYST: PMB

TEST INFORMATION

TYPE: RISING HEAD METHOD: SLUG

PIEZOMETER ID: EX10BL
SCREEN LENGTH: 3.0000 feet
SLOT SIZE (est.): 0.0200 inches
STANDPIPE RADIUS: 1.0000 inches
BOREHOLE RADIUS: 3.1250 inches
GRAVEL PACK LENGTH: 7.0000 feet
GRAVEL PACK PERM.: 0.35E-01 ft./sec.
SCREEN PERMEABILITY: 0.35E-02 ft./sec.

LENGTH USED FOR CALCULATION: 7.00 ft.

THE GRAVEL LENGTH WILL BE USED FOR CALC.

SLUG LENGTH: 15.00 feet
SLUG RADIUS: 0.50 inches

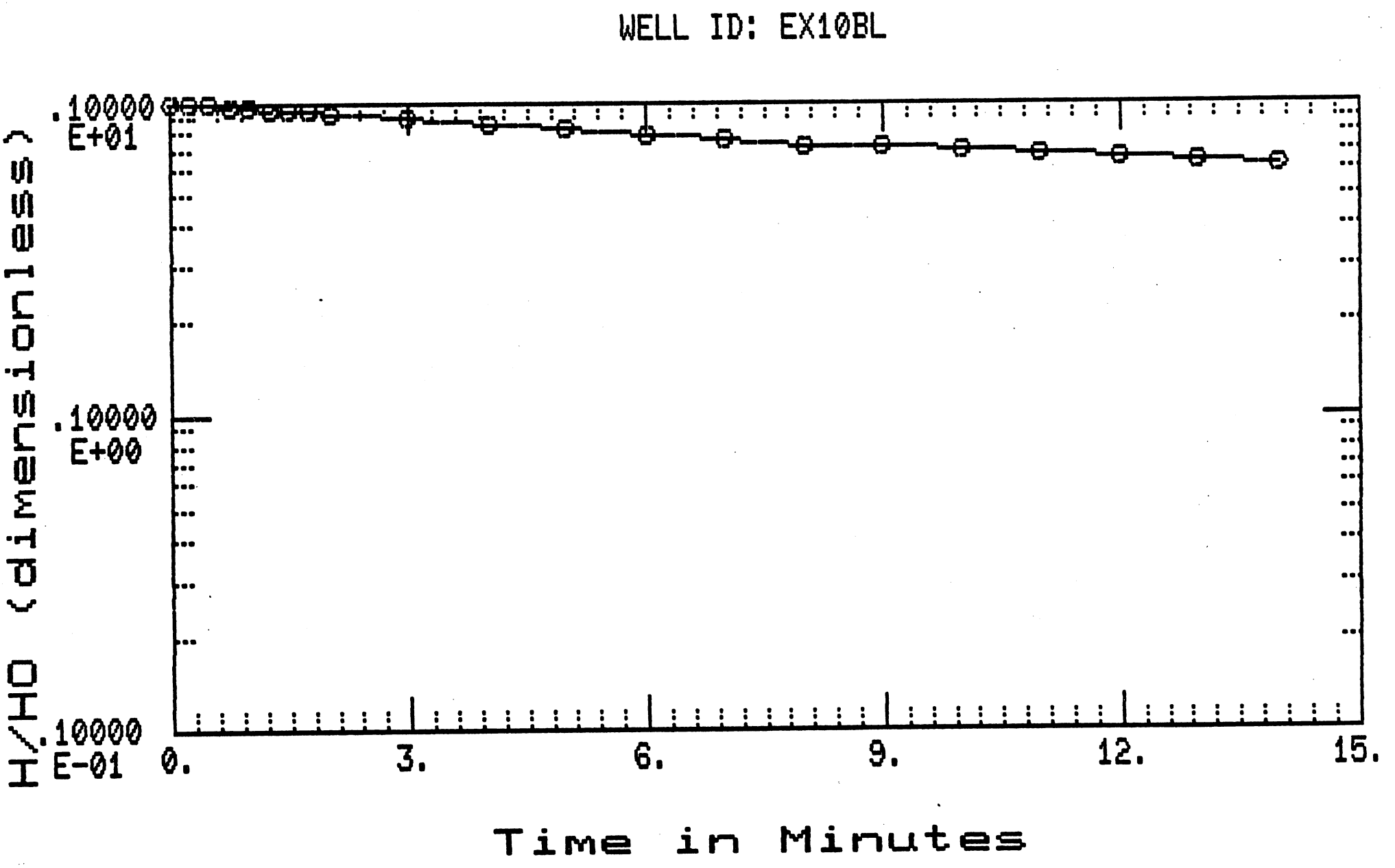
TRANSDUCER USED: 25.00 psi
INITIAL READING: 54.30% of 25.00 psi

DATA POINTS SELECTED

1. TIME: 3.00 minutes HEAD: 50.92 % of 25.00 psi
2. TIME: 13.00 minutes HEAD: 51.65 % of 25.00 psi

HYDRAULIC CONDUCTIVITY OF TEST INTERVAL:

0.20E-04 cm/sec 0.66E-06 ft/sec 0.20E-06 m/sec


WELL ID: EX10BL
.10000 E+01
.10000 E+00
.10000 E-01
H/HO (dimensionless)
0.
3.
6.
9.
12.
15.
Time in Minutes

WELL ID: EX10BL

TEST DATA:

MEASUREMENT NUMBER	TIME (HH:MM:SS)	TRANSDUCER READING (% of 25.00 psi)	HEAD RATIO (H/HO)
1	9:41: 0	62.65	1.0000
2	9:41:15	62.57	0.9904
3	9:41:30	62.47	0.9784
4	9:41:45	62.40	0.9701
5	9:42: 0	62.30	0.9581
6	9:42:15	62.22	0.9485
7	9:42:30	62.12	0.9365
8	9:42:45	62.05	0.9281
9	9:43: 0	61.97	0.9186
10	9:44: 0	61.70	0.8862
11	9:45: 0	61.42	0.8527
12	9:46: 0	61.07	0.8108
13	9:47: 0	60.80	0.7784
14	9:48: 0	60.55	0.7485
15	9:49: 0	60.35	0.7246
16	9:50: 0	60.25	0.7126
17	9:51: 0	60.10	0.6946
18	9:52: 0	59.92	0.6731
19	9:53: 0	59.77	0.6551
20	9:54: 0	59.62	0.6371
21	9:55: 0	59.47	0.6192

STS CONSULTANTS LTD. - FIELD ENGINEERING SERVICES
SINGLE WELL HYDRAULIC CONDUCTIVITY TEST

STS JOB NO.: 12959
PROJECT/LOCATION: EXXON/CRANDON
PROJECT MANAGER: JAS
TEST TECHNICIAN: JCG
DATA ANALYST: PMB

TEST INFORMATION

TYPE: FALLING HEAD METHOD: SLUG

PIEZOMETER ID: EX10BL
SCREEN LENGTH: 3.0000 feet
SLOT SIZE (est.): 0.0200 inches
STANDPIPE RADIUS: 1.0000 inches
BOREHOLE RADIUS: 3.1250 inches
GRAVEL PACK LENGTH: 7.0000 feet
GRAVEL PACK PERM.: 0.35E-01 ft./sec.
SCREEN PERMEABILITY: 0.35E-02 ft./sec.

LENGTH USED FOR CALCULATION: 7.00 ft.

THE GRAVEL LENGTH WILL BE USED FOR CALC.

SLUG LENGTH: 15.00 feet
SLUG RADIUS: 0.50 inches

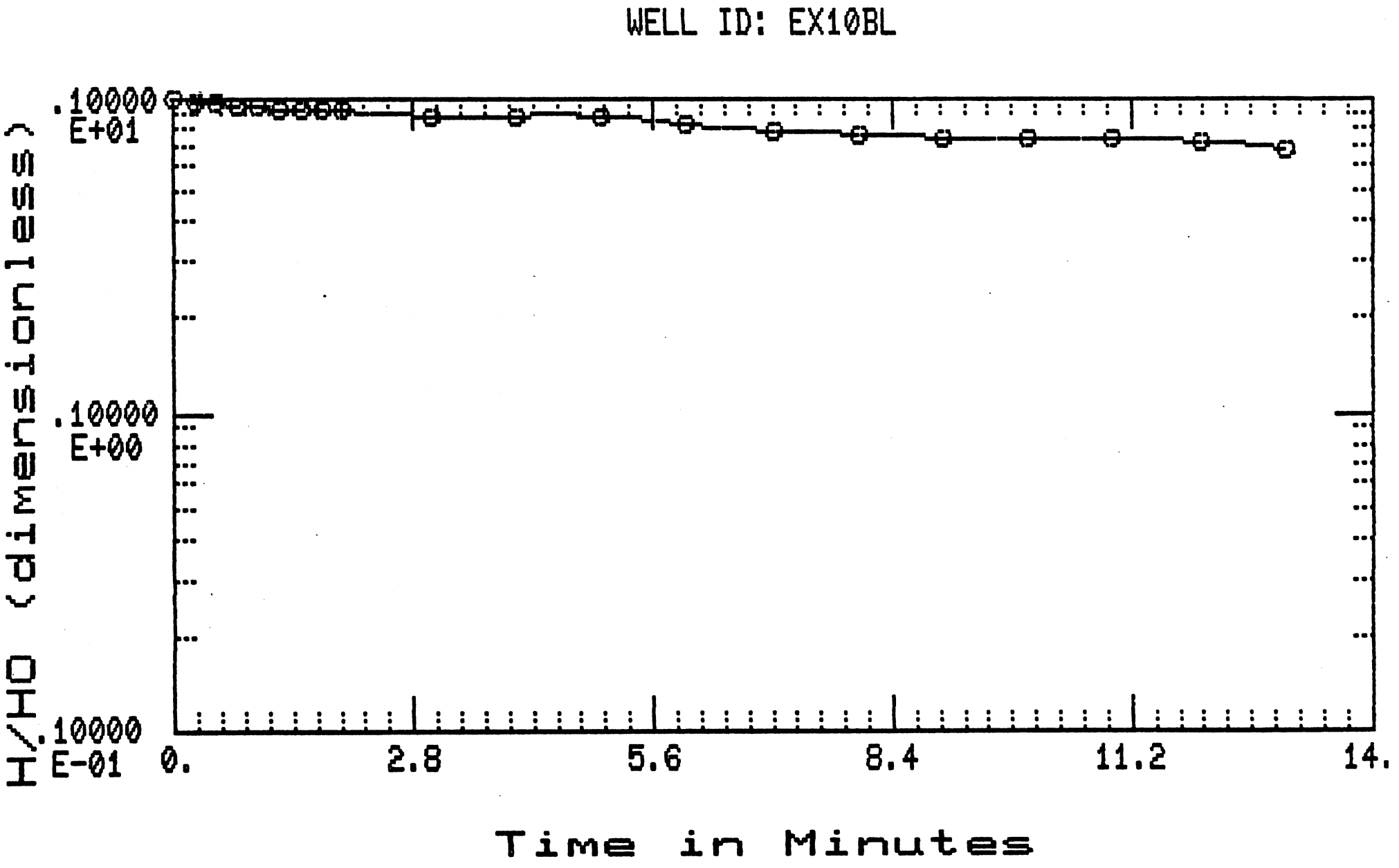
TRANSDUCER USED: 25.00 psi
INITIAL READING: 54.30% of 25.00 psi

DATA POINTS SELECTED

1. TIME: 7.00 minutes HEAD: 60.55 % of 25.00 psi
2. TIME: 14.00 minutes HEAD: 59.47 % of 25.00 psi

HYDRAULIC CONDUCTIVITY OF TEST INTERVAL:

0.22E-04 cm/sec 0.74E-06 ft/sec 0.22E-06 m/sec


WELL ID: EX10BL
.10000 E+01
.10000 E+00
.10000 E-01
H/HO (dimensionless)
0.
2.8
5.6
8.4
11.2
14.
Time in Minutes

WELL ID: EX10BL

TEST DATA:

MEASUREMENT NUMBER	TIME (HH:MM:SS)	TRANSDUCER READING (% of 0.00 psi)	HEAD RATIO (H/HO)
1	9:58: 0	50.42	1.0000
2	9:58:15	50.52	0.9742
3	9:58:30	50.60	0.9536
4	9:58:45	50.65	0.9407
5	9:59: 0	50.67	0.9356
6	9:59:15	50.72	0.9227
7	9:59:30	50.75	0.9149
8	9:59:45	50.77	0.9098
9	10: 0: 0	50.80	0.9021
10	10: 1: 0	50.92	0.8711
11	10: 2: 0	50.92	0.8711
12	10: 3: 0	50.97	0.8582
13	10: 4: 0	51.12	0.8196
14	10: 5: 0	51.27	0.7809
15	10: 6: 0	51.35	0.7603
16	10: 7: 0	51.42	0.7423
17	10: 8: 0	51.45	0.7345
18	10: 9: 0	51.47	0.7294
19	10:10: 0	51.50	0.7216
20	10:11: 0	51.65	0.6830

WATER BUDGET CALCULATIONS

STATE OF WISCONSIN

DEPARTMENT OF NATURAL RESOURCES
SOLID WASTE MANAGEMENT BUREAU

WATER BALANCE PROGRAM

FOR: EXXON CRANDON PROJECT MRDF EXISTING CONDITIONS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
TEMPERATURE (F)	10.5	14.6	25.8	41.6	54.4	63.3	67.9	65.5	56.5	46.4	30.9	17.1	
MONTHLY i VALUES	0.00	0.00	0.00	1.10	3.97	6.59	8.12	7.32	4.55	2.04	0.00	0.00	33.69
UNADJUSTED POT. EVAPO-TRANSP.	0.00	0.00	0.00	0.03	0.08	0.11	0.13	0.12	0.08	0.05	0.00	0.00	
LATITUDE CORRECTION (r)	23.8	24.1	30.6	33.7	38.5	38.8	39.4	36.4	31.2	28.2	23.7	22.3	
POTENTIAL EVAPO-TRANSPIRATION	0.00	0.00	0.00	1.01	3.08	4.26	5.12	4.36	2.49	1.41	0.00	0.00	
PRECIPITATION	1.03	0.81	1.50	2.39	3.45	3.97	3.64	4.74	3.87	2.26	1.83	1.23	30.72
CUMULATIVE SNOW PACK (IN)	4.09	4.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.83	3.06	
CORRECTED EQUIV. PRECIP. (IN)	-0.00	0.00	6.40	2.39	3.45	3.97	3.64	4.74	3.87	2.26	0.00	0.00	
RUNOFF COEFFICIENT	0.06	0.06	0.06	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.06	0.06	
MONTHLY RUNOFF (IN)	-0.00	0.00	0.38	0.07	0.10	0.12	0.11	0.14	0.12	0.07	0.00	0.00	
INFILTRATION (IN)	-0.00	0.00	6.02	2.32	3.35	3.85	3.53	4.60	3.75	2.19	0.00	0.00	
INFILTRATION MINUS PET (IN)	-0.00	0.00	6.02	1.31	0.27	-0.41	-1.59	0.24	1.26	0.78	0.00	0.00	
ACCUMULATED WATER LOSS (IN)	-0.00	-0.00	0.00	0.00	0.00	-0.41	-2.00	0.00	0.00	0.00	0.00	0.00	
SOIL MOISTURE STORAGE (IN)	3.00	3.00	3.00	3.00	3.00	2.60	1.49	1.72	2.99	3.00	3.00	3.00	
MONTHLY MOISTURE CHANGE (IN)	-0.00	0.00	0.00	0.00	0.00	-0.40	-1.11	0.24	1.26	0.01	0.00	0.00	
ACTUAL EVAPO-TRANSP. (IN)	0.00	0.00	0.00	1.01	3.08	4.25	4.64	4.36	2.49	1.41	0.00	0.00	
NET PERCOLATION (IN)	0.00	0.00	6.02	1.31	0.27	0.00	0.00	-0.00	0.00	0.77	0.00	0.00	8.36

NOTE: THE FOLLOWING CONDITIONS WERE USED IN COMPUTING THIS WATER BALANCE PER THORNTHWAITE & MATHER / EPA 1975 METHODS.

1 THE PROPOSED SITE HAS BEEN ESTIMATED TO BE AT 45.44 DEGREES NORTH LATITUDE.

2 THE FOLLOWING STATION(S), AT THE NOTED RELATIVE LOCATIONS, WERE REFERENCED FOR ATMOSPHERIC DATA
1 RHINELANDER WHICH IS 27.9 MILES WNW THE SITE LOCATION

3 THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) DATA FOR PRECIPITATION AND TEMPERATURE, FOR THE YEARS 1951 THROUGH 1980 FOR THE STATION(S) NOTED IN ITEM 2, HAS BEEN REFERENCED IN THIS ANALYSIS.

4 UNADJUSTED POTENTIAL EVAPO-TRANSPIRATION VALUES HAVE BEEN CALCULATED USING THE EQUATION DEVELOPED BY THORNTHWAITE & MATHER AND NOT EPA/1975 TABLE 3 WHICH VARIES AS MUCH AS 0.01 FROM THE DEFINING EQUATION.

5 A SNOW PACK (IN EQUIVALENT INCHES OF RAINFALL) IS ACCUMULATED FOR EACH SUB 32 DEGREE FARENHEIT MONTH FROM OCTOBER THROUGH SEPTEMBER. THE TOTAL SNOW PACK IS THEN DISPERSED AS EQUIVALENT PRECIPITATION DURING A SPRING MELT EVENT, STARTING WHEN TEMPERATURES APPROACH 32 DEGREES.

6 THE CORRECTED EQUIVALENT PRECIPITATION IS THE SUM OF THE MONTHLY PRECIPITATION MINUS THE AMOUNT ADDED TO THE ACCUMULATED SNOW PACK PLUS THE ESTIMATED MONTHLY SNOW MELT.

7 RUNOFF COEFFICIENTS HAVE BEEN SELECTED PER CHOW, FENN, ET.AL. FOR THE TOPSOIL TYPE SPECIFIC TO THIS SITE FOR THE SURFACE SLOPE WHICH HAS BEEN ESTIMATED AS .02 FEET PER FOOT.

8 SELECTING AVAILABLE MOISTURE VALUES FROM THE RANGE OF VALUES RECORDED BY SCS, THE FOLLOWING FINAL COVER SYSTEM HAS BEEN ANALYZED: THE ROOT ZONE HAS BEEN ESTIMATED AT; 30 INCHES
THE FINAL COVER WAS SET AT; 60 INCHES OF SILTY SAND WITH 10 % AVAILABLE MOISTURE

9 FOR MONTHS WHEN POTENTIAL EVAPO-TRANSPIRATION EXCEEDS INFILTRATION, THE MOISTURE STORAGE VALUES ARE COMPUTED BY THE EQUATION USED TO GENERATE EPA/1975 TABLES 11 THROUGH 22. THE VALUES DO NOT MATCH THE EQUATION VALUES AT ALL POINTS. THESE VARIATIONS DON'T AFFECT THE MONTHLY MOISTURE CHANGE VALUES BY MORE THAN 0.01.

10 ALL COMPUTED TABLE VALUES HAVE BEEN ROUNDED TO THE NEAREST 0.01 FOR PRINTING FORMAT. COMPUTER STORAGE ACCURACY OF THESE VALUES, RESULTS IN AN ANNUAL TOTAL PERCOLATION VALUE ACCURACY OF PLUS OR MINUS 0.05.

STATE OF WISCONSIN

DEPARTMENT OF NATURAL RESOURCES
SOLID WASTE MANAGEMENT BUREAU

WATER BALANCE PROGRAM

FOR: EXXON CRANDON PROJECT MRDF FINAL COVER 2% SLOPES

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
TEMPERATURE (F)	10.5	14.6	25.8	41.6	54.4	63.3	67.9	65.5	56.5	46.4	30.9	17.1	
MONTHLY i VALUES	0.00	0.00	0.00	1.10	3.97	6.59	8.12	7.32	4.55	2.04	0.00	0.00	33.69
UNADJUSTED POT. EVAPO-TRANSP.	0.00	0.00	0.00	0.03	0.08	0.11	0.13	0.12	0.08	0.05	0.00	0.00	
LATITUDE CORRECTION (r)	23.8	24.1	30.6	33.7	38.5	38.8	39.4	36.4	31.2	28.2	23.7	22.3	
POTENTIAL EVAPO-TRANSPIRATION	0.00	0.00	0.00	1.01	3.08	4.26	5.12	4.36	2.49	1.41	0.00	0.00	
PRECIPITATION	1.03	0.81	1.50	2.39	3.45	3.97	3.64	4.74	3.87	2.26	1.83	1.23	30.72
CUMULATIVE SNOW PACK (IN)	4.09	4.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.83	3.06	
CORRECTED EQUIV. PRECIP. (IN)	-0.00	0.00	6.40	2.39	3.45	3.97	3.64	4.74	3.87	2.26	0.00	0.00	
RUNOFF COEFFICIENT	0.15	0.15	0.15	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.15	0.15	
MONTHLY RUNOFF (IN)	-0.00	0.00	0.96	0.24	0.35	0.40	0.36	0.47	0.39	0.23	0.00	0.00	
INFILTRATION (IN)	-0.00	0.00	5.44	2.15	3.11	3.57	3.28	4.27	3.48	2.03	0.00	0.00	
INFILTRATION MINUS PET (IN)	-0.00	0.00	5.44	1.14	0.03	-0.69	-1.84	-0.09	0.99	0.62	0.00	0.00	
ACCUMULATED WATER LOSS (IN)	-0.00	-0.00	0.00	0.00	0.00	-0.69	-2.53	-2.63	0.00	0.00	0.00	0.00	
SOIL MOISTURE STORAGE (IN)	3.41	3.41	3.72	3.72	3.72	3.07	1.84	1.79	2.79	3.41	3.41	3.41	
MONTHLY MOISTURE CHANGE (IN)	-0.00	0.00	0.31	0.00	0.00	-0.65	-1.23	-0.05	0.99	0.62	0.00	0.00	
ACTUAL EVAPO-TRANSP. (IN)	0.00	0.00	0.00	1.01	3.08	4.22	4.51	4.31	2.49	1.41	0.00	0.00	
NET PERCOLATION (IN)	0.00	0.00	5.13	1.14	0.03	0.00	0.00	0.00	0.00	-0.00	0.00	0.00	6.30

NOTE: THE FOLLOWING CONDITIONS WERE USED IN COMPUTING THIS WATER BALANCE PER THORNTHWAITE & MATHER / EPA 1975 METHODS.

1 THE PROPOSED SITE HAS BEEN ESTIMATED TO BE AT 45.44 DEGREES NORTH LATITUDE.

2 THE FOLLOWING STATION(S), AT THE NOTED RELATIVE LOCATIONS, WERE REFERENCED FOR ATMOSPHERIC DATA
1 RHINELANDER WHICH IS 27.9 MILES WNW THE SITE LOCATION

3 THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) DATA FOR PRECIPITATION AND TEMPERATURE, FOR THE YEARS 1951 THROUGH 1980 FOR THE STATION(S) NOTED IN ITEM 2, HAS BEEN REFERENCED IN THIS ANALYSIS.

4 UNADJUSTED POTENTIAL EVAPO-TRANSPIRATION VALUES HAVE BEEN CALCULATED USING THE EQUATION DEVELOPED BY THORNTHWAITE & MATHER AND NOT EPA/1975 TABLE 3 WHICH VARIES AS MUCH AS 0.01 FROM THE DEFINING EQUATION.

5 A SNOW PACK (IN EQUIVALENT INCHES OF RAINFALL) IS ACCUMULATED FOR EACH SUB 32 DEGREE FARENHEIT MONTH FROM OCTOBER THROUGH SEPTEMBER. THE TOTAL SNOW PACK IS THEN DISPERSED AS EQUIVALENT PRECIPITATION DURING A SPRING MELT EVENT, STARTING WHEN TEMPERATURES APPROACH 32 DEGREES.

6 THE CORRECTED EQUIVALENT PRECIPITATION IS THE SUM OF THE MONTHLY PRECIPITATION MINUS THE AMOUNT ADDED TO THE ACCUMULATED SNOW PACK PLUS THE ESTIMATED MONTHLY SNOW MELT.

7 RUNOFF COEFFICIENTS HAVE BEEN SELECTED PER CHOW, FENN, ET.AL. FOR THE TOPSOIL TYPE SPECIFIC TO THIS SITE FOR THE SURFACE SLOPE WHICH HAS BEEN ESTIMATED AS .02 FEET PER FOOT.

8 SELECTING AVAILABLE MOISTURE VALUES FROM THE RANGE OF VALUES RECORDED BY SCS, THE FOLLOWING FINAL COVER SYSTEM HAS BEEN ANALYZED: THE ROOT ZONE HAS BEEN ESTIMATED AT; 30 INCHES
THE FINAL COVER WAS SET AT; 6 INCHES OF SILT LOAM WITH 22 % AVAILABLE MOISTURE
54 INCHES OF SILTY SAND WITH 10 % AVAILABLE MOISTURE

9 FOR MONTHS WHEN POTENTIAL EVAPO-TRANSPIRATION EXCEEDS INFILTRATION, THE MOISTURE STORAGE VALUES ARE COMPUTED BY THE EQUATION USED TO GENERATE EPA/1975 TABLES 11 THROUGH 22. THE VALUES DO NOT MATCH THE EQUATION VALUES AT ALL POINTS. THESE VARIATIONS DON'T AFFECT THE MONTHLY MOISTURE CHANGE VALUES BY MORE THAN 0.01.

10 ALL COMPUTED TABLE VALUES HAVE BEEN ROUNDED TO THE NEAREST 0.01 FOR PRINTING FORMAT. COMPUTER STORAGE ACCURACY OF THESE VALUES, RESULTS IN AN ANNUAL TOTAL PERCOLATION VALUE ACCURACY OF PLUS OR MINUS 0.05.

STATE OF WISCONSIN

DEPARTMENT OF NATURAL RESOURCES
SOLID WASTE MANAGEMENT BUREAU

WATER BALANCE PROGRAM

FOR: EXXON CRANDON PROJECT MRDF FINAL COVER 25% SLOPES

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
TEMPERATURE (F)	10.5	14.6	25.8	41.6	54.4	63.3	67.9	65.5	56.5	46.4	30.9	17.1	
MONTHLY i VALUES	0.00	0.00	0.00	1.10	3.97	6.59	8.12	7.32	4.55	2.04	0.00	0.00	33.69
UNADJUSTED POT. EVAPO-TRANSP.	0.00	0.00	0.00	0.03	0.08	0.11	0.13	0.12	0.08	0.05	0.00	0.00	
LATITUDE CORRECTION (r)	23.8	24.1	30.6	33.7	38.5	38.8	39.4	36.4	31.2	28.2	23.7	22.3	
POTENTIAL EVAPO-TRANSPIRATION	0.00	0.00	0.00	1.01	3.08	4.26	5.12	4.36	2.49	1.41	0.00	0.00	
PRECIPITATION	1.03	0.81	1.50	2.39	3.45	3.97	3.64	4.74	3.87	2.26	1.83	1.23	30.72
CUMULATIVE SNOW PACK (IN)	4.09	4.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.83	3.06	
CORRECTED EQUIV. PRECIP. (IN)	-0.00	0.00	6.40	2.39	3.45	3.97	3.64	4.74	3.87	2.26	0.00	0.00	
RUNOFF COEFFICIENT	0.30	0.30	0.30	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.30	0.30	
MONTHLY RUNOFF (IN)	-0.00	0.00	1.92	0.48	0.69	0.79	0.73	0.95	0.77	0.45	0.00	0.00	
INFILTRATION (IN)	-0.00	0.00	4.48	1.91	2.76	3.18	2.91	3.79	3.10	1.81	0.00	0.00	
INFILTRATION MINUS PET (IN)	-0.00	0.00	4.48	0.90	-0.32	-1.08	-2.21	-0.57	0.61	0.40	0.00	0.00	
ACCUMULATED WATER LOSS (IN)	-0.00	-0.00	0.00	0.00	-0.32	-1.40	-3.61	-4.18	0.00	0.00	0.00	0.00	
SOIL MOISTURE STORAGE (IN)	2.17	2.17	3.72	3.72	3.40	2.52	1.36	1.17	1.77	2.17	2.17	2.17	
MONTHLY MOISTURE CHANGE (IN)	-0.00	0.00	1.55	0.00	-0.32	-0.88	-1.15	-0.20	0.61	0.40	0.00	0.00	
ACTUAL EVAPO-TRANSP. (IN)	0.00	0.00	0.00	1.01	3.08	4.06	4.07	3.99	2.49	1.41	0.00	0.00	
NET PERCOLATION (IN)	0.00	0.00	2.93	0.90	0.00	0.00	0.00	0.00	-0.00	0.00	0.00	0.00	3.83

NOTE: THE FOLLOWING CONDITIONS WERE USED IN COMPUTING THIS WATER BALANCE PER THORNTHWAITE & MATHER / EPA 1975 METHODS.

1 THE PROPOSED SITE HAS BEEN ESTIMATED TO BE AT 45.44 DEGREES NORTH LATITUDE.

2 THE FOLLOWING STATION(S), AT THE NOTED RELATIVE LOCATIONS, WERE REFERENCED FOR ATMOSPHERIC DATA
1 RHINELANDER WHICH IS 26.4 MILES WNW THE SITE LOCATION

3 THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) DATA FOR PRECIPITATION AND TEMPERATURE, FOR THE YEARS 1951 THROUGH 1980 FOR THE STATION(S) NOTED IN ITEM 2, HAS BEEN REFERENCED IN THIS ANALYSIS.

4 UNADJUSTED POTENTIAL EVAPO-TRANSPIRATION VALUES HAVE BEEN CALCULATED USING THE EQUATION DEVELOPED BY THORNTHWAITE & MATHER AND NOT EPA/1975 TABLE 3 WHICH VARIES AS MUCH AS 0.01 FROM THE DEFINING EQUATION.

5 A SNOW PACK (IN EQUIVALENT INCHES OF RAINFALL) IS ACCUMULATED FOR EACH SUB 32 DEGREE FARENHEIT MONTH FROM OCTOBER THROUGH SEPTEMBER. THE TOTAL SNOW PACK IS THEN DISPERSED AS EQUIVALENT PRECIPITATION DURING A SPRING MELT EVENT, STARTING WHEN TEMPERATURES APPROACH 32 DEGREES.

6 THE CORRECTED EQUIVALENT PRECIPITATION IS THE SUM OF THE MONTHLY PRECIPITATION MINUS THE AMOUNT ADDED TO THE ACCUMULATED SNOW PACK PLUS THE ESTIMATED MONTHLY SNOW MELT.

7 RUNOFF COEFFICIENTS HAVE BEEN SELECTED PER CHOW, FENN, ET.AL. FOR THE TOPSOIL TYPE SPECIFIC TO THIS SITE FOR THE SURFACE SLOPE WHICH HAS BEEN ESTIMATED AS .25 FEET PER FOOT.

8 SELECTING AVAILABLE MOISTURE VALUES FROM THE RANGE OF VALUES RECORDED BY SCS, THE FOLLOWING FINAL COVER SYSTEM HAS BEEN ANALYZED: THE ROOT ZONE HAS BEEN ESTIMATED AT; 30 INCHES
THE FINAL COVER WAS SET AT; 6 INCHES OF SILT LOAM WITH 22 % AVAILABLE MOISTURE
54 INCHES OF SILTY SAND WITH 10 % AVAILABLE MOISTURE

9 FOR MONTHS WHEN POTENTIAL EVAPO-TRANSPIRATION EXCEEDS INFILTRATION, THE MOISTURE STORAGE VALUES ARE COMPUTED BY THE EQUATION USED TO GENERATE EPA/1975 TABLES 11 THROUGH 22. THE VALUES DO NOT MATCH THE EQUATION VALUES AT ALL POINTS. THESE VARIATIONS DON'T AFFECT THE MONTHLY MOISTURE CHANGE VALUES BY MORE THAN 0.01.

10 ALL COMPUTED TABLE VALUES HAVE BEEN ROUNDED TO THE NEAREST 0.01 FOR PRINTING FORMAT. COMPUTER STORAGE ACCURACY OF THESE VALUES, RESULTS IN AN ANNUAL TOTAL PERCOLATION VALUE ACCURACY OF PLUS OR MINUS 0.05.

STS Consultants Ltd.
CALCULATION SHEET

PROJECT: CRANDON PROJECT JOB NO.: 14028 PAGE: 1 OF: 1

SUBJECT: MROF WATER BUDGET DIVISION:

ORIGINATOR: JAS DATE: 11-20-85 CHECKED BY: JWK DATE: 11-20-85

PURPOSE: CALCULATE AMOUNT OF ANNUAL LEACHATE GENERATION

ASSUMPTIONS:
1) CELL 1 IS CLOSED AND PROPERLY COVERED
2) CELL 2 IS FILLED WITH REFUSE BUT NO FINAL COVER
3) CELL 3 IS OPEN - ½ OF PRECIPITATION EVAPORATES
4) WASTE IS AT FIELD CAPACITY SO THAT ALL EXCESS PRECIPITATION IN OPEN CELLS ENTERS LEACHATE COLLECTION SYSTEM
5) NET PERCOLATION THROUGH THE 5' OF TILL FINAL COVER ENTERS DRAIN AND FLOWS TO EMBANKMENT SEEPAGE AREAS - PVC MEMBRANE CUTS OFF 100% OF NET PERCOLATION FROM ENTERING REFUSE
   slopes 2% = 6.3 inches net percolation
   " 25% = 3.8 inches " "
6) AREA OF EACH CELL IS APPROX. 97,400 sq ft
   58% HAS 2% SLOPES (56,500 sq ft)
   42% HAS 25% SLOPES (40,900 sq ft)

MID-DEVELOPMENT

a) 15.4 inches precip. on cell 3 = 935,000 gallons
b) 15.4 inches precip. on cell 2 = 935,000 gallons
c) cell 1 percolation on 25% slopes = (96,900 gal.) } diverted to seepage embankments
   3.8 inches on 40,900 sq ft
d) cell 1 percolation on 2% slopes = (221,900 gal.) }
   6.3 inches on 56,500 sq ft

total leachate generation at mid-development (cell 1 closed, cells 2+3 open) 1,870,000 gallons annually

POST-CLOSURE

a) percolation on 25% slopes
   3.8 inches on 40,900 sq ft x 3 cells 290,600 gallons
b) percolation on 2% slopes
   6.3 inches on 56,500 sq ft x 3 cells 665,600 gallons

Note: all percolation will be diverted to seepage embankments - none will enter refuse 956,200 gallons annually

VOLUME ESTIMATE CALCULATIONS

STS Consultants Ltd.	PROJECT: EXXON MRDF FEASIBILITY STUDY			FIGURE NO.
	TITLE: DESIGN CAPACITY CALCULATION			JOB NO. 14028
	DATE 11/19/85	BY JWK	APPROVED BY JAS	SCALE
CALCULATION SHEET				

DESIGN CAPACITY IS CALCULATED BY SUMMING THE VOLUMES OF THE GEOMETRIC FORMS THAT MAKE UP THE FACILITY:

- PER CELL:

a) 1 BASE FRUSTUM OF PYRAMID = V_1
b) 1 TOP FRUSTUM OF PYRAMID = V_2
c) 1 IRREGULAR POLYHEDRON = V_3
d) 2 HALF PYRAMIDS = V_4 & V_5

$V_1 = \frac{1}{3}\left[(\text{AREA BASE}) + (\text{AREA TOP}) + \sqrt{(\text{AREA BASE})(\text{AREA TOP})}\right] h$

WHERE h = HEIGHT

$= \frac{1}{3}\left[(72)^2 + (312)^2 + \sqrt{(72)^2(312)^2}\right] 30$

$= 1,249,920\ ft^3 = \underline{46,293\ yd^3}$

$V_2 = \frac{1}{3}\left[(312)^2 + (248)^2 + \sqrt{(312)^2(248)^2}\right] 8$

$= 629,931\ ft^3 = \underline{23,331\ yd^3}$

$V_3 = \frac{1}{2}\left[(\text{BASE})(\text{HEIGHT})\right](\text{LENGTH})$

$= \frac{1}{2}(248)(5)(208)$

$= 128,960\ ft^2 = \underline{4776\ yd^3}$

$V_4 = \frac{1}{2}\ \frac{1}{3}(\text{AREA BASE})(\text{HEIGHT})$

$= \frac{1}{6}(456)(40)(5)$

$= 15,200\ ft^3 = \underline{563\ yd^3}$

$V_5 = \frac{1}{2}\ \frac{1}{3}(40)(40)(5)$

$= 1333\ ft^3 = \underline{49\ yd^3}$

TOTAL FACILITY VOLUME $= 3(V_1 + V_2 + V_3 + V_4 + V_5)$

$= 3(46,293 + 23,331 + 4776 + 563 + 49)$

$= 225,036\ yd^3$

REFUSE & DAILY COVER CAPACITY = TOTAL CAPACITY LESS LINER & DRAIN AND FINAL COVER VOLUMES

$= 225,036 - 24,206 - 78,957$

$= 121,873\ yd^3$

STS Consultants Ltd.	PROJECT: EXXON MRDF FEASIBILITY STUDY			FIGURE NO.
	TITLE: MATERIAL BALANCE CALCULATION			JOB NO. 14028
	DATE 11/19/85	BY JWK	APPROVED BY JAS	SCALE
CALCULATION SHEET				

CUT VOLUME:

GEOMETRY: TOTAL CUT VOLUME EQUALS THE SUM OF CUTS FROM 3 CELLS. EACH CELL IS CONSTRUCTED AS A FRUSTUM OF A PYRAMID.

EQUATIONS: (1) $V = \frac{1}{3}(A_1 + A_2 + \sqrt{A_1 A_2})\,h$

(2) $V_{TOT} = 3\,V$

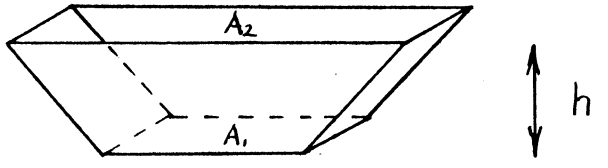
WHERE: A_1 = AREA OF ONE BASE

A_2 = AREA OF SECOND BASE

h = ALTITUDE

V = VOLUME OF SINGLE FRUSTUM

V_{TOT} = TOTAL MRDF VOLUME



COMPUTATION:

$A_1 = (72')^2 = 5{,}184\ ft^2$

$A_2 = (272')^2 = 97{,}344\ ft^2$

$h = 25'$

$V = \frac{1}{3}(5{,}184 + 97{,}344 + \sqrt{(5{,}184)(97{,}344)})\,25$

$V = 1{,}041{,}600\ ft^3 = 38{,}578\ yd^3$

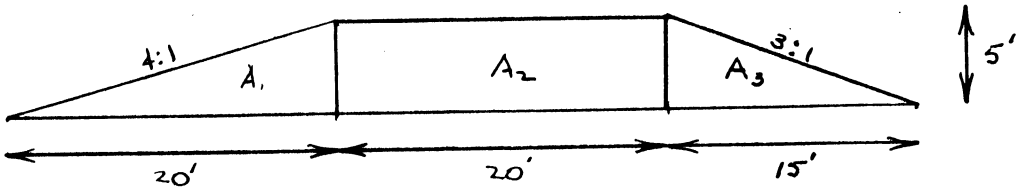
$V_{TOT} = 3(38{,}578) = \underline{115{,}733\ yd^3}$

STS Consultants Ltd.	PROJECT: EXXON MROF FEASIBILITY STUDY			FIGURE NO.
	TITLE: DIKE FILL REQUIREMENT			JOB NO. 14028
	DATE 11/19/85	BY JWK	APPROVED BY JAS	SCALE
CALCULATION SHEET 1				

DIKE FILL VOLUME:

GEOMETRY: TOTAL FILL VOLUME EQUALS 1) CROSS-SECTIONAL AREA OF DIKE * LINEAR FOOTAGE OF DIKE PLUS
2) VOLUME OF 8 CUBES PLUS
3) VOLUME OF 1 PYRAMID WITH 3:1 SLOPES LESS
4) VOLUME OF 1 PYRAMID WITH 4:1 SLOPES

1) DIKE CROSS-SECTION



$A_1 = \frac{1}{2}(b)(h)$
$= \frac{1}{2}(20)(5)$
$= 50\ ft^2$

$A_2 = (b)(h)$
$= (20)(5)$
$= 100\ ft^2$

$A_3 = \frac{1}{2}(15)(5)$
$= 37.5$

$V_1 = (A_1 + A_2 + A_3)\,L$ WHERE L = LENGTH OF DIKE = 3,120'
$= (50 + 100 + 37.5)\,3{,}120$
$= 585{,}000\ ft^3 = 21{,}667\ yd^3$

STS Consultants Ltd.	PROJECT: EXXON MRDF FEASIBILITY STUDY			FIGURE NO.
	TITLE: DIKE FILL REQUIREMENT			JOB NO. 14028
	DATE 11/9/85	BY JWK	APPROVED BY SAS	SCALE
CALCULATION SHEET 2				

2) VOLUME OF 8 CUBES:

$V_2 = 8(L \times W \times h)$ WHERE $L = 20', W = 20', h = 5'$

$= 8(20 \times 20 \times 5)$

$= 16{,}000 ft^2 = 592.6$

3) VOLUME OF 3:1 PYRAMID:

$V_3 = \frac{1}{3}(A_b)(h)$ WHERE A_b - AREA OF BASE

$= \frac{1}{3}(900)(5)$

$= 1500 ft^2 = 55.6 yd^3$

4) VOLUME OF 4:1 PYRAMID:

$V_4 = \frac{1}{3}(1600)(5)$

$= 2666.7 ft^2 = 98.8 yd^3$

TOTAL VOLUME $= V_1 + V_2 + V_3 - V_4$

$= 21{,}667 + 593 + 56 - 99$

$= 22{,}217 yd^3$