WELDON SPRING SITE REMEDIAL ACTION PROJECT

DISPOSAL FACILITY
GEOTECHNICAL CHARACTERIZATION REPORT
MKES REPORT NO. 3840R-7005-0

OCTOBER 1991

REVISION 0

PREPARED BY

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES DIVISION
180 HOWARD STREET
SAN FRANCISCO, CALIFORNIA 94105

FOR

MK-FERGUSON COMPANY
AND
JACOBS ENGINEERING GROUP
7295 HIGHWAY 94 SOUTH
ST. CHARLES, MISSOURI 63301

TABLE OF CONTENTS

SECTION		PAGE
1	INTRODUCTION	1
1.1	Objectives	1
1.2	Scope	1
1.3	Background	2
1.4	Other Related Studies and References	3
2	SYNOPSIS OF GEOTECHNICAL INVESTIGATIONS	6
2.1	General	6
2.2	Previous Field Investigations by Others	6
2.3	PMC Phase I and Phase II Investigations	10
2.3.1	Disposal Facility Area	10
2.3.2	Areas Outside the Disposal Facility Area	11
2.3.3	Potential Borrow Sources	11
2.4	Assessment of Pre-Phase III Investigations	11
2.5	PMC Phase III Investigation	16
3	SUMMARY OF TESTING PROGRAMS AND RESULTS	18
3.1	Summary of Geotechnical Testing Programs	18
3.2	Subsurface and Potential Borrow Source Materials and Data Reduction	25
3.3	Classification and Index Properties	43
3.3.1	Particle-Size Analysis	43
3.3.2	Atterberg Limits/Plasticity	45
3.3.3	Specific Gravity	57

TABLE OF CONTENTS

SECTION		PAGE
3.3.4	Natural Moisture Content	65
3.3.5	In Situ Density	67
3.4	Moisture-Density and Capillary-Moisture Relations	67
3.4.1	Standard Proctor Compaction	67
3.4.2	Capillary-Moisture Relationships	68
3.5	Strength and Deformation Characteristics	74
3.5.1	Unconsolidated-Undrained (UU) Triaxial Compression	74
3.5.2	Consolidated-Undrained (CU) Triaxial Compression	79
3.5.3	California Bearing Ratio	80
3.6	Volume Change Characteristics	102
3.6.1	One-Dimensional Consolidation	102
3.6.2	Cation Exchange Capacity	105
3.7	Permeability	105
3.8	Corrosivity	110
3.8.1	Resistivity	110
3.8.2	Sulfates and Chlorides	110
3.8.3	Acidity/Alkalinity	112
3.8.4	Percent Solids	112
3.9	Standard Penetration Test	112
3.10	Quality Assurance	113

TABLE OF CONTENTS

SECTION		PAGE
4	CONCLUSIONS AND RECOMMENDATIONS	114
4.1	Site Description and Subsurface Conditions	114
4.2	Materials	120
4.2.1	Topsoil	120
4.2.2	Subsoil	120
4.2.3	Satisfactory Materials	121
4.2.4	Unsatisfactory and Unstable Materials	121
4.2.5	Low-Permeability Soils	122
4.3	Potential Borrow Sources	123
4.3.1	Topsoil/Subsoil	123
4.3.2	Low Permeability Material	123
4.4	Soil Properties and Parameters	126
4.4.1	Unit Weights	127
4.4.2	Strength Parameters for Stability Analysis	127
4.4.3	Soil Parameters for Settlement Estimates	128
4.4.4	Permeability of Soil Liners and Cover Components	128
4.4.5	Cracking Potential	130
4.4.6	Corrosiveness of Soils	131
4.5	Site Preparation and Earthwork	132
4.5.1	Clearing and Grubbing	132
4.5.2	Excavation, Filling and Backfilling	133

TABLE OF CONTENTS

SECTION		PAGE
5	REFERENCES	135

APPENDIXES

A MKES Phase III Field Investigation Program
- A-1 IOC Report on Phase III Field Investigation
- A-2 Logs of Phase III Borings

B MKES Phase III Investigation Test Results

C Calculation for Evaluation of Soil Properties

LIST OF FIGURES

FIGURE		PAGE
1-1	Area and Vicinity Map of the Weldon Spring Site	4
1-2	Site Location Plan and Limit of Possible Disposal Area	5
2-1	Location Map for Borings, Test Pits and Geologic Profiles	7
2-2	Location Map for Test-Pits for Potential Off-Site Clay Borrow Sources	8
3-1	Summary Plot of Gradation Limits — Topsoil/Fill	46
3-2	Summary Plot of Gradation Limits — Loess	47
3-3A	Summary Plot of Gradation Limits— Ferrelview Clay: Overall Values	48
3-3B	Summary Plot of Gradation Limits— Ferrelview Clay: Northern CP	49
3-3C	Summary Plot of Gradation Limits— Ferrelview Clay: Southern CP	50
3-3D	Summary Plot of Gradation Limits— Ferrelview Clay: TSA	51
3-3E	Summary Plot of Gradation Limits— Ferrelview Clay: MSA	52
3-4	Summary Plot of Gradation Limits — Clay Till	53
3-5	Summary Plot of Gradation Limits — Basal Till	54
3-6	Summary Plot of Gradation Limits — Residuum	55
3-7	Summary Plot of Gradation Limits — Potential Borrow Source No. 1	56
3-8	Summary of Atterberg Limits — Topsoil/Fill	58
3-9	Summary of Atterberg Limits - Loess	59
3-10	Summary of Atterberg Limits — Ferrelview Clay: Overall Values	60
3-11	Summary of Atterberg Limits — Clay Till	61
3-12	Summary of Atterberg Limits — Basal Till	62
3-13	Summary of Atterberg Limits — Residuum	63
3-14	Summary of Atterberg Limits — Potential Borrow Source No. 1	64
3-15	Summary of Compaction Tests — Various Soil Units	69
3-16	Summary of Compaction Tests — Potential Borrow Source No. 1	70
3-17	Summary of Capillary Moisture Tests - Remolded Loess	71
3-18	Summary of Capillary Moisture Tests - Remolded Ferrelview Clay	72
3-19	Summary of Capillary Moisture Tests - Potential Borrow Source No. 1	73

LIST OF FIGURES
(Continued)

FIGURE		PAGE
3-20	Summary of Strength Envelopes — UU Triaxial, Undisturbed Sample - Loess	75
3-21	Summary of Strength Envelopes — UU Triaxial, Undisturbed Sample - Ferrelview Clay	76
3-22	Summary of Strength Envelopes — UU Triaxial, Undisturbed Sample - Clay Till	77
3-23	Summary of Strength Envelopes — UU Triaxial, Undisturbed Sample - Basal Till	78
3-24A	Summary of Total Strength Envelopes — CU Triaxial, Undisturbed Sample - Topsoil/Fill	81
3-24B	Summary of Effective Strength Envelopes — CU Triaxial, Undisturbed Sample - Topsoil/Fill	82
3-25A	Summary of Total Strength Envelopes — CU Triaxial, Undisturbed Sample - Loess	83
3-25B	Summary of Effective Strength Envelopes — CU Triaxial, Undisturbed Sample - Loess	84
3-26A	Summary of Total Strength Envelopes — CU Triaxial, Undisturbed Sample - Ferrelview Clay	85
3-26B	Summary of Effective Strength Envelopes — CU Triaxial, Undisturbed Sample - Ferrelview Clay	86
3-27A	Summary of Total Strength Envelopes — CU Triaxial, Undisturbed Sample - Clay Till	87
3-27B	Summary of Effective Strength Envelopes — CU Triaxial, Undisturbed Sample - Clay Till	88
3-28A	Summary of Total Strength Envelopes — CU Triaxial, Undisturbed Sample - Basal Till	89
3-28B	Summary of Effective Strength Envelopes — CU Triaxial, Undisturbed Sample - Basal Till	90
3-29A	Summary of Total Strength Envelopes — CU Triaxial, Undisturbed Sample - Residuum	91

LIST OF FIGURES
(Continued)

FIGURE		PAGE
3–29B	Summary of Effective Strength Envelopes — CU Triaxial, Undisturbed Sample - Residuum	92
3–30	Summary of Strength Envelopes — UU Triaxial, Remolded Sample - Loess	93
3–31	Summary of Strength Envelopes — UU Triaxial, Remolded Sample - Ferrelview	94
3–32A	Summary of Total Strength Envelopes — CU Triaxial, Remolded Sample - Loess	95
3–32B	Summary of Effective Strength Envelopes — CU Triaxial, Remolded Sample - Loess	96
3–33A	Summary of Total Strength Envelopes — CU Triaxial, Remolded Sample - Ferrelview	97
3–33B	Summary of Effective Envelopes — CU Triaxial, Remolded Sample - Ferrelview	98
3–34	Summary of Strength Envelopes — UU Triaxial, Remolded Sample - Potential Borrow Source No. 1	99
3–35A	Summary of Total Strength Envelopes — CU Triaxial, Remolded Sample - Potential Borrow Source No. 1	100
3–35B	Summary of Effective Strength Envelopes — CU Triaxial, Remolded Sample - Potential Borrow Source No. 1	101
3–36	Distribution of Preconsolidation Pressures - Overall Area	104
4–1	Geologic Profile, Section B	115
4–2	Geologic Profile, Section D	116
4–3	Geologic Profile, Section F	117
4–4	Geologic Profile, Section G	118
4–5	Legend For Geologic Profiles	119
4–6	Representative Preconsolidation Pressure of In-situ Soils	129

LIST OF TABLES

TABLE		PAGE
2-1	General Information Regarding Borings and Test Pits	9
2-2	Number of Valid Tests Performed in Investigations Conducted Prior to 1988	12
2-3	Number of Tests Performed in MKE Phases I and II Investigations	13
2-4	Total Number of Valid Tests Performed as of 1990 and the Recommended Minimum Number of Geotechnical Laboratory Tests	15
3-1	Average Values of Laboratory Testing Results From Previous (Pre-1988) Investigations	19
3-2	Summary of Soil Testing Programs	21
3-3	Number and Types of Laboratory Test Activity According to Specific Areas	24
3-4	Summary of Soil Test Results (Phase I, II and III)	26
3-5	Summary of Averaging of Index Properties for Overall Site Area	40
3-6	Summary of Averaging of Index Properties for Disposal Cell Area	41
3-7	Summary of Averaging of Index Properties for Potential Borrow Source No. 1.	42
3-8	Legend of Symbols used in Graphs	44
3-9	Additional Soil Properties Calculated from Average Values of Test Results	66
3-10	Laboratory CBR Test Results	102
3-11	Summary of Consolidation Parameters from Tests on Undisturbed Samples	103
3-12	Summary of Coefficient of Permeability for Undisturbed On-Site Soils	106
3-13	Summary of Coefficient of Permeability for Remolded On-Site Soils	108
3-14	Summary of Coefficient of Permeability for Remolded Borrow Soils	109
3-15	Corrosivity Test Results	111
3-16	Typical SPT Blow Counts for Various Soil Units	113
4-1	Recommended Unit Weights and Strength Parameters for Stability Analysis for In-Situ Soil Units and Compacted Fill Materials	124
4-2	Recommended Soil Parameters for Settlement Estimates for DF	125
4-3	Relationship Between Atterberg Limits and Volume Change of Material	131

1 INTRODUCTION

1.1 Objectives

This report presents the results of Phases I, II and III geotechnical investigations conducted by the Project Management Contractor (PMC) and soil parameters and other recommendations for the design of a disposal facility (DF) for the Weldon Spring Site Remedial Action Project (WSSRAP). The geotechnical investigations were conducted to support the remedial investigation, feasibility study, siting, design and construction of a proposed disposal facility in the vicinity of the Chemical Plant at the Weldon Spring Site (WSS); and to provide data for design of various on-site areas and temporary facilities such as the administration building, Raffinate Pit Dike No. 4, Temporary Storage Area (TSA), Material Staging Area (MSA) and the Water Treatment Plant (WTP) facilities. The Phase II investigation also included an exploration of two off-site borrow areas as potential sources of clayey soils.

The WSSRAP Chemical Plant Geotechnical Investigations Report (MKF and JEG 1990b), which contains an abridged treatise on the background, surface feature, geology and hydrogeology of the site and presents the PMC Phases I and II (also referred to as MKE or MKES Phases I and II) geotechnical field investigation and laboratory test results, should be used as a supplemental document for this report. To avoid repetition in presenting the background and Phases I and II investigation testing results, the geotechnical investigation report (MKF and JEG 1990b) is referred to frequently herein.

1.2 Scope

This report specifically addresses the geotechnical engineering aspects of the subsurface soils within the vicinity of the proposed cell(s) of the disposal facility and suitable clayey materials from potential borrow sources for the design of a disposal cell at the WSS. The scope does not cover geotechnical engineering aspects of all areas investigated and is limited to the scoping items listed below:

1. Collect, organize, reduce and evaluate available geotechnical test results from MKE Phases I, II and III programs. Summarize findings in tables, charts and graphs.

2. Prepare geotechnical cross-sections (geologic profiles).

3. Develop conclusions and recommendations of geotechnical parameters for the investigated soils for disposal cell design calculations on foundation settlement, cover and liner material, cracking potential, embankment stability and subgrade bearing.

The scope does not include the following specific items that were addressed in separate studies or reports.

1. Geophysical investigation assessment.

2. Geotechnical engineering conclusions and recommendations for the excavation and removal of the raffinate pit dikes and sludges, and the design and construction of the TSA, MSA, WTP facilities and access and haul roads.

3. Hydraulic conductivity of the subsurface soil strata.

4. Geology and hydrogeology of the WSS.

5. Contamination of the subsurface soils.

6. Conclusions and recommendations for design elements not listed in Scoping Item 3.

1.3 Background

The WSSRAP is being conducted as a major System Acquisition under the Surplus Management Program (SFMP) of the United States Department of Energy (DOE). The major goals are to eliminate the potential hazards to the public and the

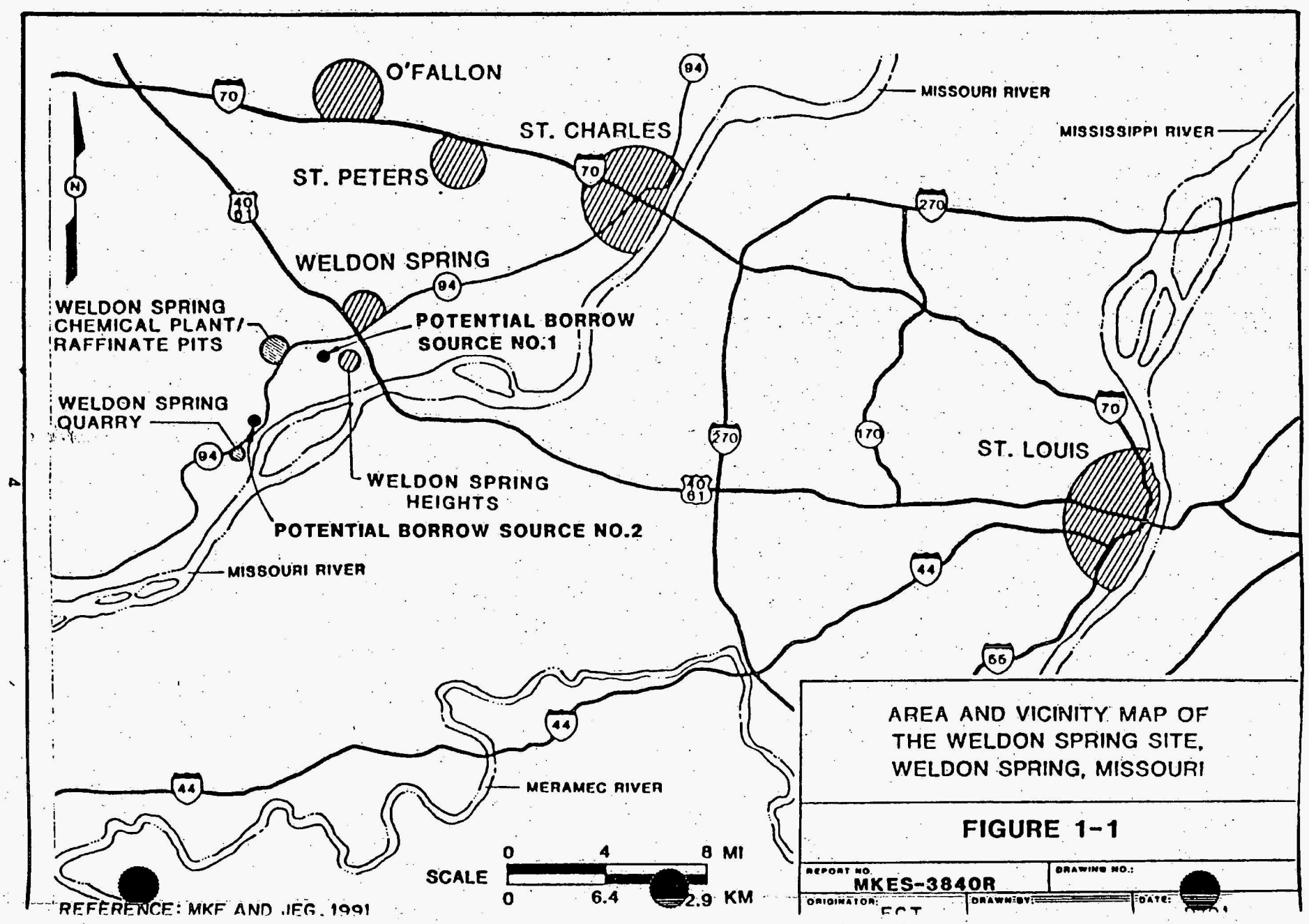
environment that are associated with contamination at the WSS and, to the extent possible, to make surplus real property available for other uses.

As illustrated in Figure 1-1, the WSS is located approximately 30 miles west of St. Louis, Missouri, in southwestern St. Charles County. The site is in an area just west of Missouri State Highway 94, approximately 2 miles southwest of its junction with U.S. Highway 40 (Interstate 64). The respective locations of potential off-site Borrow Source Nos. 1 and 2, for low permeability (clayey) soil are approximately two miles east and south of the WSS. It should be noted that Borrow Source No. 1 is located across Highway 94 from the WSS.

The embankment portion of the proposed disposal facility (DF), also referred to as the disposal cell, will be used for long-term storage of untreated, treated and/or processed contaminated waste materials from the WSS. The possible limit suitable for the disposal facility, as identified in the Siting Study (MKES 1991b), and various proposed and existing temporary facilities are shown in Figure 1-2.

1.4 Other Related Studies and References

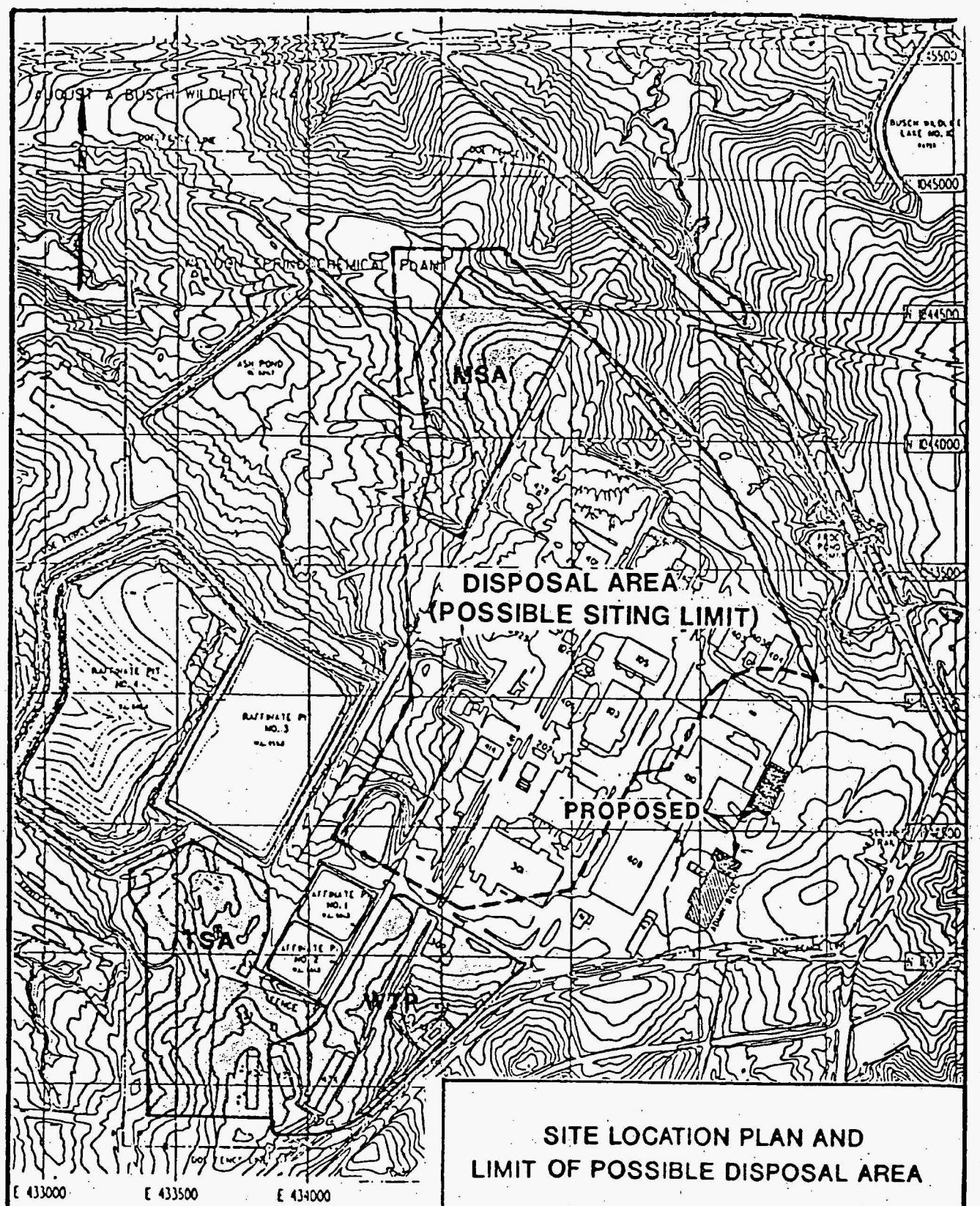
The PMC Phases I, II, and III geotechnical investigations were conducted by MK Environmental Services (MKES) as part of the PMC field data collection for the remedial investigation/feasibility study process. In addition to providing geotechnical parameters for DF design, the data and results were used to support other remedial investigation (RI) documents and special studies, including the RI report (MKF and JEG 1990c), site suitability study (MKF and JEG 1990a), chemical plant (site) geotechnical investigations report (MKF and JEG 1990b), grading plan study (MKES 1991d), liner and foundation studies (MKES 1991c); and temporary facilities design including the TSA, MSA and WTP. Brief descriptions of these facilities were included in Section 1 of the geotechnical investigations report (MKF and JEG 1990b).



AREA AND VICINITY MAP OF THE WELDON SPRING SITE, WELDON SPRING, MISSOURI

FIGURE 1-1

REFERENCE: MKE AND JEG, 1991



LEGEND:

- EXISTING BUILDING TO REMAIN
- PERMANENT BUILDING TO BE ADDED

500 0 500

SCALE FEET

SITE LOCATION PLAN AND
LIMIT OF POSSIBLE DISPOSAL AREA

FIGURE 1-2

REPORT NO.	DRAWING NO.:	
MKES-3840R		
ORIGINATOR: ECT	DRAWN BY:	DATE: 9/91

2 SYNOPSIS OF GEOTECHNICAL INVESTIGATIONS

2.1 General

Field investigations of the subsurface strata at the Weldon Spring Site (WSS) have been conducted by various organizations since 1955 for site characterization, geophysical studies, hydrogeology studies and acquisition of data for design of on-site facilities. As part of these investigations, 167 boreholes (including borings drilled for installation of monitoring wells) have been drilled and 41 test pits have been excavated. Locations and identifying numbers for these holes, wells and test pits are shown in Figure 2-1. General information regarding each series of borings and test pits is presented in Table 2-1. The results of these investigations and the investigation for low-permeability soils at two potential borrow sources near the site (see Figures 1-1 and 2-2), are discussed herein.

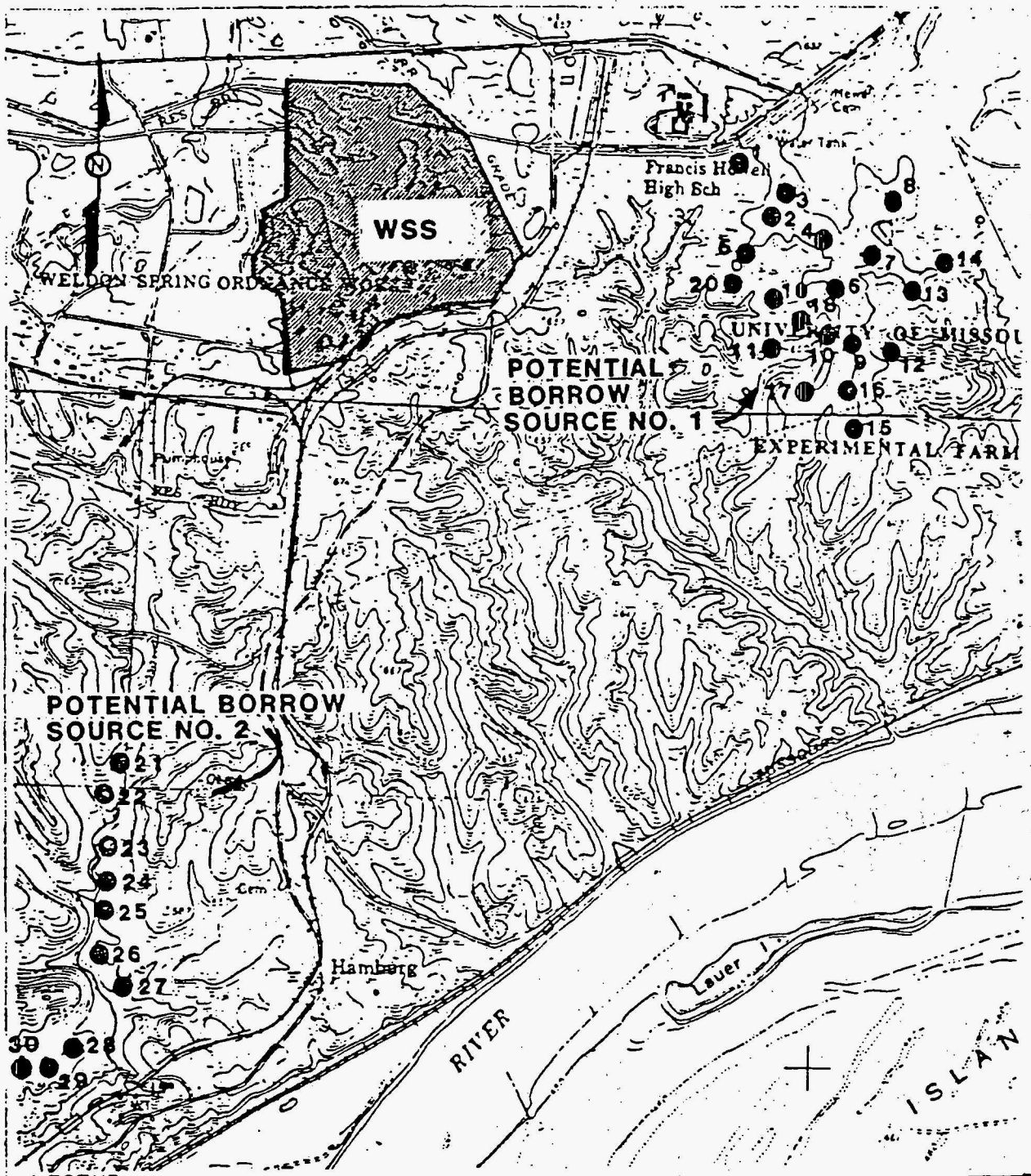
Brief synopses of investigations preceding Phase III are presented in Sections 2.2 through 2.4 below. The Phase III investigation is described in detail in Section 2.5.

2.2 Previous Field Investigations By Others

Previous geotechnical investigations by various organizations other than the PMC and the years when they were performed are listed below. Numbers in parentheses represent the year in which the corresponding reports were published.

- U.S. Army Corps of Engineers (COE) - 1954 (1955, 1970)
- Henry M. Reitz Consulting Engineers (HMR) - 1963 (1964)
- Bechtel National, Inc. (BNI) - 1982-1984 (1984)
- Bechtel National, Inc. (BNI) - 1986 (1987)

The PMC and its off-site engineering support group (primarily MKES) have reviewed and evaluated these geotechnical investigations in depth. The purposes of



REFERENCE: MKF AND JEG, 1991
SOURCE MAP: USGS QUAD MAP

OFF-SITE CLAY BORROWS SOURCES
TEST PIT LOCATION MAP

FIGURE 2-2

REPORT NO. MKES-3840R	EXHIBIT NO.	
ORIGINATOR ECT	DRAWN BY JM	DATE 9/91

Table 2-1

General Information Regarding Borings and Test Pits

Designation	Type and Area	Firm/Agency	Year
AH-1 and AH-2	Angled borehole number - chemical plant area	PMC (Phase II)	1989
B-1 to B-22	Borehole number - raffinate pit area	Bechtel National, Inc.	1983
B-15A, etc.	Replacement hole for B-15	Bechtel National, Inc.	1983
G-1 to G-24	Borehole number - chemical plant area	Bechtel National, Inc.	1986
G-54-1 to G-54-11	Borehole number - chemical plant area	Corps of Engineers	1954
GMW-3 series	Borehole completed as a monitoring well (NG)	Bechtel National, Inc.	1986
GT-2T71 to GT-2T82	Test pit number - chemical plant area	PMC (MKES Phase I)	1988
GT-31 to GT-36	Borehole number - raffinate pit No. 4	PMC (MKES Phase I)	1988
GT-37 to GT-41	Borehole number - admin. bldg. area	PMC (MKES Phase I)	1988
GT-42 to GT-57	Borehole number - chemical plant area	PMC (MKES Phase I)	1988
GT-58P to GT 67P	Borehole number - chemical plant area -P added if hole completed as piezometer	PMC (MKES Phase II)	1989
GT-68 to GT-74	Borehole number - chemical plant area	PMC (MKES Phase III)	199[illegible]
GTS-1 to GTS-7	Borehole number - temporary storage area	PMC (MKES Phase II)	198[illegible]
MW-2001 series	Monitoring well number - within chemical plant area (NG)	PMC	1988-1989
MW-3001 series	Monitoring well number - wells completed adjacent to the Chemical plant area (NG)	PMC	1988-1989
MW-4001 series	Monitoring well number - wells completed outside WSS area (NG)	PMC	1988-1989
PW-1 to PW-3	Pumping well number - Chemical Plant Area (NG)	PMC	1989
OB-2j	Observation well adjacent to pumping well (NG)	PMC	1989
T-1 to T-6	Backhoe trench number	Bechtel National, Inc.	1986
TPBS-1 to TPBS-30	Test pit number - borrow source area	PMC (MKES Phase II)	1989
TPMS-1 to TPMS-9	Test pit number - materials storage area	PMC (Phase II addition)	1990
TR-1 to TR-15	Trench number - Chemical Plant Area	Bechtel National, Inc.	1983

NOTES: NG stands for Non-Geotechnical holes.
Reference: MKF and JEG 1990b

each investigation and the findings are summarized and presented in the Geophysical/Geotechnical Investigation Sampling Plan Report (MKF and JEG 1988).

2.3 PMC Phase I and Phase II Investigations

The Geophysical/Geotechnical Investigation Sampling Plan (MKF and JEG 1988) proposed additional investigations necessary to demonstrate the suitability of the site for construction of a satisfactory disposal facility. The PMC Phases I and II Investigations, conducted in 1988 and 1989 respectively, were based on the sampling plan recommendations and the conceptualized disposal cell areas identified from 1987 through 1989. The geotechnical aspects of these investigations consisted of engineering characterization of the subsurface soils in the raffinate pit dike No. 4, the administration building area, the Temporary Storage Area, and the proposed disposal cell area in the chemical plant vicinity. These investigations also included the evaluation of the on-site upper strata materials and potential off-site borrow source clayey materials as possible fill materials for the remedial action.

A total of 46 boreholes and 51 test pits were completed in these two phases. Details of these investigations were presented in the Chemical Plant geotechnical investigations report (MKF and JEG 1990b).

2.3.1 Disposal Facility Area

The WSS disposal facility (DF), as proposed in 1987 and 1988 and for which the Phase I and Phase II investigations were performed, was located in a rectangularly shaped area approximately bounded by a line 750 feet west of the eastern site boundary, the limits of the existing chemical plant buildings at the north end, and raffinate pits No. 1 and No. 3 on the southern and western sides, respectively. It should be noted that the current conceptual DF area has been extended into the northwestern corner where the Material Staging Area is currently located. The area to be covered by the disposal facility has changed from approximately 36 acres in the 1987 and 1988 conceptual studies, to 56 acres in the 1991 conceptual siting study.

2.3.2 Areas Outside the Disposal Facility Area

Other site facility areas investigated during the Phase I and Phase II investigations include: the administration building, the raffinate pit dike No. 4, the Temporary Staging Area, and the Material Staging Area. The Phase III investigation included the site water treatment plant facilities. Figure 1-2 indicates the approximate locations of these facilities.

2.3.3 Potential Borrow Sources

Potential borrow materials for construction consist of on-site uncontaminated subsurface soils (within the upper 15 feet where excavation may take place but possibly excluding some unsatisfactory loess and fill) for general fill, and selected off-site clayey borrow sources (Sources No. 1 and 2) for low permeability liner or cover materials for DF construction as well as for general fill. Additional borrow source investigations will be performed under other PMC support studies (not part of this scope).

2.4 Assessment of Pre-Phase III Investigations

In 1991, the conceptual layout of the disposal cell was revised and expanded to adjust for updated waste quantity and design criteria changes, as presented in the siting study report (MKES 1991a). Based on this study, an assessment of the deficiency of previous geotechnical data was completed and planning for an additional investigation to obtain the required additional data (PMC Phase III investigation) was performed. This assessment, which is described below, is specifically intended for the design of the disposal cell and the site water treatment plant facilities, and does not include off-site borrow sources nor other site construction facilities. As stated above, additional investigation of off-site borrow sources will be evaluated by other supporting studies.

To assess the data deficiency, the numbers of valid laboratory tests performed in previous investigations were summarized. A valid test is one where testing procedure and result appear reasonable. The numbers of tests performed on samples of various WSS subsurface soil strata in investigations prior to 1988 are presented in Table 2-2. The numbers of tests performed in PMC Phases I and II geotechnical investigations are listed in Table 2-3. The number of tests performed as of the end of 1990 (Pre-PMC

TABLE 2-2
NUMBER OF VALID TESTS PERFORMED IN
INVESTIGATIONS CONDUCTED PRIOR TO 1988

TESTS	Ferrelview Clay			Clay Till			Basal Till		
	BNI (1984)	BNI (1987)	TOTAL	BNI (1984)	BNI (1987)	TOTAL	BNI (1984)	BNI (1987)	TOTAL
Sieve Analysis	5	10	15	2	18	20	-	6	6
Atterberg Limits	5	8	13	2	16	18	-	5	5
Shrinkage Limit	-	-	-	-	-	-	-	-	-
Specific Gravity	4	11	15	2	17	19	-	1	1
In situ Moisture	15	7	22	7	15	22	-	3	3
In situ Dry Density	12	7	19	5	14	19	-	5	5
Compaction	-	-	3 *	-	-	-	-	-	-
U U Test	1	-	1	-	-	-	-	-	-
C U Test	1	-	1	-	-	-	-	-	-
Consolidation	-	-	-	-	-	-	-	-	-
Permeability	-	-	-	-	-	-	-	-	-

No tests were performed on Topsoil/Fill, Loess or Residuum

* 1 Compaction test by COE, 2 by HMR

Ref : MKF & JEG 1988

TABLE 2-3
NUMBER OF TESTS PERFORMED IN
MKE PHASES I & II INVESTIGATIONS

TESTS	Loess	Ferrelview Clay	Clay Till	Basal Till	Residuum	TOTAL
Sieve Analysis	12	39	14	4	7	76
Atterberg Limits	13	45	10	2	2	72
Shrinkage Limit	5	7	1	0	0	13
Specific Gravity	4	23	10	2	2	41
In situ Moisture	17	71	16	3	12	119
In situ Dry Density	11	33	15	3	4	66
Compaction	0	16	0	0	0	16
U U Test	1	12	2	1	0	16
C U Test	1	7	2	1	1	12
Consolidation	2	10	6	0	3	21
Permeability	3	13	9	3	2	30

Phase III) and the recommended minimum number of tests from the sampling plan (MKF and JEG 1988) are shown in Table 2–4.

The deficiencies identified below arise mainly from the changes in the conceptual plan of the disposal cell from 1988 until the present, and the lack of good quality undisturbed samples for the Clay Till, Basil Till and Residuum materials. The results of the deficiency analysis for each soil stratum are:

- Topsoil/Fill and Loess – These two layers are scheduled to be removed and hence the numbers of tests performed on these layers are considered to be adequate from a foundation design standpoint.

- Ferrelview (Formation) clay - Though this layer seems to have been adequately sampled and tested for previous cell locations, there are certain geographic regions, mainly the northwestern corner and the northern and southern portions of the potential disposal cell area, where additional data are needed because of the possible extensions of the disposal facility into these areas. Additional information is also needed for the design of temporary facilities such as the site water treatment plant and retention ponds. Therefore additional tests, including strength and consolidation tests, are recommended for the Phase III testing program.

- Clay Till - The previous investigations (pre-1988, MKE Phase I and MKE Phase II) of this soil stratum concentrated mainly on classification testing of disturbed samples due to the lack of undisturbed samples for strength and consolidation tests. Additional testing is required in Phase III to remedy this deficiency.

- Basal Till and Residuum - The number of tests on Basal Till does not meet the requirements given in Table 2–4. Testing of Residuum is also minimal due to the lack of soil samples. However, because of the depth and the anticipated strength and stiffness of these materials, the impact to the disposal cell design is minor and therefore, the normal minimum test requirement of 3 to 5 tests for strength and consolidation parameters can be waived to

TABLE 2-4
TOTAL NUMBER OF VALID TESTS PERFORMED AS OF JULY 1991
AND THE RECOMMENDED MINIMUM NUMBER OF
GEOTECHNICAL LABORATORY TESTS

TESTS	Loess		Ferrelview Clay		Clay Till		Basal Till		Residuum	
	Performed as of 1991	ecommended minimum (1)	Performed as of 1991	ecommended minimum (1)	Performed as of 1991	ecommended minimum (1)	Performed as of 1991	ecommended minimum (1)	Performed as of 1991	ecommended minimum (1)
Sieve Analysis	20	(2)	45	5	17	5	9	5	12	(2)
Atterberg Limits	22		48	12	15	12	7	12	3	
Shrinkage Limit	4		4	-	1	-	0	-	0	
Specific Gravity	6		24	3	10	3	5	3	4	
In situ Moisture	25		59	18	24	18	7	18	14	
In situ Dry Density	10		31	18	21	18	6	18	7	
Compaction	0		16	2	0	2	0	2	0	
U U Test	6		13	5	4	5	2	5	0	
C U Test	3		8	3	3	3	3	3	1	
Consolidation	3		11	5	7	5	3	5	3	
Permeability	14		35	5	16	5	6	5	5	

(1) Ref : MKF & JEG 1988
(2) No minimum number was recommended for Loess and Residuum materials

reduce time and cost factors. Undisturbed samples obtained from the Phase III investigation were tested to determine soil characteristics.

2.5 PMC Phase III Investigation

The PMC Phase III geotechnical investigation was conducted between April and September 1991. The field activity, consisting of the drilling and sampling of 7 boreholes at the WSS, was completed on April 15, 1991; and the laboratory testing of soil samples, conducted by Chen-Northern, Inc. and JTC Environmental Consultants, Inc., was completed in August 1991. The locations of the boreholes, numbered GT-68 through GT-74, are shown in Figure 2-1. Drilling was performed by Geotechnology Services, Inc. under the supervision of a geotechnical engineer from M-K Environmental Services. A field report and the boring logs are presented in Appendix A-1 and A-2, respectively.

Drilling was accomplished with a Central Mining Equipment CME-750 drill rig using continuous hollow-stem flight-augers having an outside diameter (O.D.) of 7.5 inches and an inside diameter (I.D.) of 3.75 inches. All holes were drilled to auger refusal at the top of bedrock. No rock coring was performed and groundwater level was not measured.

Soil sampling was performed on 2.5 foot centers. Disturbed soil samples were obtained using a 2.0-inch O.D., 1.5-inch I.D. Standard Penetration Test (SPT) sampler. Selected portions of each SPT sample were placed in capped glass jars. Relatively undisturbed samples were obtained using a California split-barrel sampler having an O.D. of 3.0 inches and I.D. of 2.5 inches. Four 6-inch long, 2.5-inch I.D. brass liners were placed inside the California sampler to retrieve samples. Each retrieved, 6-inch liner was capped and taped. Both the SPT and California samplers were driven a depth of 18 inches beyond the lead auger using a 140-pound safety hammer, free-falling 30 inches. The number of blows required to drive the SPT sampler for each 6-inch interval was recorded and the final two 6-inch drives were summed and expressed as blows per foot (commonly known as STP blow counts for the STP method). Undisturbed samples, where possible, were obtained by hydraulically pushing 3.0-inch diameter, 36-inch long steel Shelby tubes to a depth of 30 inches. Upon retrieval, both ends of the tube were sealed with molten bee's wax, capped, and taped. Any excess

space in the tube after waxing was filled with cuttings to prevent or minimize movement of the sample within the tube.

Soils encountered were described in accordance with the Unified Soil Classification System (USCS). Samples not selected for testing were stored on-site in Building 410.

All borings were abandoned by plugging with Volclay Grout manufactured by American Colloid Company, following standard procedure performed in earlier WSSRAP investigations.

3 SUMMARY OF TESTING PROGRAMS AND RESULTS

3.1 Summary of Geotechnical Testing Programs

The purpose of the laboratory testing programs was to provide geotechnical data to characterize the subsurface soils and potential clayey Borrow Source Nos. 1 and 2 for use in various studies and design of the proposed disposal cell and related facilities. Geotechnical engineering parameters were or will be developed from laboratory test results and substantiated by comparison to field data and empirical values.

Test results from the pre-PMC investigations (prior to 1988) were reviewed and evaluated by the PMC in 1988. The findings were presented in the Geophysical/Geotechnical Investigation Sampling Plan (MKF and JEG 1988). For reference, Table 3-1 shows the summary of average test results from pre-PMC investigations. The numbers of valid results from tests of each type performed in these investigations are shown in Table 2-2.

The PMC geotechnical laboratory testing programs for Phases I, II and III investigations were conducted by various laboratories from June 1988 to July 1991. The numbers and types of all tests performed for each soil stratum under these three phases are listed in Table 2-4. A total of 9 testing programs for the disposal cell site vicinity, intermittently numbered one through twelve, were implemented. Table 3-2 summarizes the dates each program was transmitted for testing and the respective laboratory assigned for the testing. These programs were planned in stages to facilitate testing as samples were obtained during field investigations. Typically, each program specified which soil samples would be tested, the type of tests, the testing methods and specific testing instructions.

The five laboratories that conducted the testing were:

- Chen-Northern, Inc., Denver, CO
- Geotechnology Engineering and Environmental Services Inc. (Geotechnology), St. Louis, MO

TABLE 3-1: AVERAGE VALUES OF LABORATORY TESTING RESULTS FROM PREVIOUS (PRE-1988) INVESTIGATIONS. (Sh. 1 of 2)

Unit	Statistic[a]	% of Grain Size: Gravel	Sand	Silt	Clay	Liquid Limit[b]	Plastic Index	Unified Soil Classif.	Specific Gravity (g/cm^3)	Unit Weight (lb/ft^3): Dry	Wet	Moisture Content Equiv. (%)	Centrifuge Moisture (%)
Loess	Ma	0	4.4	64	31.6	30	13	CL	2.58	98.8	110.0	--	--
	S	0	1.3	3	4.0	--	--	--	--	7.1	12.4	--	--
	N	5	5	5	5	1	1	1	1	6	6	0	0
Ferrelview Formation	Ma	2.8	9.8	49.6	39.6	52.2	35.1	CL-CH	2.61	101.3	122.3	24.7	45.4
	S	4.1	5.5	6.9	10.9	7.8	7.5	--	0.07	12.4	9.4	0.6	8.5
	N	10	10	10	10	8	8	8	11	8	8	7	5
Clay Till	Ma	0.4	22.4	31.7	45.6	50.3	34.2	CL	2.60	104.8	123.8	19.3	39.7
	S	1.0	4.5	2.4	4.5	10.5	8.4	--	0.09	4.4	7.0	3.0	5.7
	N	18	18	18	18	16	16	16	18	14	14	15	13
Basal Till	Ma	10.7	18.7	39.8	30.8	41.6	23.6	GC-CL	2.45	99.8	118.6	20.9	38.5
	S	17.1	14.3	23.0	8.1	14.1	11.7	--	--	7.8	8.1	3.8	2.1
	N	6	6	6	6	5	5	5	1	5	5	3	2
Fill	Ma	20	48	19	13			SM	2.45				
	S	--	--	--	--			--	--				
	N	1	1	1	1			1	1				

(a) Statistics given are: Ma - mean; S = sample standard deviation; N = number of test results in computation of statistic

(b) Blanks indicate data of the type indicated were not available in the Bechtel National (1987) reference

(c) Void ratio = (specific gravity x unit weight of water -1)/dry unit weight

(d) Specific retention - centrifuge moisture equivalent x 0.80

(e) Specific yield = porosity - specific retention

(f) Saturation = (specific gravity x moistre content)/void ratio

(g) Activity = plastic index/percent of clay

TABLE 3-1: (CONT.) AVERAGE VALUES OF LABORATORY TESTING RESULTS FROM PREVIOUS (PRE-1988) INVESTIGATIONS. (Sh. 2 of 2)

Unit	Statistic[a]	Void Ratio[c]	Porosity (%)	Specific Retention (%)[d]	Specific Yield (%)[e]	Saturation[f]	Activity[g]	Effective Cation Exch. Cap. (meq/100g)	Distribution Ratio (mg/l)
Loess	Ma	--	--	--	--	--	--	--	--
	S	--	--	--	--	--	--	--	--
	N	--	--	--	--	--	--	0	0
Ferrelview Formation	Ma	0.61	38	36	2	100	0.89	60.3	54.8
	S	--	--	--	--	--	--	0.1	9.7
	N	--	--	--	--	--	--	2	2
Clay Till	Ma	0.55	35	32	3	91.2	0.75	69.0	34.2
	S	--	--	--	--	--	--	11.7	6.2
	N	---	--	--	--	--	--	2	2
Basal Till	Ma	0.53	35	31	4	96.6	0.77	29.0	206
	S	--	--	--	--	--	--	--	--
	N	--	--	--	--	--	--	1	1
Fill	Ma	--	--	--	--	--	--		
	S	--	--	--	--	--	--		
	N	--	--	--	--	--	--		

[a]Statistics given are: Ma = mean; S = sample standard deviation; N = number of test results in computation of statistic

[b]Blanks indicate data of the type indicated were not available in the Bechtel National (1987) reference

[c]Void ratio = (specific gravity x unit weight of water -1)/dry unit weight

[d]Specific retention = centrifuge moisture equivalent x 0.80

[e]Specific yield = porosity - specific retention

[f]Saturation = (specific gravity x moisture content)/void ratio

[g]Activity = plastic index/percent of clay

See Section 12 for SI conversion factors

TABLE 3-2 Summary of Soil Testing Programs

TEST PROGRAM #	REQUEST NO.	DATE REQUESTED	PURPOSE	LABORATORY
1	1	06/23/88	Administration Building	Chen-Northern, Inc.
2	2	07/27/88	Raffinate pit No. 4	Chen-Northern, Inc.
3	3	10/14/88	Disposal cell	Chen-Northern, Inc.
5	2A	05/26/89	Disposal cell	Geotechnology/metaTRACE/Chen-Northern
6	3A	06/26/89	Borrow sources	Geotechnology/metaTRACE/Chen-Northern /Hannibal Testing
7	2B	08/25/89	Disposal cell	Geotechnology Services, Inc.
8	5	10/11/89	Temporary Storage Area	Geotechnology Services, Inc.
11	8	08/03/90	Material Staging Area	Geotechnology Services, Inc.
12		05/08/91	Chemical Plant and Site WTP	Geotechnology Services, Inc.

- MetaTRACE, Inc., Earth City, MO
- Hannibal Testing Laboratories, Inc. (HTL), Hannibal, MO
- JTC Environmental Consultants, Inc. (JTC), Maryland, MO

Chen-Northern performed the first group of tests, in 1988. Geotechnology performed the laboratory testing in 1989 and 1990, except for the cation exchange capacity tests and the capillary moisture tests, which were subcontracted to metaTRACE, Inc. and to Chen-Northern, Inc., respectively. In situ samples taken by drive tube methods from the vertical walls of off-site clay borrow test pits in 1989 were tested by Hannibal Testing Laboratory for natural moisture content and dry density. Chen-Northern again performed soil tests in 1991; and the soil chemical tests were performed by JTC Environmental Consultants, Inc.

Soil test samples from 1988 were shipped in specially constructed wooden boxes to Chen-Northern in Denver by overnight air freight. These samples were discarded following the testing. Samples designated for Geotechnology were transported to their St. Louis location in site vehicles. The samples from the material staging area were returned to the site for storage for possible future testing. The rest were discarded after testing. Samples for Chen-Northern in 1991 were transported to the Denver location by air. Samples for JTC were transported by land to the Maryland location. These samples are being stored at the laboratories after testing and will be discarded 12 months following completion of the test program.

Standard test methods were used to conduct the testing to follow standard practices and to assure that the laboratory test results are reliable and compatible with empirical correlations. Most of the laboratory soil tests were performed in accordance with the American Society for Testing and Materials (ASTM) standard test procedures (ASTM 1991). The triaxial shear tests, which included the consolidated undrained compression tests with pore pressure measurements (R tests), the unconsolidated undrained compression tests (Q tests), and the triaxial constant-head permeability tests, were all performed in accordance with the methods described in U.S. Army Corps of Engineers Manual EM 1110-2-1906 (COE 1970). The cation exchange capacity test

was performed in accordance with U.S. Environmental Protection Agency's (EPA 1988) SW 846, 3rd edition, Test Method 9081. The pH, sulfate content, and chloride content tests for soil corrosivity were performed in accordance with EPA Methods for Chemical Analysis of Water and Wastes (MCAWW) test methods (EPA 1982).

Special instructions or slight modifications to the standard test methods were included in the test programs. These usually included specified confining pressures for triaxial shear and consolidation tests, consolidation loading increments, and density and water content for remolded specimens.

The laboratory tests and methods used in the testing programs included (ASTM 1990, COE 1970, SCS 1967, EPA 1982 and 1988):

- Sieve Analysis - ASTM C136
- Sieve Analysis with Hydrometer - ASTM D422
- Atterberg Limits - ASTM D4318
- Shrinkage Limit - ASTM D427
- Unit Weight/Void Ratio - ASTM C29
- Specific Gravity - ASTM D854
- Moisture Content - ASTM D2216
- Dry Density - ASTM D2937
- One Dimensional Consolidation Test - ASTM D2435
- Triaxial (R) Compression Test - EM 1906, Appendix X
- Triaxial (Q) Compression Test - EM 1906, Appendix X
- Triaxial Permeability - EM 1906, Appendix VII
- Capillary-Moisture Relationships - ASTM D2325 and D3152
- Moisture-Density Relationships - ASTM D698
- Cation Exchange Capacity - EPA SW 846, #9081
- Sulfate and Chloride Contents - MCAWW 325.3 and 375.4
- Acidity/Alkaline, pH - MCAWW 150.1
- Percent Solids - MCAWW 325.3
- Soil Resistivity - ASTM G57, with modification.

Table 3-3 shows the number of tests by each test method on samples from the administration building area, the material staging area, the raffinate pit No. 4 dike, the

TABLE 3-3 : NUMBER & TYPE OF LABORATORY TEST ACTIVITY ACCORDING TO SPECIFIC AREAS

TESTS	CHEMICAL PLANT	MATERIALS STAGING AREA	RAFFINATE PIT # 4 DIKE	BORROW SOURCES	ADMINISTRATION BUILDING
Sieve Analysis	46	17	16	18	6
Atterberg Limits	35	16	14	20	10
Shrinkage Limit	4	-	-	4	7
Specific Gravity	30	-	3	13	3
In situ Moisture	82	-	16	20	11
In situ Dry Density	57	-	10	-	8
Compaction	13	16	-	12	1
U U Test	17	-	-	6	2
C U Test	7	-	5	6	-
Consolidation	21	-	-	3	3
Permeability	45	17	1	13	-
Capillary Moisture	8	-	-	12	-
Cation Exchange Capacity	8	-	-	6	-

clay borrow sources, and the chemical plant area including the TSA. A brief discussion of the significance and applicability of each type of test and test results is presented in the following sections.

Table 3-4 shows the summary of all soil test results from the MKE Phases I, II and III investigation programs. Laboratory test data and results (Phases I and II) received by the PMC prior to December 1990 were presented in the Appendix of the geotechnical investigations report (MKF & JEG 1990b). Test data results (Phases II and III) received by the PMC after December 1990 are included in Appendix B.

3.2 Subsurface and Potential Borrow Source Materials and Data Reduction

The soils for testing consisted of the subsurface soils at the WSS and clayey soils in the two selected potential clayey borrow sources shown in Figure 1-1.

The subsurface (overburden) soils at the WSS were grouped according to the geologic stratified units identified during field investigations and soil data reduction. Geologic profiles (cross sections) were generated based on boring log data and test results (Figures 4-1 through 4-4). The geologic units encountered at the site, from original ground surface to top of weathered bedrock, are: Topsoil, Fill, Loess, Ferrelview clay, Clay Till, Basal Till and Residuum. Most of the subsurface soils at the site were clayey soils with varying degrees of silty, sandy or gravelly contents. A small percentage, usually within the loess or deeper geologic units such as the basal till and the residuum, were clayey silt or clayey gravels. A summary description of each geologic unit (also referred to as soil unit or soil type) from the earlier reports (MKF and JEG 1990a and b) is presented here for reference.

- Topsoil/Fill - The uppermost soil unit at the site consists of large areas of disturbed fill and a thin veneer (less than 6 inches) of top soil. Fill is highly variable in thickness and composition. Large volumes of fill were used in constructing the existing dikes for the raffinate pits and Ash Pond (up to 20 feet thickness). Fill was also used for general site embankment construction, site grading, and drainage control prior to the construction of the chemical plant structures.

TABLE 3-4 : SUMMARY OF SOIL TEST RESULTS

Job No. 3840 Project Name WSSRAP Feature Geotechnical Characterization

Test Pit Number	Sample Number	Depth From	Depth To	Lab Class USCS	Mechanical Analysis Gravel	Sand	Fines	Atterberg Limits LL	PI	Shrinkage Limit	Specific Gravity G	Natural w	γ_d	Compaction* Optimum w	γ_d	Shear Strength Test	Initial w av	γ_d av	c	phi	Consolidation Co	Cr	Pp	Permeability w	γ_d	k (Conf Pr)	Capillary Moisture	Cation Exch Cap	Calif Bearing Ratio	Soil Unit
		ft	ft		%	%	%	%	%	%		%	pcf	%	pcf		%	pcf	psf	deg			ksf	%	pcf	cm/sec (ksf)	%	meq/100g		
GT-31	ST-02	4.0	6.5	CL	0	10	90	36	20		2.68	20.9	103.1																	F
	ST-06	18.0	20.5		0	4	96					20.1	104.6																	F
GT-32	ST-01	1.0	3.5	CL	0	4	96	32	13			20.1	101.4			CU	27.3	97.2	c=550 c'=330	ϕ=25 ϕ'=40										L
	ST-02	9.0	10.5	CH	0	15	85	64	46			26.4	90.5			CU	30.7	92.5	c=410 c'=110	ϕ=10 ϕ'=21										F
	ST-03	18.5	21.0		3	8	89					36.3	82.9																	C
GT-33	ST-04	5.0	7.5	CL	0	4	96	45	27							CU	30.6	92.5	c=600 c'=610	ϕ=5 ϕ'=8				32.0	90.4	1.1E-7 (0.12)				D
	ST-14	22.0	24.5	CL	0	6	94	30	10			15.7	100.7																	L
GT-34	SS-05	7.0	8.5	CH	0	20	80	55	38			20.8																		D
	SB-17	27.0	28.5	CL	0	7	93	40	23			15.4	111.0																	F
GT-35	SS-02	3.0	4.5	CH	0	10	90	59	41			22.5																		D
	SS-08	13.0	14.5	CL	0	14	86	49	31		2.63	18.9																		D
	SS-11	17.5	19.0									16.0																		D
	SB-15	25.0	26.5	CL	0	5	95	42	23			20.8	104.6			CU	23.3	103.5	c=330 c'=400	ϕ=14 ϕ'=20										D
	SS-20	31.0	32.5	CL	0	1	99	45	23			19.8																		L
GT-36	ST-06	8.5	11.0	CL	0	22	78	48	32			22.6	100.2			CU	24.5	101.5	c=180 c'=160	ϕ=18 ϕ'=24										D
	SS-09	14.0	15.5	CL	0	5	95	43	24			23.8																		D
	ST-12	18.5	21.0	CL	0	1	99	46	29		2.70	21.5	97.8																	L
GT-37	SB-01	1.5	3.0	CH				58	34	8																				L
	ST-03	5.0	7.5	CL	0	3	97	45	29	11	2.67	24.4	101.2			UU	26.7	96.4	1160											L
	SS-05	9.0	10.5									20.7																		F
	ST-06	10.5	13.0	CH	0	3	97	55	39			25.1	100.3																	F
GT-38	SS-02	3.0	4.5	CL	0	2	98	37	18	19.4		21.8				UU	29.7	95.5	1110											L
	ST-03	4.5	7.0	CL	0	1	99	48	29	18.4		27.3	96.8																	L

Note : Values of w & γ_d for UU & CU tests are average values.

Shear strength, consolidation and permeability tests were performed on undisturbed samples unless otherwise stated.

* Std Proctor Test

** Unreliable test results due to low confining pressure, which resulted in higher values.

*** Possible unreliable results due to testing being performed on Split Spoon samples (disturbed sampling method).

TABLE 3-4 : SUMMARY OF SOIL TEST RESULTS

Job No. 3840 Project Name WSSRAP Feature Geotechnical Characterization

Test Pit Number	Sample Number	Depth From	Depth To	Lab Class USCS	Mechanical Analysis Gravel	Mechanical Analysis Sand	Mechanical Analysis Fines	Atterberg Limits LL	Atterberg Limits PI	Shrinkage Limit	Specific Gravity G	Natural w	Natural γ_d	Compaction* Optimum w	Compaction* Optimum γ_d	Shear Strength Test	Shear Strength Initial w av	Shear Strength Initial γ_d av	Shear Strength e	Shear Strength phi	Consolidation Cc	Consolidation Cr	Consolidation Pp	Permeability w	Permeability γ_d	Permeability k (Conf Pr)	Capillary Moisture	Cation Exch Cap	Calif Bearing Ratio	Soil Unit
		ft	ft		%	%	%	%	%	%		%	pcf	%	pcf		%	pcf	psf	deg			ksf	%	pcf	cm/sec (ksf)	%	meq/100g		
GT-39	SS-02	4.0	5.5	CL	0	1	99	38	19	15.9		26.8	105.0																	F
GT-39	ST-03	5.5	8.0								2.66	23.2	100.6	17.9	107.5															F
	COMP	5.5	12.0																											F
GT-39	ST-05	12.0	14.5	CH	0	6	94	65	48		2.68	25.1	99.4																	F
GT-41	SS-02	3.5	4.0	CL				48	28	11.8		27.9	94.4																	TS
	SS-02	4.0	4.5	CL				48	28	12.8		28.6	95.1																	D
	SS-04	6.0	7.5	CL				40	23			24.5																		F
GT-42	ST-05	9.5	12.0									16.9	113.3																	C
	SB-08	17.0	18.5									12.4	119.4																	C
GT-43	SS-02	1.5	3.0									14.5																		L
	ST-04	6.0	8.5	CL				48	32		2.66	24.4	98.6			CU	31.4	91.0	c=460 c'=430	ϕ=9 ϕ'=12				27.0 to 30.5	95.7 to 91.6	<9.0E-4 (0.07)** <7.0E-8 (0.29)**				F
	ST-10	21.5	23.8	CL	0	26	74	47	32		2.71	18.6	106.5			UU	19.1	106.5	860											C
	SB-17	40.0	41.5	CL				31	12		2.59	17.6	109.9											21.7 to 31.4	106.3 to 106.8	<6.0E-8 (0.43)** <4.0E-8 (0.72)**				B
	SS-19	50.0	51.0		29	46	25					20.4																		R
GT-44	ST-03	5.0	7.5									17.6	106.2			CU	19.5	105.8	c=190 c'=180	ϕ=24 ϕ'=32										C
	SB-10	22.5	24.0									45.0	76.5																	R
GT-45	SS-01	1.0	2.5									18.1																		TS
	ST-04	7.5	10.0									21.3	103.3																	F
	ST-07	15.0	17.5									22.1	104.5											19.9 to 23.5	106.5 to 102.8	<8.0E-5 (0.21)** <2.0E-8 (0.58)**				C
GT-46	ST-03	5.0	7.5									22.1	99.6								0.202	0.027	6.6	20.0 to 23.3	103.7 to 103.0	5.0E-4 (0.07)** 3.0E-6 (0.43)**				F
GT-47	ST-05	10.0	12.5	CL	0	2	98	45	28		2.69	22.9	99.5								0.216	0.060	6.5							F
	SB-09	20.0	21.5	CH				51	36			20.5	72.4																	C
	SS-14	32.5	34.0									14.8																		R

Note: Values [illegible] γ_d for UU & CU tests are average values.

Shear [illegible], consolidation and permeability tests were performed on undisturbed samples unless otherwise stated.

See page 12 of this table for legend of Soil Units

* Std Proctor Test

** [illegible]ble test results due to low confining pressures, which resulted in higher values.

*** [illegible]le unreliable results due to testing being performed on Split Spoon samples (disturbed sampling method).

TABLE 3-4 : SUMMARY OF SOIL TEST RESULTS

Job No. 3840 Project Name WSSRAP Feature Geotechnical Characterization

Test Pit Number	Sample Number	Depth From	Depth To	Lab Class USCS	Mechanical Analysis Gravel	Sand	Fines	Atterberg Limits LL	PI	Shrinkage Limit	Specific Gravity G	Natural w	γd	Compaction* Optimum w	γd	Shear Strength Test	Initial w av	γd av	c	phi	Consolidation Cc	Cr	Pp	Permeability w	γd	k (Cond Pr)	Capillary Moisture	Cation Exch Cap	Calif Bearing Ratio	Soil Unit
		ft	ft		%	%	%	%	%	%		%	pcf	%	pcf		%	pcf	psf	deg			ksf	%	pcf	cm/sec (ksf)	%	meq/100g		
GT-54	ST-03	4.5	7.0	CL	0	3	97	42	25			21.8	100.1			CU	24.9	98.6	c=370 c'=390	φ=19° φ'=25										TS
GT-54	SS-08	17.0	18.5									21.8																		L
GT-55	ST-02	2.5	5.0									22.8	96.0																	L
	ST-04	7.5	10.0	CL/CH	0	1	99	50	29		2.75	30.7	89.4								0.260	0.041	6.7	28.8 to 30.9	94.0 to 92.8	1.0E-5 (0.14)* <2.0E-6 (0.5)**				L
	ST-06	12.5	15.0	CH	0	1	99	51	33		2.82	22.8	103.7			UU	23.4	101.0	1460		0.462	0.042	18.5			8.0E-09				F
	ST-08	17.5	20.0	CL				42	27			22.5	103.0			UU	22.5	103.0	1390											F
GT-55	SB-12	27.5	29.0					70	50			25.2	99.6			CU	23.7	101.4	c=205 c'=260	φ=13 φ'=16	0.268	0.096	7.6			2.0E-09				R
GT-56	ST-02	5.0	7.5	CL	0	2	98	30	12		2.62	20.4	101.1			UU	18.7	103.9	2330		0.380	0.033	9.9			2.9E-08				L
																CU	22.1	103.7	c=330 c'=230	φ=25 φ'=31										
	ST-04	10.0	12.5									26.5	98.1											26.7 to 29.7	96.2 to 92.6	2.0E-7 (0.14)* <3.0E-8 (0.5)**				F
	ST-06	15.0	17.0	CL	0	26	74	44	29			19.0	109.9								0.248	0.061	30.0			2.9E-09				C
	SB-08	19.5	21.0	CL	0	19	81	42	27		2.66	21.5	105.6			UU	21.4	105.6	1660											C
	SS-09	22.0	23.5	CH	4	6	90	71	50			27.1																		R
GT-57	SS-02	5.0	6.5									26.3																		L
	ST-03	7.5	10.0	CL				42	25			27.4	93.5			UU	20.9	104.4	1690											L
	ST-06	15.6	16.5									22.7																		F
	SB-11	27.5	29.0		55	10	35					17.1																		R
GT-58P	ST-01	2.5	5.0	CH	0	4	96	54	23			22.9														2.0E-7 (1) 4.0E-7 (3)				L
	ST-03	7.5	10.0	CH	0	5	95	66	46		2.69	16.6									0.202	0.040	7.0	21.9 to 23.8	104.8	6.0E-8 (1) <1.0E-9 (3)				F
	ST-09	22.5	24.0								2.65										0.150	0.018	14.5			4.0E-8 (2) <1.0E-9 (4)				C
	SB-11	28.5	29.0	GC	50	10	40					1.3	117.4																	R
GT-59	ST-02	5.0	7.5																					23.0 to 21.8	102.4	4.0E-7 (1) 2.0E-7 (3)				F

Note: Values of w & γd for UU & CU tests are average values. * Std Proctor Test ** Unreliable test results due to low confining pressures, which resulted in higher values.

Shear strength, consolidation and permeability tests were performed on undisturbed samples unless otherwise stated. *** Possible unreliable results due to testing being performed on Split Spoon samples (disturbed sampling method).

See page 12 of this table for legend of Soil Units

TABLE 3-4 : SUMMARY OF SOIL TEST RESULTS

Job No. 3840 Project Name WSSRAP Feature Geotechnical Characterisation

Test Pit Number	Sample Number	Depth From	Depth To	Lab Class USCS	Mechanical Analysis Gravel	Sand	Fines	Atterberg Limits LL	PI	Shrinkage Limit	Specific Gravity G	Natural w	Natural γ_d	Compaction* Optimum w	Optimum γ_d	Shear Strength Test	Initial w av	Initial γ_d av	c	phi	Consolidation Cc	Cr	Pp	Permeability w	γ_d	k (Cref Pr)	Capillary Moisture	Cation Exch Cap	Calif Bearing Ratio	Soil Unit
		ft	ft		%	%	%	%	%	%		%	pcf	%	pcf		%	pcf	psf	deg			ksf	%	pcf	cm/sec (ksf)	%	meq/100g		
GT-59	ST-06	15.0	17.5																					19.3 to 20.2	110.5	<1.0E-9 (2)				C
GT-60P	ST-04	12.5	15.0								2.72	22.0	104.5								0.170	0.035	8.2							F
GT-60P	ST-10	27.5	30.0	CL	0	21	79	44	27		2.70	19.0	109.5								0.152	0.045	7.6	18.7 to 19.6	109.1	5.0E-8 (3) <1.0E-9 (6)				C
	SB-15	41.0	41.5	CL	7	16	77	35	13							CU	19.9	105.3	c=830 c'=360	ϕ=20 ϕ'=34				19.0 to 20.9	105.5 105.1	7.0E-8 (4) 2.0E-7 (7)				B
	SS-16	45.0	46.5	SC	33	37	30																							B
	SB-17	48.5	49.0	SC	22	50	28																	13.9 to 22.4	105.1	1.0E-7 (4) 2.0E-7 (7)				B
GT-61	SS-13	32.5	34.0	CH	0	27	73																							C
	SB-18	50.5	51.5	GC	36	34	30					11.0	118.9																	B
GT-62	ST-07	17.5	20.0									28.0												25.7 to 24.5	100.3	5.0E-8 (2) <1.0E-9 (4)				F
	SB-15	38.0	39.0	GC	43	17	40				2.76										0.372	0.075	10.3	7.8 to 15.8	100.1	3.0E-5 (3) 6.0E-8 (5)				B
GT-63P	ST-01	2.5	5.0	CH	6	7	87	56	32															22.9 to 24.2	100.4	7.0E-9 (1)				F
	ST-09	22.5	25.0	CL	0	25	75	43	28		2.75	16.4	113.9								0.203	0.036	15.0	17.6 to 19.1	110.0	9.0E-9 (2)				C
	SB-15	38.0	38.5	SC	40	45	15																							B
GT-65P	SB-16	40.0	41.5	GC	42	24	34																	29.5 to 33.0	81.3	8.0E-7 (4) 4.0E-7 (7)				B
GT-67P	ST-08	20.0	22.5																					17.9 to 19.8	110.2	1.0E-7 (2)				C
GT-68	6810	25.0	25.7	CL	5	24	71	47	34		2.69	16.5	110								0.220	0.058	12.4							C
	6813	32.5	34.0	CL	1	4	95	40	27																					B
	6815	37.5	39.0		9	7	84																							B
GT-69	6906	15	17.5	CL	0	28	72	41	29			14.1	112.1			UU			7150											C

Note : Value of w & γ_d for UU & CU tests are average value. * Std Proctor Test ** Unreliable test results due to low confining pressures, which resulted in higher values.

Shear strength, consolidation and permeability tests were performed on undisturbed samples unless otherwise stated. *** Possible unreliable results due to testing being performed on Split Spoon samples (disturbed sampling method).

See p[illegible] this table for legend of Soil Units

TABLE 3-4 : SUMMARY OF SOIL TEST RESULTS

Job No. 3840 Project Name WSSRAP Feature Geotechnical Characterisation

Test Pit Number	Sample Number	Depth From ft	Depth To ft	Lab Class USCS	Mechanical Analysis Gravel %	Sand %	Fines %	Atterberg Limits LL %	PI %	Shrinkage Limit %	Specific Gravity G	Natural w %	Natural γ_d pcf	Compaction* Optimum w %	Compaction* Optimum γ_d pcf	Shear Strength Test	Initial w av %	Initial γ_d av pcf	c psf	phi deg	Consolidation Cc	Cr	Pp ksf	Permeability w %	γ_d pcf	k (Cons/Pr) cm/sec (ksf)	Capillary Moisture %	Cation Exch Cap meq/100g	Calif Bearing Ratio	Soil Unit
GT-69	6908	20	22.5	CL				40	23		2.77	15.6	116.3			UU			6960											
																CU	15.6	116.3	c=1270 c'=1320	ϕ=19 ϕ'=25	0.177	0.042	16.5							B
	6910	25	26.5								(-4) 2.74 (+4) 2.59	9.6																		R
GT-70	7004	10	12.5	CL	0	7	93	41	26		2.75	18.8	110.1			CU	18.8	110.1	c=750 c'=850	ϕ=16 ϕ'=20	0.215	0.061	13.3							F
GT-71	7108	20	22.5	CL	0	32	68	47	33			16.3	111			CU	11.3	111.0	c=730 c'=860	ϕ=17 ϕ'=21										C
	7110	25	27.5	CH				54	39		2.72	20.9	106.2			CU	20.9	106.2	c=640 c'=790	ϕ=21 ϕ'=28	0.417	0.068	23.4							B
	7112	30	31.5								(-4) 2.74 (+4) 2.44	22.5	88																	R
GT-73	7306	15	17.5	CH	0	16	84	64	45		2.74	32.4	92.4								0.305	0.131	3.0							F
	7314	35	36.5	CL				38	22		2.71	22.5	107.3								0.162	0.037	2.8							B
GT-73	7316	40	41.5	CL-CH				50	33		(-4) 2.70 (+4) 2.56	10.2																		R
GT-74	7402	5	7.5	CH	0	3	97	55	42			24.2	99.9			CU	24.2	99.9	c=750 c'=680	ϕ=16 ϕ'=23										TS
	7406	15	17.5	CL	1	27	72	42	30			17.8	110.3			CU	17.8	110.3	c=160 c'=180	ϕ=23 ϕ'=32										C
GT-2T71	BU-01A	3.5	6.5	CL	0	2	98	39	17		2.69	28.3		15.4	108.0	CU	18.8	105.2	c=0	ϕ=14							20.2			F
	BU-02A	6.5	12.0	CH	0	3	97	52	37	8	2.51	17.3		18.5	106.9	UU	21.2	101.8	2020		0.245	0.039	4.0	21.0 to 23.65	104.4	2.0E-8 (1)	20.5	88.26		F
GT-2T72	BU-01A	7.5	10.5	CL-M	0	5	95	27	6		2.68	22.1		12.5	116.1													49.02		F
GT-2T74	BU-01A	4.0	8.5	CL	0	3	97	42	24		2.74	25.9		16.1	106.3	CU	18.5	102.0	c=820 c'=290	ϕ=13 ϕ'=29							17.2	83.91		L
GT-2T75	BU-01A	2.5	6.5	CL	0	1	99	39	17		2.61	20.8				UU	26.7	97.4	2320	5							17.4			F
	BU-01A	4.0	8.5	CL										17.6	108.0															F

Note : Values of w & γ_d for UU & CU tests are average values.

Shear strength, consolidation and permeability tests were performed on undisturbed samples unless otherwise stated.

See page 12 of this table for legend of Soil Units

* Std Proctor Test

** Unreliable test results due to low confining pressures, which resulted in higher values.

*** Possible unreliable results due to testing being performed on Split Spoon samples (disturbed sampling method).

TABLE 3-4 : SUMMARY OF SOIL TEST RESULTS

Job No. 3840 Project Name WSSRAP Feature Geotechnical Characterization

Test Pit Number	Sample Number	Depth From	Depth To	Lab Class USCS	Mechanical Analysis Gravel	Sand	Fines	Atterberg Limits LL	PI	Shrinkage Limit	Specific Gravity G	Natural w	Natural γd	Compaction* Optimum w	Optimum γd	Shear Strength Test	Initial w av	Initial γd av	c	phi	Consolidation Cc	Cr	Pp	Permeability w	γd	k (Conf Pr)	Capillary Moisture	Cation Exch Cap	Calif Bearing Ratio	Soil Unit
		ft	ft		%	%	%	%	%	%		%	pcf	%	pcf		%	pcf	psf	deg			ksf	%	pcf	cm/sec (ksf)	%	meq/100g		
GT-2T75	BU-02B	6.5	12.0	CH	0	3	97	77	56	7	2.71	23.1		20.1	102.3	CU	23.6	98.3	c=310 c'=0	φ=13 φ'=21	0.214	0.033	6.0	23.4 to 24.9	97.5	<1.0E-9 (1)	21.2	79.00		F
GT-2T77	BU-01B	1.5	4.0	CH	0	1	99	50	33		2.55	16.6		16.6	104.3	CU	19.2	99.8	c=335 c'=270	φ=14 φ'=23							17.9	70.21		F
	BU-02A	7.0	10.5	CL	0	3	97	49	26		2.66	24.6		19.2	104.4									22.0 to 22.3	103	2.0E-8 (1)	21.6	59.65		F
GT-2T78	BU-01A	4.0	6.5	CL	0	2	98	30 28	11 10		2.71	14.7		11.7	114.9	UU	14.3	110.3	2310								13.4	33.23		L
	BU-02B	6.5	12.0	CH	0	3	97	58	39		2.69	20.1		14.6 21.3	115.6 104.2	UU	23.9	98.7	2310					24.0 to 29.1	99.2	4.0E-8 (1)	24.2	71.69		F
GT-2T79	BU-01A	1.0	6.5	CL	0	2	98	49	26	18	2.72	14.0																		F
	BU-02A	6.5	12.0	CH	0	3	97	62	43			23.1																		F
GT-2T80	BU-01A	0.5	8.0	CL	0	4	96	38	18			18.1																		F
GT-2T81	BU-01A	0.5	6.5	CL	1	10	89	36	18	11		20.4																		TS
	BU-02A	6.5	12.0	CL	0	4	96	40	23			21.0																		TS
GT-2T82	BU-01A	0.5	3.5	CL	0	4	96	42	23			13.8																		F
	BU-02A	3.5	6.0	CH	0	3	97	53	31			25.2																		F
	BU-03A	6.0	10.0	CL	2	21	77	48	27			16.2		—	—	—												—		C

Note: Values of w & γd for UU & CU tests are average values.

Shear strength, consolidation and permeability tests were performed on undisturbed samples unless otherwise stated.

See page 12 of this table for legend of Soil Units

* Std Proctor Test

** Unreliable test results due to low confining pressures, which resulted in higher values.

*** Possible unreliable results due to testing being performed on Split Spoon samples (disturbed sampling method).

TABLE 3-4 : SUMMARY OF SOIL TEST RESULTS

Job No. 3840 Project Name WSSRAP Feature Temporary Storage Area

Test Pit Number	Sample Number	Depth From	Depth To	Lab Class USCS	Mechanical Analysis Gravel	Mechanical Analysis Sand	Mechanical Analysis Fines	Atterberg Limits LL	Atterberg Limits PI	Shrinkage Limit	Specific Gravity G	Natural w	Natural γd	Compaction* Optimum w	Compaction* Optimum γd	Shear Strength Test	Shear Strength Initial w av	Shear Strength Initial γd av	Shear Strength c	Shear Strength phi	Consolidation Cc	Consolidation Cr	Consolidation Pp	Permeability w	Permeability γd	Permeability k (Conf Pr)	Capillary Moisture	Cation Exch Cap	Calif Bearing Ratio	Soil Unit
		ft	ft		%	%	%	%	%	%		%	pcf	%	pcf		%	pcf	psf	deg			ksf	%	pcf	cm/sec (ksf)	%	meq/100g		
GTS-1	ST-03	5.0	7.5	CL	0	3	97	40	20			23.3	97.5	17.5 (comp GTS-3)	102.8 with ST-02									21.1 to 23.8	98.4	2.0E-7 (1) (comp with GTS-3,ST-02)				F
GTS-2	ST-02	2.5	5.0									25.5	95.0	18.3 (comp with (GTS-4,ST-04)	103.0									21.7 to 22.7	97.8	8.0E-8 (1) (comp with GTS-4,ST-04)				P
	ST-04	7.5	10.0									20.6	102.5																	
	COMP	2.5	10.0	CL	0	3	97	44	24																					F
GTS-3	ST-02	5.0	7.5	CH	1	3	96	53	34			29.6	89.9	(composite see GTS-1 ST-03)												(composite see GTS-1 ST-03)				P
GTS-4	ST-02	2.5	5.0	CH	8	4	88	51	28			28.4	92.3	17.7 (comp)	103.3									20.8 to 21.4	102.3	2.0E-7 (1) (composite)	--			F
	ST-04	7.5	10.0	CL	0	6	94	41	21			21.5	102.9	(See GTS 2 ST-02)																P
GTS-5	BULK	0.0	5.0	CH	1	7	92	53	35			21.7		17.5	106.4									20.7 to 23.6	101.0	2.0E-8 (1)				TS
GTS-6	BULK	0.0	5.0	CL	0	1	99	43	21			19.7		18.3	104.6									21.6 to 23.0	100.0	1.0E-7 (1)				F
GTS-7	BULK	0.0	5.0	CH	0	5	95	59	35			23.8		19.2	102.7									21.0 to 24.6	99.2	9.0E-8 (1)				TS

Note : Values of w & γd for UU & CU tests are average values. * Std Proctor Test ** Unreliable test results due to low confining pressures, which resulted in higher values.

Shear strength, consolidation and permeability tests were performed on undisturbed samples unless otherwise stated. *** Possible unreliable results due to testing being performed on Split Spoon samples (disturbed sampling method).

See page 12 of this table for legend of Soil Units

TABLE 3-4 : SUMMARY OF SOIL TEST RESULTS

Job No. 3840 Project Name WSSRAP Feature Materials Staging Area

Test Pit Number	Sample Number	Depth From	Depth To	Lab Class USCS	Mechanical Analysis Gravel	Mechanical Analysis Sand	Mechanical Analysis Fines	Atterberg Limits LL	Atterberg Limits PI	Shrinkage Limit	Specific Gravity G	Natural w	Natural γd	Compaction* Optimum w	Compaction* Optimum γd	Shear Strength Test	Shear Strength Initial w av	Shear Strength Initial γd av	Shear Strength c	Shear Strength phi	Consolidation Co	Consolidation Cr	Consolidation Pp	Permeability w	Permeability γd	Permeability k (Const Pr)	Capillary Moisture	Cation Exch Cap	Calif Bearing Ratio	Soil Unit
		ft	ft		%	%	%	%	%	%		%	pcf	%	pcf		%	pcf	psf	deg			ksf	%	pcf	cm/sec (ksf)	%	meq/100g		
TPMS-1	BU-01	0.0	6.0	CH	0	7	93	51	32			20.0		17.4	103.0									17.7 to 25.1	98.6	7.0E-8 (1)			2.45	F
TPMS-2	BU-01	0.0	2.0	CL	0	6	94	49	29			18.3		18.7	104.3									18.2 to 29.8	100.2	2.0E-8 (1)				L
	BU-02	2.0	6.0	CH	0	20	80	67	46			21.9		21.0	100.6									20.7 to 29.6	95.2	<1.0E-9 (1)			2.25	F
TPMS-3	BU-01	1.0	6.0	CL	0	16	84	39	19			22.4		17.1	104.0									17.7 to 24.1	99.5	3.0E-7 (1)			2.74	F
TPMS-4	BU-01	1.0	3.5	CL	0	10	90	49	29			20.0		18.6	105.4									18.8 to 28.2	99.7	9.0E-9 (1)				L
	BU-02	4.0	6.5	CH	0	14	86	73	49			27.5		22.8	95.5									21.3 to 33.1	92.3	<1.0E-9 (1)				F
TPMS-5	BU-01	1.0	7.0	CL	0	4	96	37	20			19.8		15.9	108.1									17.2 to 23.0	100.9	2.0E-6 (1)			3.75	L
	BU-02	8.0	10.0	CH	0	2	98	73	49			26.6		21.7	97.8									20.9 to 32.9		9.0E-9 (1)				P
TPMS-6	BU-01	1.0	5.0	CL	0	2	98	40	22			15.7		16.4	104.0									14.9 to 25.7	99.4	1.0E-7 (1)				L
	BU-02	5.5	7.5	CH	0	4	96	72	47			19.4		21.3	100.4									20.6 to 28.0	94.8	<1.0E-9 (1)				F
TPMS-7	BU-01	1.0	7.0	CL	0	4	96	37	20			19.7		17.4	107.2									17.5 to 21.9	102.4	1.0E-7 (1)				L
	BU-02	7.0	9.5	CH	0	3	97	82	58			20.3		21.1	94.7									15.5 to 29.3	101.7	1.0E-7 (1)				P
TPMS-8	BU-01	1.0	5.0	CL	0	3	97	30	11			9.9		16.3	108.0									16.1 to 20.5	103.5	6.0E-8 (1)			2.43	L
	BU-02	5.0	10.5	CH	0	6	94	63	44			23.1		21.4	98.6									20.0 to 32.2	93.1	<1.0E-9 (1)			1.55	F
	BU-03	12.0	14.0		0	45	55					11.1																		C
TPMS-9	BU-01	1.0	7.0	CL	0	3	97	38	18			16.5		15.4	104.9									15.0 to 22.8	100.5	3.0E-7 (1)			3.05	L
	BU-02	8.0	15.0	CH	0	5	95	69	45			15.1		24.1	95.9									23.7 to 34.6	90.2	4.0E-8 (1)				F

Note: Values of w & γd for UU & CU tests are average values. * Std Proctor Test ** Unreliable test results due to low confining pressures, which resulted in higher values.

Shear strength, consolidation and permeability tests were performed on undisturbed samples unless otherwise stated. *** Possible unreliable results due to testing being performed on Split Spoon samples (disturbed sampling method).

See page [illegible] this table for legend of Soil Units

TABLE 3-4 : SUMMARY OF SOIL TEST RESULTS

Job No. 3840 Project Name WSSRAP Feature Potential Borrow Source No. 1

Test Pit Number	Sample Number	Depth From ft	Depth To ft	Lab Class USCS	Mechanical Analysis Gravel %	Sand %	Fines %	Atterberg Limits LL %	PI %	Shrinkage Limit %	Specific Gravity G	Natural w %	Natural γ_d pcf	Compaction* Optimum w %	Compaction* Optimum γ_d pcf	Shear Strength Test	Initial w av %	Initial γ_d av pcf	c psf	phi deg	Consolidation Cc	Cr	Pp ksf	Permeability w %	Permeability γ_d pcf	Permeability k (Cent Pr) cm/sec (ksf)	Capillary Moisture %	Cation Exch Cap meq/100g	Calif Bearing Ratio	Soil Unit
TPRS-1	2A	2.6	7.1	CL	0	9	91	31	13	-	2.65	18.1		15.6	110.4	UU	18.3	107.5	2810					18.4 to 19.1	108.2	3.0E-7 (1)	16.2	56.08		
																CU	18.5	107.4	c=1040	ϕ=16										
																			c'=1160	ϕ'=21										
	3A	7.1	9.2	MH				60	21		2.7	26.4		20.1	105.6	UU	21.9	100.7	2500											
																CU	22.2	100.9	c=170	ϕ=17	0.28	0.05	1.275					57.03		
																			c'=170	ϕ'=23										
	4A	9.2	14.1	CL	1	37	62	42	18	22	2.55	20.5		14.6	116.1									17.3 to 18.2	111.0	4.0E-8 (1)	15.6			
TPRS-6	1A	0.6	9.1	ML	0	3	97	38	11		2.64	24.6		19.3	102.9	UU	22.5	98.4	2860					23.3 to 23.2	99.9	2.0E-8 (1)	19.2			
																CU	22.8	99.7	c=590	ϕ=19										
																			c'=490	ϕ'=26										
	2A	9.1	12.6	CH				64	44		2.74	24.9		20.9	100.3	UU	21.5	98.5	3340		0.22	0.07	1.32	24.3 to 28.9	94.6	1.0E-8 (1)	24.4	79.91		
																CU	24.3	95.2	c=390	ϕ=10										
																			c'=270	ϕ'=18										
TPRS-8	1A	0.6	4.3	CL	0	2	98	34	16		2.73	21.8		17.4	108	UU	20.1	103	2300					20.8 to 21.3	102.9	3.0E-8 (1)	20.2			
																CU	20.5	104.1	c=630	ϕ=19										
																			c'=195	ϕ'=35										
	2A	4.3	8.5	CL	0	2	98	31	12	16	2.64	13.3		15.6	109.4									19.6 to 20.2	106.0	2.0E-7 (1)	16.0			
	3A	8.5	11.9	CL/CH	0	2	98	50	30		2.59	21.0		20.5	101.9	UU	21.6	99.5	2600											
																CU	23.8	97.3	c=445	ϕ=9	0.2	0.06	1.21	23.9 to 28.9	97.3	5.0E-9 (1)	23.0	75.26		
																			c'=510	ϕ'=10										
TPRS-10	1A	0.6	6.1	ML				49	17			23.5												20.2 to 27.0	102.1	1.0E-7 (1)	19.7			
	2A	8.2	10.9	ML	0	3	97	43	11			20.1												21.1 to 24.4	101.7	2.0E-8 (1)	20.8			
	3A	10.9	13.4	CH	0	5	95	61	43	9		23.1												24.5 to 30.1	97.0	<1.0E-9 (1)	24.7	74.21		
TPRS-11	1A	0.6	10.4	CL	0	3	97	33	12		2.72	25.3												20.9 to 23.3	99.5	3.0E-8 (1)	18.2			
	2A	10.4	12.3	CH	0	2	98	57	27	11	2.69	27.4												22.3 to 31.2	98.5	3.0E-8 (1)	27.2	73.52		
TPRS-13	Test 1	4.6	5	CL								27.7	92.2																	

Note: Values of w & γ_d for UU & CU tests are average values.

Shear strength, consolidation and permeability tests were performed on undisturbed samples unless otherwise stated.

See page 12 of this table for legend of Soil Units

* Std Proctor Test

** Unreliable test results due to low confining pressures, which resulted in higher values.

*** Possible unreliable results due to testing being performed on Split Spoon samples (disturbed sampling method).

TABLE 3-4 : SUMMARY OF SOIL TEST RESULTS

Job No. 3840 Project Name WSSRAP Feature Potential Borrow Source No. 1

Test Pit Number	Sample Number	Depth From	Depth To	Lab Class USCS	Mechanical Analysis Gravel	Mechanical Analysis Sand	Mechanical Analysis Fines	Atterberg Limits LL	Atterberg Limits PI	Shrinkage Limit	Specific Gravity G	Natural w	Natural γ_d	Compaction* Optimum w	Compaction* Optimum γ_d	Shear Strength Test	Shear Strength Initial w av	Shear Strength Initial γ_d av	Shear Strength e	Shear Strength phi	Consolidation Cc	Consolidation Cr	Consolidation Pp	Permeability w	Permeability γ_d	Permeability k (Conf Pr)	Capillary Moisture	Cation Exch Cap	Calif Bearing Ratio	Soil Unit
		ft	ft		%	%	%	%	%	%		%	pcf	%	pcf		%	pcf	pcf	deg			ksf	%	pcf	cm/sec (ksf)	%	meq/100g		
TPBS-14	2A	2.9	8.4	CL	0	2	98	35	15			25.2																			
TPBS-14	3A	8.4	11.8	ML	0	2	98		NP			22.4																			
	Test 2	4.9	5.3	CL								25.9	93.6																		
TPBS-15	1A	2.4	10.8	ML	0	3	97	41	9			25.5																			
	2A	10.8	12.9	CH	2	4	94	71	50			28.1																			
	3A	7.1	9.2		1	13	86																								
	Test 3	5.9	6.3	CL								23.8	89.1																		
TPBS-16	Test 4	5.4	5.8	CL								24.3	98.7																		
TPBS-17	Test 5	6.0	6.4	CL								24.8	96.8																		
TPBS-18	Test 6	4.8	5.2	CL								19.9	97.5																		
TPBS-19	Test 7	4.9	5.3	CL								24.0	99.0																		
TPBS-20	Test 8	5.4	5.8	CL								25.6	96.7																		

Note : Values of w & γ_d for UU & CU tests are average values.

Shear strength, consolidation and permeability tests were performed on undisturbed samples unless otherwise stated.

See page 12 of this table for legend of Soil Units

* Std Proctor Test

** Unreliable test results due to low confining pressures, which resulted in higher values.

*** Possible unreliable results due to testing being performed on Split Spoon samples (disturbed sampling method).

TABLE 3-4 : SUMMARY OF SOIL TEST RESULTS

Job No. 3840 Project Name WSSRAP Feature Potential Borrow Source No. 2

Test Pit Number	Sample Number	Depth From	Depth To	Lab Class USCS	Mechanical Analysis Gravel	Mechanical Analysis Sand	Mechanical Analysis Fines	Atterberg Limits LL	Atterberg Limits PI	Shrinkage Limit	Specific Gravity G	Natural w	Natural γd	Compaction* Optimum w	Compaction* Optimum γd	Shear Strength Test	Shear Strength Initial w av	Shear Strength Initial d av	Shear Strength e	Shear Strength phi	Consolidation Cc	Consolidation Cr	Consolidation Pp	Permeability w	Permeability γd	Permeability k (Conf Pr)	Capillary Moisture	Cation Exch Cap	Calif Bearing Ratio	Soil Unit
		ft	ft		%	%	%	%	%	%		%	pcf	%	pcf		%	pcf	psf	deg			ksf	%	pcf	cm/sec (ksf)	%	meq/100g		
TPBS-23	1A	0.7	13.1	CL	0	3	97	37	21		2.71	26.2		18.2	106.3									21.5 to 22.1	102.0	4.0E-7 (1)				
	Test 9	5.7	6.1	CL								28.3	91.8																	
TPBS-25	Test 11	4.1	4.5	CL								23.5	100.1																	
TPBS-26	Test 10	4.9	5.3	CL								24.8	98.9																	
TPBS-28	1A	0.7	9.9	CL	0	5	95	38	19		2.65	23.2		14.9	109.8															
	Test 12	3.8	4.2	CL								26.4	95.2																	
TPBS-29	Test 13	4.8	5.2	CL								28.0	96.1																	
TPBS-30	1A	1.8	12.4	ML	0	10	90	37	12		2.62	28.0		18.3	104.6															
	Test 14	4.9	5.3	CL								26.4	95.3																	

LEGEND FOR SOIL UNITS

- D Dike Fill
- TS Top Soil/Existing Fill
- L Loess
- F Ferrelvlaw Clay
- C Clay Till
- B Basal Till
- R Residuum

Note: Values of w & γd for UU & CU tests are average values. * Std Proctor Test ** Unreliable test results due to low confining pressures, which resulted in higher values.

Shear strength, consolidation and permeability tests were performed on undisturbed samples unless otherwise stated. *** Possible unreliable results due to testing being performed on Split Spoon samples (disturbed sampling method).

See page 12 of this table for legend of Soil Units

Laboratory test results for this material indicate that the moisture content ranges from 20 to 29%, the dry unit weight from 94 to 102 pounds per cubic foot (pcf), the fines content (minus No. 200 sieve) from 79 to 97% and the plasticity index (PI) from 11 to 42.

- Loess - the Loess unit underlying the topsoil/fill is randomly scattered across the site, possibly because it is a wind blown deposit (MGS 1977). Loess distribution may also have been affected by extensive reworking of the upper subsurface during site preparation and construction. Loess thicknesses ranging from a few inches to 10.5 feet were encountered during field investigations. Materials from this unit consist primarily of a mottled gray silt to dark yellowish-orange, clayey silt or silty clay. The Loess exhibits low to medium plasticity with a PI ranging from 10 to 34. It does not collapse when wet like other wind deposited soils that are commonly called loess and are typically found in this part of the country. Fines content ranges from 90 to 99%. The moisture content ranges from 10 to 31% and the dry unit weight ranges from 89 to 105 pcf.

- Ferrelview - The Ferrelview (Formation) clay, which underlies the Loess unit, is one of the more extensive soil units within the site overburden. Unit thickness ranges from a few inches to 22 feet. This soil is typically dark, yellowish-orange to brown with grey mottling, silty clay and clayey silt, very stiff and of low to high plasticity (PI from 6 to 58). The percent of fines encountered ranges from 80 to 99%, the moisture content from 10 to 31%, and the dry unit weight from 90 to 111 pcf.

  Some Ferrelview clay contains a higher percentage of silt, possibly derived from the underlying clay till. Samples of clay from this formation have a characteristic conchoidal fracture and often exhibit slickensides.

- Clay Till - The Clay Till underlying the Ferrelview clay is the most horizontally extensive soil unit at the WSS. The thickness of this unit ranges up to 30 feet. It consists of massive and very stiff, yellowish brown, silty clay and clayey silt having a medium to high plasticity with minor amounts of sand

and rounded to subrounded gravel. The PI generally ranges from 25 to 50. The fines content ranges from 55 to 95. The moisture content ranges from 11 to 36%, and the dry unit weight from 72 to 119 pcf.

- Basal Till - The Basal Till is found mostly in the western and north-central portions of the site. The unit ranges in thickness from 0 to 8 feet. It is typically a yellowish brown, sandy-silty-gravelly clay to clayey gravel. The Basal Till is more gravelly than the overlying soil units. Test results show that the PI generally ranges 12 and 39, the fines from 28 to 98%, the moisture content from 11 to 26%, and the dry unit weight from 102 to 119 pcf.

- Residuum - The Residuum is found immediately above the bedrock throughout the site region. It is laterally extensive on the site. This soil unit is interpreted to be a pre-Pleistocene weathering horizon of the underlying bedrock (BNI 1984). Its thickness varies from 0 to approximately 25 feet. The material is a distinctive red to yellow, consisting of gravelly clay to gravelly silt, clayey sand, and gravel. The gravel consists of angular, weathered chert or limestone rock fragments. The interstitial clay is often highly plastic and forms a tight matrix around the gravel-sized rock fragments. Samples obtained for testing probably represent residuum with higher fines content because of poor sample recovery from residuum with higher gravel content. The PI for the interstitial clay portion ranges from 33 to 50. Fines in the tested samples range from 15 to 90%, moisture content ranges from 1 to 45% and the dry unit weight from 77 to 117 pcf.

The typical range of values for each soil type given above are for the overall site. To reduce and evaluate the soil test results, average (arithmetic mean) values were specifically calculated according to soil types for overall site area and for the disposal cell area. These average values are presented in Tables 3-5 and 3-6. Table No. 3-7 presents the average values for the suitable off-site clay borrow source investigated so far, namely, Source No. 1. The number of tests (points), maximum and minimum values and standard deviation are also shown in these tables. The values for borrow source No. 2 were not summarized because it was found to be unsuitable as a clay source (see section 4.3).

TABLE 3-5 :SUMMARY OF AVERAGING OF INDEX PROPERTIES FOR OVERALL AREA

Project Name WSSRAP

Hole or Trench #	Sample Number	Depth		Lab Class	Mechanical Analysis			Atterberg Limits		Shrin -kage	Specific Gravity	Natural		
		From	To	USCS	Gravel	Sand	Fines	LL	PI	Limit	G	Water Content	Unit d	Weight t
		ft	ft		%	%	%	%	%	%		%	pcf	pcf
TOPSOIL/FILL														
Number of points					6	6	6	9	9	4		10	5	5
Mean Values					0.3	8.3	91.3	47.5	29.7	10.7		22.2	100.0	123.0
Maximum Values					1.0	21.0	97.0	59.0	42.0	18.1		28.6	102.3	124.2
Minimum Values					0.0	3.0	79.0	33.0	11.0	10.7		20.4	94.4	120.7
Standard Deviation					0.5	6.1	6.1	8.4	8.9	2.8		2.7	3.1	1.3
LOESS														
Number of points					20	20	20	22	22	4	6	25	10	10
Mean Values					0.0	3.2	96.9	41.6	22.2	14.4	2.70	20.8	98.3	120.9
Maximum Values					0.0	10.0	99.0	58.0	34.0	19.4	2.75	30.7	104.7	126.8
Minimum Values					0.0	1.0	90.0	30.0	10.0	8.3	2.62	9.9	89.4	116.5
Standard Deviation					0.0	2.2	2.2	8.0	7.1	4.7	0.04	4.7	4.3	3.4
FERRELVIEW CLAY														
Number of points					45	45	45	48	48	4	24	59	31	[illegible]
Mean Values					0.3	5.1	94.6	52.2	32.8	12.3	2.69	22.6	100.0	123.6
Maximum Values					8.0	20.0	99.0	82.0	58.0	17.5	2.82	32.4	111.0	133.1
Minimum Values					0.0	1.0	80.0	27.0	6.0	7.3	2.51	13.8	89.9	114.4
Standard Deviation					1.5	4.4	4.7	12.5	11.8	4.5	0.07	3.9	5.2	4.1
CLAY TILL														
Number of points					17	17	17	15	15		10	24	21	20
Mean Values					0.9	23.2	75.9	48.8	32.9		2.71	19.2	105.7	127.9
Maximum Values					5.0	45.0	95.0	74.0	50.0		2.79	36.3	119.4	134.2
Minimum Values					0.0	5.0	55.0	39.0	25.0		2.65	11.1	72.4	113.0
Standard Deviation					1.6	9.0	8.6	9.1	7.1		0.04	5.8	11.3	5.1
BASAL TILL														
Number of points					9	9	9	7	7		5	7	6	6
Mean Values					12.1	21.8	66.1	40.0	23.7		2.69	18.9	109.2	128.4
Maximum Values					36.0	50.0	98.0	54.0	39.0		2.77	25.7	118.9	134.4
Minimum Values					0.0	2.0	28.0	31.0	12.0		2.59	11.0	101.6	120.9
Standard Deviation					13.7	15.8	27.9	6.7	8.6		0.06	4.4	6.6	4.4
RESIDUUM														
Number of points					12	12	12	3	3		4	14	4	4
Mean Values					37.9	19.3	42.8	63.7	44.3		2.74	18.8	95.4	115.6
Maximum Values					65.0	46.0	90.0	71.0	50.0		2.76	45.0	117.4	124.7
Minimum Values					4.0	6.0	15.0	50.0	33.0		2.70	1.3	76.5	107.8
Standard Deviation					18.3	13.2	23.2	9.7	8.0		0.02	10.0	15.1	[illegible]5

TABLE 3-6 :SUMMARY OF AVERAGING OF INDEX PROPERTIES FOR DISPOSAL CELL AREA

Project Name WSSRAP

Hole or Trench #	Sample Number	Depth		Lab Class	Mechanical Analysis			Atterberg Limits		Shrinkage	Specific Gravity	Natural		
		From	To	USCS	Gravel	Sand	Fines	LL	PI	Limit	G	Water Content	Unit d	Weight t
		ft	ft		%	%	%	%	%	%		%	pcf	pcf
TOPSOIL/FILL														
Number of points								1	1			2	1	1
Mean Values								33.0	11.0			22.2	102.3	124.2
Maximum Values								33.0	11.0			22.9	102.3	124.2
Minimum Values								33.0	11.0			21.4	102.3	124.2
Standard Deviation								0.0	0.0			0.8	0.0	0.0
LOESS														
Number of points					12	12	12	12	12		3	14	3	3
Mean Values					0.0	3.7	96.3	40.5	20.7		2.69	19.4	95.5	118.8
Maximum Values					0.0	10.0	99.0	54.0	29.0		2.75	30.7	101.1	121.7
Minimum Values					0.0	1.0	90.0	30.0	11.0		2.62	9.9	89.4	116.9
Standard Deviation					0.0	2.3	2.3	8.1	6.4		0.05	5.0	4.8	2.1
FERRELVIEW CLAY														
Number of points					24	24	24	27	27	2	17	32	14	14
Mean Values					0.0	4.9	95.1	56.5	36.9	12.4	2.70	22.3	100.7	124.3
Maximum Values					0.0	20.0	99.0	82.0	58.0	17.5	2.82	28.0	110.1	130.8
Minimum Values					0.0	1.0	80.0	39.0	17.0	7.3	2.55	14.0	90.3	115.3
Standard Deviation					0.0	4.8	4.8	12.5	10.9	5.1	0.06	3.5	4.6	3.6
CLAY TILL														
Number of points					12	12	12	11	11		8	17	15	14
Mean Values					0.8	25.8	73.5	48.5	33.0		2.70	18.2	106.5	128.8
Maximum Values					5.0	45.0	84.0	74.0	50.0		2.79	33.7	119.4	134.2
Minimum Values					0.0	15.0	55.0	39.0	25.0		2.65	11.1	72.4	118.6
Standard Deviation					1.7	7.7	7.3	9.5	7.0		0.04	4.8	11.2	3.8
BASAL TILL														
Number of points					8	8	8	6	6		4	6	5	5
Mean Values					13.6	24.0	62.4	40.3	24.0		2.69	18.3	110.6	129.0
Maximum Values					36.0	50.0	98.0	54.0	39.0		2.77	25.7	118.9	134.4
Minimum Values					0.0	2.0	28.0	31.0	12.0		2.59	11.0	101.6	120.9
Standard Deviation					13.8	15.4	27.3	7.1	9.3		0.07	4.5	6.4	4.6
RESIDUUM														
Number of points					9	9	9	2	2		2	11	4	4
Mean Values					33.3	17.7	49.0	70.5	50.0		2.75	19.8	95.4	115.6
Maximum Values					65.0	46.0	90.0	71.0	50.0		2.76	45.0	117.4	124.7
Minimum Values					4.0	6.0	18.0	70.0	50.0		2.74	1.3	76.5	107.8
Standard Deviation					18.4	12.1	23.4	0.5	0.0		0.01	10.9	15.1	6.6

24 Sep 91

TABLE 3-7 :SUMMARY OF AVERAGING OF INDEX PROPERTIES FOR POTENTIAL BORROW SOURCE NO. 1

Project Name WSSRAP

Hole or Trench #	Sample Number	Depth		Lab Class	Mechanical Analysis			Atterberg Limits		Shrinkage	Specific Gravity	Natural		
		From	To	USCS	Gravel	Sand	Fines	LL	PI	Limit	G	Water Content	Unit d	Weight t
		ft	ft		%	%	%	%	%	%		%	pcf	pcf
Number of points					15	15	15	16	16	4	10	25	8	8
Mean Values					0.3	6.1	93.6	46.3	21.8	14.5	2.67	23.2	95.5	118.8
Maximum Values					2.0	37.0	98.0	71.0	50.0	22.2	2.74	28.1	99.0	122.8
Minimum Values					0.0	2.0	62.0	31.0	9.0	8.5	2.55	11.1	89.1	110.3
Standerd Deviation					0.6	8.8	9.0	12.5	12.8	5.2	0.06	3.9	3.3	3.9

Data processing, reduction and averaging of the large number of test results were accomplished by utilizing the standard PC software programs LOTUS(Lotus 1986) and ALLWAYS(Funk Software 1988). The PC program GRAPHER(Golden Software 1988) was also used to prepare summary graphs and charts, utilizing data already entered in LOTUS. Evaluation of the test results and soil properties was performed as a formal calculation, and is presented in Appendix C. For presentation, specific symbols were selected for each type of soil unit and used consistently in the graphs throughout the report. Table No. 3-8 presents a legend of the symbols used in those graphs.

The soils were tested in the undisturbed (in situ) state and in some cases, in the remolded (compacted) state. The undisturbed state applies to all geologic soil units encountered and the test results will be used mainly for foundation analyses. The remolded state applies primarily to the Ferrelview clay unit because soils within this unit will be excavated due to site grading and are suitable candidate soils as backfill or common fill.

The clayey soils at the two potential borrow sources were investigated mainly for their suitability as potential disposal facility liner and low permeability materials and secondly, as common fill material.

3.3 Classification and Index Properties

To verify, identify and characterize the soil units, a suite of tests consisted of particle size analysis, Atterberg limits, specific gravity, natural water content and dry unit weight was performed. Using the results of these tests and the descriptions provided in the boring logs, samples from field investigations were classified according to the Unified Soil Classification System (ASTM D2487). Unless indicated otherwise, all average values presented in this report represent overall site values.

3.3.1 Particle-Size Analysis

The particle-size analysis or sieve analysis, with or without hydrometer, determines the distribution of the various particle sizes in soil. Standard sieves are used to separate particles of all sizes except silts and clays, for which a hydrometer analysis is used. Particle size distribution is used to classify soils, estimate permeability (using empirical correlations), and analyze the potential for particle migration at the interface of two soils.

TABLE 3-8 : LEGENDS OF SYMBOLS USED IN GRAPHS

⊕	TOPSOIL/FILL
○	LOESS
□	FERRELVIEW CLAY
△	CLAY TILL
◇	BASAL TILL
☆	RESIDUUM

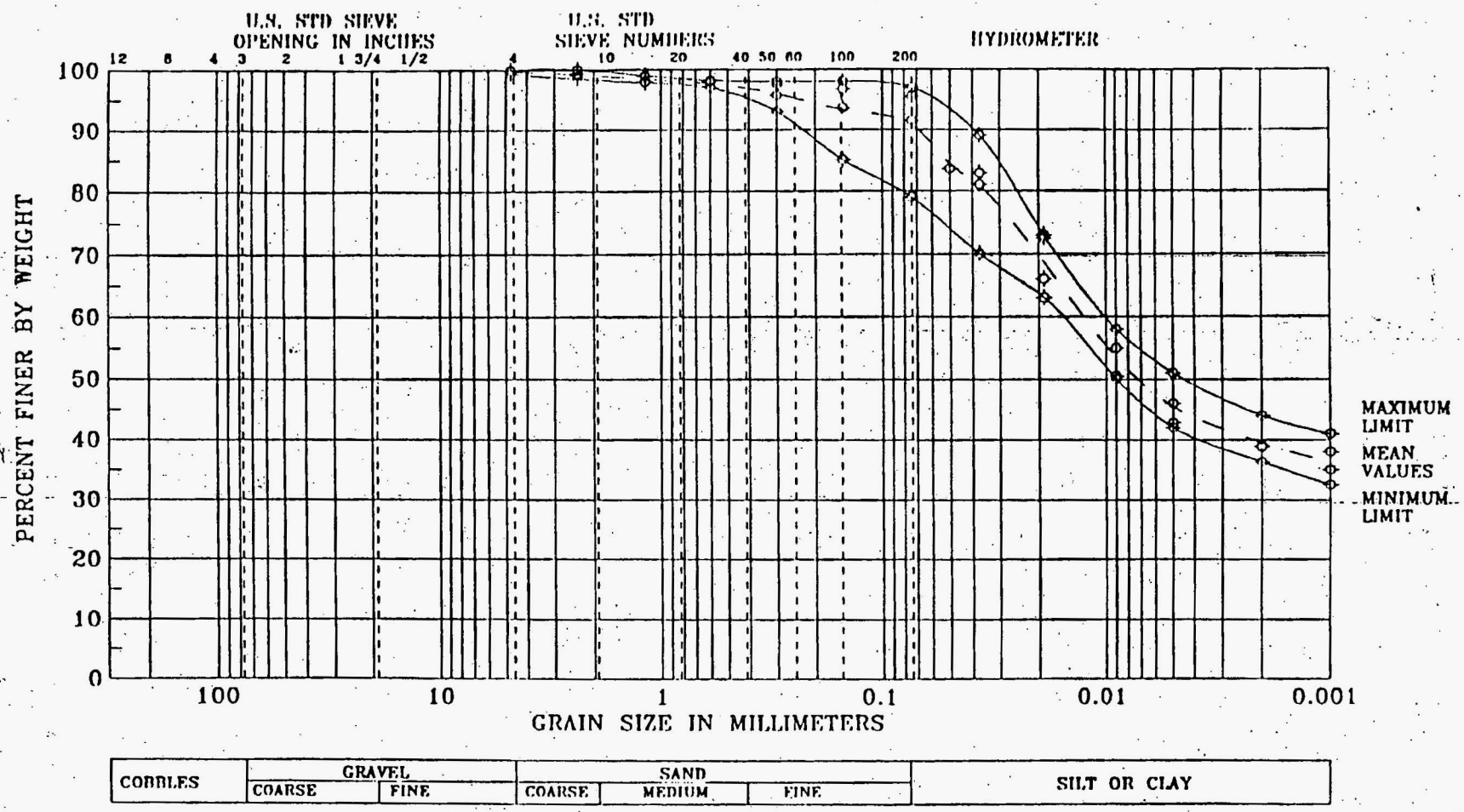
Most of the soils encountered at the site contain more than 50 percent (by weight) of fines (percent passing #200 sieve). Therefore, the average (arithmetic mean) fines content was calculated for each soil type and presented for comparison and soil characterization.

As can be seen from Table 3-5, an overall average fines content of 88% was calculated for the topsoil/fill geologic unit, 97% for Loess, 95% for Ferrelview clay, 76% for Clay Till, 66% for Basal Till and 42% for Residuum. The percent of fines generally decreases with the deeper geologic units as the gravel content increases. The average values indicate that with the exception of the Residuum, all soil units are classified as silts or clays. The gradation test results for each geologic unit are plotted in Figures 3-1 through 3-6. The grain size curves plotted in the figures represent the average values and the maximum and minimum limits. The plots show that the grain size distribution within each soil unit, geographically within the site, are generally uniform with no apparent differences. Furthermore, the results for the Ferrelview Clay are plotted for the overall site area and the following four geographical areas: the northern chemical plant area, the southern chemical plant area, the Temporary Storage Area and the Material Staging Area (Figures 3-2B through 3-2E). The limits of each area are shown in Figure 2-1. Gradation test summary for Potential Clay Borrow Source No. 1 is shown in Figure 3-7. The average fines content is 94%.

3.3.2 Atterberg Limits/Plasticity

Atterberg limits are index properties, and include liquid limit, plastic limit, and plasticity index. These properties are used in classifying soils and estimating relative plasticity, consistency, and activity. In some cases, these properties also correlate with compressibility, permeability, compactability, shear-strength and shrink-swell characteristics.

The shrinkage limit is typically defined to be the water content required to just fill the voids of a cohesive soil at the minimum void ratio obtained by drying. It is used to determine the shrinkage potential or possibility of development of cracks in cohesive soils. The results range from 12 to 15% for materials tested, which include Loess, Ferrelview clay, topsoil/fill and Borrow Source No. 1 materials.

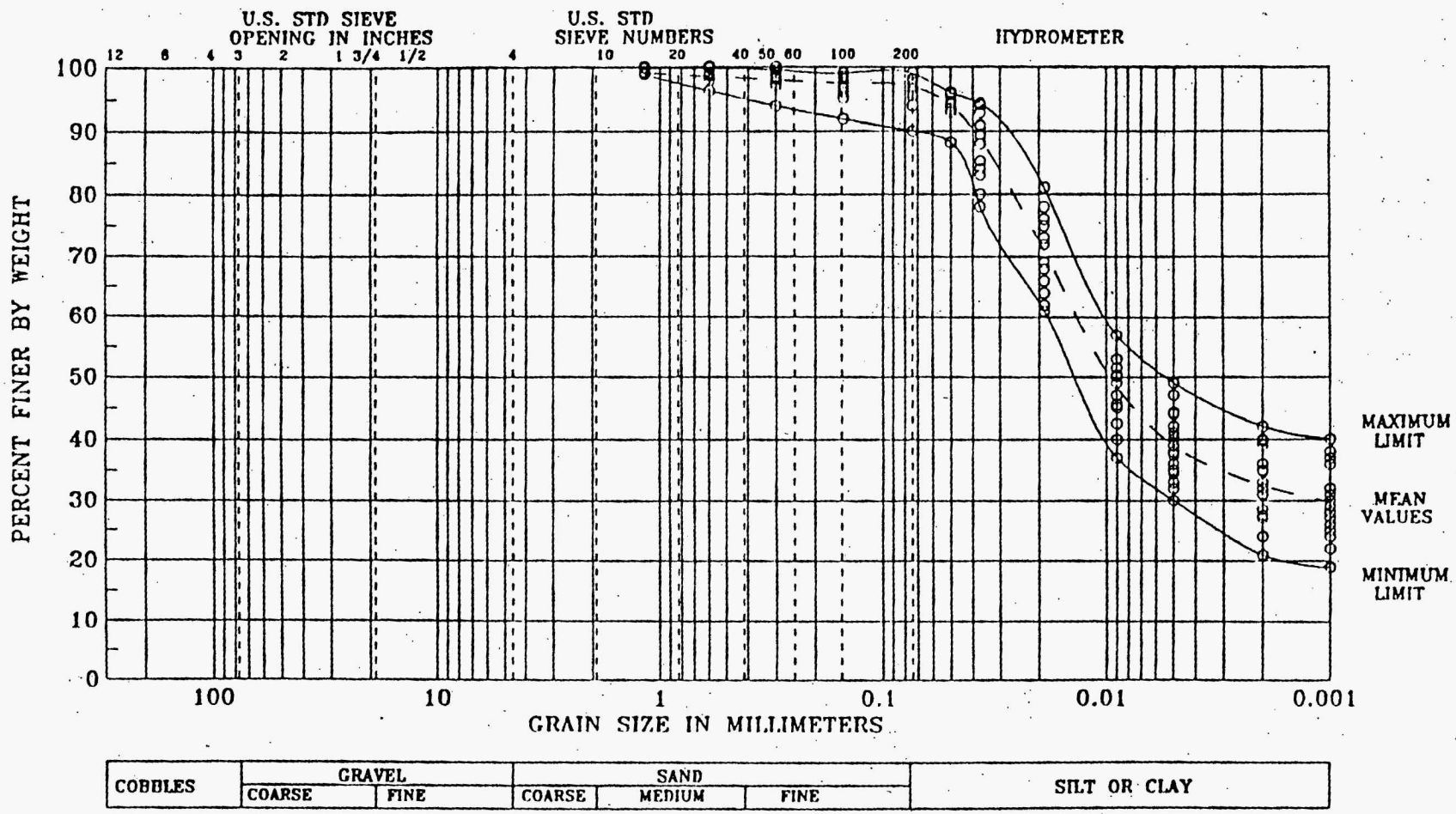


SUMMARY PLOT OF GRADATION LIMITS

TOPSOIL/FILL
OVERALL AREA

FIGURE 3-1

REPORT NO.MKES-3840R-7005	DRAWING NO.	
ORIGINATOR: ND	DRAWN BY: ND	DATE:

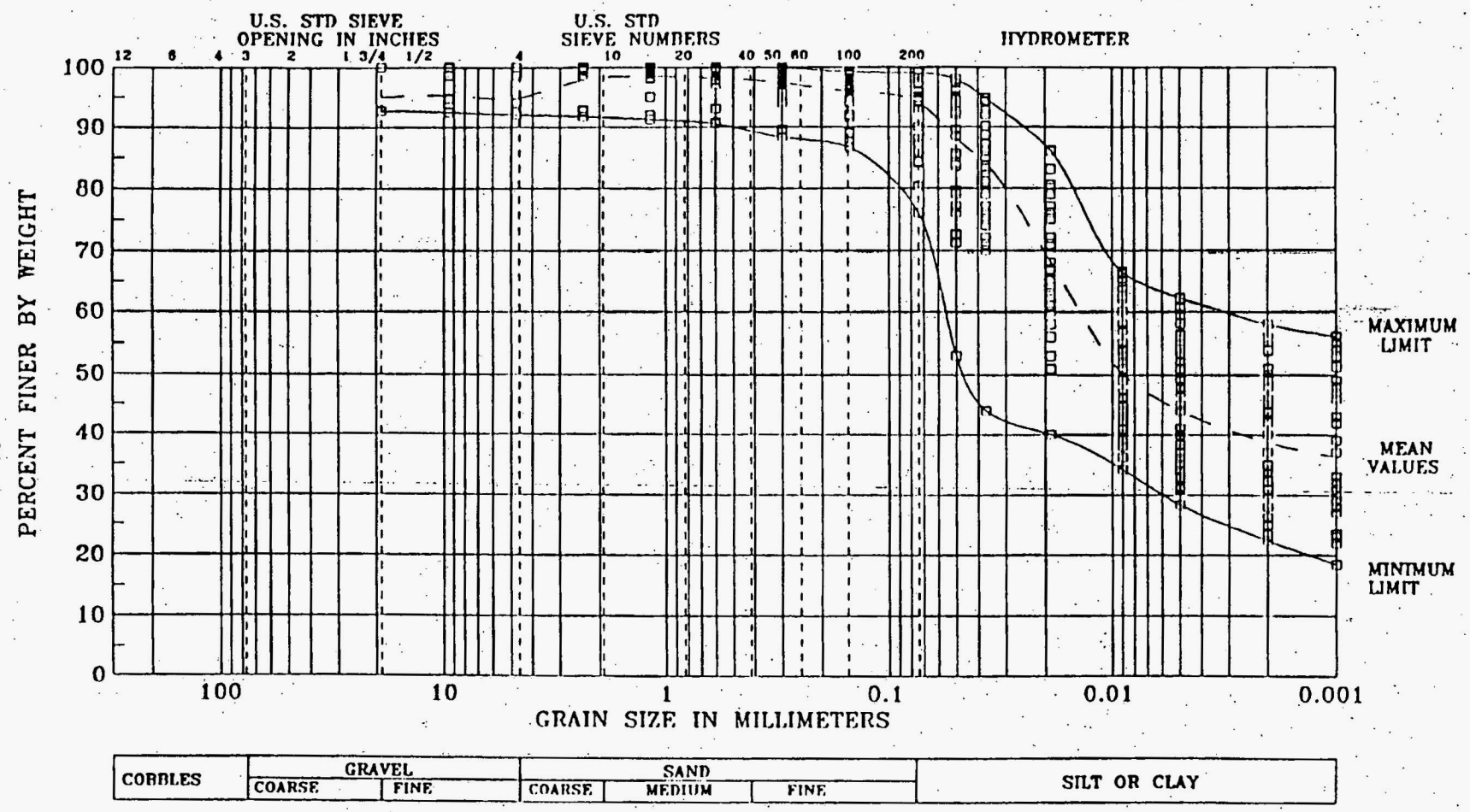


SUMMARY PLOT OF GRADATION LIMITS

LOESS
OVERALL AREA

FIGURE 3-2

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR: ND	DRAWN BY: ND	DATE:

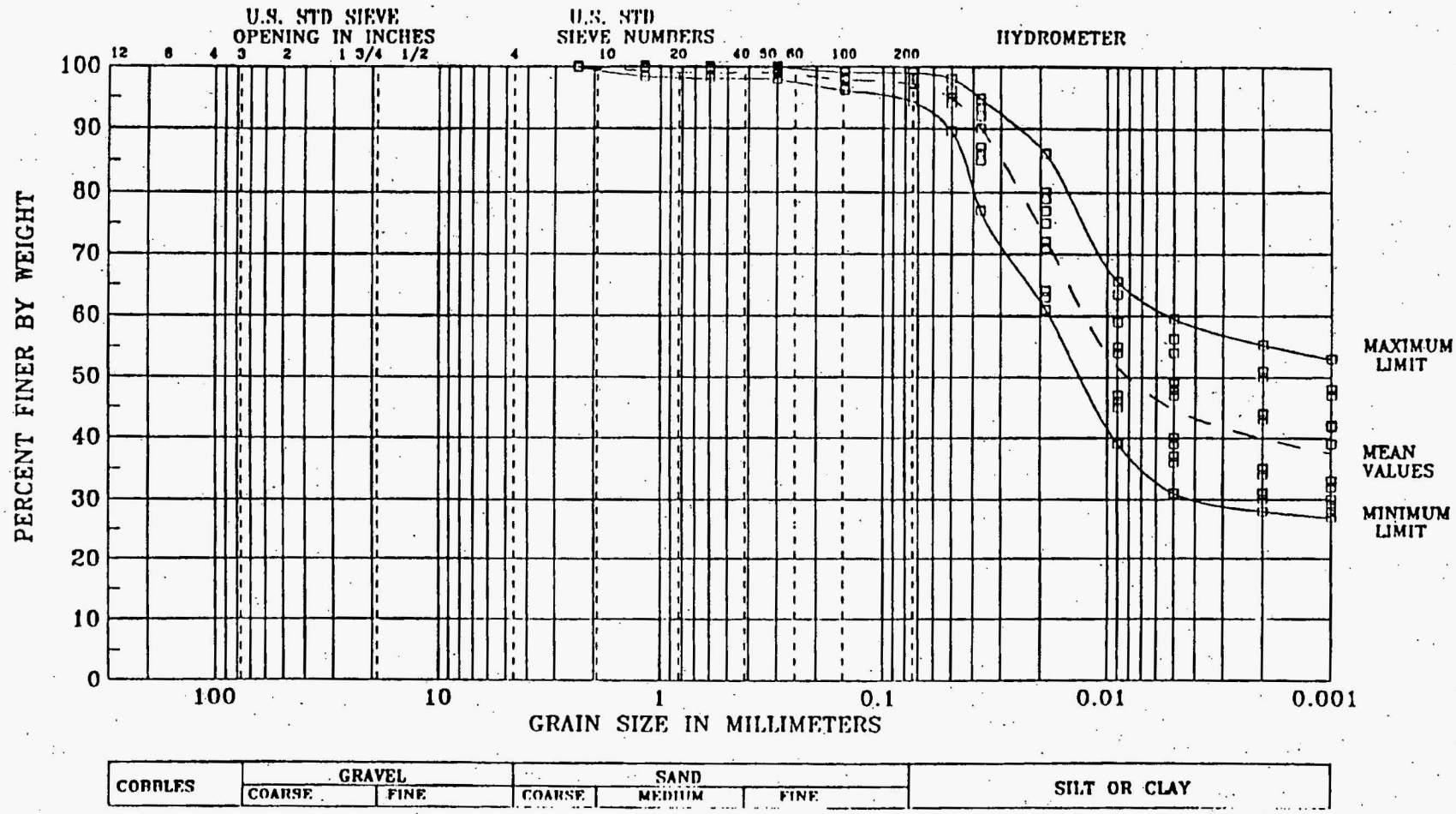


SUMMARY PLOT OF GRADATION LIMITS

FERRELVIEW CLAY
OVERALL VALUES

FIGURE 3-3 A

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR: ND	DRAWN BY: ND	DATE:

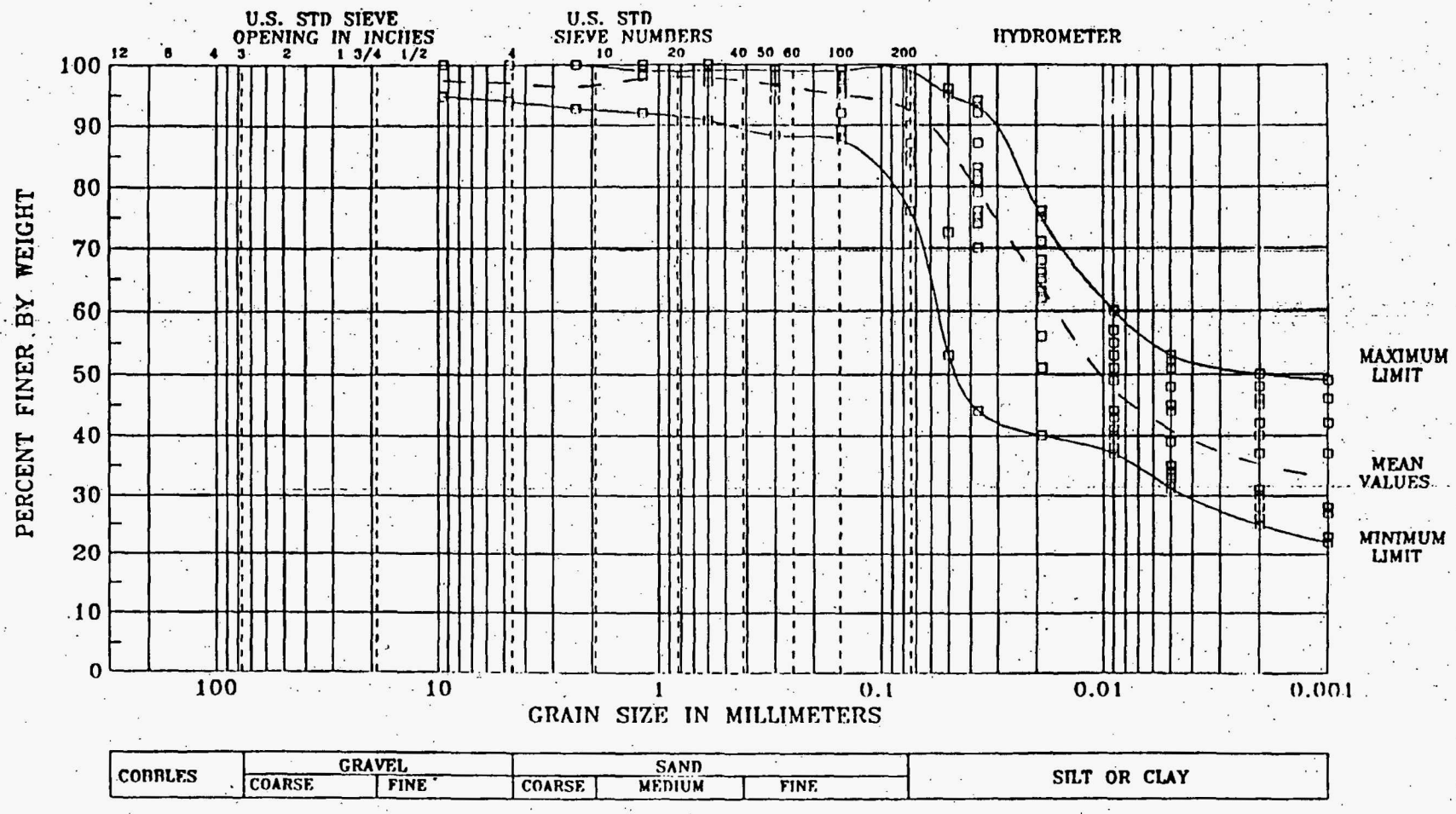


SUMMARY PLOT OF GRADATION LIMITS

FERRELVIEW CLAY
NORTHERN CHEMICAL PLANT AREA

FIGURE 3-3 B

REPORT NO.MKES-3840R-7005	DRAWING NO.	
ORIGINATOR: ND	DRAWN BY: ND	DATE:

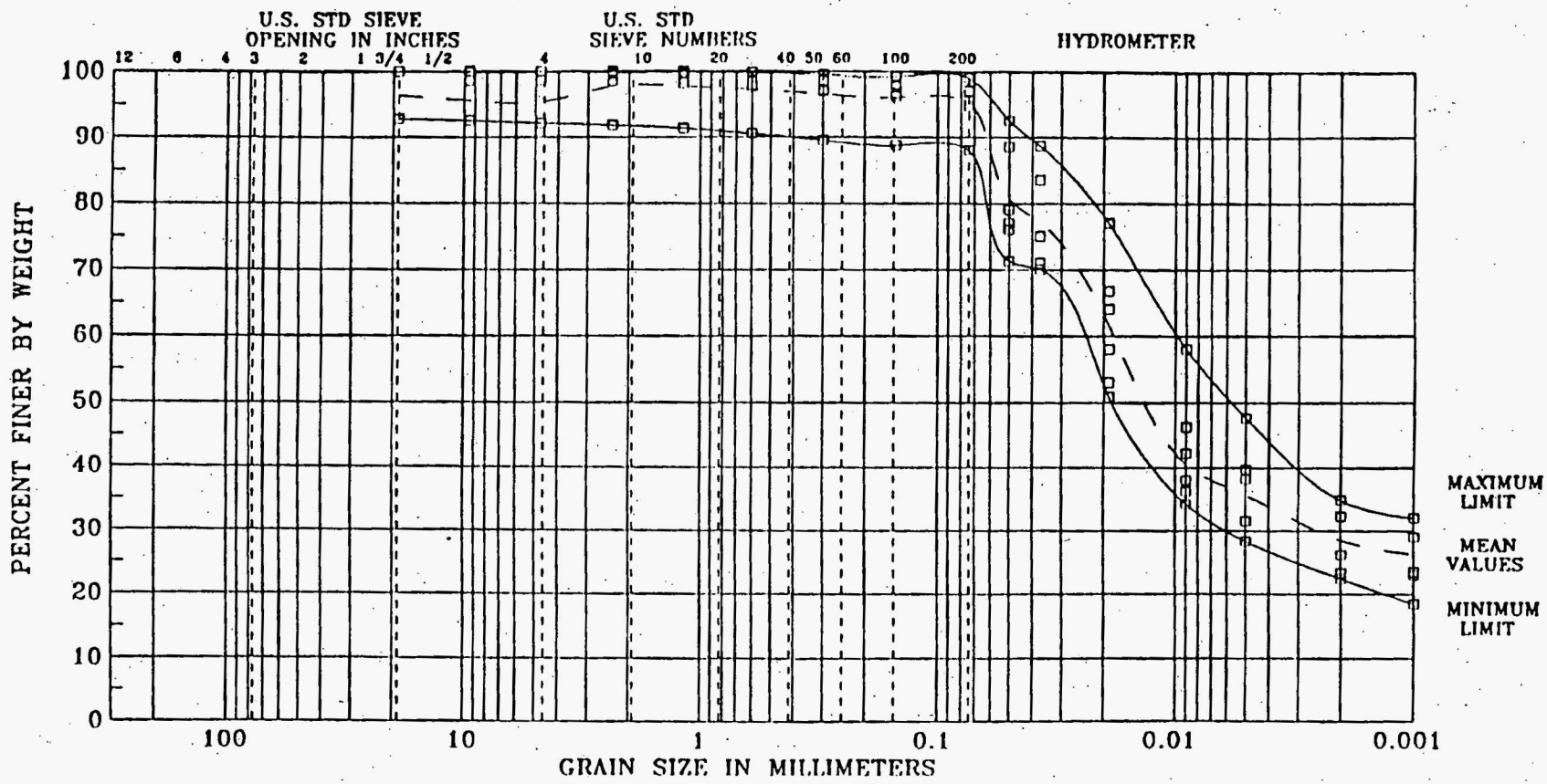


SUMMARY PLOT OF GRADATION LIMITS

FERRELVIEW CLAY
SOUTHERN CHEMICAL PLANT AREA

FIGURE 3-3 C

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR: ND	DRAWN BY: ND	DATE:



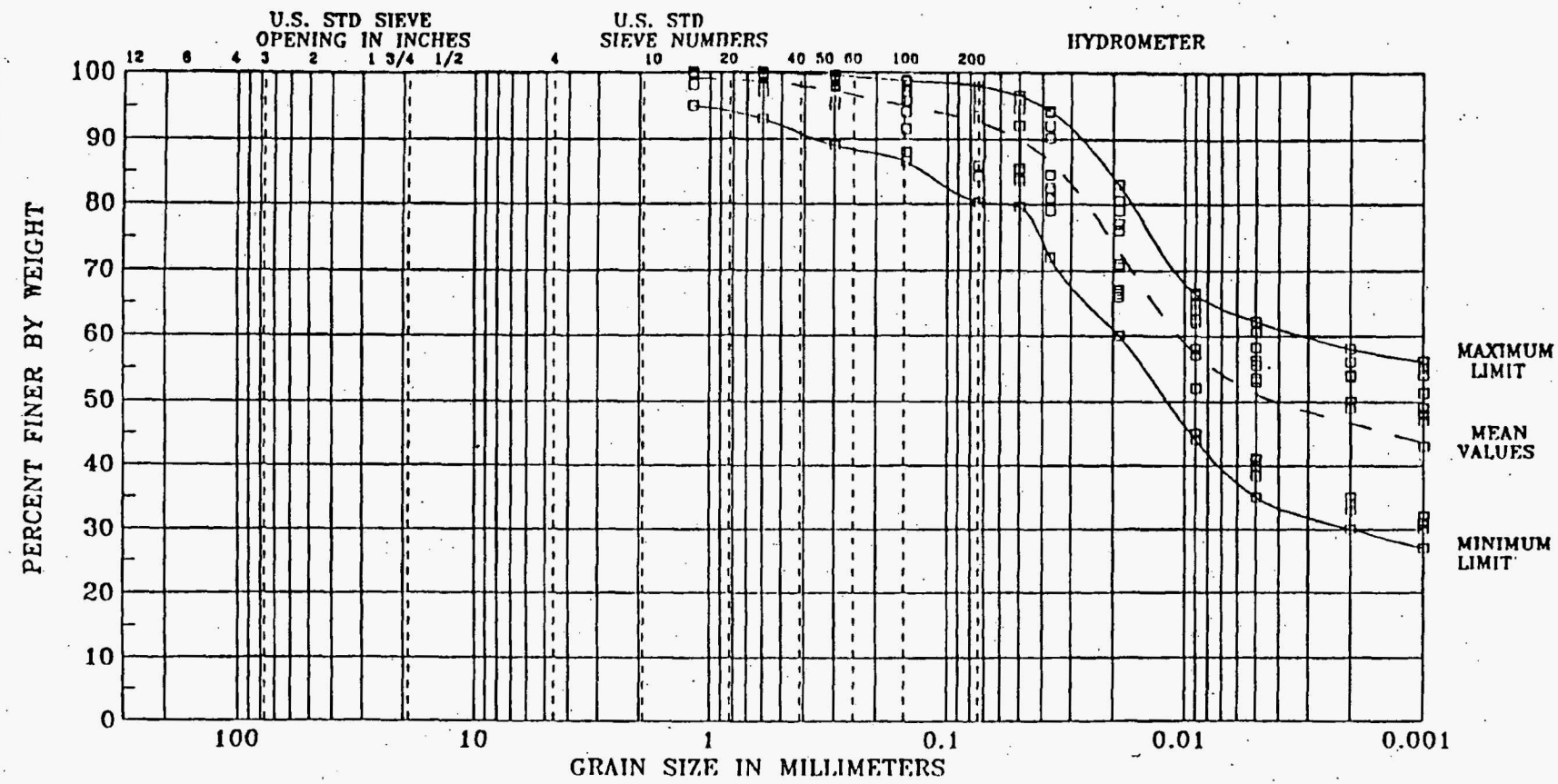
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SUMMARY PLOT OF GRADATION LIMITS

FERRELVIEW CLAY
TEMPORARY STORAGE AREA

FIGURE 3-3 D

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR: ND	DRAWN BY: ND	DATE:



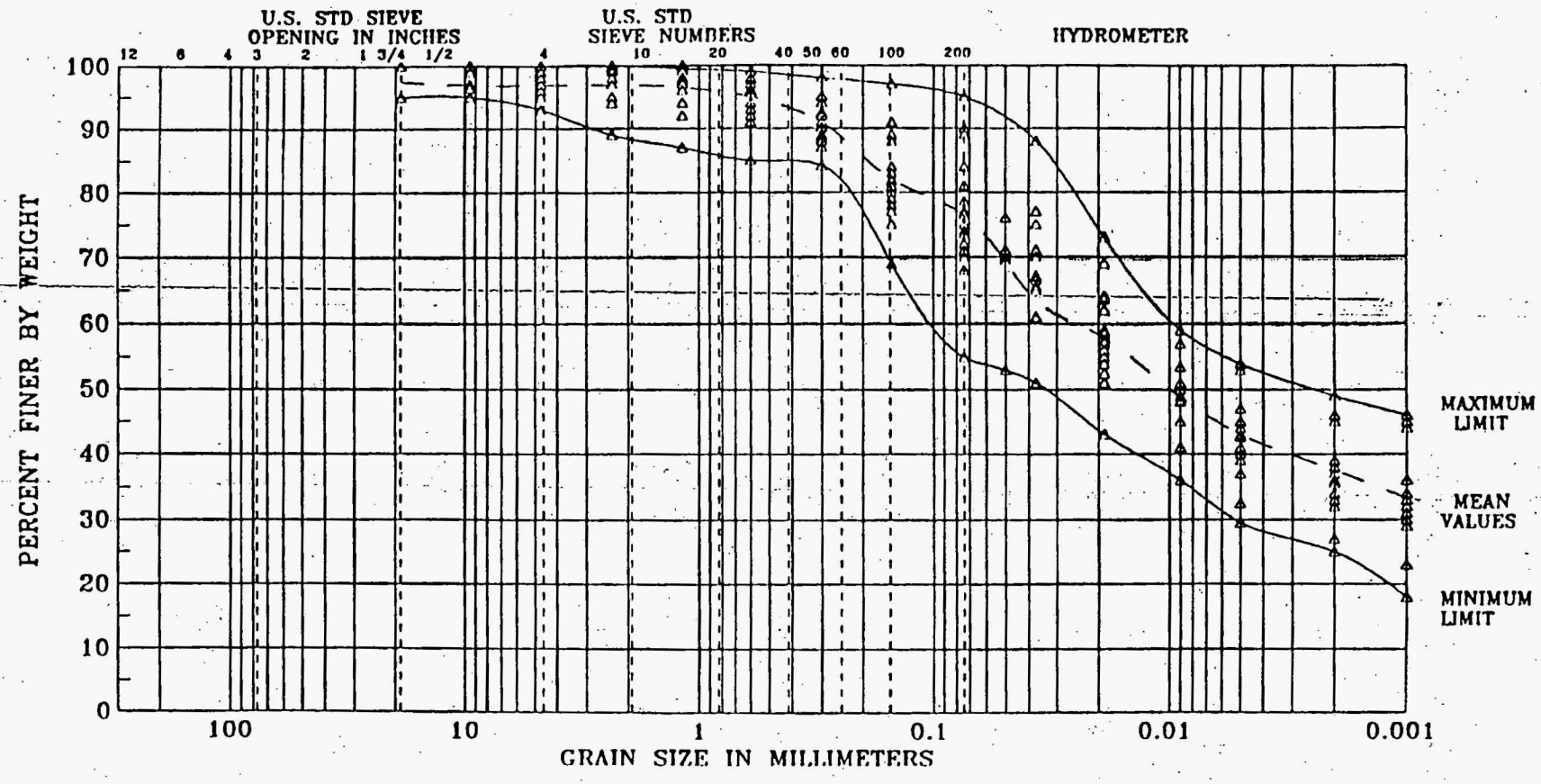
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SUMMARY PLOT OF GRADATION LIMITS

FERRELVIEW CLAY
MATERIALS STAGING AREA

FIGURE 3-3 E

REPORT NO. MKES -3840R-7005	DRAWING NO.	
ORIGINATOR: ND	DRAWN BY: ND	DATE:



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

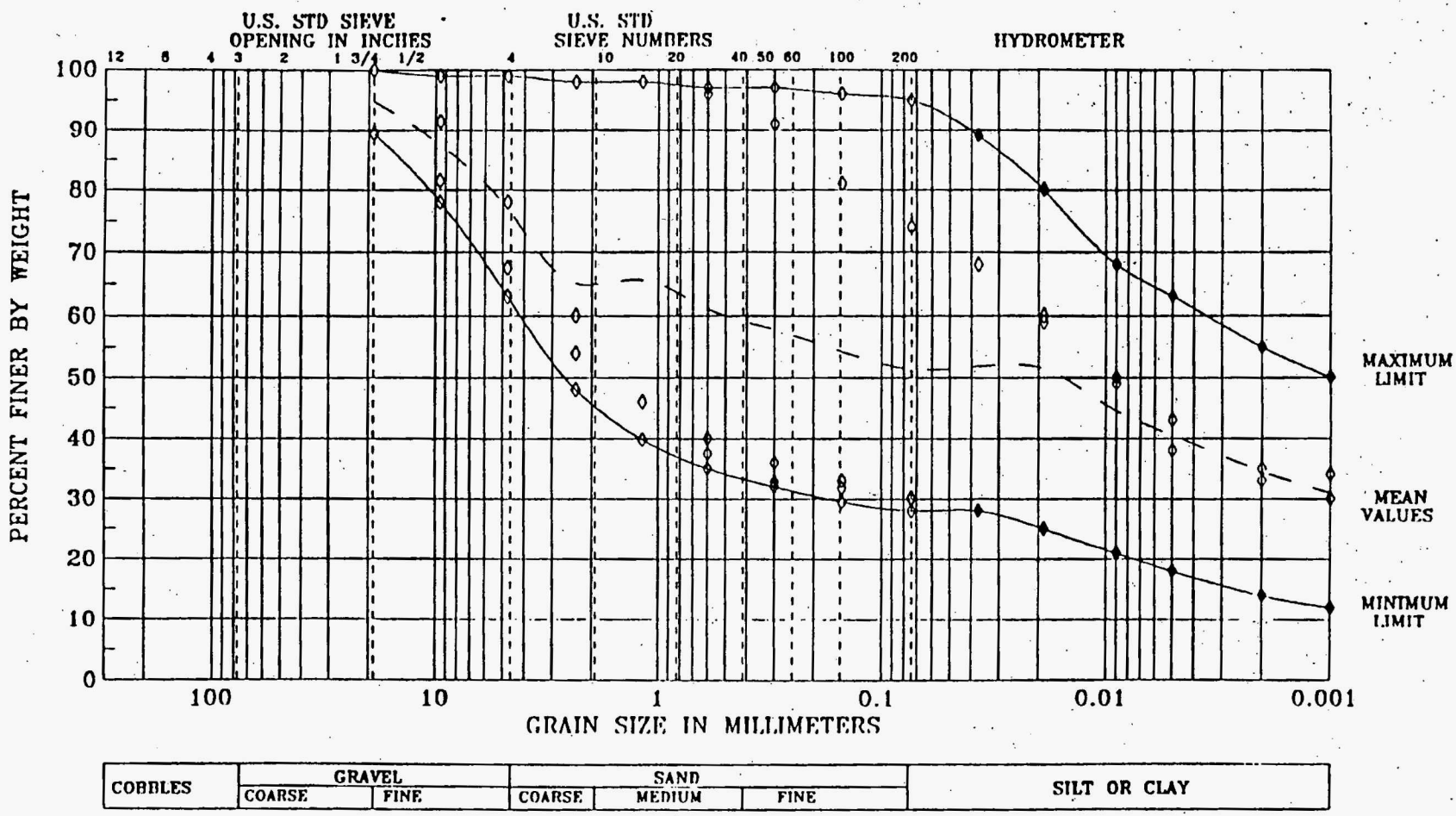
SUMMARY PLOT OF GRADATION LIMITS

CLAY TILL
OVERALL AREA

FIGURE 3-4

REPORT NO. MKES-3840R-7005 DRAWING NO.

ORIGINATOR: ND DRAWN BY: ND DATE:



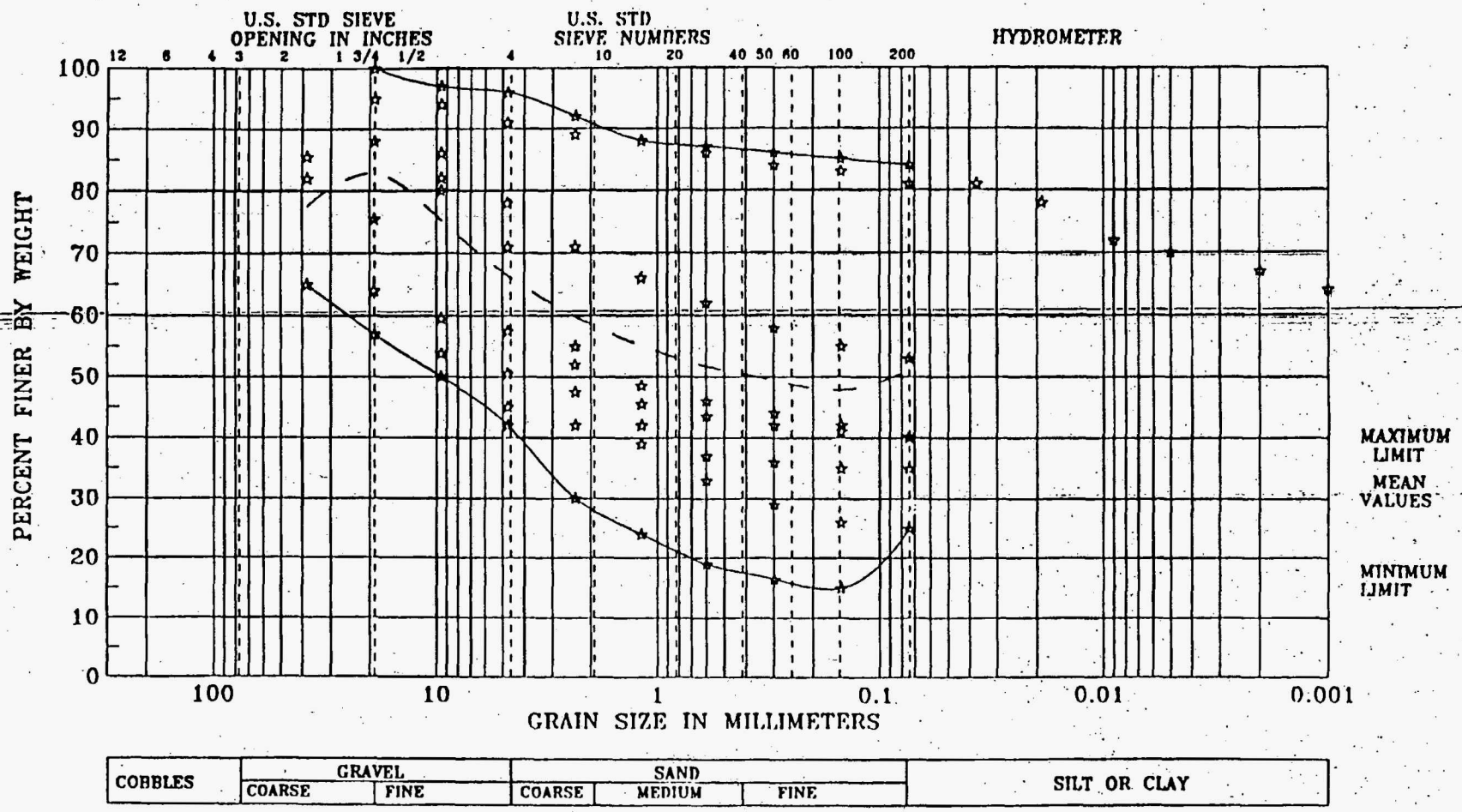
♦ ASSUMED VALUES

SUMMARY PLOT OF GRADATION LIMITS

BASAL TILL
OVERALL AREA

FIGURE 3-5

REPORT NO. MKES -3840R-7005	DRAWING NO.	
ORIGINATOR: ND	DRAWN BY: ND	DATE: 09/23/91



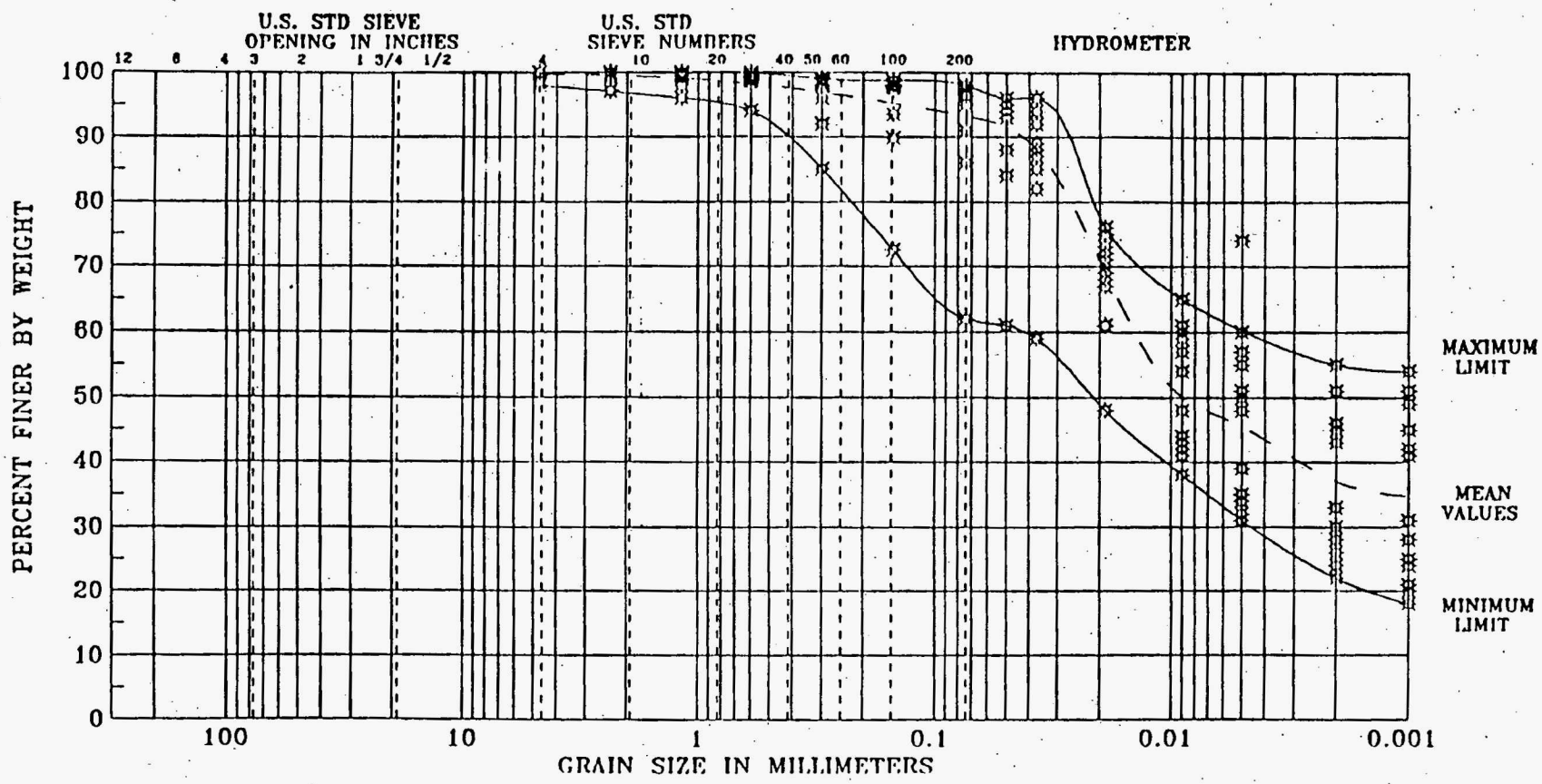
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SUMMARY PLOT OF GRADATION LIMITS

RESIDUUM
OVERALL AREA

FIGURE 3-6

REPORT NO. MKES -3840R-7005	DRAWING NO.	
ORIGINATOR: ND	DRAWN BY: ND	DATE:



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SUMMARY PLOT OF GRADATION LIMITS

POTENTIAL BORROW SOURCE NO. 1

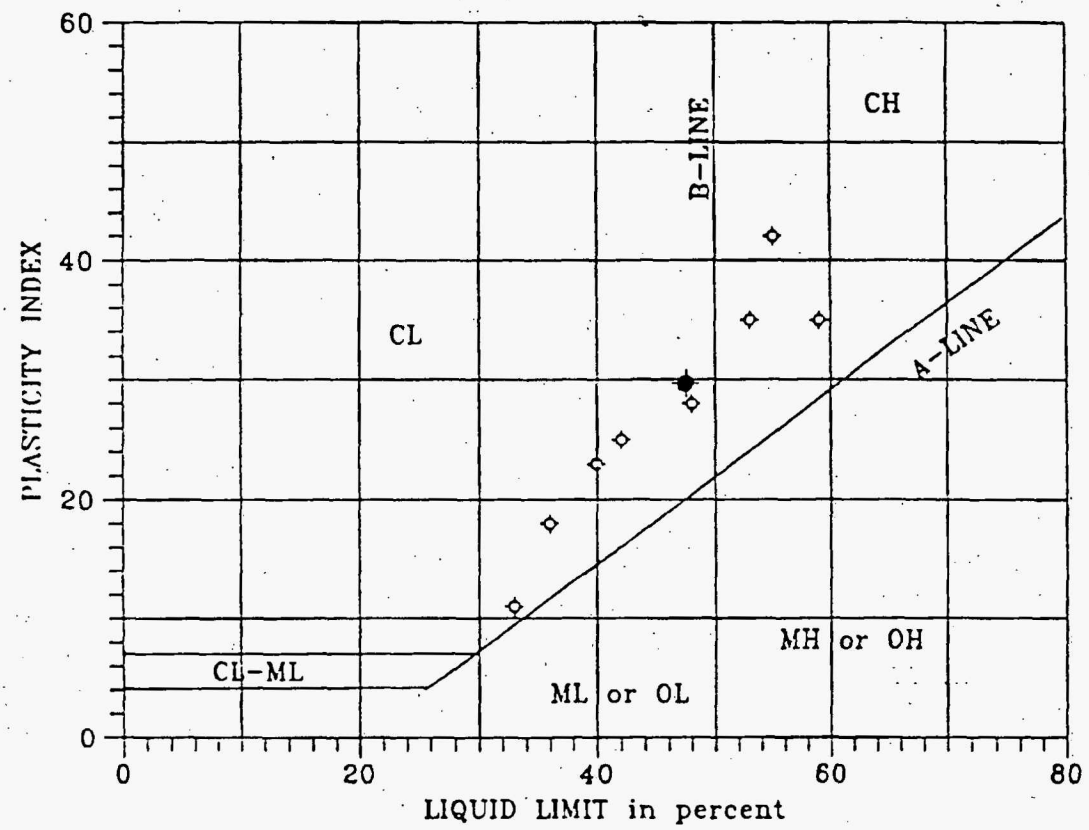
FIGURE 3-7

REPORT NO.MKES-3840R-7005	DRAWING NO.	
ORIGINATOR: ND	DRAWN BY: ND	DATE:

The results of the Atterberg limits for the various geologic units are plotted on the plasticity charts in Figures 3-8 through 3-13, and for Borrow Source No. 1 in Figure 3-14. The topsoil and fill materials are predominantly classified in the CL and CH categories according to the Unified Soil Classification System. The average liquid limit (LL) is 48% and the average plastic index (PI) is 30. The Loess is predominately CL except for one sample classified as CH and one as MH. The average LL is 42% and the average PI is 23. As stated above, test results for the Ferrelview clay are divided into the northern chemical plant area, southern chemical area, material staging area (MSA) and Temporary Storage Area (TSA) and plotted. This was performed because of the large number of data points available for this soil unit and also because of the need to determine if the soil characteristics vary with geographical distribution. Different symbols other than the standard ones cited earlier were used in the plot. With the exception of the material in the MSA, the plasticity of the Ferrelview clay does not show any areal trend or difference across the site. This soil unit, as a whole for the site, consists of CL and CH materials covering a broad range of plasticity values. With the exception of one sample classified as CL-ML material (LL=27, PI=6), the liquid limit for the soil unit ranges from 36 to 82% with an average of about 50%, and the PI ranges from 16 to 58 with an average of about 32. One sample was classified in the CL-ML category. The Ferrelview clay in the MSA in general has a higher plasticity than the rest of the site (CH material), with an average LL of 62% and PI of 42. The Clay Till is a CL-CH material with an average LL of 48% and average PI of 33. The Basal Till is predominantly a CL material; only one sample is classified in the CH category. The average LL is 40% and the average PI is 24. Only three Atterberg limit tests were performed on the Residuum matrix due to the gravelly nature of the Residuum. The fines content in the Residuum is highly plastic with an average LL of 64% and a PI of 44. Soils from potential clay Borrow Source No. 1 consist predominantly of CL, with some CH and ML classifications. The overall LL ranges from 31 to 71% and the overall PI ranges from 9 to 50. The overall average LL is 46% and PI is 22.

3.3.3 Specific Gravity

Specific gravity is the ratio of the weight of a given unit volume of any solid material to the weight of a given unit of water (at 4°C). When used with the unit weight and moisture content of a soil, the specific gravity can be applied to many



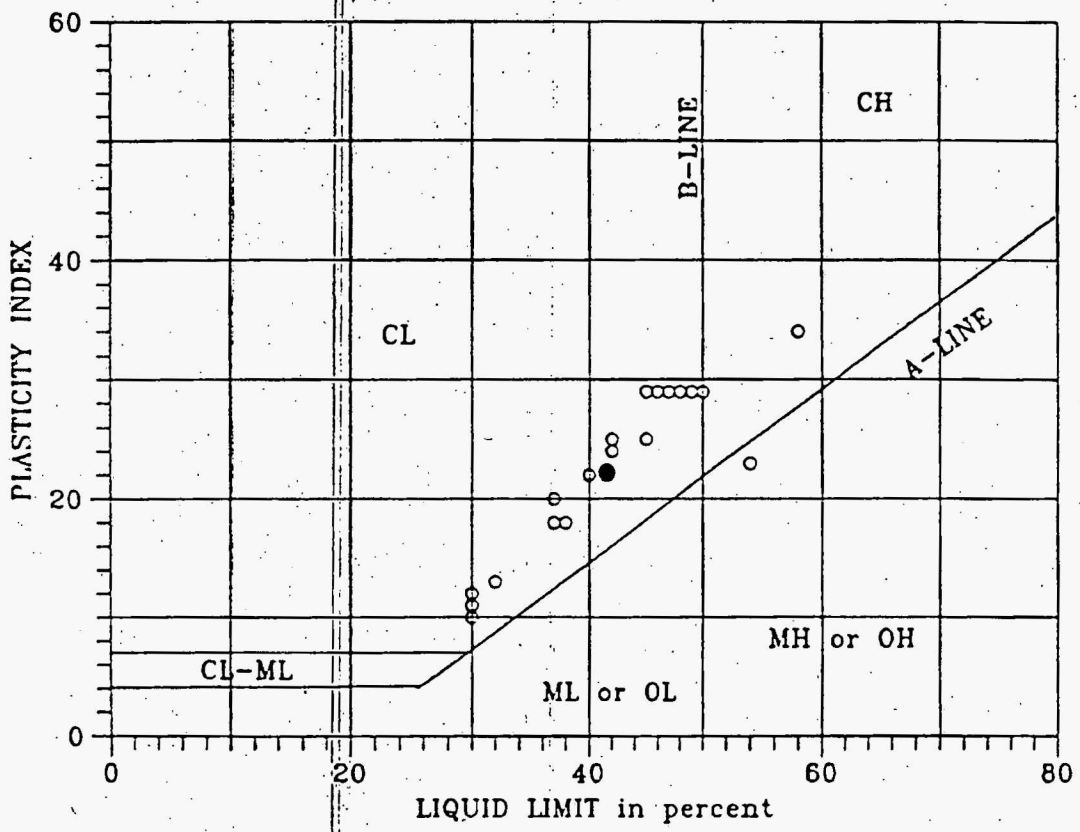
Average Value

PLASTICITY CHART FOR

TOPSOIL/FILL
OVERALL AREA

FIGURE 3-8

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT,1991



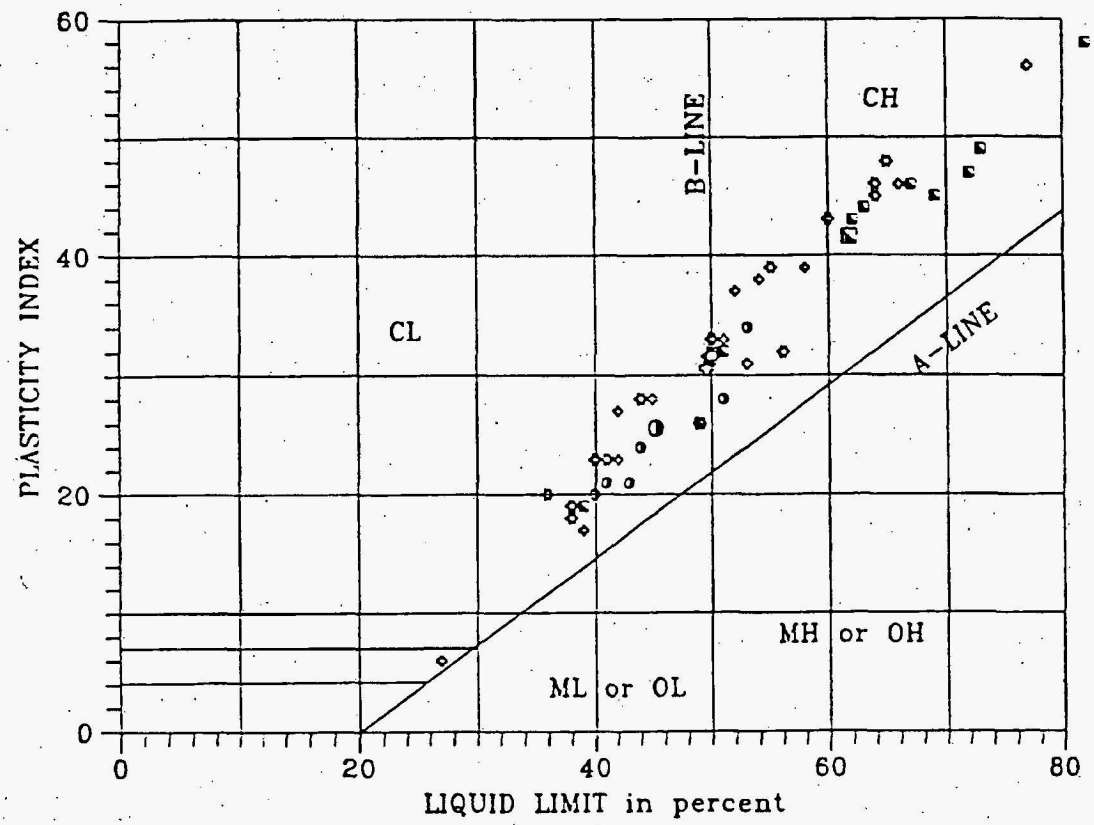
● Average Value

PLASTICITY CHART FOR

LOESS
OVERALL AREA

FIGURE 3-9

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN.: ND	DATE: OCT,1



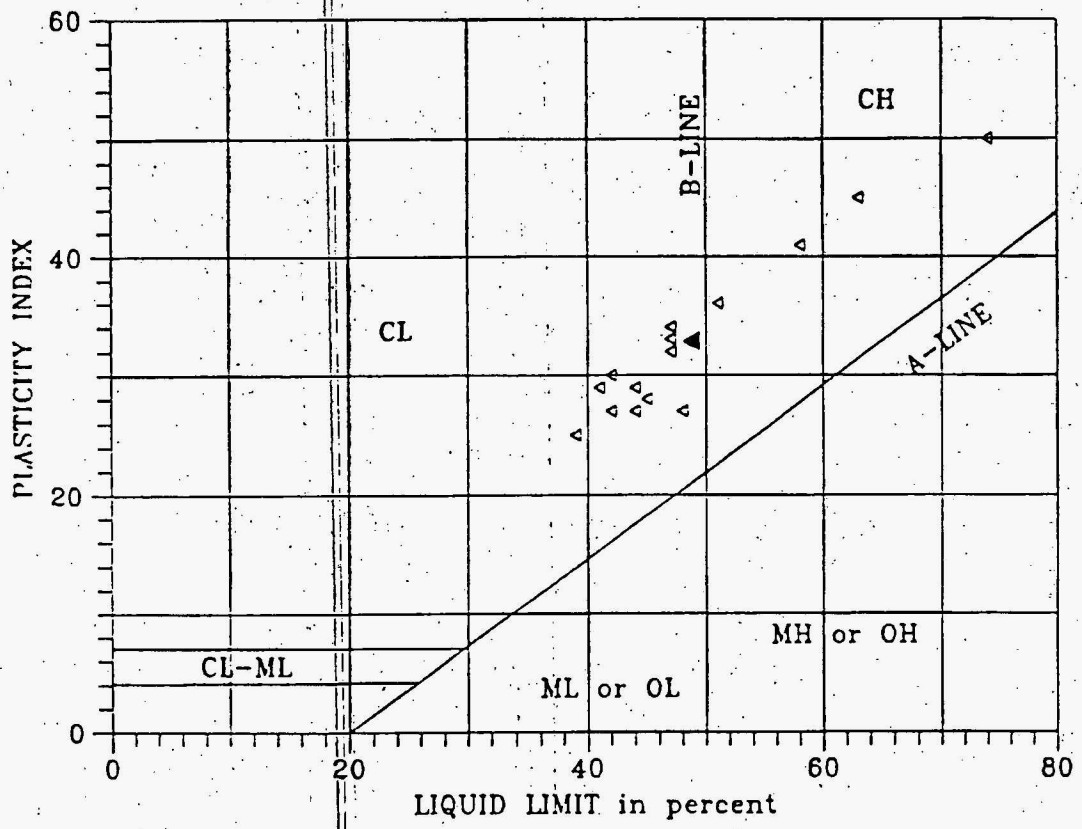
- Northern Chemical Plant Area (N.C.P)
- N.C.P Average Value
- Southern Chemical Plant Area (S.C.P)
- S.C.P Average Value
- Materials Staging Area (M.S.A)
- M.S.A Average Value
- Temporary Storage Area (T.S.A)
- T.S.A Average Value

PLASTICITY CHART FOR

FERRELVIEW CLAY
OVERALL VALUES

FIGURE 3-10

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT.1991



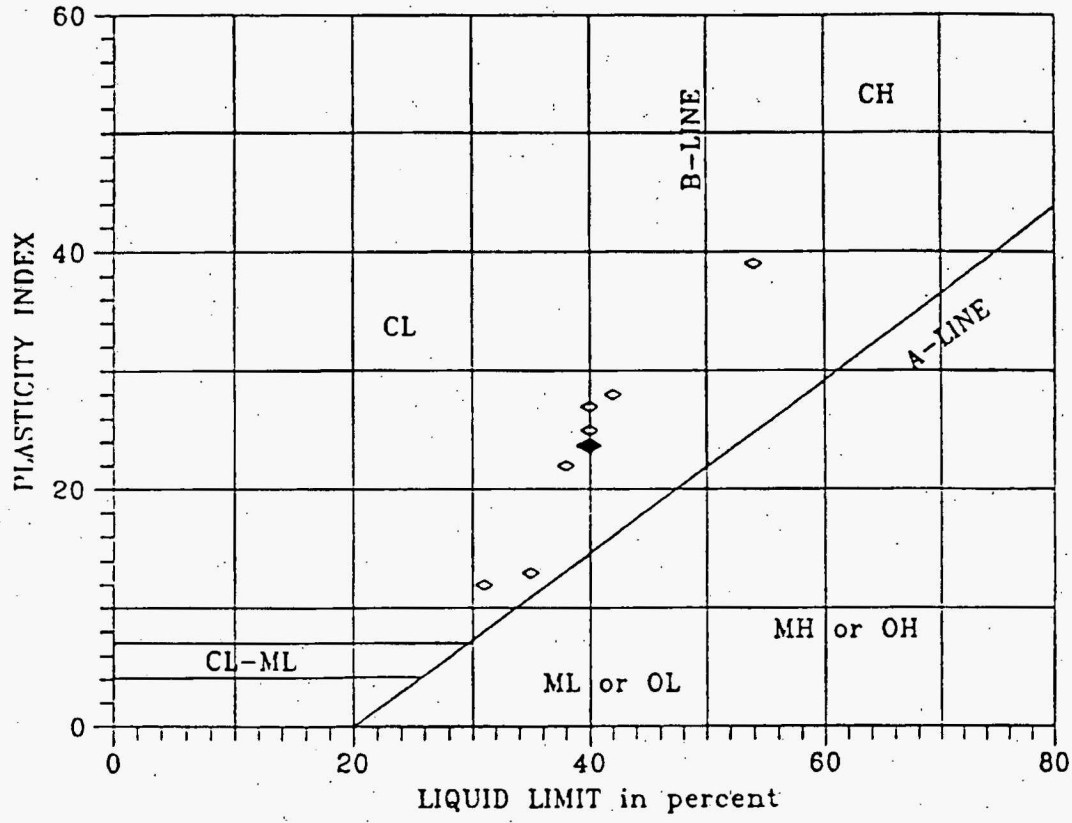
◀ Average Value

PLASTICITY CHART FOR

CLAY TILL
OVERALL AREA

FIGURE 3-11

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR: ND	DRAWN : ND	DATE: OCT,1991



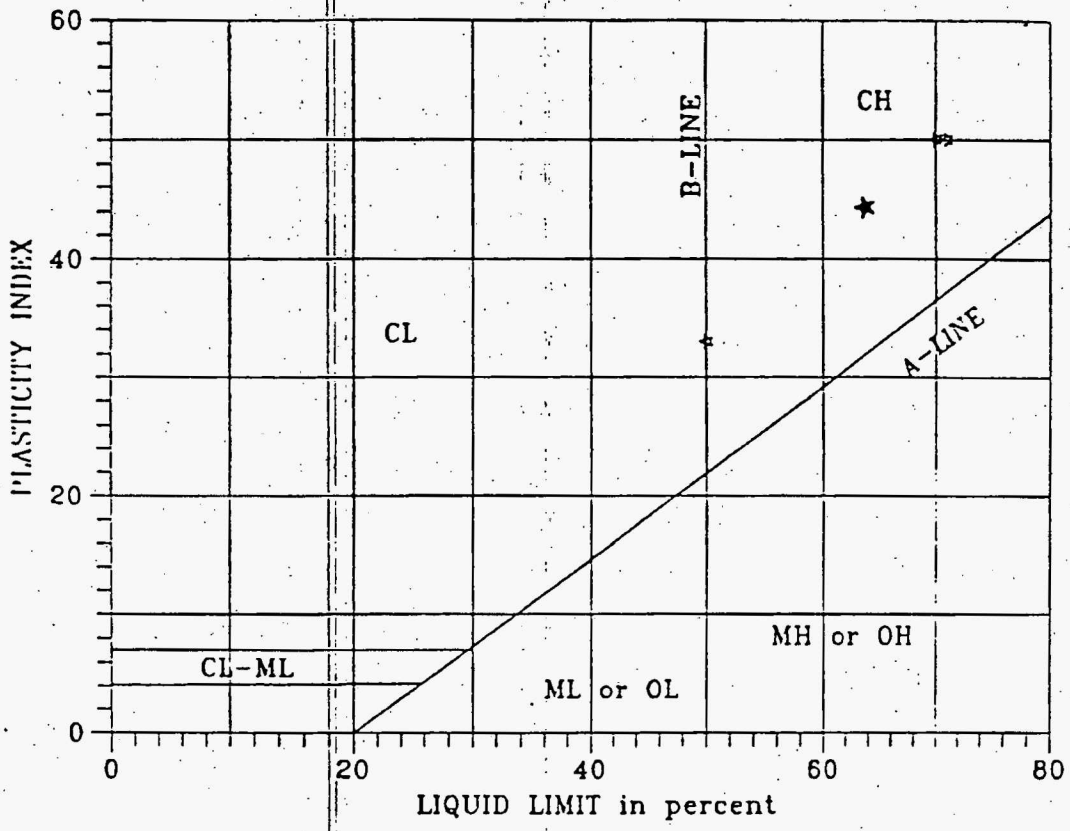
◆ Average Value

PLASTICITY CHART FOR

BASAL TILL
OVERALL AREA

FIGURE 3-12

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR: ND	DRAWN : ND	DATE: OCT,1991



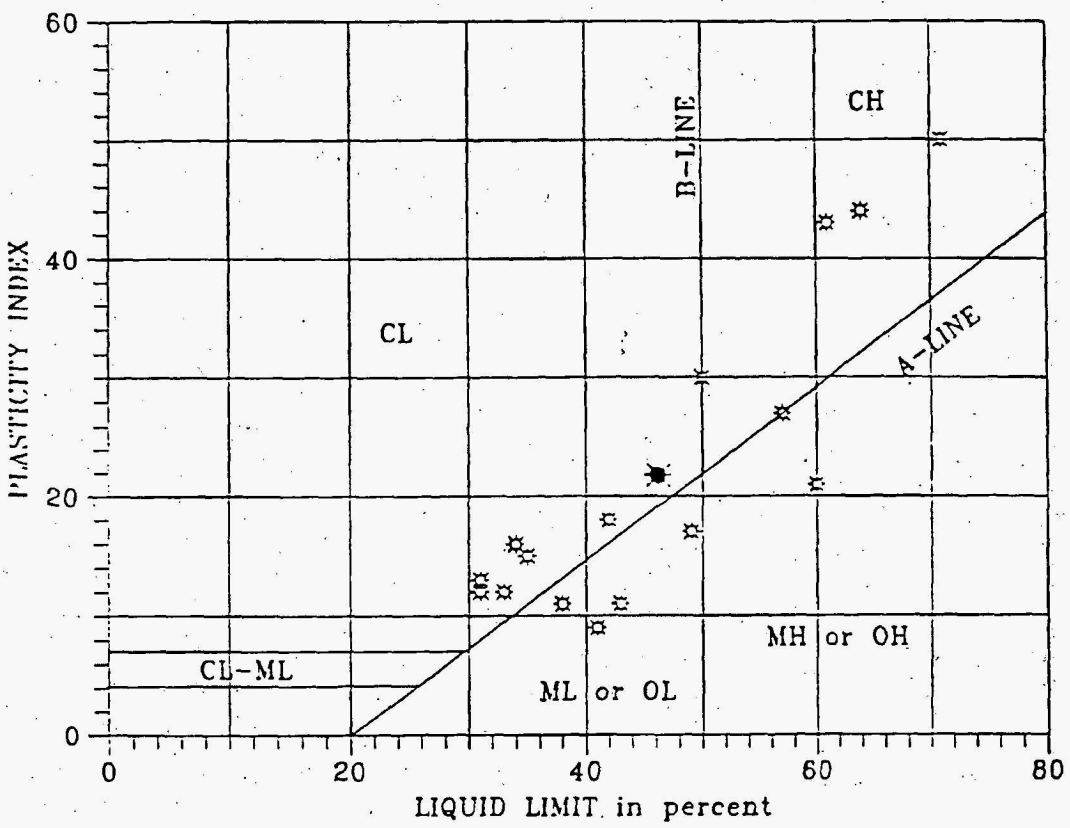
★ Average Value

PLASTICITY CHART FOR

RESIDUUM
OVERALL AREA

FIGURE 3-13

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR: ND	DRAWN : ND	DATE: OCT,1991



Average Value

PLASTICITY CHART FOR

POTENTIAL BORROW SOURCE NO. 1
OVERALL AREA

FIGURE 3-14

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR: ND	DRAWN : ND	DATE: OCT.1991

equations expressing relationships among air, water and soil solids; to determine additional basic parameters such as void ratio, degree of saturation, porosity and effective porosity. Table 3-9 shows the calculated average values of these parameters for each of Loess, Ferrelview clay, Clay Till and Basal Till soil type. The average values is obtained by averaging the calculated parameter using test results of specific gravity, moisture content and dry unit weight from individual samples. Due to the lack of test results for individual soil samples for the Topsoil/fill and residuum, the additional basic parameters were calculated using average values of specific gravity, moisture content and dry unit weight from these two soil types.

The specific gravity (Table 3-9) averages about 2.7 for the Topsoil/Fill, Loess, Ferrelview clay, clay Till and Basal Till, and 2.74 for Residuum. These values are typical for the types of soils encountered. The void ratios calculated using the average values range from 0.57 for Basal Till to 0.79 for Residuum. Degrees of saturation range from 65% for Residuum to 94% for Ferrelview clay. The porosities range from 0.35 for Basal Till to 0.44 for Residuum and the effective porosities range from 0.02 for the Ferrelview clay to 0.16 for Residuum.

3.3.4 Natural Moisture Content

The moisture content test determines the moisture content, or pore water content (% of dry soil weight) of a soil-water mixture. It is used extensively in determining soil index properties, soil behavior correlations, and soil consistency. The moisture content, defined as the ratio of the weight of water in the pores of soil to the weight of the soil, is used in most equations expressing relationships among air, water, and solids in a soil. When used with Atterberg limits, moisture content can provide some indication of whether a soil is reconsolidated.

The natural moisture content or water content of the soil is the moisture content of the soil in the in-situ condition when the soil sample was taken. It should be noted that the moisture content for samples obtained near the ground surface or above permanent groundwater level will vary seasonally due to climactic factors such as temperature, rainfall, length of dry period, etc., whereas for samples from deep below the ground surface or below the permanent water level, it will probably not change much over a seasonal period.

TABLE 3-9 : ADDITIONAL SOIL PROPERTIES CALCULATED FROM AVERAGE VALUES OF TEST RESULTS

	OVERALL AVERAGE VALUES			CALCULATED VALUES			
Soil Type	Specific Gravity Gs	Natural Moisture Content w (%)	Dry Unit Weight γ_d (pcf)	Void ratio (1) e	Deg of Saturation (2) S (%)	Porosity (3) n	Effective Porosity (4) n_e
TOPSOIL/FILL	2.70 •	23.4	98.4	(5) 0.712	(5) 88.7	(5) 0.416	(5) 0.047
LOESS	2.70	20.8	98.3	0.705	90.4	0.411	0.040
FERRELVIEW	2.69	22.6	100.0	0.678	94.3	0.403	0.022
CLAY TILL	2.71	19.2	105.7	0.619	93.2	0.378	0.025
BASAL TILL	2.69	18.9	109.2	0.571	90.6	0.362	0.035
RESIDUUM	2.74	18.8	95.4	(5) 0.792	(5) 65.0	(5) 0.442	(5) 0.155

Formulas for Calculation :

(1) $e = (Gs \cdot \gamma w / \gamma d) - 1$

(2) $S = Gs \cdot w / e$

(3) $n = e/(1+e)$

(4) $n_e = (1-S)n$

(5) Overall average values used because of lack of specific data.

• Assumed value.

The overall average natural moisture content values for the site soils were calculated and shown in Tables 3-5 and 3-9. These values typically range from 19 to 23% and do not exhibit large variation with soil types and depths. The overall average natural moisture content for the soils at potential clay Borrow Source No. 1 is 23%.

3.3.5 In Situ Density

The dry density test is used to determine the dry unit weight of a soil. It is the basis for determining overburden stresses and other soil properties useful in settlement calculations. In situ density can also be used as an indicator of past stresses and loadings on the soil, and to determine soil horizons and volume-weight relationships.

The average dry density values for each site soil type are shown in Tables 3-5 and 3-9. The total (moist) unit weight was calculated using the moisture content and the dry unit weight test results for each soil sample tested. The average total unit weight was calculated by averaging each calculated total unit weight. The overall average dry and total unit weights, respectively, are 101 and 123 pounds per cubic foot (pcf) for the topsoil/fill; 98 and 121 pcf for Loess; 100 and 124 pcf for Ferrelview clay; 106 and 128 pcf for Clay Till; 109 and 128 pcf for Basal Till and 95 and 116 pcf for Residuum. The overall average dry unit weight for Borrow Source No. 1 soils is 96 pcf and the average total unit weight is 119 pcf.

3.4 Moisture-Density and Capillary-Moisture Relations

3.4.1 Standard Proctor Compaction

The compaction test develops moisture-density characteristics for a soil that is compacted at a specified energy level. Each soil has unique moisture-density characteristics. The test utilized a standard compaction mold and a hammer to compact the soil. A series of tests at varying moisture contents yields a compaction curve from which the maximum dry density and the optimum moisture content (OMC) can be determined. The minimum density and range of water content to be used in the field can then be specified.

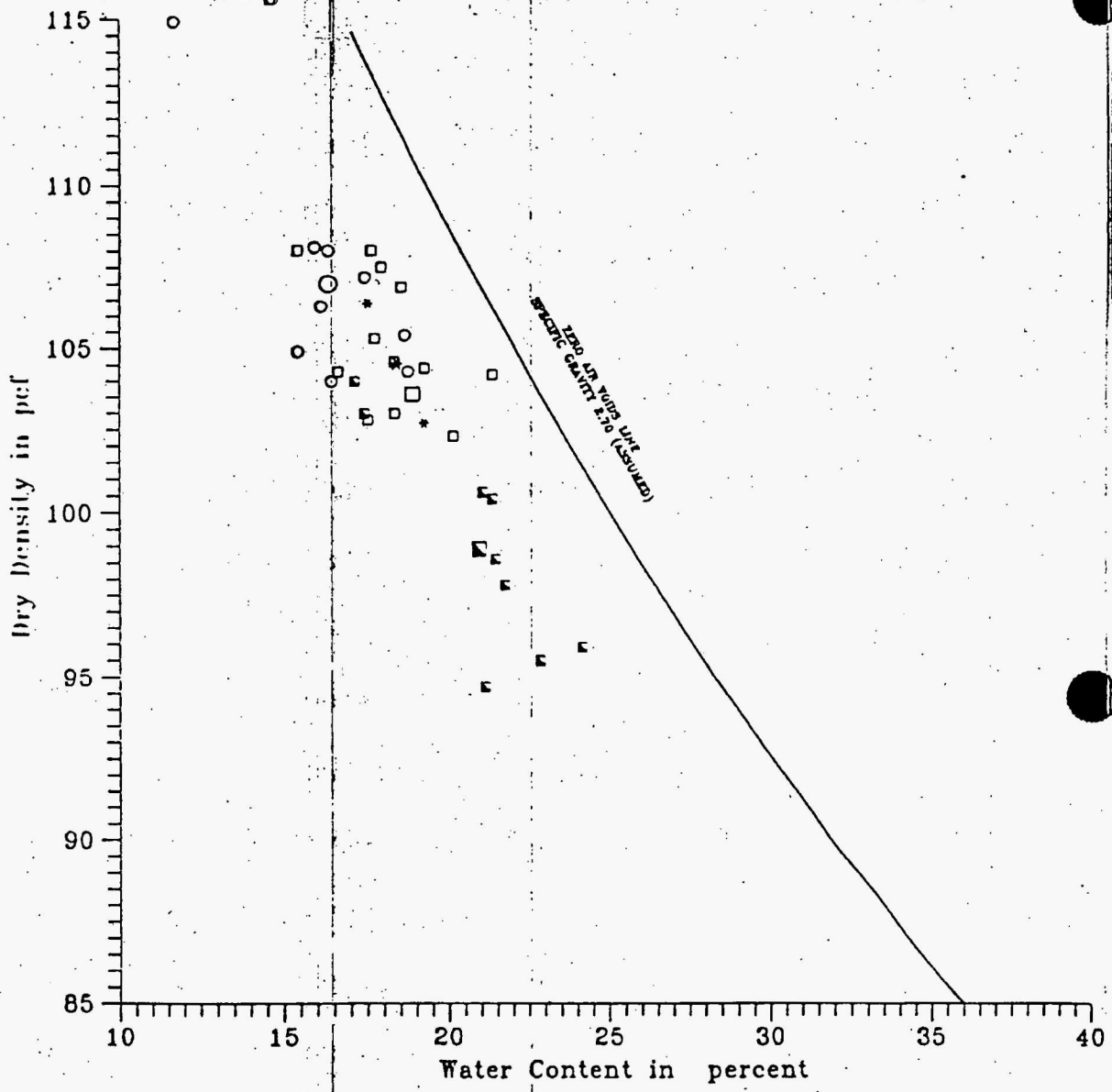
Compaction tests were performed on soils which will potentially require compaction during remedial operations. These include both materials to be relocated and potential backfill or fill materials originated either on-site or off-site. The test results (maximum dry density and OMC) for on-site soil units are plotted in Figures 3-15 and for potential clay Borrow Source No. 1 in Figure 3-16. Average values were also calculated and plotted in the graph. In general, the Loess exhibits the highest compacted dry density. The Ferrelview clay shows a wide range of values, with a maximum dry density from 94 to 116 pcf and OMC from 12 to 25%. The CH material from the MSA generally has a maximum dry density of less than 100 pcf. The average maximum dry density and the average optimum moisture content, respectively, are 105 pcf and 18.5% for the topsoil/fill material; 107 pcf and 16% for Loess; 104 pcf and 19% for Ferrelview clay; and 107 pcf and 18% for Borrow Source No. 1. Basil Till and Residuum materials were not tested due to their greater depth at the site.

3.4.2 Capillary-Moisture Relationships

The capillary-moisture relationship test determines the moisture content retained in the soil subjected to a given soil-water tension. The tensions applied usually range from 1 to 15 atmospheres (bars). The test results are used to estimate the long-term moisture content of the soil, for radon barrier design, and for correlating unsaturated hydraulic conductivities with soil saturation. The moisture content at 15 bar tension, generally defined as the wilting point of the soil, is normally considered as the long term moisture content, according to one of several procedures used to determine the long term moisture content.

This test was performed on selected soil samples of Loess and Ferrelview clay, because these materials will be placed in the disposal cell. Twelve tests were performed on borrow source materials. The sample specimens were remolded (compacted) to 95% of standard Proctor maximum dry density at 3% above optimum moisture content to simulate the anticipated recommended remedial action compaction requirement.

Results are shown in Figures 3-17, 3-18 and 3-19 for Loess, Ferrelview clay and Potential Borrow Source No. 1, respectively. The moisture content at 15 bar averages



- Dike Fill Material
- Dike Fill Average Value
- Loess
- Loess Average Value
- Ferrelview Clay
- Ferrelview Clay Average Value
- Ferrelview Clay (M.S.A)
- M.S.A Average Value

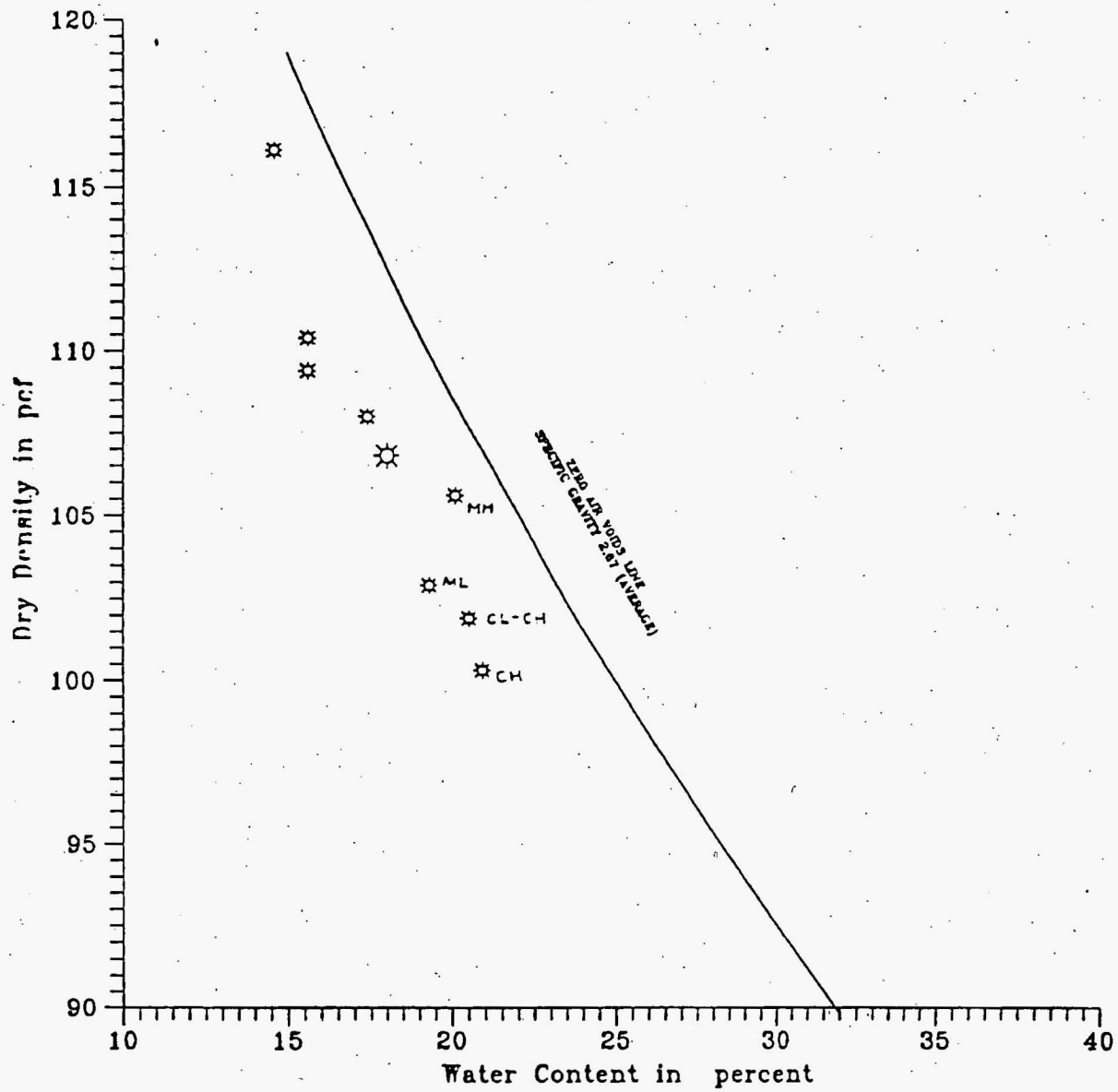
SUMMARY OF COMPACTION TESTS

OVERALL AREA

VARIOUS SOIL UNITS

FIGURE 3-15

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT.1991

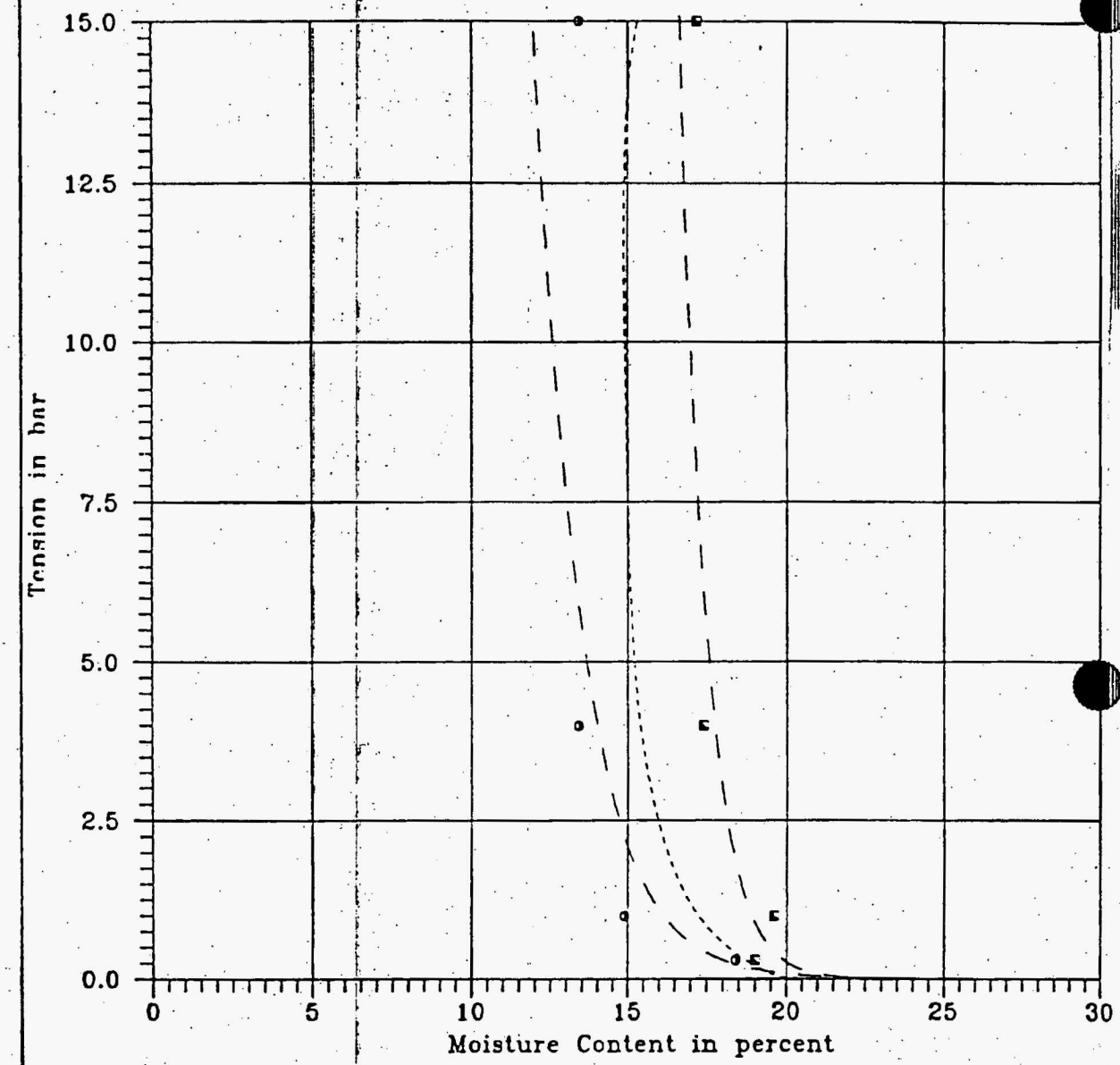


Potential Borrow Source No. 1
Average Value

SUMMARY OF COMPACTION TESTS
POTENTIAL BORROW SOURCE NO. 1

FIGURE 3-16

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR: ND	DRAWN : ND	DATE: OCT,1991



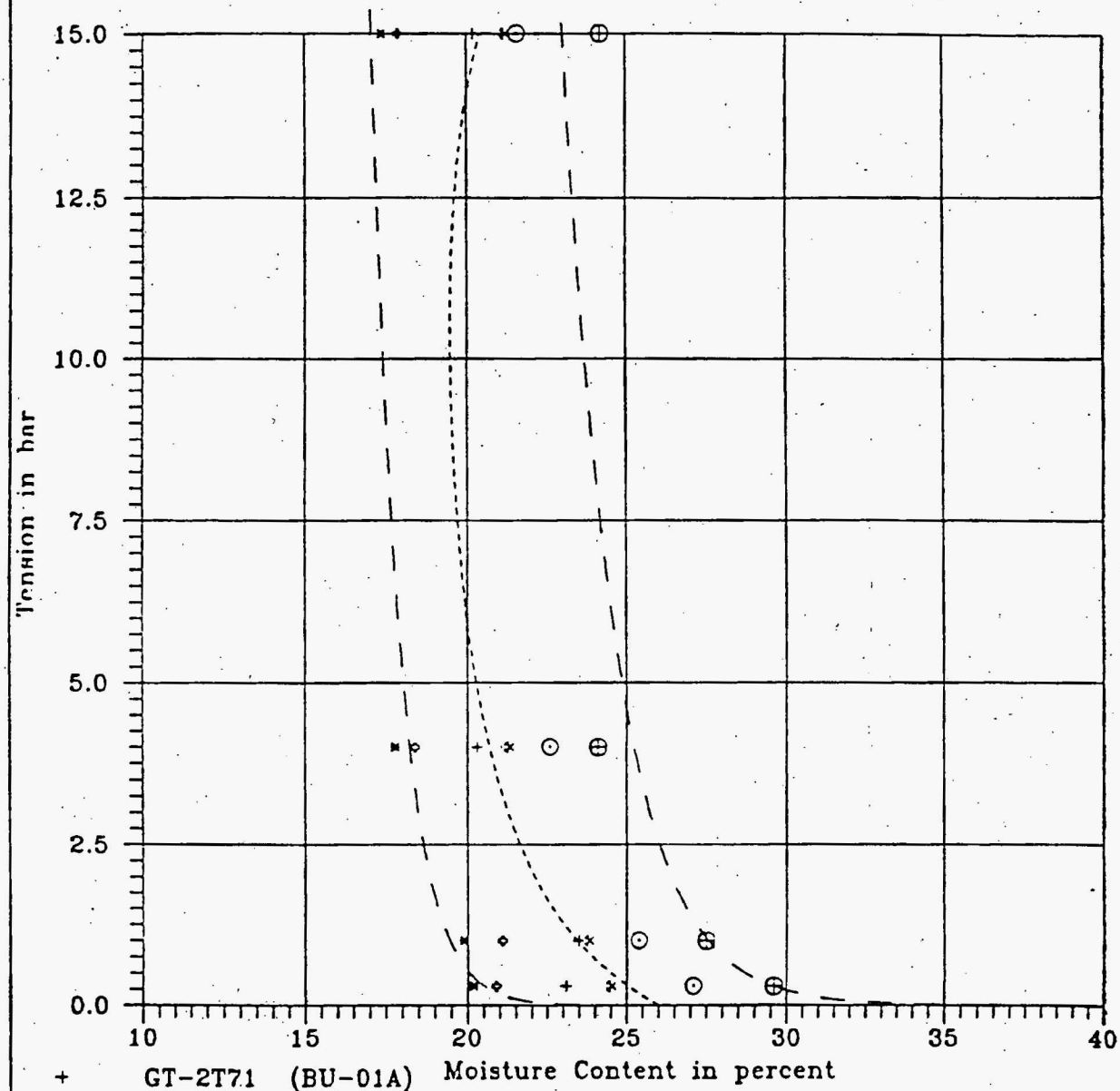
GT-2T74 (BU-01A)
GT-2T78 (BU-01A)
----- Average Value
— — Max. & Min. Values

SUMMARY OF CAPILLARY MOISTURE TESTS

REMOLDED LOESS

FIGURE 3-17

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR: ND	DRAWN : ND	DATE: OCT,1991



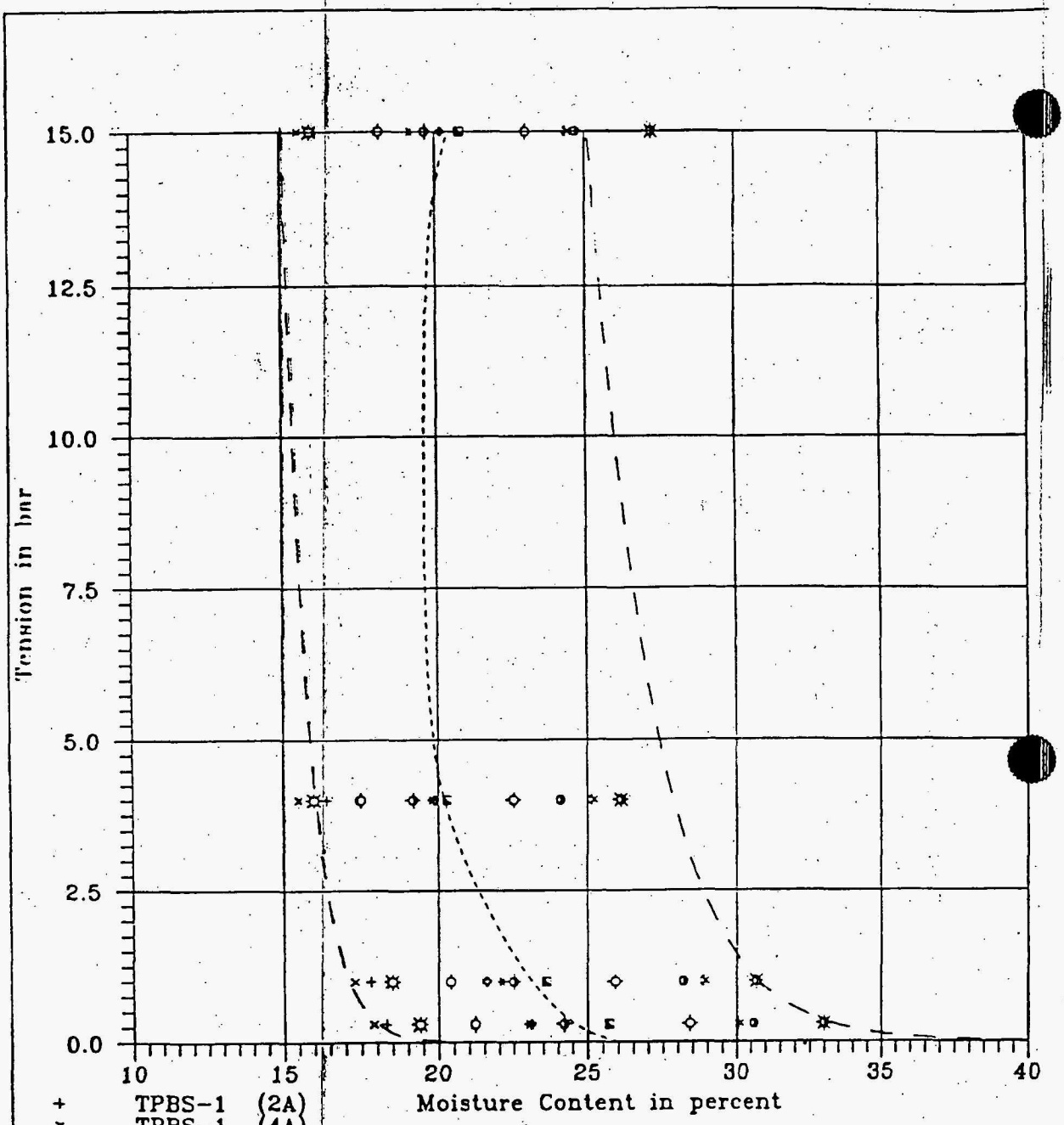
+ GT-2T71 (BU-01A)
× GT-2T71 (BU-02A)
• GT-2T75 (BU-01A)
⊗ GT-2T75 (BU-02B)
◇ GT-2T77 (BU-01B)
⊙ GT-2T77 (BU-02A)
⊕ GT-2T78 (BU-02B)
----- Average Value
— — Max. & Min. Values

SUMMARY OF CAPILLARY MOISTURE TESTS

REMOLDED FERRELVIEW CLAY

FIGURE 3-18

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR: ND	DRAWN : ND	DATE: OCT,1991



+ TPBS-1 (2A)
× TPBS-1 (4A)
TPBS-6 (1A)
× TPBS-6 (2A)
TPBS-8 (1A)
TPBS-8 (2A)
TPBS-8 (3A)
TPBS-10 (1A)
TPBS-10 (2A)
TPBS-10 (3A)
TPBS-11 (1A)
TPBS-11 (2A)
----- Average Value
— — Max. & Min. Values

SUMMARY OF CAPILLARY MOISTURE TESTS

POTENTIAL BORROW SOURCE NO. 1

FIGURE 3-19

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR: ND	DRAWN : ND	DATE: OCT,1991

about 16% for Loess and 20% for Ferrelview clay. These values are very close to the average optimum molding moisture content values (see Section 3.4.1) determined from standard Proctor compaction tests. The range of 15-bar values for Borrow Source No. 1 material is from 16 to 27%, which is about 0 to 7% above the range of optimum moisture content obtained from the Standard Proctor testing.

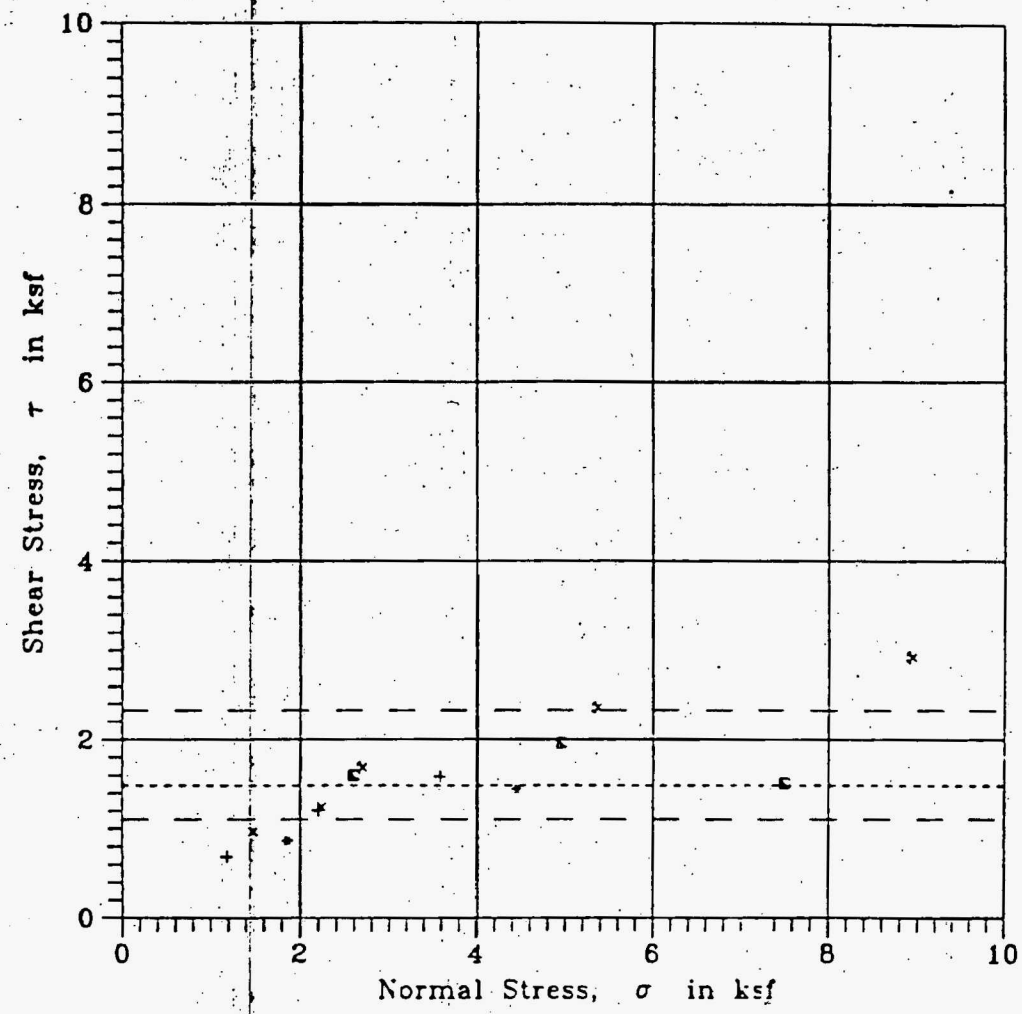
3.5 Strength and Deformation

3.5.1 Unconsolidated – Undrained (UU) Triaxial Compression

The UU triaxial compression or Q test determines the total shear strength parameters and stress/strain characteristics of a soil. The test simulates short-term or end-of-construction conditions by not allowing excess pore pressures resulting from confining and axial stresses to dissipate. A series of samples of a soil are tested at different confining pressures to develop the parameters and characteristics.

UU tests were performed on undisturbed samples of on-site soils to determine the total shear strength parameters for soil units which have to bear the load of the disposal and other facilities. Some UU tests were also performed on compacted samples of potential borrow source materials to determine their remodeled strength characteristics. UU tests were also performed on remolded samples of on-site materials to evaluate their effectiveness as potential borrow materials. The peak deviation stress $(\sigma_1 - \sigma_3)_{max}$ was taken as the failure criterion. Most samples were saturated when tested. Unsaturated test specimens are noted as such in the appropriate figures. For saturated cohesive soils, the cohesion is equal to the undrained shear strength, Su, which is the radius of the Mohr's Circle, $(\sigma_1 - \sigma_3)/2$. Su values from unsaturated test specimen will usually be higher than those from saturated conditions and therefore, in most analytical cases, only interpretation of strength from saturated condition is used.

Results of the undrained shear strength of undisturbed samples of in-situ soils at the site are shown in Figure 3-20 through 3-23. Average undrained shear strength (Su) values for saturated condition for Loess range from 1100 psf to 2330 psf with an arithmetic mean of 1490 psf. Ferrelview clay Su values range from 870 psf to 1460 psf with a mean value of 1180 psf. Su values for Clay Till have a minimum value of 860 psf and a maximum of 1660 psf with an average value of 1260 psf. The high Su values from unsaturated samples were omitted from averaging because it would be



LEGEND :

+	GT-37	(ST-03)
×	GT-38	(ST-03)
●	GT-50	(ST-02)
⊠	GT-56	(ST-02)
▣	GT-57	(ST-03)

— — Max. & Min Values

----- Average Values

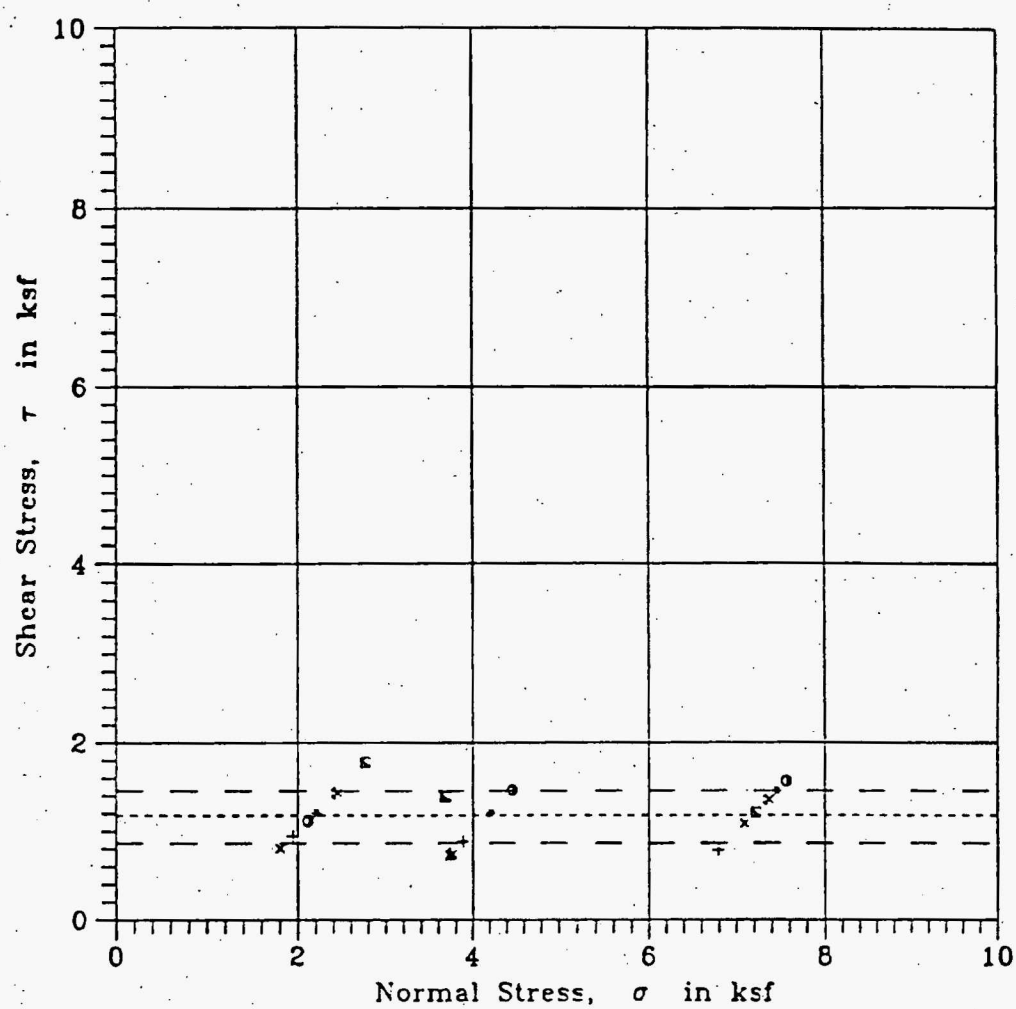
SUMMARY OF STRENGTH ENVELOPES

UU TRIAXIAL TEST, UNDISTURBED SAMPLE

LOESS

FIGURE 3-20

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT.1991



LEGEND :

+	GT-48	(ST-03)
×	GT-48	(ST-07)
●	GT-51	(ST-03)
✱	GT-52	(ST-04)
▫	GT-55	(ST-06)
○	GT-55	(ST-08)

----- Average Value

— — Max. & Min. values

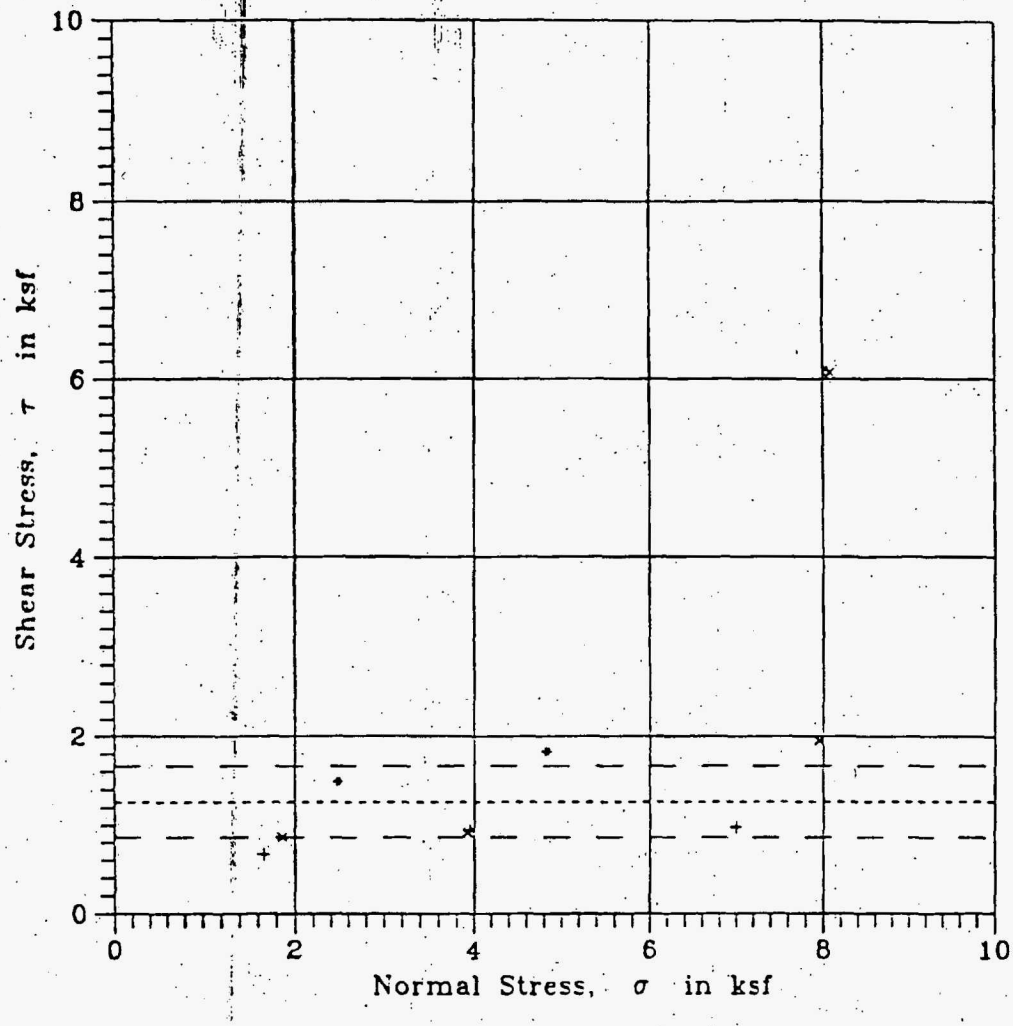
SUMMARY OF STRENGTH ENVELOPES

UU TRIAXIAL TEST, UNDISTURBED SAMPLE

FERRELVIEW CLAY

FIGURE 3-21

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT,1991



LEGEND :

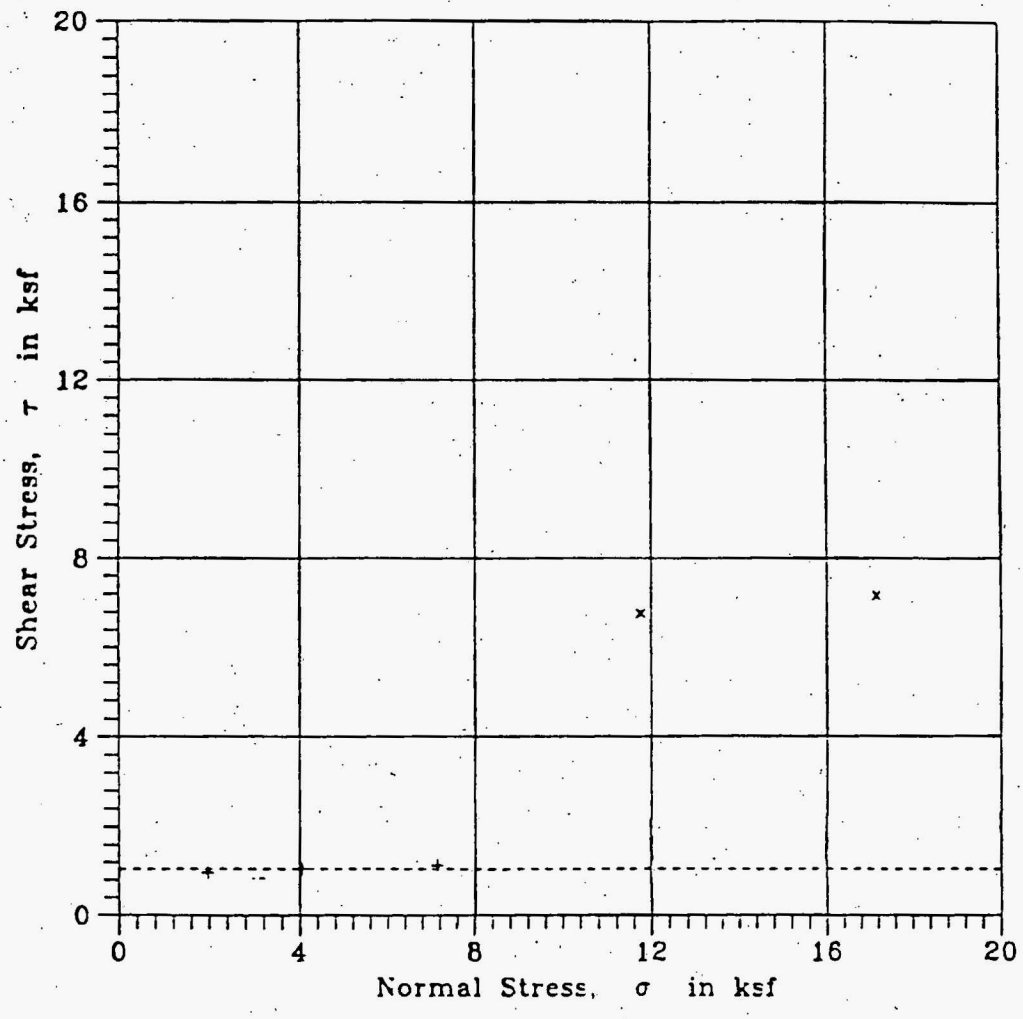
+ GT-43 (ST-10)
× GT-50 (ST-06)
* GT-56 (ST-08)
* GT-69 (6906) [1]
----- Average Values
— — Max. & Min. values

[1] Unsaturated sample. Values not included in averaging.

SUMMARY OF STRENGTH ENVELOPES
UU TRIAXIAL TEST, UNDISTURBED SAMPLE
CLAY TILL

FIGURE 3-22

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT,1991



LEGEND :

+ GT-52 (ST-14)[1]

× GT-69 (6908)[1]

----- Average Value

[1]Unsaturated sample values not included in averaging.

SUMMARY OF STRENGTH ENVELOPES

UU TRIAXIAL TEST, UNDISTURBED SAMPLE

BASAL TILL

FIGURE 3-23

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT.1991

unconservative if used. Thus the only valid Su result obtained for Basal Till was 1060 psf.

A UU test was performed on one remolded Loess sample at unsaturated condition (Figure 3-30). The average Su was 5060 psf. Since this value is for unsaturated condition, it was not used. The Su values for remolded Ferrelview clay range from 2020 psf to 2320 psf with an average value of 2220 psf (Figure 3-31).

For potential Borrow Source No. 1 material, the Su values for remolded samples ranged from 2300 psf to 3260 psf with an average value of 2720 psf (Figure 3-34).

All remolded samples were compacted to 95% maximum dry density at about 3% above optimum moisture content, as determined from the standard proctor compaction test.

3.5.2 Consolidated – Undrained (CU) Triaxial Compression

The CU triaxial compression or R test determines total and effective shear strength parameters and stress/strain characteristics of a soil. The test simulates undrained loading under long-term conditions by allowing consolidation of the soil sample before uniaxial loading is applied. A series of samples of a soil are tested at different consolidation/confining pressures to develop the parameters and characteristics.

CU tests were performed on undisturbed and remolded samples of Loess and Ferrelview clay materials. Some CU tests were also performed on potential Borrow Source No. 1 materials. All samples were tested under saturated or close to saturated condition unless otherwise noted. Remolded samples were compacted to 95% of maximum dry density at about 3% above the optimum moisture content as determined from the Standard Proctor compaction tests.

The failure criterion was defined as the loading conditiona at maximum ratio of the effective stresses, i.e. $(\sigma_1'/\sigma_3')_{max}$. To determine the values of the total and effective shear strength parameters, plots on p-q diagram consisting of variables q vs p at failure were generated from test results for each specimen; where p is the average of the principal stresses, σ_1 and σ_3, and q is one-half the difference of the principal stresses, i.e., $(\sigma_1 - \sigma_3)/2$.

The best fit line was plotted for each test sample (generally 3 specimens) to determine the variables a and α. The a is the q-intercept of the best fit line on the p-q diagram and α is the angle it makes with the horizontal. For effective parameters, a' and α' were obtained from p-q plots of effective stress test results. The shear

strength parameters of cohesion, c, and angle of internal friction, ϕ, and c' and ϕ' (for effective) were obtained using the following equations:

1. $\phi = \sin^{-1}\tan\alpha$
2. $c = a/\cos\phi$
3. $\phi' = \sin^{-1}\tan\alpha'$
4. $c' = a'/\cos\phi'$

The p-q plots, commonly called the K_f-lines, are shown on Figures 3-24 through 3-29 for undisturbed on site soils and Figures 3-32 and 3-33 for remolded on site soils. Remolded Borrow Source No. 1 material is shown in Figure 3-35. The plots were drawn by plotting all p-q values of one particular geologic unit on one figure and also plotting a K_f-line of average values for that unit as a dashed line. The maximum and minimum K_f-lines are also shown, when applicable.

Among the undisturbed samples, Topsoil had an average c value of 560 psf and ϕ of 17.5°, and an average c' value of 535 psf and ϕ' of 24°. The corresponding c, ϕ and c', ϕ' values for Loess were 440 psf, 25° and 280 psf, 35.5°. Ferrelview clay had c = 502 psf, ϕ = 12.4°, c' = 440 psf and ϕ' = 18°. Clay till had c = 360 psf, ϕ = 21°, c' = 407 psf and ϕ' = 28°. The Basil Till had c = 920 psf, ϕ = 20°, c' = 823 psf and ϕ' = 29°. Only one test was performed on Residuum material, mainly to serve as a check on its strength parameters. It had a c of 205 psf, ϕ of 13°, c' of 260 psf, and ϕ' of 29°.

The single test performed on remolded Loess gave a c value of 820 psf, ϕ of 13°, c' of 290 psf and ϕ' of 29°. The corresponding values for remolded Ferrelview clay were 323 psf, 13.5°, 90 psf and 19°.

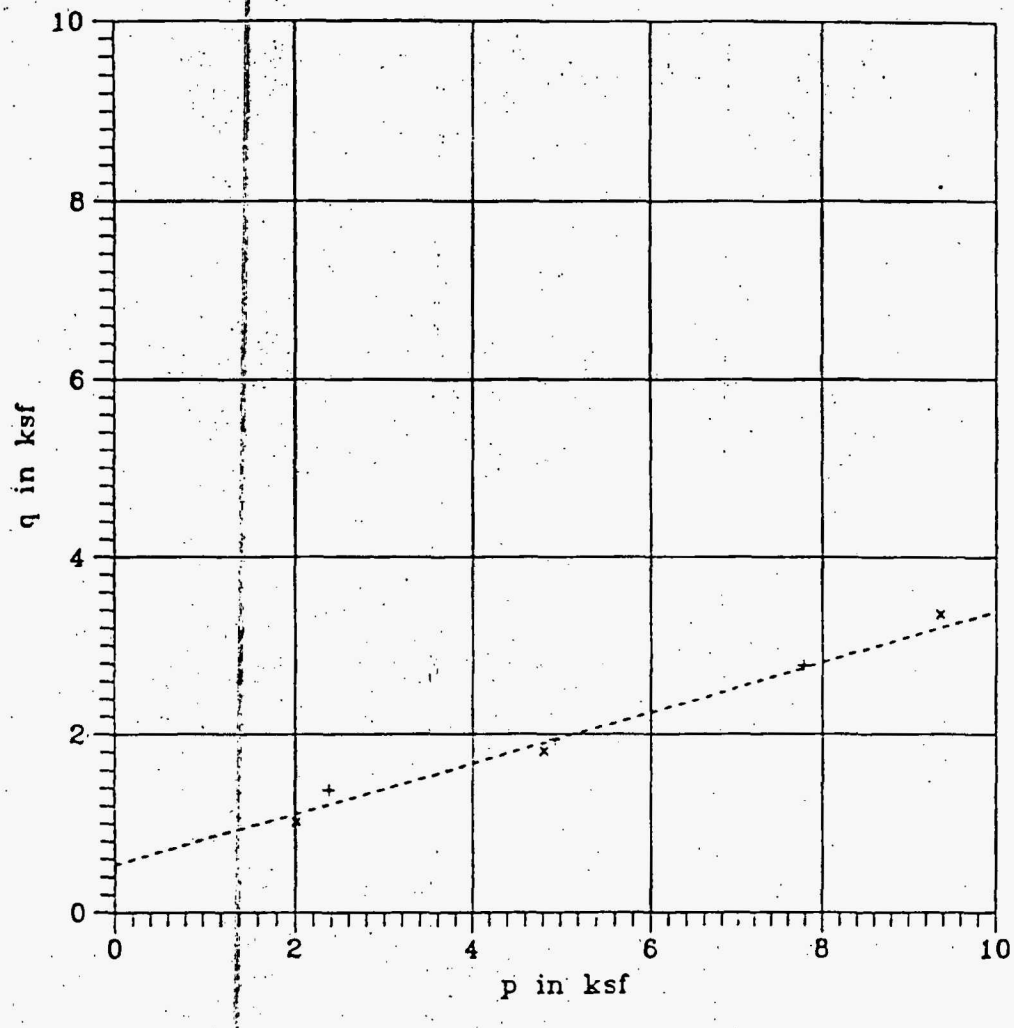
The shear strength parameters for the potential borrow source materials were c = 544 psf, ϕ = 15°, c' = 466 psf and ϕ' = 22°.

3.5.3 California Bearing Ratio

The California Bearing Ratio (CBR) is generally used to design pavements for roads or areas with traffic loads.

Laboratory CBR tests were performed on test pit samples from the Material Staging Area. The tests were one-specimen tests, soaked, using a 6-inch mold and a

Summary of average values :
a = 534.1 psf, α= 16.7 °
c = 560.0 psf, Φ= 17.5 °



NOTES :
1. α and a are from graph.
2. $\Phi = \sin^{-1}\tan\alpha$, $c = a/\cos\Phi$

LEGEND :
+ GT-74 (7402)
× GT-54 (ST-03)
----- Average Envelope

SUMMARY OF TOTAL STRENGTH ENVELOPES FROM p-q DIAGRAM

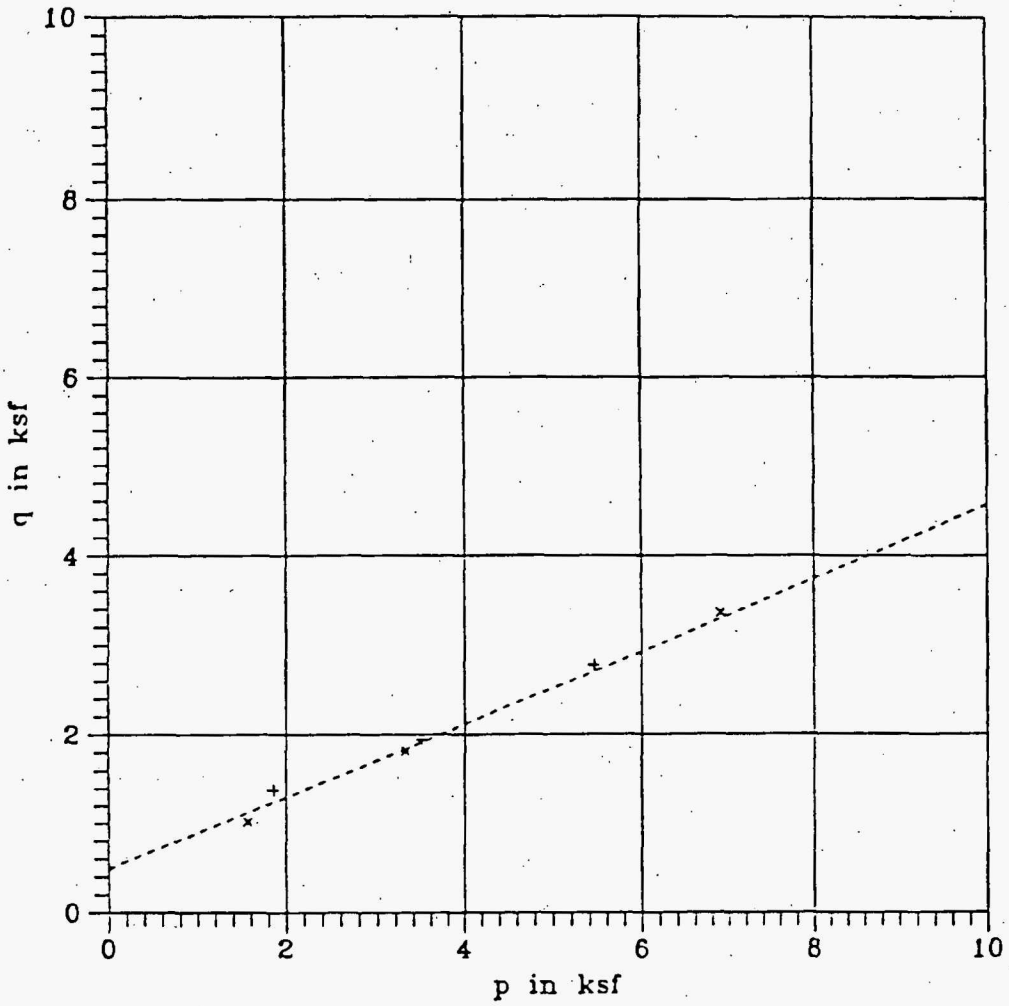
CU TRIAXIAL, UNDISTURBED SAMPLE

TOPSOIL/FILL

FIGURE 3-24 A

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT,1991

Summary of average values :
a = 488.7 psf, α= 22.1 °
c = 535.0 psf, Φ= 24.0 °



NOTES :
1. α and a are from graph.
2. $\Phi = \sin^{-1}\tan\alpha$, $c = a/\cos\Phi$

LEGEND :
+ GT-74 (7402)
× GT-54 (ST-03)
----- Average Envelope

SUMMARY OF EFFECTIVE STRENGTH ENVELOPE FROM p-q DIAGRAM

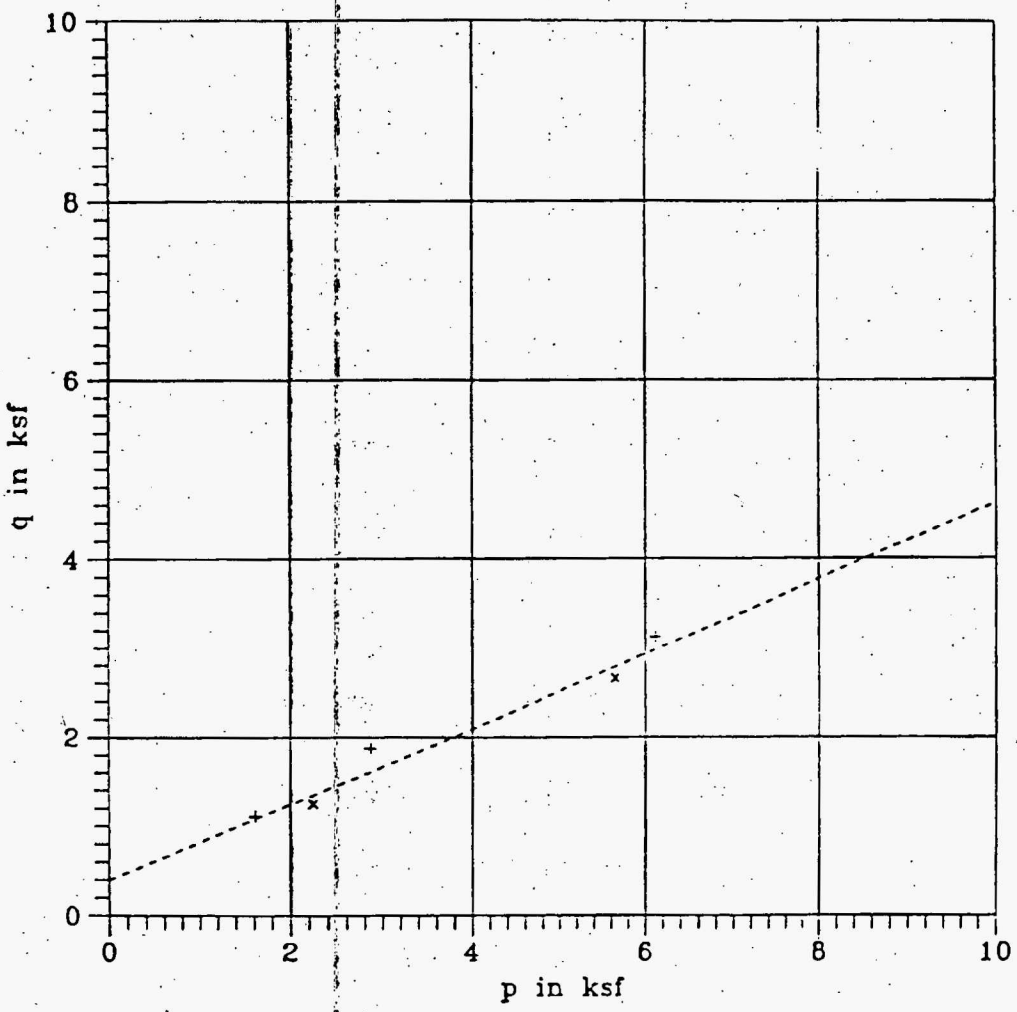
CU TRIAXIAL, UNDISTURBED SAMPLE

TOPSOIL/FILL

FIGURE 3-24 B

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT.1991

Summary of average values :
a = 398.8 psf, α= 22.9 °
c = 440.0 psf, Φ= 25.0 °



NOTES :
1. α and a are from graph.
2. $\Phi = \sin^{-1}\tan\alpha$, $c = a/\cos\Phi$

LEGEND :
+ GT-32 (ST-01)
× GT-56 (ST-02)
----- Average Envelope

SUMMARY OF TOTAL STRENGTH ENVELOPES FROM p-q DIAGRAM

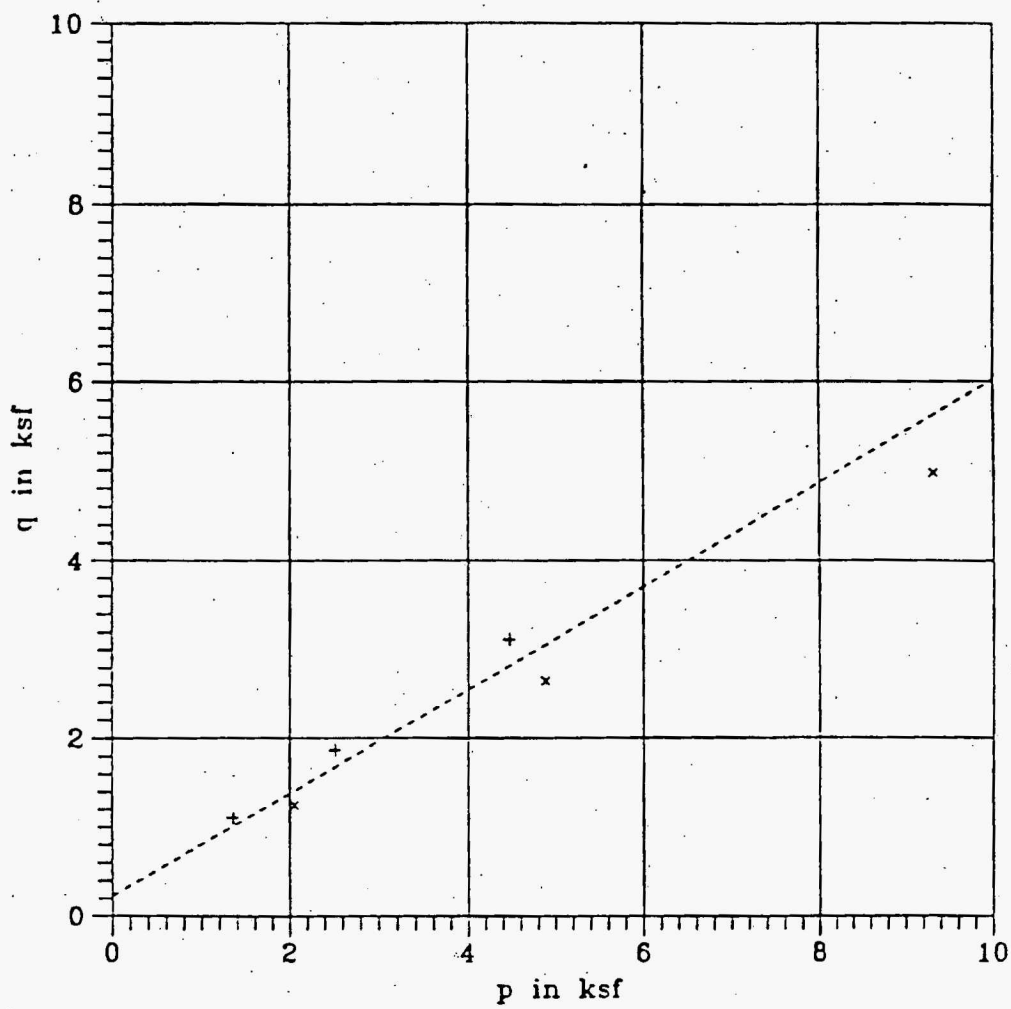
CU TRIAXIAL, UNDISTURBED SAMPLE

LOESS

FIGURE 3-25 A

REPORT NO. MXES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT,1991

Summary of average values :
a = 228.0 psf, α= 30.1 °
c = 280.0 psf, Φ= 35.5 °



NOTES :
1. α and a are from graph.

2. $\Phi = \sin^{-1}\tan\alpha$, $c = a/\cos\Phi$

LEGEND :
+ GT-32 (ST-01)
× GT-56 (ST-02)
----- Average Envelope

SUMMARY OF EFFECTIVE STRENGTH ENVELOPES FROM p-q DIAGRAM

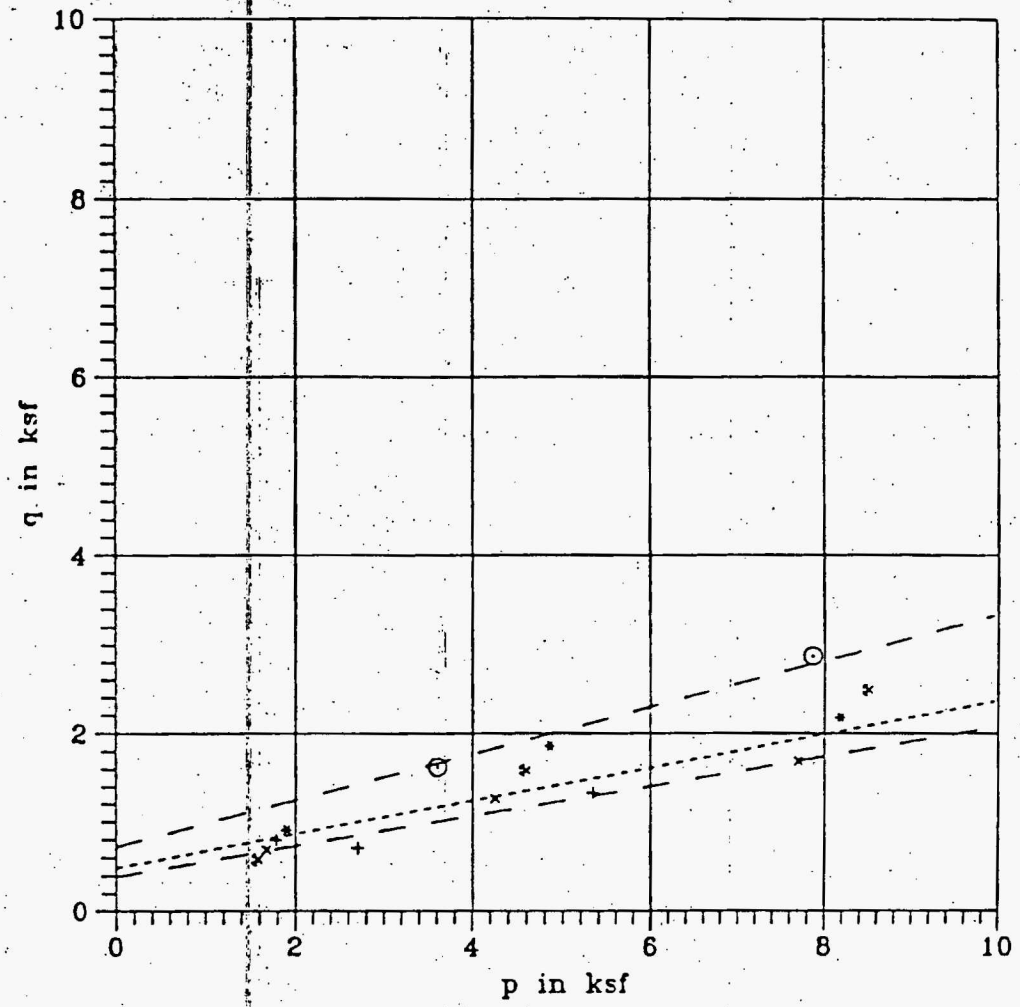
CU TRIAXIAL, UNDISTURBED SAMPLE

LOESS

FIGURE 3-25 B

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT.1991

Summary of average values :
a = 490.3 psf, α= 12.1 °
c = 502.0 psf, Φ= 12.4 °



NOTES :
1. α and a are from graph.
2. $\Phi = \sin^{-1}\tan\alpha$, $c = a/\cos\Phi$

LEGEND :

+ GT-32 (ST-02)
× GT-43 (ST-04)
• GT-48 (ST-05)
⊛ GT-52 (ST-06)
⊙ GT-70 (7004)
----- Average Envelope
— — Max. & Min. Envelopes

SUMMARY OF TOTAL STRENGTH ENVELOPES FROM p-q DIAGRAM

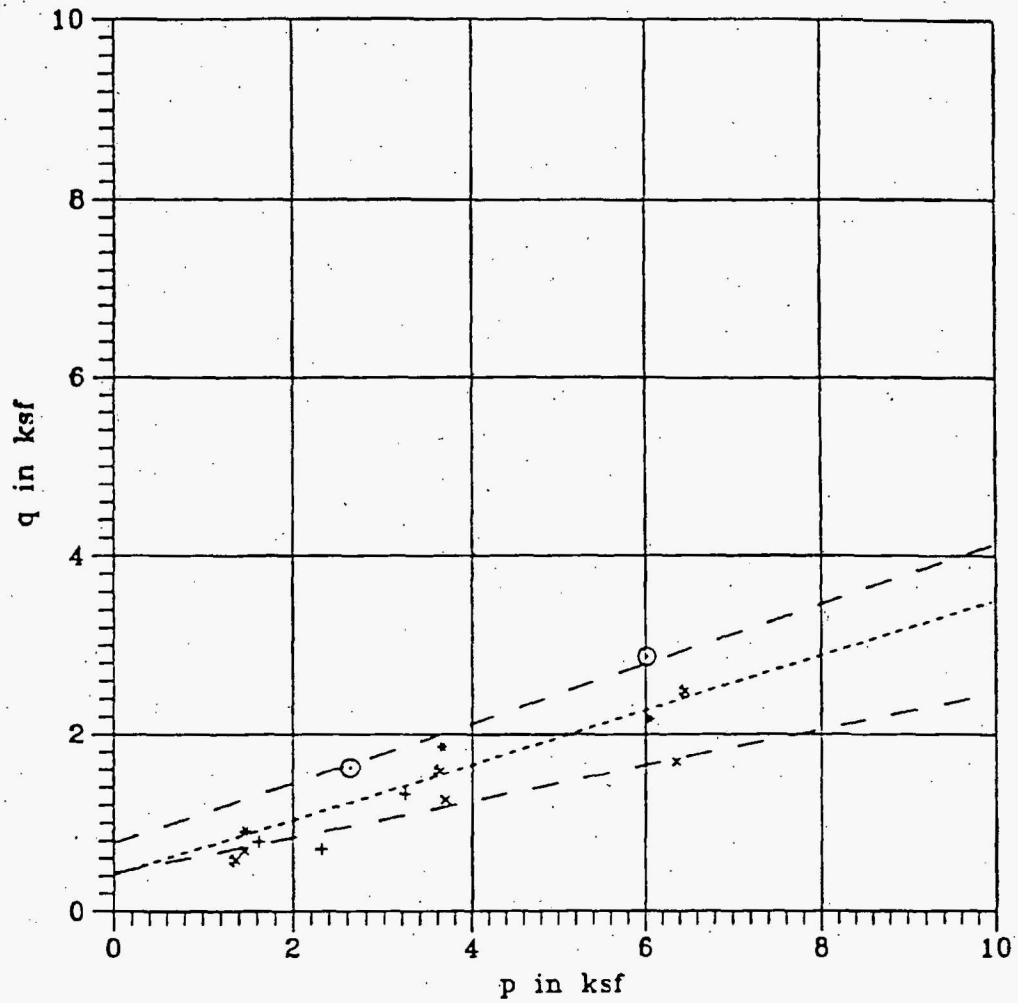
CU TRIAXIAL, UNDISTURBED SAMPLE

FERRELVIEW CLAY

FIGURE 3-26 A

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT.1991

Summary of average values :
a = 418.5 psf, α= 17.2 °
c = 440.0 psf, Φ= 18.0 °



NOTES :
1. α and a are from graph.
2. $\Phi = \sin^{-1}\tan\alpha$, $c = a/\cos\Phi$

LEGEND :

+ GT-32 (ST-02)
× GT-43 (ST-04)
* GT-48 (ST-05)
⊛ GT-52 (ST-06)
⊙ GT-70 (7004)
----- Average Envelope
— — Max. & Min. Envelopes

SUMMARY OF EFFECTIVE STRENGTH ENVELOPE FROM p-q DIAGRAM

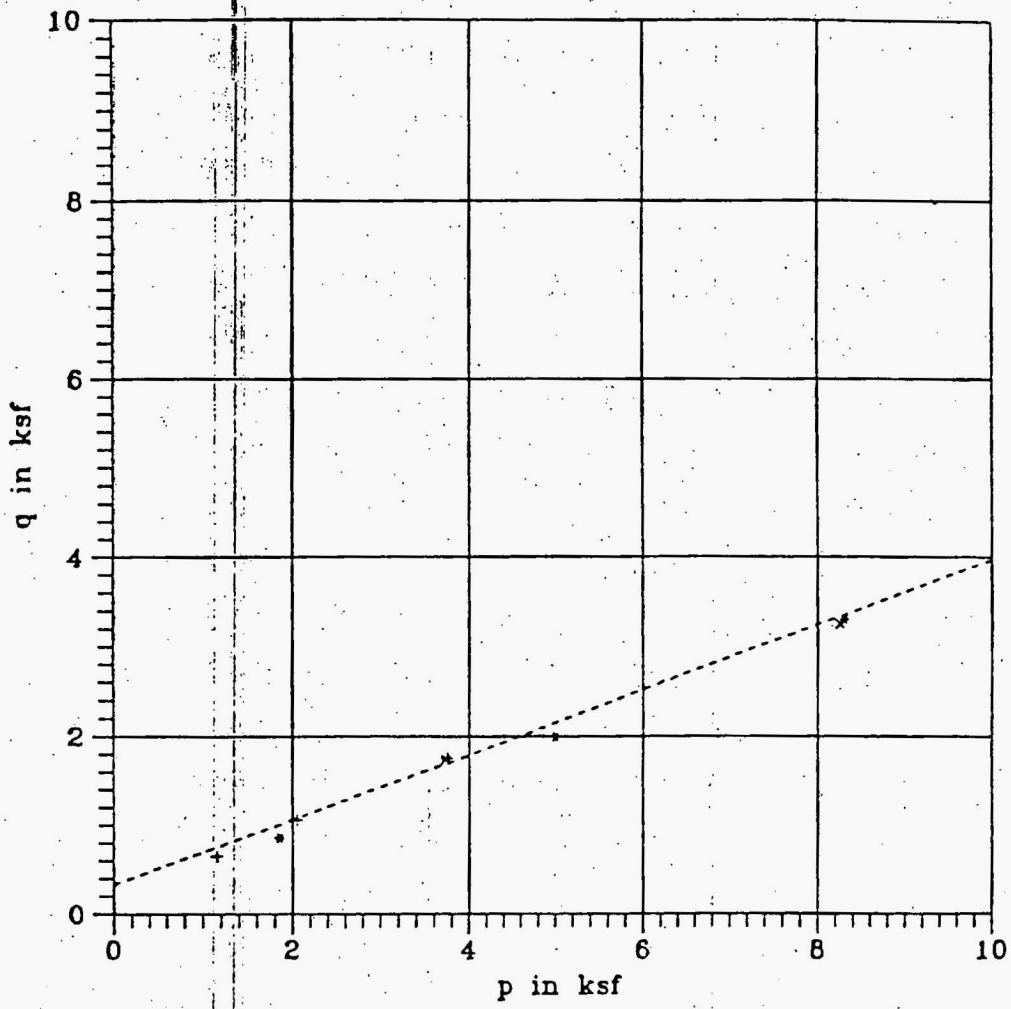
CU TRIAXIAL, UNDISTURBED SAMPLE

FERRELVIEW CLAY

FIGURE 3-26 B

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT,1991

Summary of average values :
a = 335.3 psf, α= 20.0 °
c = 360.0 psf, Φ= 21.3 °



NOTES :
1. α and a are from graph.
2. $\Phi = \sin^{-1}\tan\alpha$, $c = a/\cos\Phi$

LEGEND :

+ GT-44 (ST-03)
× GT-71 (7108)
● GT-74 (7406)
----- Average Envelope

SUMMARY OF TOTAL STRENGTH ENVELOPES FROM p-q DIAGRAM

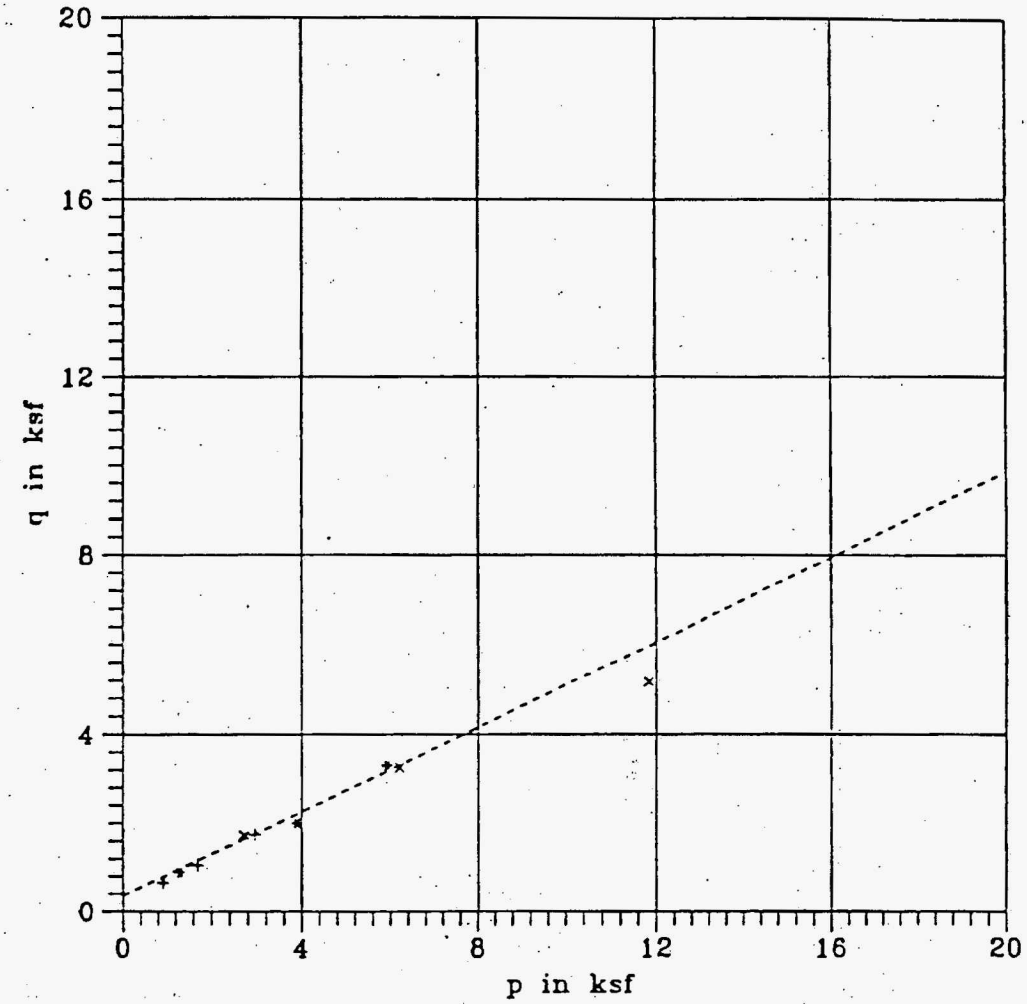
CU TRIAXIAL, UNDISTURBED TEST

CLAY TILL

FIGURE 3-27 A

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT,199[illegible]

Summary of average values :
a = 406.7 psf, α= 28.3 °
c = 358.0 psf, Φ= 25.4 °



NOTES :
1. α and a are from graph.

2. $\Phi = \sin^{-1}\tan\alpha$, $c = a/\cos\Phi$

LEGEND :

+ GT-44 (ST-03)
× GT-71 (7108)
• GT-74 (7406)
----- Average Envelope

SUMMARY OF EFFECTIVE STRENGTH ENVELOPES FROM p-q DIAGRAM

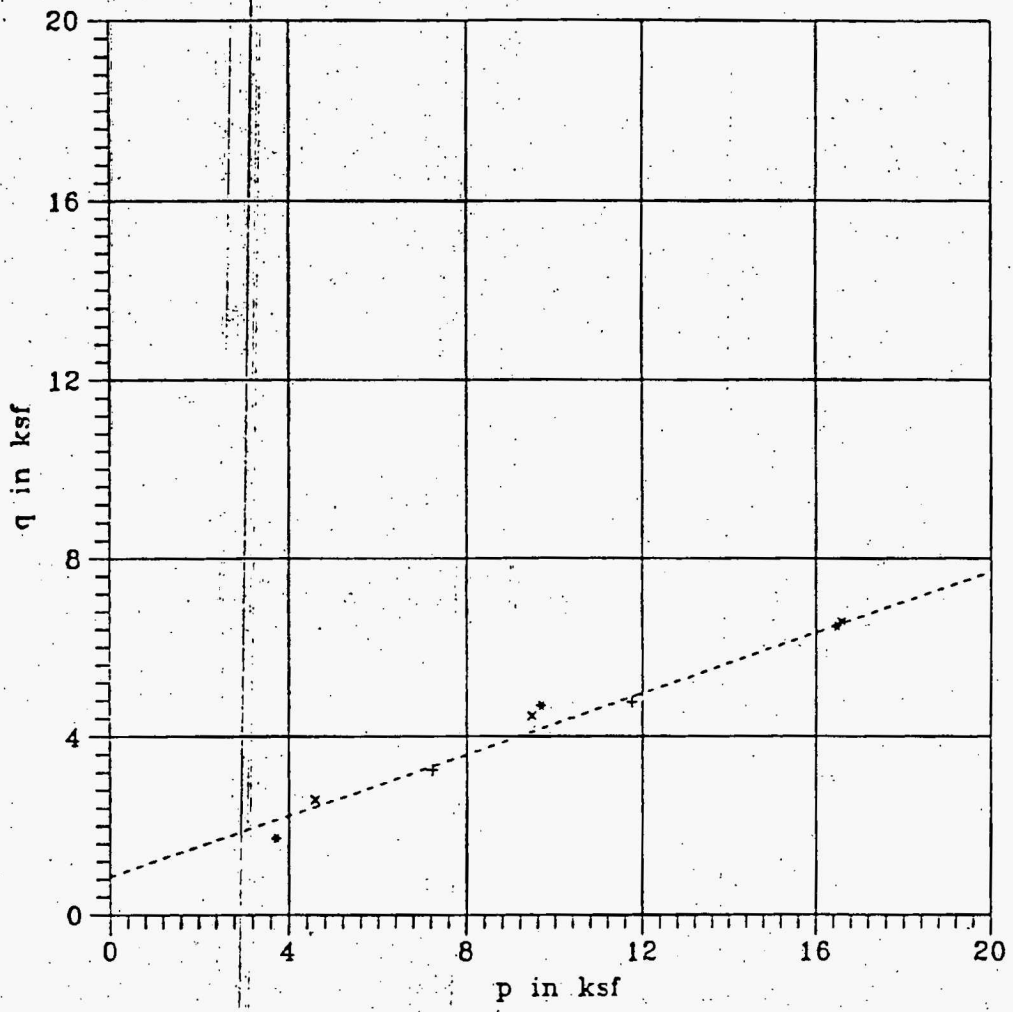
CU TRIAXIAL, UNDISTURBED TEST

CLAY TILL

FIGURE 3-27 B

REPORT NO. MKES-3B40R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT.1991

Summary of average values :
a = 864.5 psf, α= 18.9 °
c = 920.0 psf, Φ= 20.0 °



NOTES :
1. α and a are from graph.
2. $\Phi = \sin^{-1}\tan\alpha$, $c = a/\cos\Phi$

LEGEND :
+ GT-60P (SB-15)
× GT-69 (6908)
* GT-71 (7110)

SUMMARY OF TOTAL STRENGTH ENVELOPES FROM p-q DIAGRAM

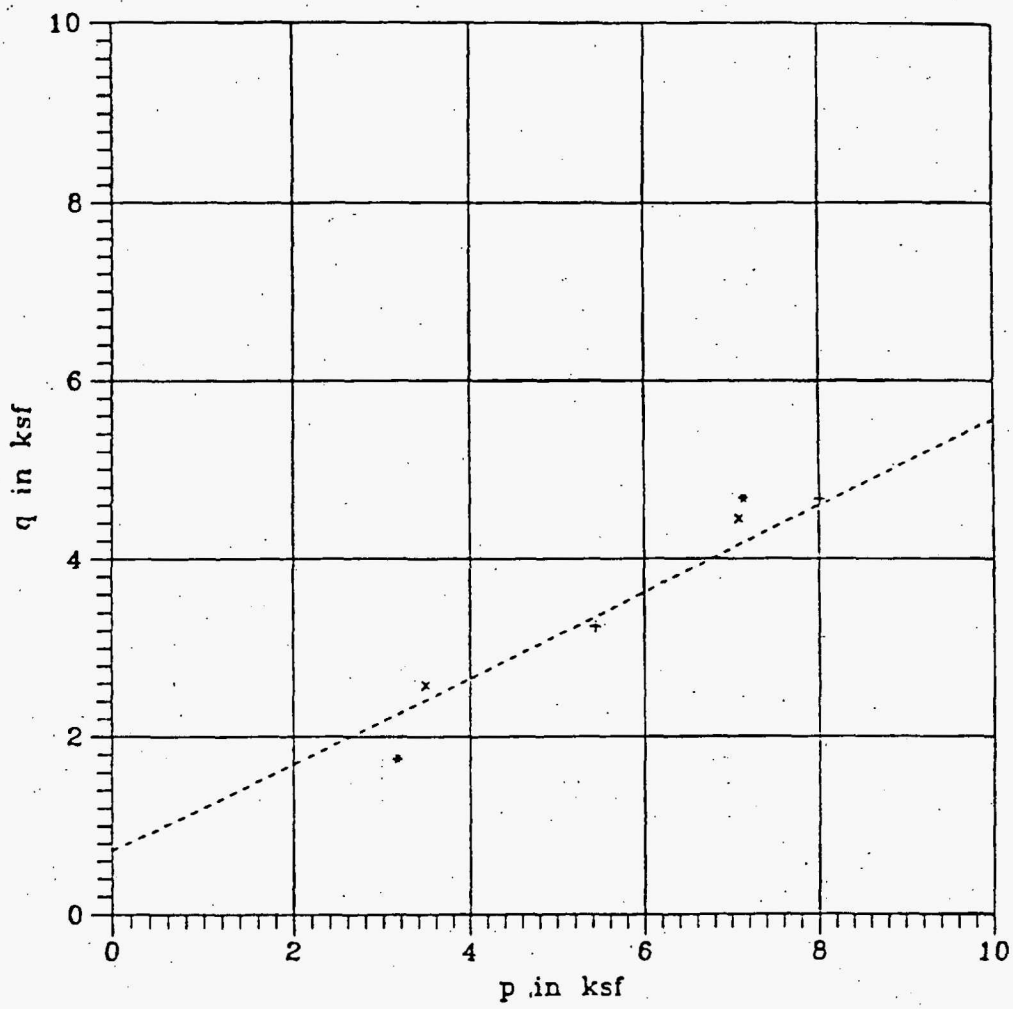
CU TRIAXIAL, UNDISTURBED TEST

BASAL TILL

FIGURE 3-28 A

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT.1991

Summary of average values :
a = 720.1 psf, α= 25.9 °
c = 823.3 psf, Φ= 29.0 °



NOTES :
1. α and a are from graph.

2. $\Phi = \sin^{-1}\tan\alpha$, $c = a/\cos\Phi$

LEGEND :
+ GT-60P (SB-15)
× GT-69 (6908)
• GT-71 (7110)

SUMMARY OF EFFECTIVE STRENGTH ENVELOPES FROM p-q DIAGRAM

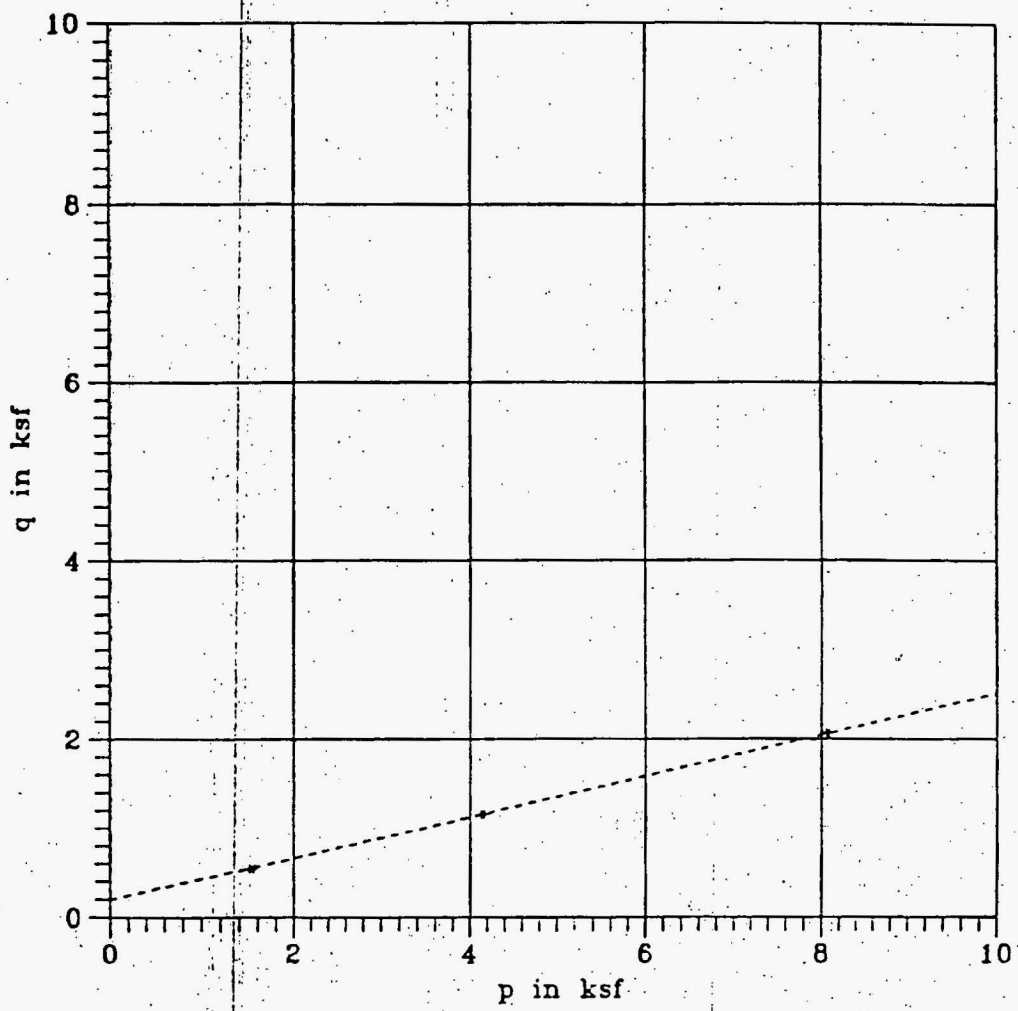
CU TRIAXIAL, UNDISTURBED TEST

BASAL TILL

FIGURE 3-28 B

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE :

Summary of average values :
a = 200.0 psf, α= 13.0 °
c = 205.0 psf, Φ= 13.0 °



NOTES :
1. α and a are from graph.
2. $\Phi = \sin^{-1}\tan\alpha$, $c = a/\cos\Phi$

LEGEND :

* GT-55 (SB-12)
----- Average Envelope

SUMMARY OF TOTAL STRENGTH ENVELOPES FROM p-q DIAGRAM

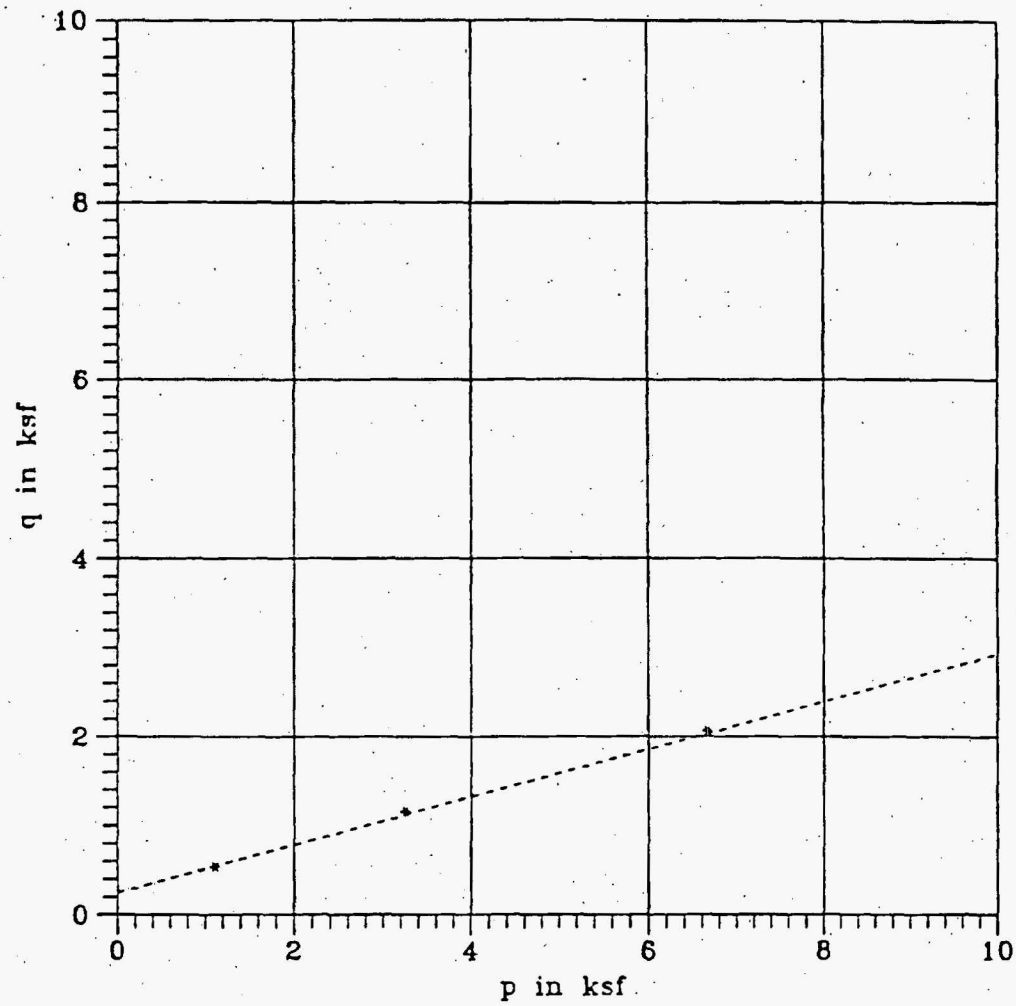
CU TRIAXIAL, UNDISTURBED SAMPLE

RESIDUUM

FIGURE 3-29 A

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT,1991

Summary of average values :
a = 250.0 psf, α= 15.0 °
c = 260.0 psf, Φ= 16.0 °



NOTES :
1. α and a are from graph.
2. $\Phi = \sin^{-1}\tan\alpha$, $c = a/\cos\Phi$

LEGEND :

• GT-55 (SB-12)
----- Average Envelope

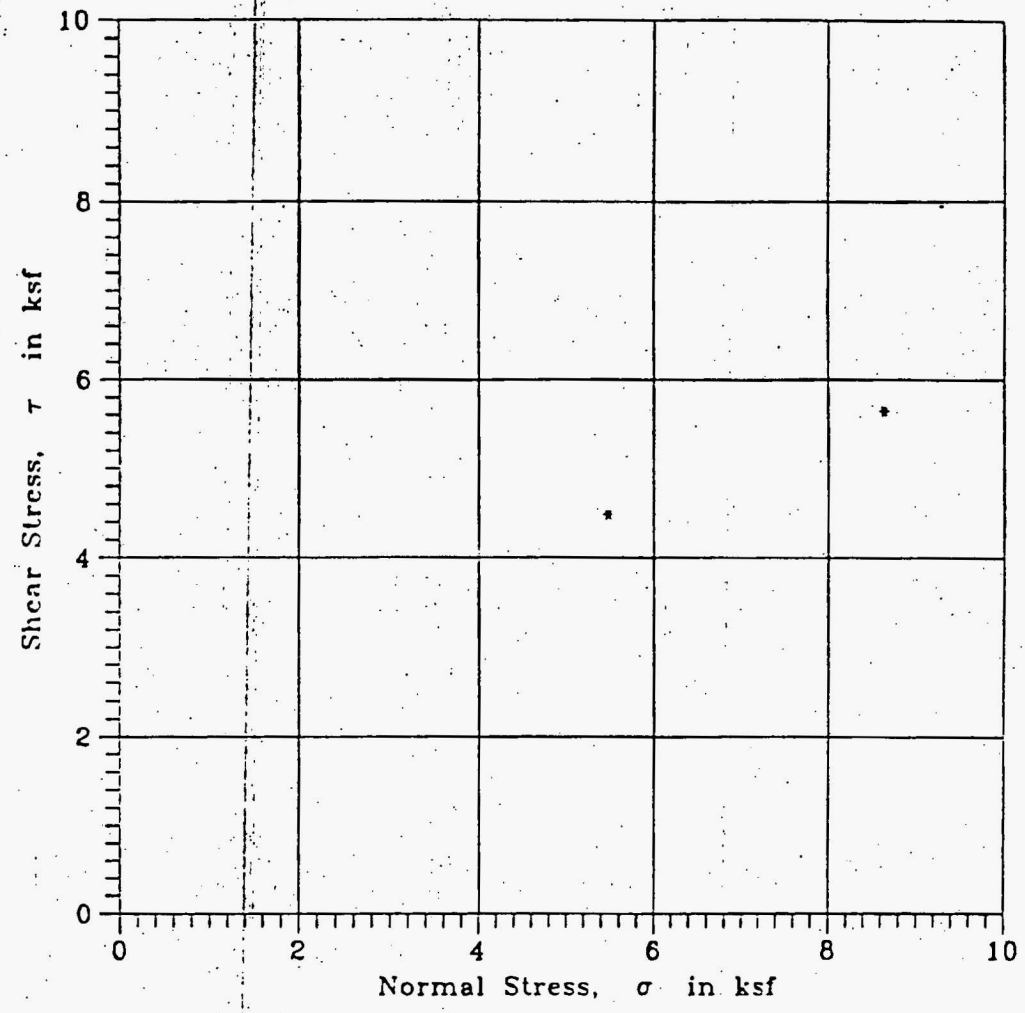
SUMMARY OF EFFECTIVE STRENGTH ENVELOPI
FROM p-q DIAGRAM

CU TRIAXIAL, UNDISTURBED SAMPLE

RESIDUUM

FIGURE 3-29 B

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT,1991



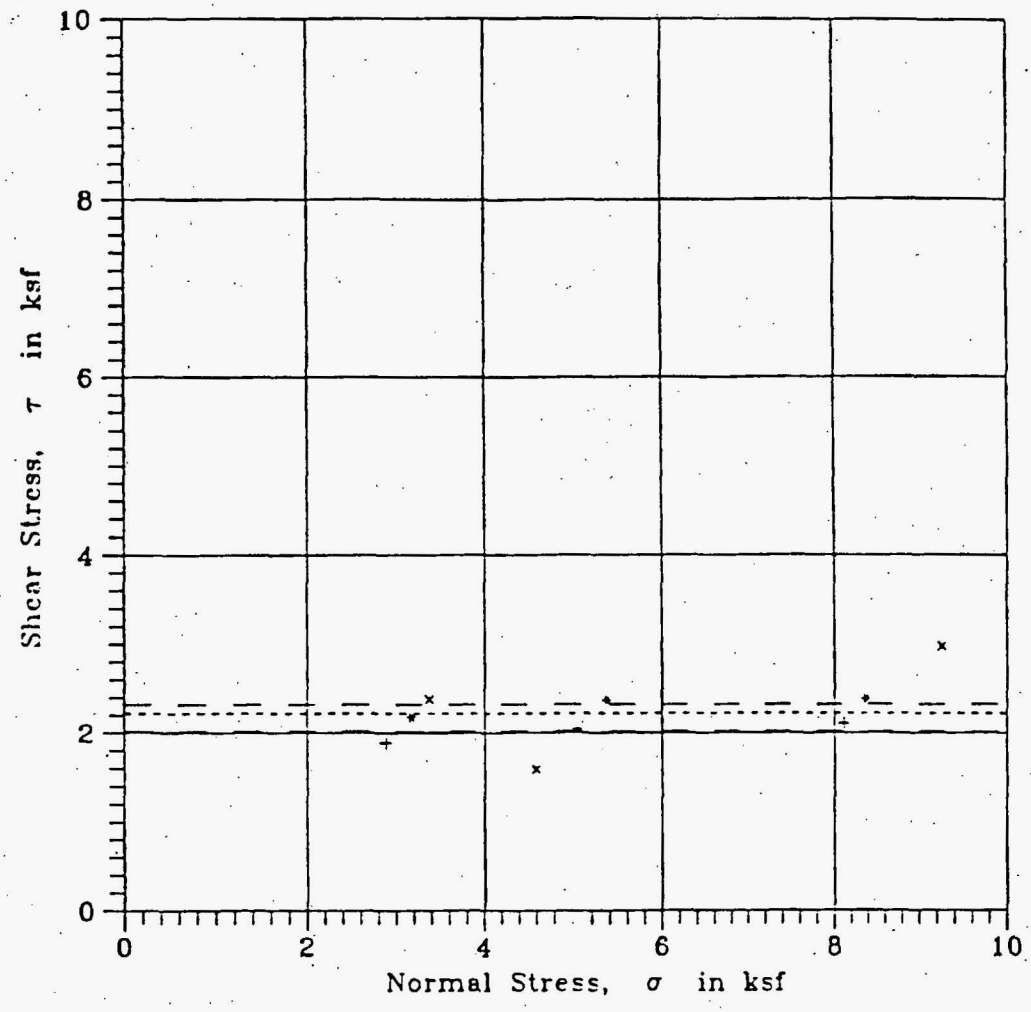
LEGEND :

• GT-2T78 (BU-01A)

SUMMARY OF STRENGTH ENVELOPES
UU TRIAXIAL TEST, REMOLDED SAMPLE
LOESS

FIGURE 3-30

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT,1991



LEGEND :

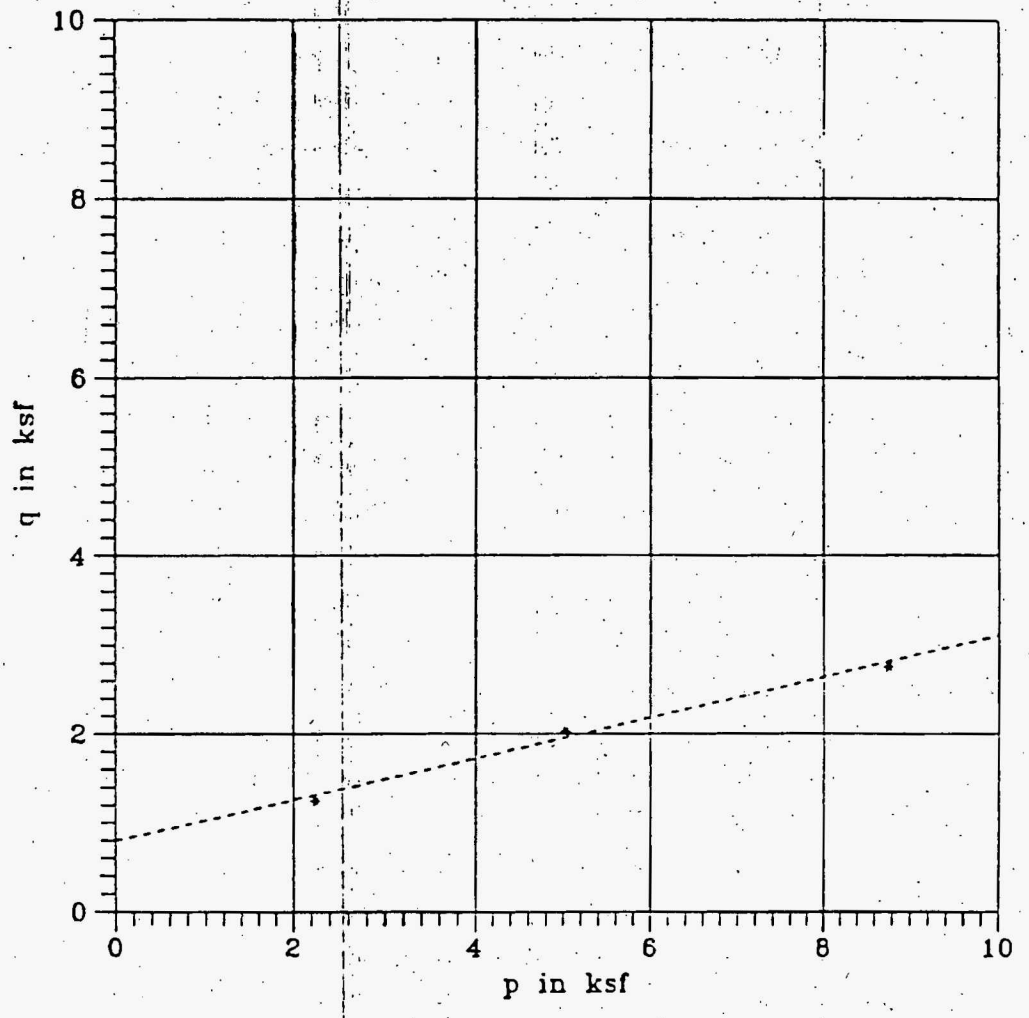
+ GT-2T71 (BU-02A)
× GT-2T75 (BU-01A)
• GT-2T78 (BU-02B)
----- Average Envelope
— — Max. & Min. Envelopes

SUMMARY OF STRENGTH ENVELOPES
UU TRIAXIAL TEST, REMOLDED SAMPLE
FERRELVIEW

FIGURE 3-31

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT.1991

Summary of average values :
a = 800.0 psf, α= 13.0 °
c = 820.0 psf, Φ= 13.0 °



NOTES :
1. α and a are from graph.
2. $\Phi = \sin^{-1}\tan\alpha$, $c = a/\cos\Phi$

LEGEND :

* GT-2T74 (BU-01A)
----- Average Envelope

SUMMARY OF TOTAL STRENGTH ENVELOPES FROM p-q DIAGRAM

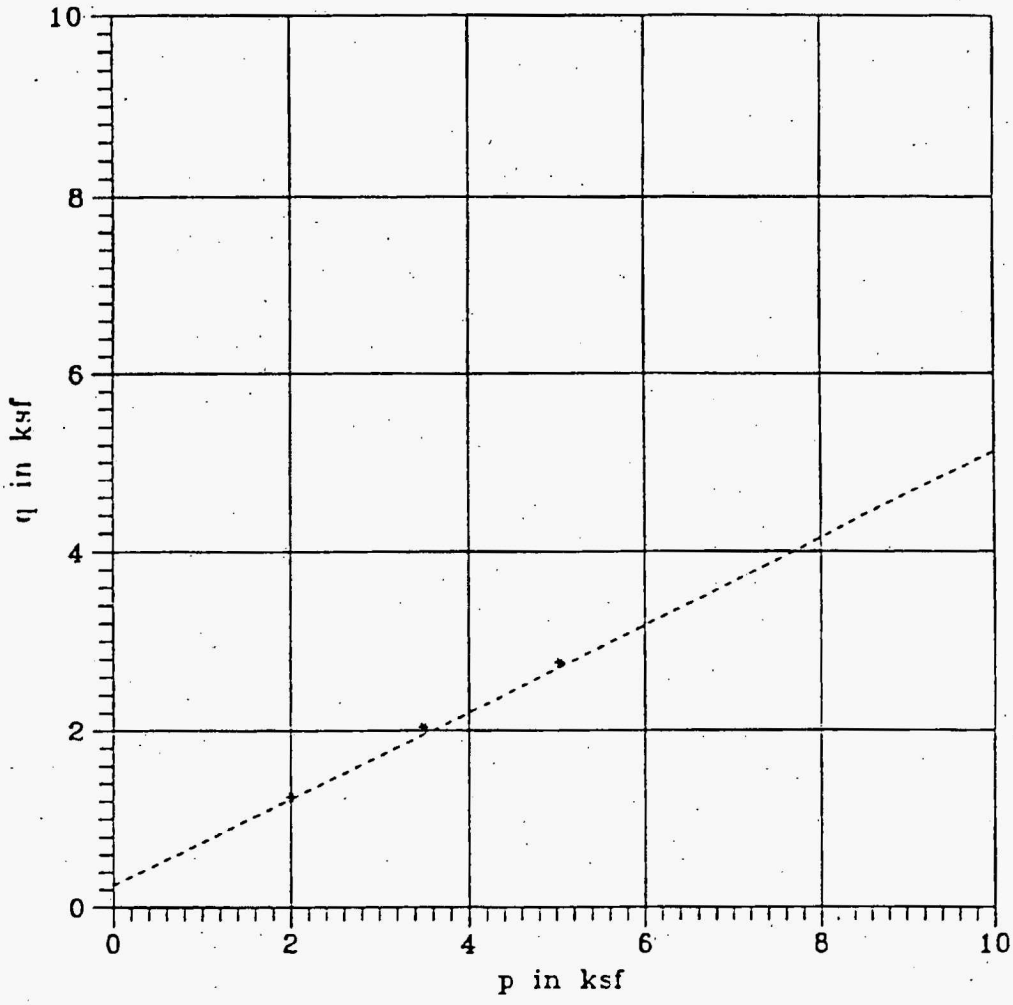
CU TRIAXIAL TEST, REMOLDED SAMPLE

LOESS

FIGURE 3-32 A

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT.1991

Summary of average values :
a = 250.0 psf, α= 26.0 °
c = 290.0 psf, Φ= 29.0 °



NOTES :
1. α and a are from graph.
2. $\Phi = \sin^{-1}\tan\alpha$, $c = a/\cos\Phi$

LEGEND :

• GT-2T74 (BU-01A)

SUMMARY OF EFFECTIVE STRENGTH ENVELOPES FROM p-q DIAGRAM

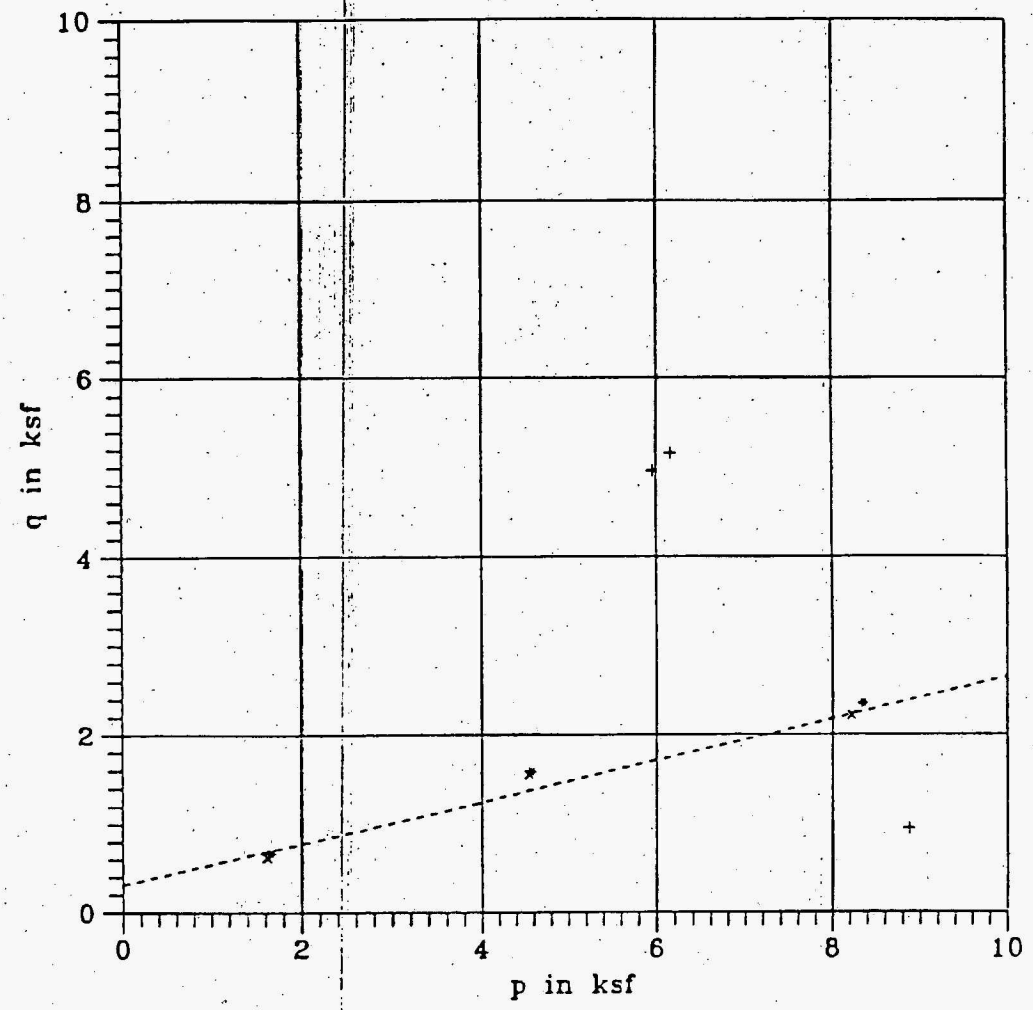
CU TRIAXIAL TEST, REMOLDED SAMPLE

LOESS

FIGURE 3-32 B

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT,1991

Summary of average values :
a = 313.6 psf, α= 13.1 °
c = 322.5 psf, Φ= 13.5 °



NOTES :
1. α and a are from graph.
2. $\Phi = \sin^{-1}\tan\alpha$, $c = a/\cos\Phi$

LEGEND :

+ GT-2T71 (BU-01A)
× GT-2T75 (BU-02B)
● GT-2T77 (BU-01B)
----- Average Envelope

SUMMARY OF TOTAL STRENGTH ENVELOPES FROM p-q DIAGRAM

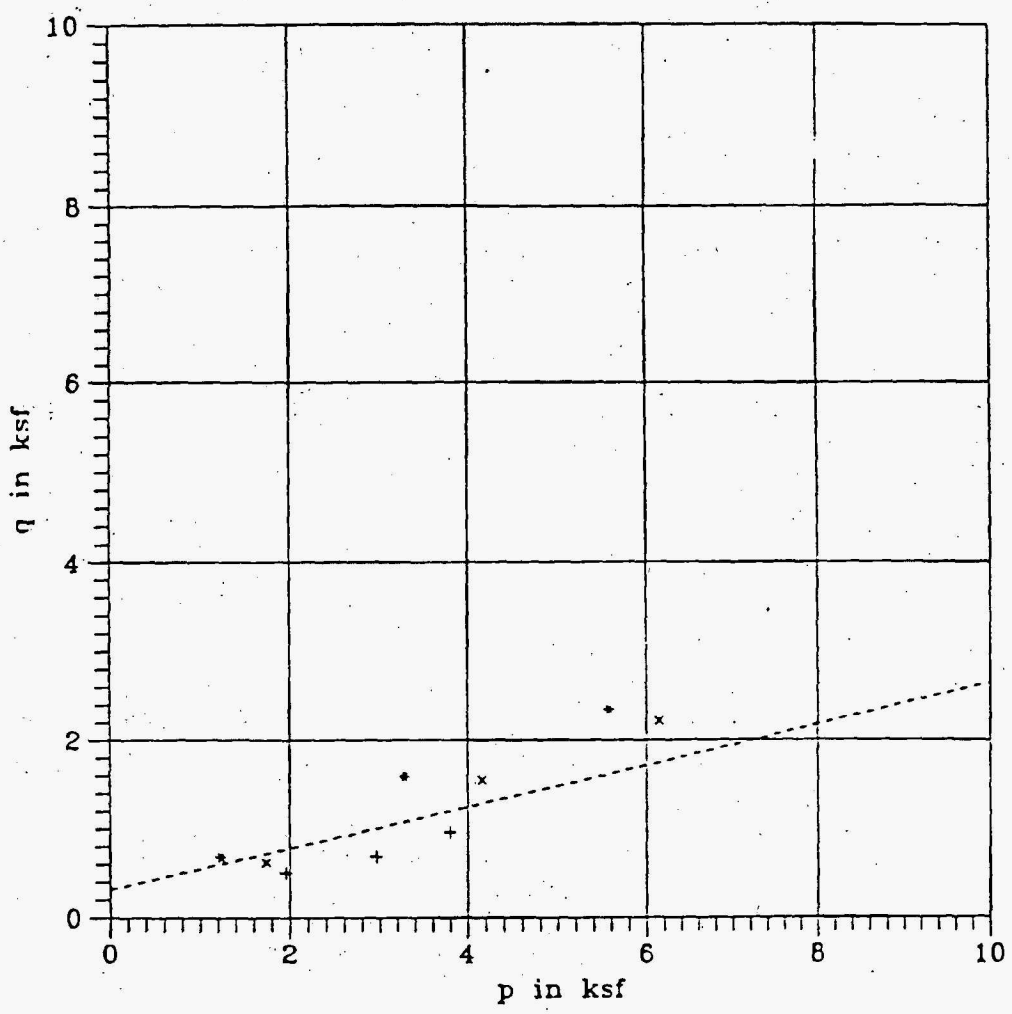
CU TRIAXIAL TEST, REMOLDED SAMPLE

FERRELVIEW CLAY

FIGURE 3-33 A

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT.1991

Summary of average values :
a = 85.0 psf, α= 18.3 °
c = 90.0 psf, Φ= 19.3 °



NOTES :
1. α and a are from graph.

2. $\Phi = \sin^{-1}\tan\alpha$, $c = a/\cos\Phi$

LEGEND :

+	GT-2T71	(BU-01A)
×	GT-2T75	(BU-02B)
•	GT-2T77	(BU-01B)

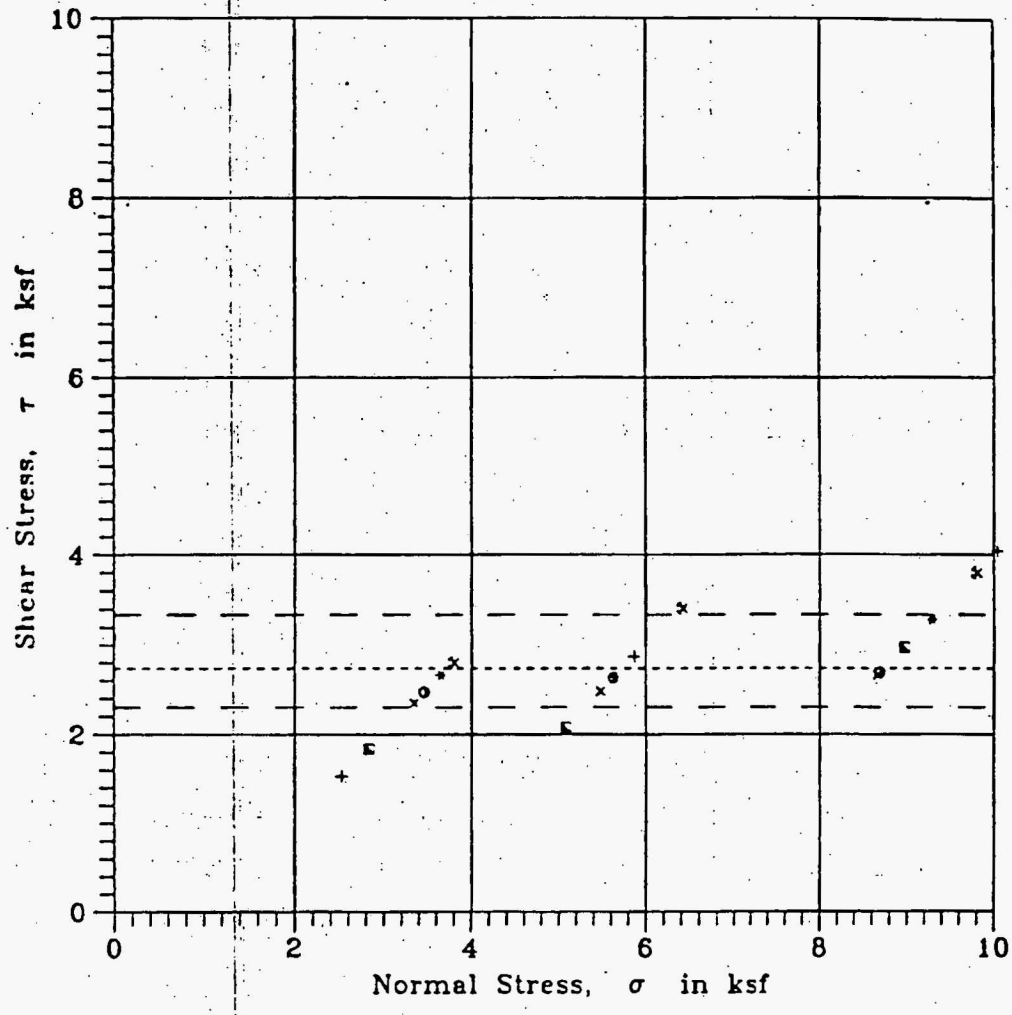
SUMMARY OF EFFECTIVE STRENGTH ENVELOPI
FROM p-q DIAGRAM

CU TRIAXIAL TEST, REMOLDED SAMPLE

FERRELVIEW CLAY

FIGURE 3-33 B

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT,1991



LEGEND :

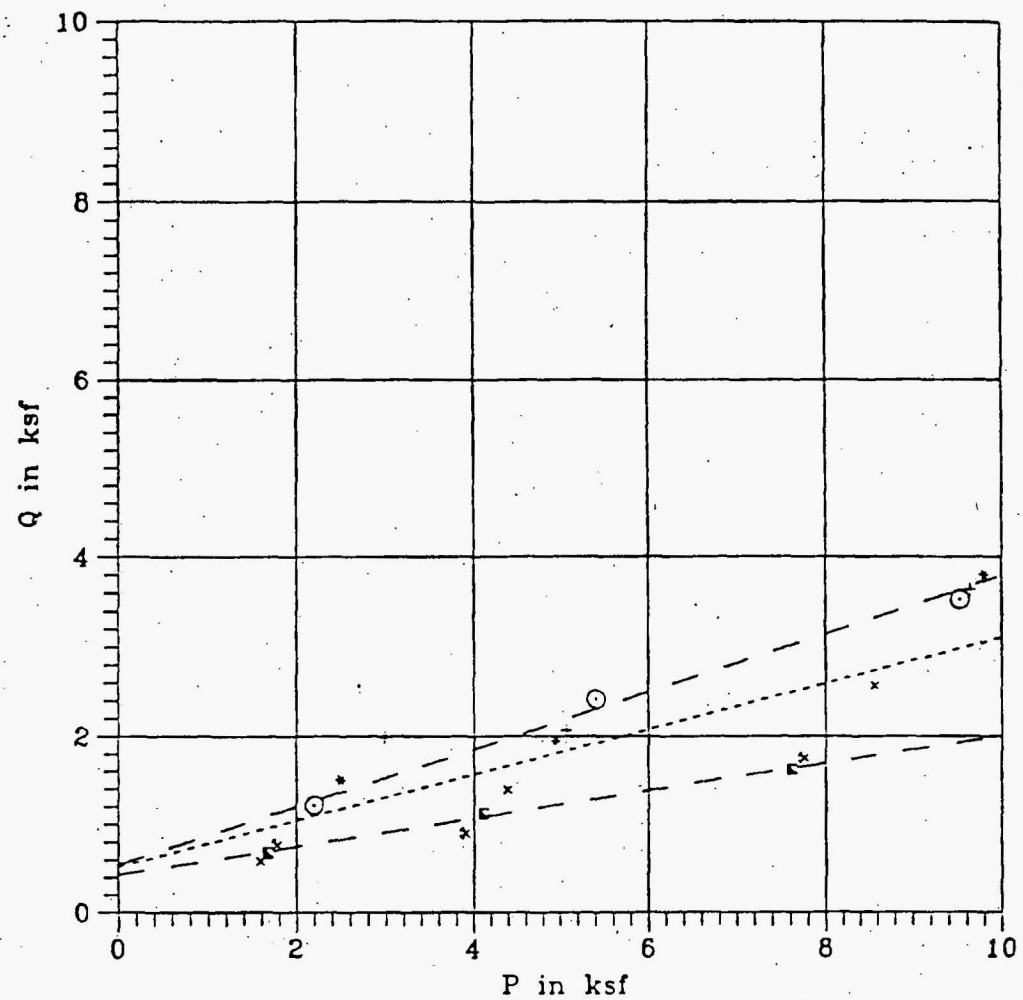
- + TPBS-1 (2A)
- × TPBS-1 (3A)
- + TPBS-6 (1A)
- × TPBS-6 (2A)
- ▪ TPBS-8 (1A)
- o TPBS-8 (3A)
- ----- Average Envelope
- — — Max. & Min. Envelopes

SUMMARY OF STRENGTH ENVELOPES
UU TRIAXIAL TEST, REMOLDED SAMPLE
POTENTIAL BORROW SOURCE NO. 1

FIGURE 3-34

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT,1991

Summary of average values :
a = 525.7 psf, α= 14.5 °
c = 544.2 psf, Φ= 15.0 °



NOTES :
1. α and a are from graph.
2. $\Phi = \sin^{-1}\tan\alpha$, $c = a/\cos\Phi$

LEGEND :

+ TPBS-1 (2A)
× TPBS-1 (3A)
• TPBS-6 (1A)
× TPBS-6 (2A)
⊙ TPBS-8 (1A)
◘ TPBS-8 (3A)
----- Average Envelope
— — Max. & Min. Envelopes

SUMMARY OF TOTAL STRENGTH ENVELOPES FROM p-q DIAGRAM

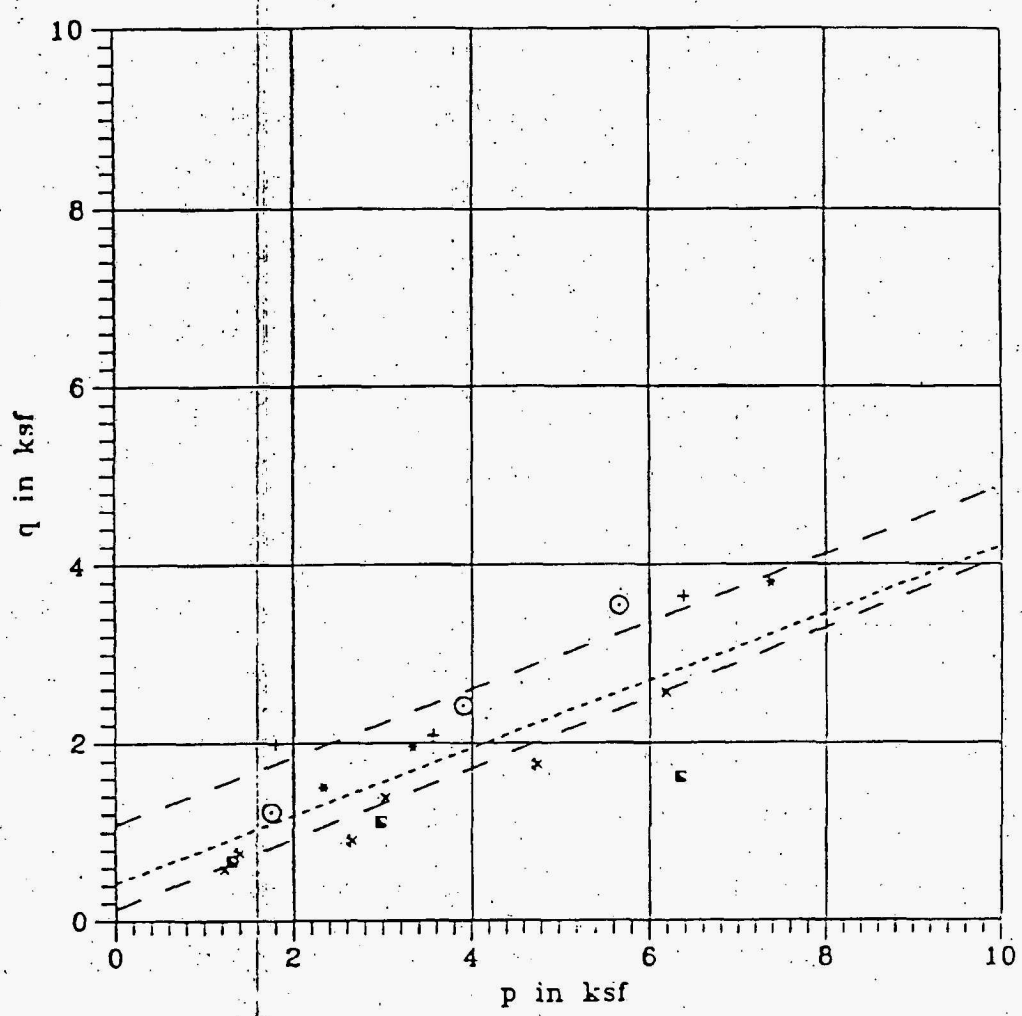
CU TRIAXIAL TEST, REMOLDED SAMPLE

POTENTIAL BORROW SOURCE NO. 1

FIGURE 3-35 A

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT,1991

Summary of average values :
a = 398.8 psf, α= 22.9 °
c = 465.8 psf, Φ= 22.2 °



NOTES :
1. α and a are from graph.

2. $\Phi = \sin^{-1}\tan\alpha$, $c = a/\cos\Phi$

LEGEND :

+ TPBS-1 (2A)
× TPBS-1 (3A)
• TPBS-6 (1A)
× TPBS-6 (2A)
⊙ TPBS-8 (1A)
▪ TPBS-8 (3A)
----- Average Envelope
— — Max. & Min. Envelopes

SUMMARY OF EFFECTIVE STRENGTH ENVELOPES FROM p-q DIAGRAM

CU TRIAXIAL TEST, REMOLDED SAMPLE

POTENTIAL BORROW SOURCE NO. 1

FIGURE 3-35 B

REPORT NO. MKES-3840R-7005	DRAWING NO.	
ORIGINATOR : ND	DRAWN : ND	DATE: OCT,1991

35-pound surcharge weight. The soils were compacted to about 95% of maximum dry density as determined from ASTM D698 test method and natural moisture content prior to testing. Table 3-10 lists the laboratory CBR test results. The CBR values range from 1.6 to 3.8, with an average value of 2.6. These values are typical for highly plastic clays (CH).

Table 3-10
Laboratory CBR Test Results

Test Pit and Sample No.	Depth (ft)	Dry Density Before Soaking (pcf)	Molding Moisture (%)	Swell (%)	CBR
TPMS-1, BU-01	0.0–6.0	98	18.1	0.2	2.5
TPMS-2, BU-02	2.0–6.0	96	22.5	1.5	2.3
TPMS-3, BU-01	1.0–6.0	99	17.8	0.8	2.7
TPMS-5, BU-01	0.0–7.0	102	16.7	-0.2	3.8
TPMS-8, BU-01	1.0–5.0	102	16.9	-0.2	2.4
TPMS-8, BU-01	5.0–10.5	94	22.5	1.6	1.6
TPMS-9, BU-01	1.0–7.0	99	16.0	0.2	3.1

3.6 Volume Change Characteristics

3.6.1 One-Dimensional Consolidation

The one-dimensional consolidation test determines consolidation characteristics for a soil. A sample is axially loaded and allowed to drain while being restrained laterally. The decrease in void ratio is measured as a function of loading and time. The consolidation characteristics obtained are used to estimate the rate and magnitude of consolidation under actual loading conditions. For in-situ materials the tests were performed on undisturbed samples. For borrow source or relocated materials, the test

were performed on remolded samples compacted to 95% maximum dry density determined from Standard Proctor compaction tests, at moisture contents 3% above optimum.

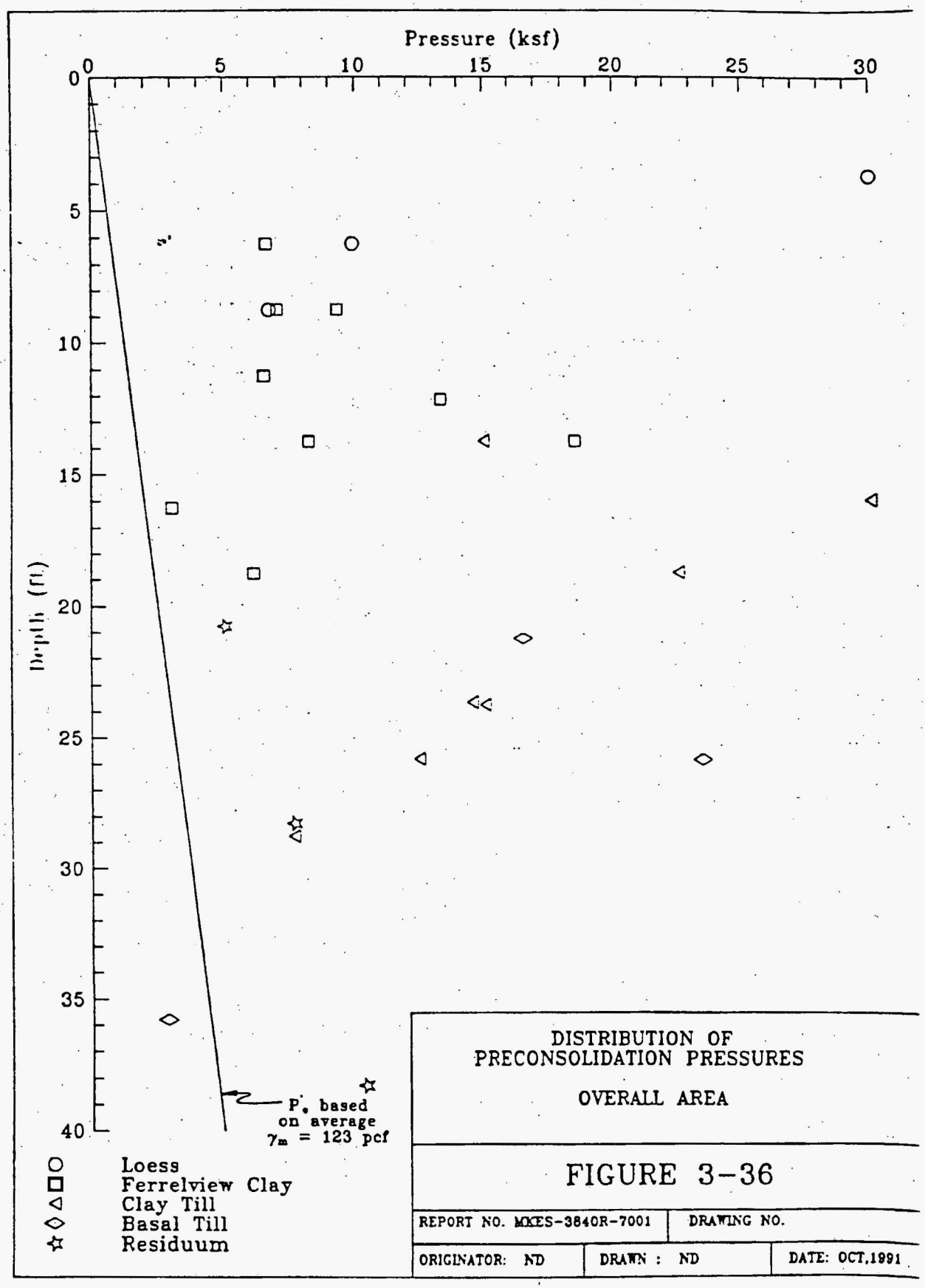
The calculations to determine parameters from consolidation curves are included in Appendix C. The parameters include compression (C_c) and recompression (C_r) indices and the preconsolidation pressure (P_p). Results for the undisturbed samples are summarized in Table 3-4. The average values for each soil type were calculated on soil samples obtained within the whole site (overall site). The average, maximum and minimum values of each geologic unit are shown in Table 3-11. The values are within typical ranges for fine-grained soils.

Table 3-11
Summary of Consolidation Parameters From Tests on Undisturbed Samples (for overall site).

Geologic Unit	Compression Index, C_c			Recompression Index, C_r		
	Average	Maximum	Minimum	Average	Maximum	Minimum
Top Soil/Fill	*	*	*	*	*	*
Loess	0.290	0.380	0.230	0.035	0.041	0.032
Ferrelview Clay	0.256	0.462	0.170	0.064	0.131	0.027
Clay Till	0.210	0.260	0.150	0.052	0.075	0.018
Basal Till	0.252	0.417	0.162	0.049	0.068	0.037
Residuum	0.302	0.372	0.265	0.089	0.097	0.075

*No test data. This layer will be removed during construction.

The preconsolidation pressures for undisturbed samples are presented in Figures 3-36 for overall site soils. It should be noted that the disposal area soils are a subset of the overall site soils. Comparison of the preconsolidation pressures to existing overburden pressures indicates that all of the soils are over consolidated, with the Basal Till and Residuum to a lesser extent.



DISTRIBUTION OF PRECONSOLIDATION PRESSURES

OVERALL AREA

FIGURE 3-36

REPORT NO. MKES-3840R-7001	DRAWING NO.	
ORIGINATOR: ND	DRAWN : ND	DATE: OCT.1991

3.6.2 Cation Exchange Capacity

The cation exchange capacity (CEC) is the charge or electrical attraction for cations per unit mass as measured in milequivalents per 100 grams of soil. The CEC is an indicator of the presence of various clay minerals such as kaolinite, illite, or montmorillinite in the soil. The clay mineral types are used in evaluating the expansiveness of a soil. It should be noted here that Petry (1980) indicated that CEC is, by itself, not an indicator of clay soil activity. The potential for activity may be predicted only when utilized with the type and amount of cations in the soil.

Only two CEC tests were performed on Loess. The two CEC values measured are 84 meq/100 g and 33 meq/100 g. Six CEC tests were performed on Ferrelview Clay and six on Borrow Source No. 1 materials. The values range from 49 to 88 meq/100 g for Ferrelview Clay and 56 to 80 meq/100g for Borrow Source No. 1 material. The average value of CEC for Ferrelview Clay was about 70 meq/100 g. The average value for Borrow Source No. 1 material was also 70 meq/100 g. From Mitchell (1976) the clay minerals seem to be of the Smectite type which consists of Montmorillonite, Saponite, Illites and Vermiculite.

3.7 Permeability

The constant-head triaxial permeability test measures the permeability, or hydraulic conductivity, of a saturated soil that is subjected to a constant head and hydraulic gradient. The tests are performed at different confining pressures to simulate in situ loading conditions. The hydraulic conductivity of a soil is used to determine seepage and groundwater flow rates. It is also used as a measure of relative imperviousness. This test was performed on both undisturbed and remolded samples. The permeability (or hydraulic conductivity) of the in-situ soil strata were discussed in detail in the site suitability report (MKF and JEG 1990a). Table 3-12 gives an updated tabulation of all valid test results* and the logarithmic mean for these results, including results from the Temporary Storage Area. The average coefficient of permeability for in-situ soils (undisturbed) are: 6.1×10^{-8} cm/sec for Loess, 1.3×10^{-8} cm/sec for Ferrelview clay, 6.9×10^{-9} cm/sec for Clay Till, 1.7×10^{-7} cm/sec for Basal Till and 2.6×10^{-7} cm/sec for Residuum.

---

*Valid Test results are defined in Sec. 2.4.

TABLE 3-12 : SUMMARY OF COEFFICIENT OF PERMEABILITY FOR UNDISTURBED ON SITE SOILS (Sheet 1 of 2)

BOREHOLE NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (ft)	COEFF. OF PERMEABILITY (cm/sec)	LOGARITHMIC MEAN (cm/sec)
DIKE FILL				
GT-33	ST-04	5.0 - 7.5	1.1E-07	1.1E-07
LOESS				
GT-50	ST-02	2.5 - 5.0	3.0E-04 **	
GT-50	ST-02	2.5 - 5.0	2.0E-05 **	
GT-55	ST-04	7.5 - 10.0	1.0E-05 **	
GT-55	ST-04	7.5 - 10.0	6.0E-06 **	
GT-56	ST-02	5.0 - 7.5	2.9E-08	
GT-58P	ST-01	2.5 - 5.0	2.0E-08	
GT-58P	ST-01	2.5 - 5.0	4.0E-07	6.1E-08
FERRELVIEW				
GT-43	ST-04	6.0 - 8.5	9.0E-04 **	
GT-43	ST-04	6.0 - 8.5	7.0E-08 **	
GT-46	ST-03	5.0 - 7.5	5.0E-04 **	
GT-46	ST-03	5.0 - 7.5	3.0E-06 **	
GT-48	ST-05	12.5 - 15.0	1.0E-08 **	
GT-48	ST-07	17.5 - 20.0	1.0E-09	
GT-48	ST-05	12.5 - 15.0	6.0E-04 **	
GT-52	ST-06	15.0 - 17.5	3.0E-06 **	
GT-55	ST-06	12.5 - 15.0	8.0E-09	
GT-56	ST-04	10.0 - 12.5	3.0E-08 **	
GT-56	ST-04	10.0 - 12.5	2.0E-07 **	
GT-58P	ST-03	7.5 - 10.0	6.0E-08	
GT-58P	ST-03	7.5 - 10.0	1.0E-09	
GT-59	ST-02	5.0 - 7.5	4.0E-07	
GT-59	ST-02	5.0 - 7.5	2.0E-07	
GT-62	ST-07	17.5 - 20.0	5.0E-08	
GT-62	ST-07	17.5 - 20.0	1.0E-09	
GT-63P	ST-01	2.5 - 5.0	7.0E-09	1.3E-08

NOTE : ** Unreliable test results due to low confining pressures used in testing. Data not used in computing mean values.

TABLE 3-12 : SUMMARY OF COEFFICIENT OF PERMEABILITY FOR UNDISTURBED ON SITE SOILS (Sheet 2 of 2)

BOREHOLE NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (ft)	COEFF. OF PERMEABILITY (cm/sec)	LOGARITHMIC MEAN (cm/sec)
CLAY TILL				
GT-45	ST-07	15.0 - 17.5	8.0E-05 **	
GT-45	ST-07	15.0 - 17.5	2.0E-08 **	
GT-50	SB-08	17.5 - 19.0	2.0E-07 **	
GT-50	SB-08	17.5 - 19.0	7.0E-08 **	
GT-51	ST-07	15.0 - 17.5	2.0E-08 **	
GT-51	ST-07	15.0 - 17.5	3.0E-06 **	
GT-51	SB-09	20.0 - 21.5	3.0E-07 **	
GT-51	SB-09	20.0 - 21.5	5.0E-08 **	
GT-56	ST-06	15.0 - 17.0	2.9E-09	
GT-58P	ST-09	22.5 - 24.0	4.0E-08	
GT-58P	ST-09	22.5 - 24.0	1.0E-09	
GT-59	ST-06	15.0 - 17.5	1.0E-09	
GT-60P	ST-10	27.5 - 30.0	1.0E-09	
GT-60P	ST-10	27.5 - 30.0	5.0E-08	
GT-63P	ST-09	22.5 - 25.0	9.0E-09	
GT-67P	ST-08	20.0 - 22.5	1.0E-07	6.9E-09
BASAL TILL				
GT-43	SB-17	40.0 - 41.5	6.0E-08 **	
GT-43	SB-17	40.0 - 41.5	4.0E-08 **	
GT-60P	SB-17	48.5 - 49.0	3.0E-07	
GT-60P	SB-15	41.0 - 41.5	2.0E-07	
GT-60P	SB-17	48.5 - 49.0	2.0E-07	
GT-60P	SB-15	41.0 - 41.5	7.0E-08	1.7E-07
RESIDUUM				
GT-55	SB-12	27.5 - 29.0	2.0E-09	
GT-62	SB-15	38.0 - 39.0	3.0E-05	
GT-62	SB-15	38.0 - 39.0	6.0E-08	
GT-65P	SB-16	40.0 - 41.5	8.0E-07	
GT-65P	SB-16	40.0 - 41.5	4.0E-07	2.6E-07

NOTE : ** Unreliable test results due to low confining pressures used in testing. Data not used in computing mean values.

TABLE 3-13 : SUMMARY OF COEFFICIENT OF PERMEABILITY FOR REMOLDED ON SITE SOILS

BOREHOLE NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (ft)	COEFF. OF PERMEABILITY (cm/sec)	LOGARITHMIC MEAN (cm/sec)
DIKE FILL				
GTS-5	BULK	0.0 - 5.0	2.0E-08	
GTS-7	BULK	0.0 - 5.0	5.0E-08	3.2E-08
LOESS				
TPMS-2	BU-01	0.0 - 2.0	2.0E-08	
TPMS-4	BU-01	1.0 - 3.5	9.0E-09	
TPMS-5	BU-01	1.0 - 7.0	2.0E-06	
TPMS-6	BU-01	1.0 - 5.0	3.0E-07	
TPMS-7	BU-01	1.0 - 7.0	1.0E-07	
TPMS-8	BU-01	1.0 - 5.0	6.0E-08	
TPMS-9	BU-01	1.0 - 7.0	3.0E-07	1.1E-07
FERRELVIEW				
GT-2T71	BU-02A	6.5 - 12.0	2.0E-08	
GT-2T75	BU-02B	6.5 - 12.0	1.0E-09	
GT-2T77	BU-02A	7.0 - 10.5	2.0E-08	
GT-2T78	BU-02B	6.5 - 12.0	4.0E-08	
TPMS-1	BU-01	0.0 - 6.0	7.0E-08	
TPMS-2	BU-02	2.0 - 6.0	1.0E-09	
TPMS-3	BU-01	1.0 - 6.0	3.0E-07	
TPMS-4	BU-02	4.0 - 6.5	1.0E-09	
TPMS-5	BU-02	8.0 - 10.0	9.0E-09	
TPMS-6	BU-02	5.5 - 7.5	1.0E-09	
TPMS-7	BU-02	7.0 - 9.5	1.0E-07	
TPMS-8	BU-02	5.0 - 10.5	1.0E-09	
TPMS-9	BU-02	8.0 - 15.0	4.0E-08	
GTS-1	ST-03	5.0 - 7.5	2.0E-07	
GTS-2	ST-02	2.5 - 5.0	8.0E-08	
GTS-4	ST-02	2.5 - 5.0	2.0E-07	
GTS-6	BULK	0.0 - 5.0	1.0E-07	1.9E-08

NOTE : ** Unreliable test results due to low confining pressures used in testing. Data not used in computing mean values.

TABLE 3-14 : SUMMARY OF COEFFICIENT OF PERMEABILITY FOR REMOLDED BORROW SOURCE SOILS

BOREHOLE NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (ft)	COEFF. OF PERMEABILITY (cm/sec)	LOGARITHMIC MEAN (cm/sec)
POTENTIAL BORROW SOURCE NO. 1				
TPBS-1	2A	2.6 - 7.1	3.0E-07	
TPBS-1	4A	9.2 - 14.1	4.0E-08	
TPBS-6	1A	0.6 - 9.1	2.0E-08	
TPBS-6	2A	9.1 - 12.6	1.0E-08	
TPBS-8	1A	0.6 - 4.3	3.0E-08	
TPBS-8	2A	4.3 - 8.5	2.0E-07	
TPBS-8	3A	8.5 - 11.9	5.0E-09	
TPBS-10	1A	0.6 - 6.1	1.0E-07	
TPBS-10	2A	8.2 - 10.9	2.0E-08	
TPBS-10	3A	10.9 - 13.4	1.0E-09	
TPBS-11	1A	0.6 - 10.4	3.0E-08	
TPBS-11	2A	10.4 - 12.3	3.0E-08	2.7E-08

NOTE : ** Unreliable test results due to low confining pressures used in testing. Data not used in computing mean values.

Test results from remolded on-site surficial soils (Fill, Loess, and Ferrelview clay) and remolded Borrow Source No. 1 soils are shown in Tables 3-13 and 3-14, respectively. A logarithmic mean coefficient of permeability of 1.4×10^{-7} cm/sec was obtained for the remolded on-site Loess and 1.0×10^{-8} cm/sec for remolded on-site Ferrelview clay soils. An average value of 2.7×10^{-8} cm/sec was obtained for the remolded Borrow Source No. 1 soils. The samples were compacted to about 95% of maximum dry density as determined by the ASTM D698 test method, at a moisture content of about 3% above optimum moisture content.

3.8 Corrosivity

A series of solids content, resistivity and chemical tests was performed on samples of the upper layer of on-site soils to determine the potential corrosive effects of harmful substances in the foundation soil on concrete and steel used in the construction of the disposal facilities. Six samples of Ferrelview clay and one sample of Clay Till, all from depths from 2.5 to 9 feet were selected for testing. The test results are shown in Table 3-15. A discussion of the test results is presented in Section 4.4.6.

3.8.1 Resistivity

The earth resistivity is a measure of the ability of the soil to serve as an electrolyte, and is an indicator of corrosivity of the soil. The soil samples were compacted in a modified "Miller" box and tested at various moisture contents, generally starting with the natural moisture content and increasing in increments of 7 to 15 percent. The resistivities generally varied from 740 to 1960 ohm-cm.

3.8.2 Sulfates and Chlorides

Sulfate and chloride content values were determined in the laboratory on leachate from the soil samples. The sulfate content for all test samples ranges from non-measurable (below quantitation limit) to 0.08%. The average sulfate content is 0.06%. The chloride contents range from 0.02% to 0.03% with an average value of 0.022%.

Table 3-5
Corrosivity Test Results

Boring No.	Sample No.	Depth (feet)	Soil	Soil Resistivity (ohm-cm)	Sulfates (mg/kg)	Chlorides (mg/kg)	pH (pH)	Percent Solids (%)
GT-68	SS-6801	2.5-4.0	Ferrelview clay	1940	864	193	7.3	85.9
GT-69	SS-6901	2.5-4.0	Ferrelview clay	1060	243	297	7.07	88.2
GT-69	SS-6903	7.5-9.0	Clay Till	1030	BQL	344	6.37	80.7
GT-70	SS-7003	7.5-9.0	Ferrelview clay	1160	BQL	214	7.49	84.6
GT-71	SS-7103	7.5-9.0	Ferrelview clay	870	509	242	6.91	85.7
GT-72	SS-7201	2.5-4.0	Ferrelview clay	1310	243	272	6.35	88.5
GT-73	SS-7301	2.5-4.0	Ferrelview clay	1600	428	170	5.39	76.8

BQL = Below Quantitation Limit

3.8.3 Acidity/Alkalinity

Acidity/Alkalinity (pH) tests determine the acidity or alkalinity of water in soils by an indicator paper. Excess of either can have detrimental effects on concrete buried in the ground. A moderate degree of acidity can cause corrosion of metals. In soil stabilization, some resinous materials are unsuitable for alkaline soils but may be satisfactory with neutral or slightly acid soils.

The pH values measured in the laboratory ranges from 5.4 to 7.5. The average value was 6.7.

3.8.4 Percent Solids

The percent solids in a soil is not a direct indicator of the corrosiveness of a soil. However, this test is generally performed to identify the percentage of solids in the soil specimen for chemical analysis. The percent solids from test results ranges from 77 to 89% with on average value of 84%.

3.9 Standard Penetration Test (SPT)

The standard penetration test (SPT) is a field test performed during drilling operations. A standard split-spoon sampler is driven with a standard-weight hammer (weighing 140 pounds), free-falling 30 inches. The number of blows required to advance the last 12 inches of the samples in each 18-inch advancement interval is referred to as the SPT blow count. The sampling equipment and methodology are described in Section 2.4 and in the Geotechnical Investigation Report (MKF and JEG 1990). The SPT was conducted at frequent intervals to obtain soil samples and the SPT blow counts in each borehole.

The blow counts correlate roughly to various soil properties, such as relative density of granular soils and the strength consistency of cohesive soils. The test is also useful as a supplement to other test results, such as approximate unit weight, angle of internal friction, and unconfined compressive strength.

Table 3-6
Typical SPT BLow Counts for Various Soil Unit
(for values measured in boreholes within cross-sections shown in report only)

Soil Unit	Range of STP Blow, Counts per foot	Average Blow Counts, N	Consistency
Fill	6-28	12	Medium to Stiff
Loess	6-18	11	Medium to Stiff
Ferrelview Clay	4-23	12	Medium to Stiff
Clay Till	6-85	20	Medium to Very Stiff
Basal Till	18-50	33	Very Stiff to Hard
Residuum	13-84	43	Very Stiff to Hard

The blow counts measured within the bore holes shown in the geologic profiles (Figures 4-1 through 4-4) are presented in the profiles. Table 3-16 shows the range of values and the average values of blow counts measured for each soil type within the profiles. The corresponding soil consistencies correlated from empirical relationships are also shown. On this basis the Fill, Loess and Ferrelview clay soils are categorized as medium to stiff; the Clay Till as medium to very stiff and Basil Till and Residuum, as very stiff to hard.

3.10 Quality Assurance

The geotechnical investigation program activities were implemented with each organization's quality assurance (QA) programs. The procedures used in field and laboratory testing, where appropriate, followed the corresponding standard procedures published by authoritative organizations including the American Society for Testing and Materials (ASTM), the U.S. Army Corps of Engineers (COE), the U.S. Environmental Protection Agency (EPA), and the U.S. Soil Conservation Service (SCS). Data reduction, review, and reporting by Morrison Knudsen Company's Environmental Services Group (MKES) were performed in accordance with the MKES' WSSRA Project Procedures and Quality Assurance Manual (MKES 1991).

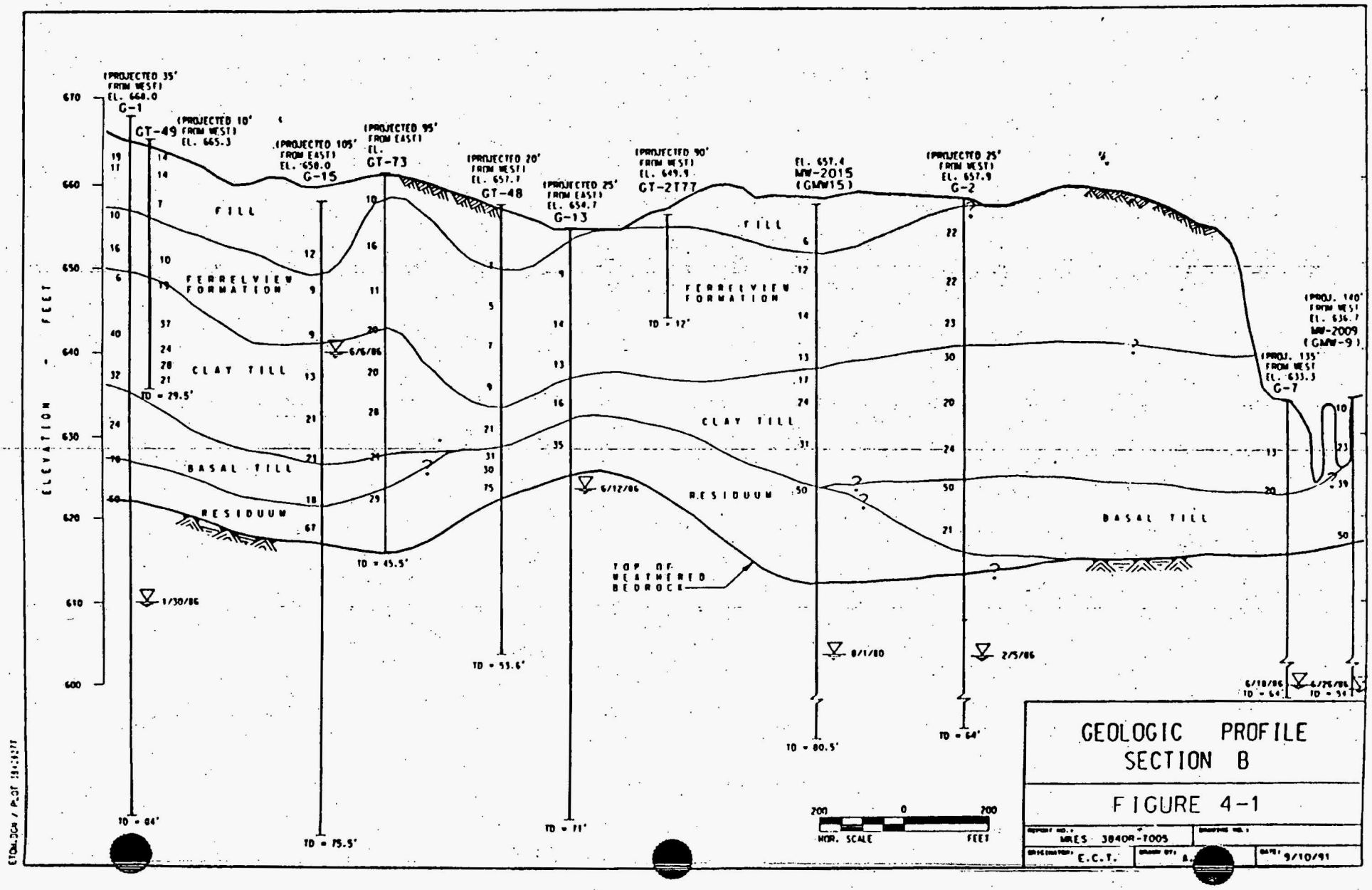
4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Site Description and Subsurface Condition

The possible siting area of the cells for the proposed disposal facility (DF) meeting the siting criteria (see Figure 1-2) is located mostly in the existing chemical plant area, with the northeastern limit located 350 feet from the existing fence line, the eastern limit 350 feet from the existing administration building, the southwestern portion 100 feet from Raffinate Pits 2 and 3, and the northwestern portion in the existing Material Staging Area. The suitability of the site for the WSS disposal facility was addressed in the site suitability study (MKF and JEG 1990a).

The DF site consists of numerous abandoned buildings and associated structures and equipment which will be demolished as part of the WSS remedial action. The existing topography is generally flat, sloping gently from the higher elevation of about 672 feet above mean sea level (MSL) near the central portion of the CP area, to lower elevations of about 650 to 640 feet near the limits of the DF siting area, except in the northern end, where the elevation drops to an average of about 630 feet. Abrupt changes in surface elevation occur in natural depressed areas or where man-made earth-moving activities, such as construction of drainage ditches and spoil piles, have taken place. A detailed description of the surface features of the site is presented in the Geotechnical Investigation Report (MKF and JEG 1990b). The proposed drainage features of the site are presented in Support Study 16 for Grading Plan (MKES 1991c) and the Surface Erosion Control Plan (MKES 1991e).

The proposed disposal facility (including the liner system) will be founded within or below the Ferrelview clay stratum. Cut and fill will be required to meet design grading requirements. The suitability of various on-site soil materials is discussed in the following sections. The hydrogeological conditions were discussed in the site suitability report (MKF and JEG 1990a). Geologic profiles (cross-sections) showing subsurface soil strata are shown in Figures 4-1 through 4-4. A legend for the geologic profiles is shown in Figure 4-5. Location of the sections are shown in Figure 2-1. The profiles are idealized and are presented for illustrative purposes only. The soil layering is based on interpolation and extrapolation between test pits and bore holes



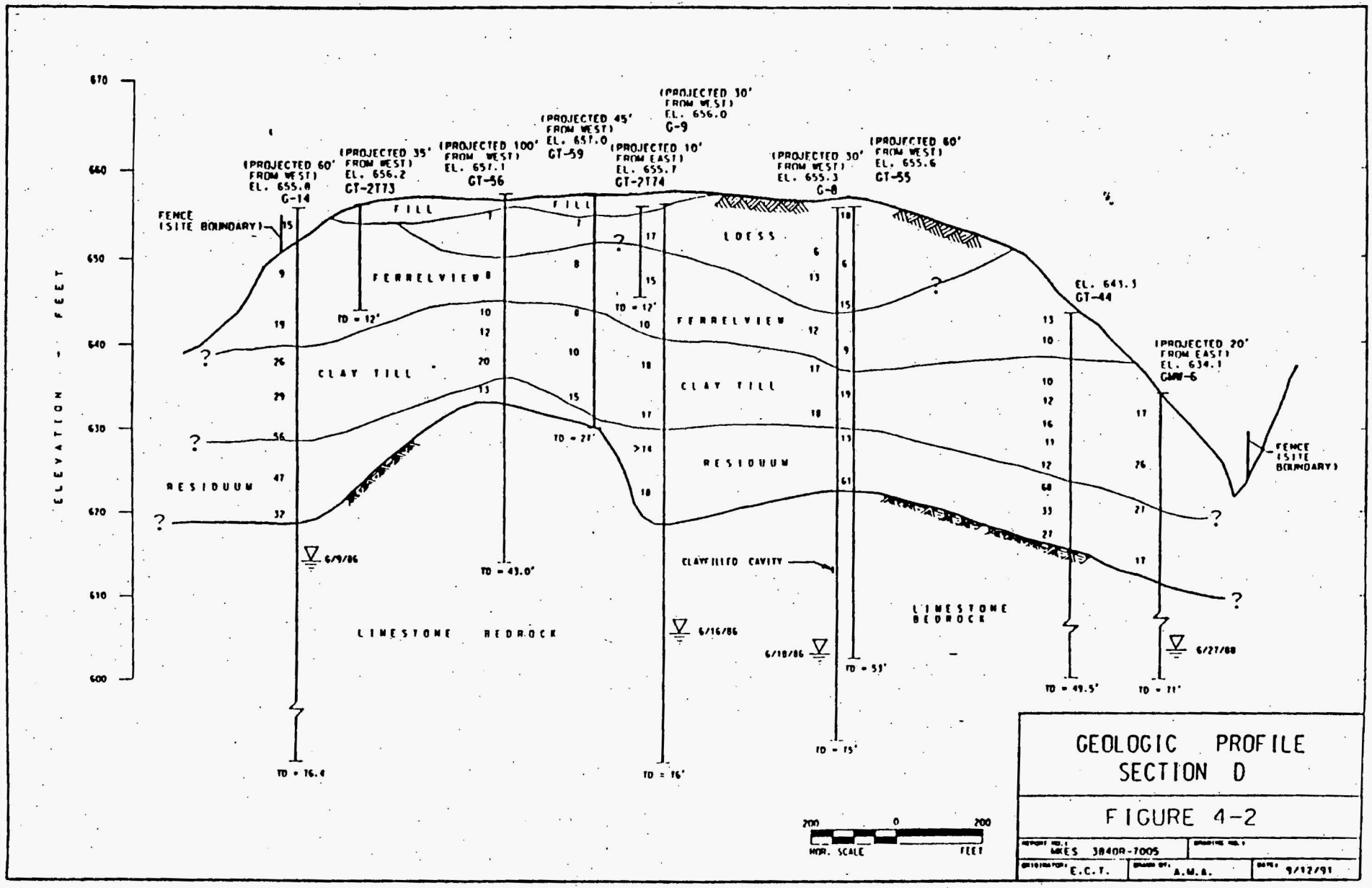
GEOLOGIC PROFILE
SECTION B

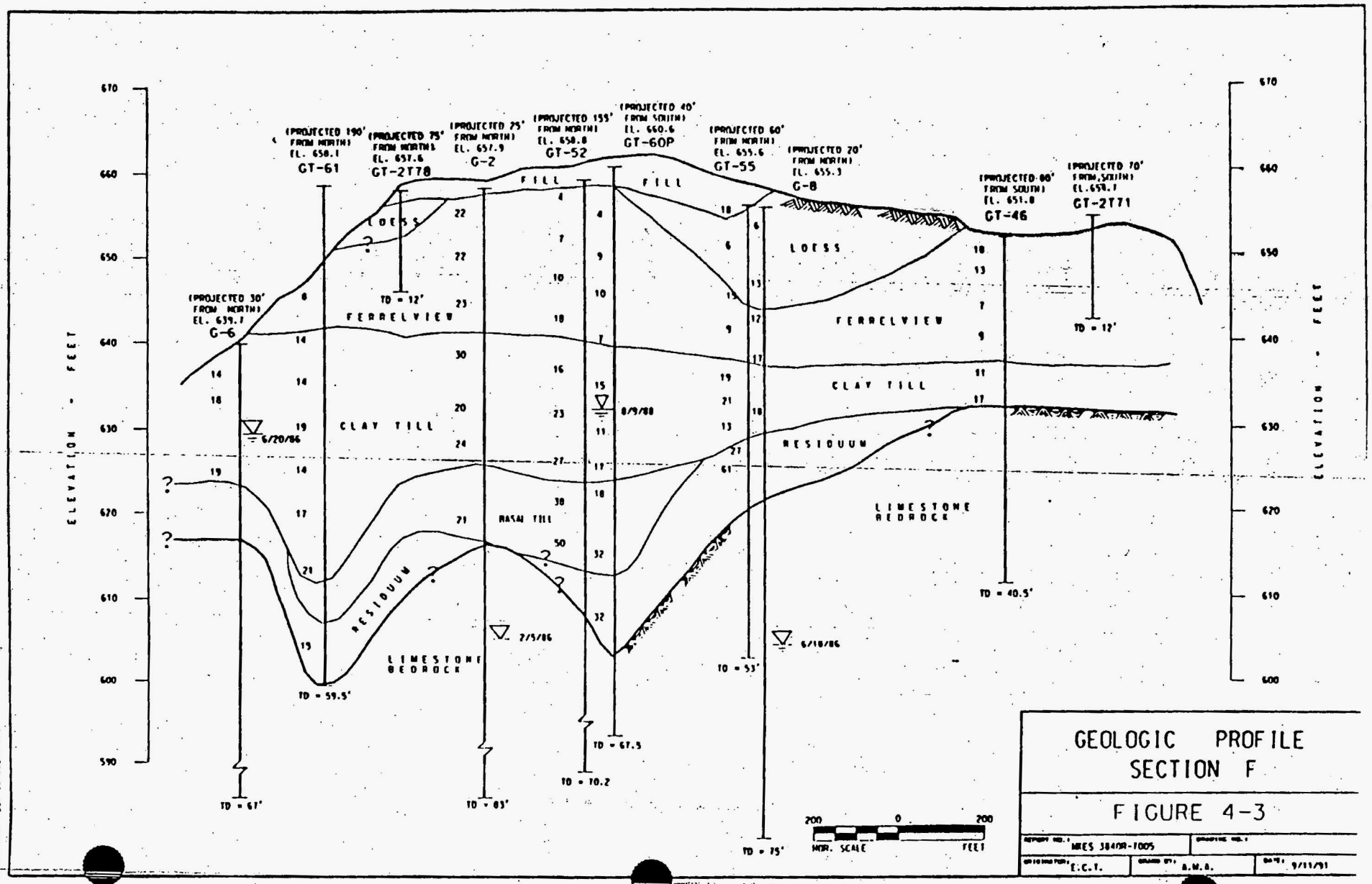
FIGURE 4-1

WRES 3840R-T005

E.C.T.

9/10/91


ELEVATION - FEET
670
660
650
640
630
620
610
600
(PROJECTED 60' FROM WEST) EL. 655.8 G-14
(PROJECTED 35' FROM WEST) EL. 656.2 GT-2T73
(PROJECTED 100' FROM WEST) EL. 657.1 GT-56
(PROJECTED 45' FROM WEST) EL. 657.0 GT-59
(PROJECTED 10' FROM EAST) EL. 655.7 GT-2T74
(PROJECTED 30' FROM WEST) EL. 656.0 G-9
(PROJECTED 30' FROM WEST) EL. 655.3 G-8
(PROJECTED 60' FROM WEST) EL. 655.6 GT-55
EL. 641.5 GT-44
(PROJECTED 20' FROM EAST) EL. 634.1 GMW-6
FENCE (SITE BOUNDARY)
FILL
LOESS
FERRELVIEW
CLAY TILL
RESIDUUM
CLAYFILLED CAVITY
LIMESTONE BEDROCK
TD = 12'
TD = 21'
TD = 43.0'
TD = 76.4
TD = 76'
TD = 75'
TD = 53'
TD = 49.5'
TD = 71'
6/9/86
6/16/86
6/18/86
6/27/88
200 0 200
HOR. SCALE FEET
GEOLOGIC PROFILE
SECTION D
FIGURE 4-2
WRES 3840R-7005
E.C.T.
A.M.A.
9/12/91
ETCM4.DGN / PLOT 3843273.300

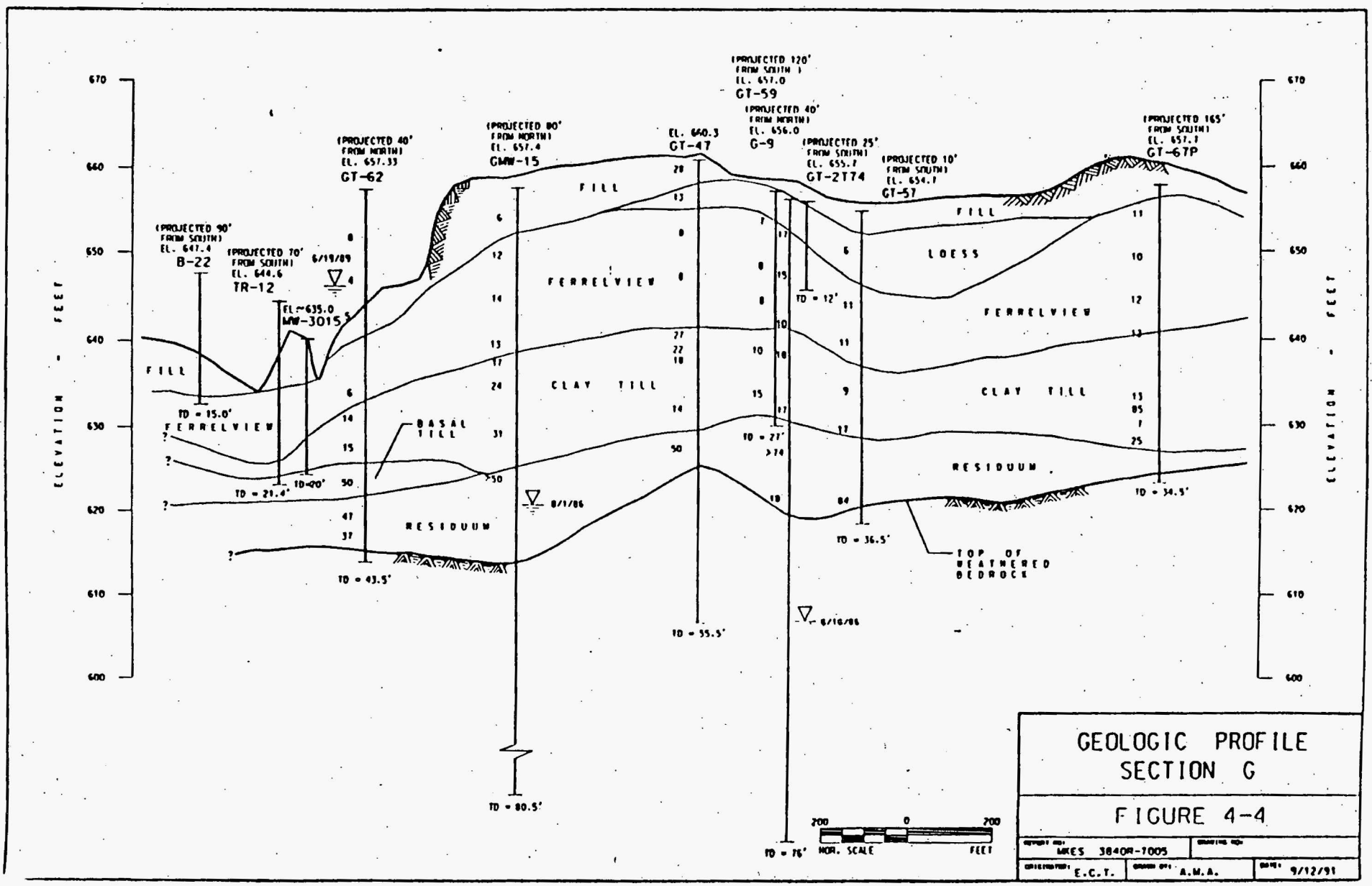


GEOLOGIC PROFILE
SECTION F

FIGURE 4-3

REPORT NO.: WES 38409-1005
DRAWING NO.:
DRAWN BY: E.C.T.
CHECKED BY: A.M.A.
DATE: 9/11/91

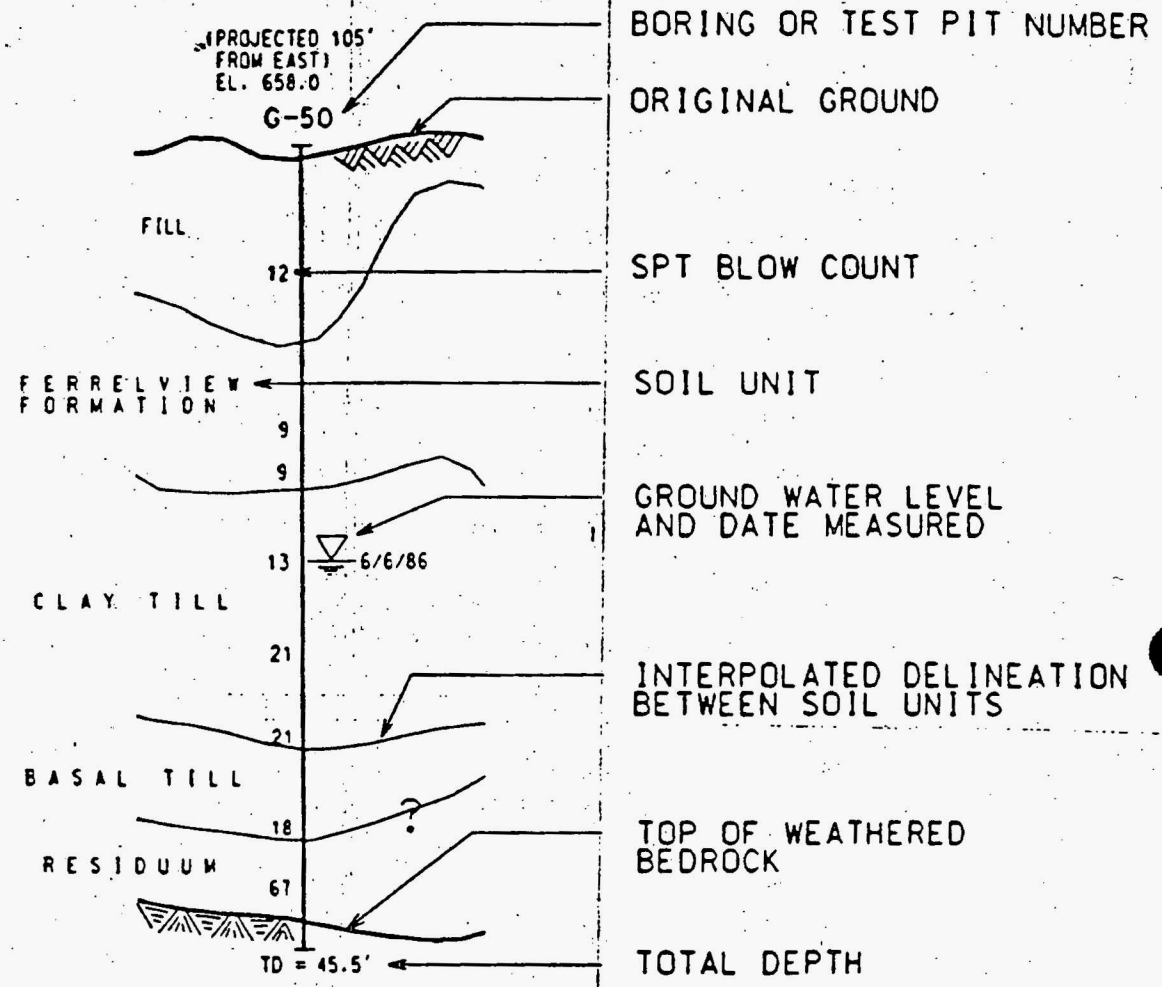
EFOH1.DGN/ PLOT 38408271.000



GEOLOGIC PROFILE SECTION G

FIGURE 4-4

REPORT NO. MKES 3840R-1005	DRAWING NO.	
DRAWN BY: E.C.T.	CHECKED BY: A.M.A.	DATE: 9/12/91



GEOLOGIC PROFILE LEGEND

FIGURE 4-5

REPORT NO.: MKES 3840R-7005		DRAWING NO.:
ORIGINATOR: E.C.T.	DRAWN BY: A.M.A.	DATE: 10/29/91

ETOMS.dgn

and may not represent the actual subsurface conditions between these points. The characteristics of the various soil units shown were described in Section 3.2.

4.2 Materials

4.2.1 Topsoil

Topsoil encountered within the construction area should be stripped and removed. The stripped topsoil, if uncontaminated, should be stockpiled for later use in revegetation; if contaminated, the material should be placed in a contaminated storage area or in the WSS disposal cell.

4.2.2 Subsoil

The subsoil to be encountered during construction at the site will be mostly Loess, Fill, raffinate pit dike fill, Ferrelview clay, and a few pockets of the deeper underlying Clay Till.

If suitable and uncontaminated, the Loess, Fill and dike fill materials should be removed and stockpiled for use as general fill and backfill materials. Contaminated Loess should be spoiled and place in the disposal cell at a later date as determined by the sequencing plans. Some of the uncontaminated Loess material could be too silty or uniformly sized for use as sound engineering fill material. This material should be used in areas designated as random fill or discarded in designated spoil areas.

In most cases, the bottom of the disposal cell will be founded within the Ferrelview clay stratum; in the other cases, within the Clay Till stratum. Both these materials are suitable as foundation subgrade for the cell. Location of the cell bottom may require embankment construction to achieve siting criteria for soil depth above bedrock. Excavated materials, if uncontaminated, should be stockpiled for general fill and backfill. Contaminated materials should be placed in a spoil pile and later disposed of in the disposal cell.

4.2.3 Satisfactory Materials

Satisfactory materials for general and random fill, and for backfill, should be uncontaminated materials from required excavation within the site, or materials from approved borrow sources, that have a maximum particle size less than six inches and less than 5% by weight of organic matter or debris; in addition, materials for general fill or backfill, should be those classified as GC, GM, SC, SM, CL and CH according to ASTM D2487 (ASTM 1991); for random fill or backfill material, or other specifically approved locations, the soil could be those classified as GW, GP, SW, SP, SM and ML. The materials can be combinations, such as CL-CH, or SP-SC, within each of their own groupings. Moisture conditioning to meet compaction requirements may be necessary.

Most of the soils encountered at the site, such as Fill, Ferrelview clay and Clay Till are satisfactory materials. Some Loess units were found to contain high silt contents; however, subject to approval by a qualified field engineer, these materials could be used for general or random fill.

4.2.4 Unsatisfactory and Unstable Materials

Materials which are frozen, contaminated, or contain excess organic matter, debris, or cobbles, or classify according to ASTM D2487 as MH, PT, OL and OH would be unsatisfactory as general fill or backfill.

Materials that are classified as GW, GP, SW, SP, SM and ML would be unsatisfactory except in specifically approved locations or as random fill or backfill. Most of the Loess material at the site should be considered unsuitable as fill unless approved by a qualified field engineer. CH materials with PI above 50 may require special conditioning for compactibility, prior to placement as fill, and may, in some cases, be deemed unsuitable as fill.

Unstable materials may be identified by the presence of waving or rutting under construction equipment traffic or by the difficulty in achieving proper compaction. Potentially unstable materials are fine-grained soils with moisture contents near or above the plastic limit as determined by ASTM D4318.

4.2.5 Low-Permeability Soils

Low-permeability soils are required as a component of the cover system and in a compacted clay liner in the leachate collection and liner system. Materials having all of the following characteristics are acceptable for use as low-permeability material on this project:

- Imported from approved borrow sources.
- Classify according to ASTM D2487 as CL or CH.
- Contain at least 60-percent fines (minus No. 200 sieve size).
- Have a liquid limit greater than 30 percent and a plasticity index greater than 10 but less than 50.
- Have no more than 10-percent gravel-size particles, with a maximum particle size of less than 2 inches.
- Are free of organic matter and debris.
- Have a maximum nominal clod size of 2 inches before placement for compaction.
- Can be brought to within the specified moisture range immediately before compaction, without requiring excessive drying.

Materials that meet these characteristics are obtainable from potential Borrow Source No. 1 or from other approved borrow sources yet to be identified. The Ferrelview clay formation is also a good source meeting the required characteristics.

4.3 Potential Borrow Sources

4.3.1 Topsoil/Subsoil

Topsoils at both Borrow Source Nos. 1 and 2 range from six inches to about one foot thick. These soils can be stripped and saved for revegetation purpose.

Soils underneath the topsoil layer at both sources can be utilized as common fill. These materials are mainly silty clay, clayey silt, and silty sandy gravel. Soil classification test results were summarized in Table 3-4.

4.3.2 Low Permeability Soil

Of the two potential clay borrow sources investigated, only source No. 1 is a suitable source for low permeability soils. The subsurface soils at source No. 2 contain numerous layers or lenses of silty and gravelly materials, which are not suitable as low permeability soils. No further investigation of material at this site was performed after a review of soil classification indices and test pit logs.

Borrow Source No. 1 was found to contain suitable materials for low permeability (clay) soils for use such as radon barrier or liner components of the disposal facilities. Test pit logs show that silty clay and clayey silt (CL-ML) of low to medium plasticity exist from the bottom of the top soil layer to approximately 9 feet depth. A highly plastic clay (CH) layer is usually found beneath the CL-ML material. Soil classification test results are presented in Section 3. The recommended shear strength and consolidation parameters for analyses for remolded soils compacted at 95% maximum dry density at about 3% above optimum moisture content as determined from the ASTM D698 test method (Standard Proctor) are presented in Tables 4-1 and 4-2, respectively.

Both these parameters are within the expected range of values for clayey soils and will not cause critical concerns from slope or foundation stability or settlement standpoints. The high plasticity indices of some of these materials place them into high volume change potential category (see Table 4-3), which indicates that these soils may be subjected to shrinkage cracking if the moisture content of the soil changes drastically

Table 4-1

Recommended Unit Weights and Strength Parameters for Stability Analysis for In-situ Soils Units and Compacted Fill Materials

MATERIALS	UNITS WEIGHTS (pcf)		STRENGTH PARAMETERS[1]				
			Short-Term Static	Long-Term Static		Seismic and Rapid Drawdown	
	Moist (γ_m)	Sat. (γ_{sat})	Su (psf)	C' (psf)	ϕ'(°)	C (psf)	ϕ (°)
Top Soil/Fill	123	126		450	23	450	16
Loess	121	124	1200	250	33	350	25
Ferrelview Clay	124	125	1000	300	16	400	10
Clay Till	128	129	1000	240	25	200	19
Basal Till	128	131	1000	600	27	700	19
Residuum	116	123	1000[5]	250	16	200	13
Compacted Fill[2][6] (on site soil)	126	127[3]	1800[4]	50	20	450	13
Compacted Fill[6] Borrow Source No. 1	119	122	2000	400	13	300	18

NOTES:

(1) Representative Value = Mean Value - ½ Standard Deviation and rounded off.

(2) Based on combined results from remolded Loess and Ferrelview clay samples.

(3) Assumed value.

(4) Based on CL material from DM 7.2-39 (Ref. 3) instead of su=2000 psf from test (Value used is somewhat conservative because the CH material has a higher su value).

(5) Assume same strengths as Basal Till.

(6) Compacted to 95% maximum dry density of ASTM D698 Test (Standard Proctor) mehtod.

Table 4-2
Recommended Soil Parameters for Settlement Estimates for Disposal Facility

Soil Unit	Total Unit Weight γ_t (pcf)	Initial Void Ratio e_0	Compression Index C_c			Recompression Index C_r			Coeff. of Consolidation C_v (ft^2/yr)	Preconsolidation Pressure P_p (psf)	Over-Consolidation Ratio OCR
			UB	Mean	LB	UB	Mean	LB			
Exist. Fill[1]	123	0.708	0.355	0.290	0.225	0.039	0.035	0.031	20.5	8300	9.5
Loess	121	0.708	0.355	0.290	0.225	0.039	0.035	0.031	20.5	8300	9.5
Ferrelview	124	0.732	0.347	0.256	0.164	0.094	0.064	0.034	29.6	7500	6.0
Clay Till	128	0.574	0.245	0.210	0.174	0.065	0.052	0.038	74.0	7800	3.2
Basal Till	128	0.604	0.369	0.252	0.135	0.063	0.049	0.035	25.3	P_0[2]	1.0[2]
Residuum	116	1.027	0.352	0.302	0.252	0.099	0.089	0.079	3.6	7600	2.9

(1) Consolidation parameters are assumed to be the same as that of the Loess material.
(2) Assumed normally consolidated.

NOTES: UB = Upper Bound
LB = Lower Bound

at any time. Special attention should also be given during design to ensure that the low PI materials can withstand expected differential subsidence.

As discussed above, both the CL-ML and CH materials typically extend from below the topsoil layer to at least 12 feet depth. Rough quantity estimates indicated that at least 1.5 million cu. yds. of suitable materials are available. These materials can be excavated with front-end loaders or dozers and loaded into "over the highway" haul trucks, which can travel on the existing highway as part of the hauling route. Another possible means of transportation is a conveyor system. In addition, the material could be loaded, transported and unloaded with scrapers, provided a specially constructed haul route, including highway crossing with or without grade separation, is approved and implemented, to cross highway (Highway 94) which separates the site and the borrow source. Detailed study of transportation alternatives will be undertaken in another special study by the PMC.

4.4 Soil Properties and Parameters

Part of the soil test result evaluation is to provide material properties for analysis and calculation during disposal facility design phases. Soil properties for slope stability, settlement, cracking and subgrade bearing calculations are required. Only materials with available field or laboratory test results from the investigation programs will be addressed. Materials that may be imported from unknown sources or materials such as vitrified or chemically stabilized products that may be generated during remedial action will not be included. No evaluation of test results from raffinate pit dikes was performed unless the results have a direct impact on disposal cell design and analysis.

Soil parameters for moisture content, unit weight, strength and consolidation for analytical purposes are shown in Tables 4-1 and 4-2. These values were developed based on test results for the overall site. It can also be noted that there is little difference or trend between test results for the whole site and results specifically from within the disposal area. Therefore, these values should be used as general averages for most engineering applications for the disposal area (such as for slope stability and settlement analyses). Where major differences are observed for certain parameters for other areas, the test results should be examined separately.

Parameters for the various on-site geologic units and for compacted on-site and off-site borrow soils were developed from laboratory test results or empirical correlations. In most cases, the recommended value is the average value based on the valid data points.

4.4.1 Unit Weights

The moist unit weights and saturated unit weights are shown in Table 4-1. These unit weights are determined by multiplying the dry unit weight by the sum of one plus the moisture content, expressed in decimal form. The moisture content of the soil could vary according to the anticipated condition. For example, the natural moisture content (as tested) would be used to calculate the in-situ moist unit weight of the soil or the moisture content (by calculation) at saturated condition for a soil inundated for a long period. On the other hand, for unit weight for radon barrier calculation (not included), the long term moisture content (driest state) or the dry unit weight should be used because this would give a more conservative analytical result.

4.4.2 Strength Parameters for Stability Analysis

The recommended strength properties of various soils within the overall disposal facility site are shown in Table 4-1. Strength parameters for in-situ and compacted soils (at about 95% maximum dry density and 3% above OMC as determined by ASTM D698) were determined based on average values from laboratory test results (triaxial shear tests) and empirical correlations. Total strength parameters from unconsolidated-undrained (UU) triaxial shear tests were determined for short-term condition studies. Effective strength parameters from CU tests were developed for long-term condition studies and total strength parameters from CU tests for long term seismic conditions.

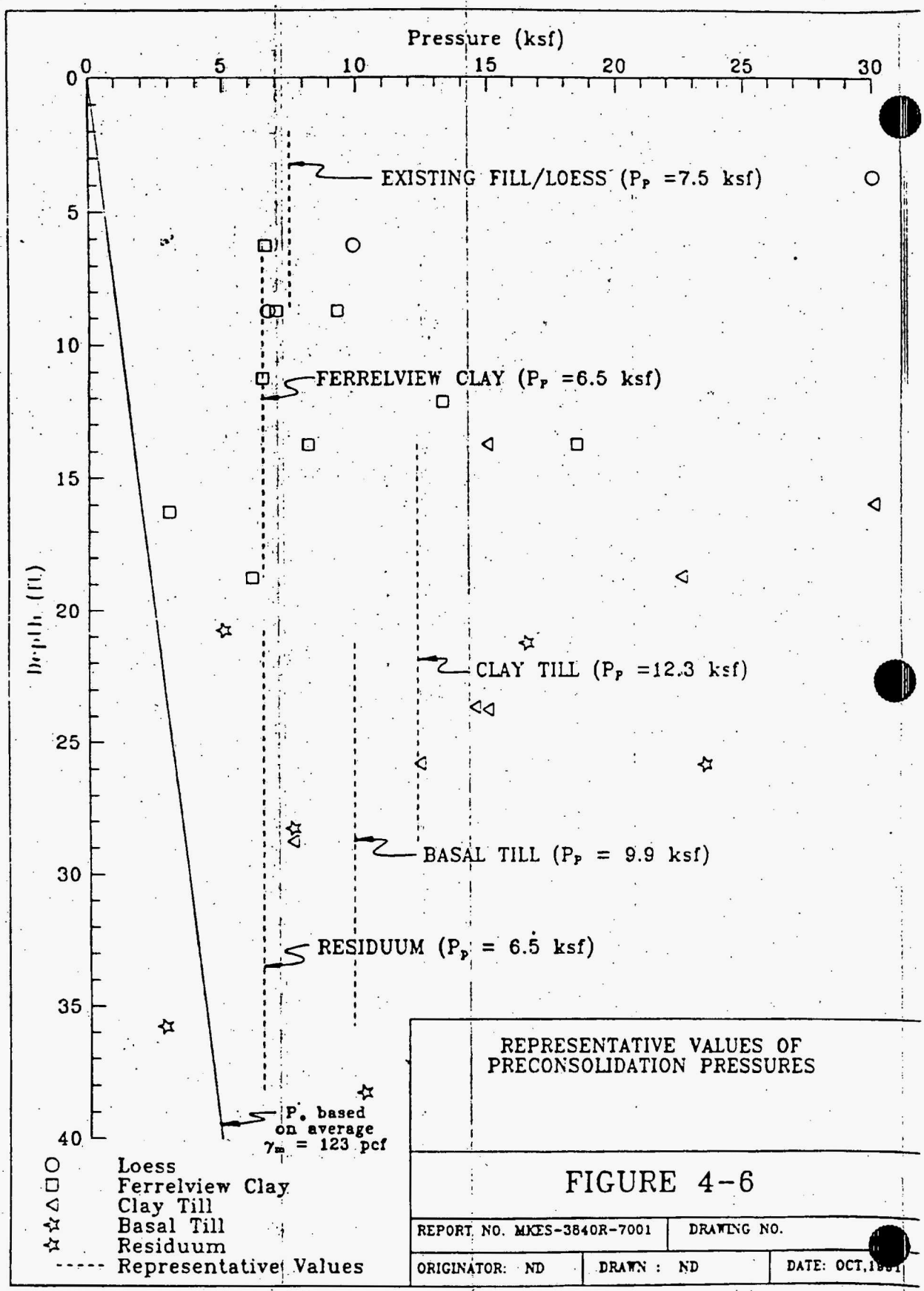
The strength properties for each soil were developed in general by slightly reducing the mean value of each soil to account for uncertainties and built-in conservatism. In cases where a few or only one test result is available for a particular soil unit, empirical values, correlations with STP blow counts, or conservative assumptions were used in developing the recommended analytical values.

4.4.3 Soil Parameters for Settlement Estimates

To estimate the settlement, soil properties such as the unit weight and void ratio are required. The unit weights are shown in Table 4-1. The soil parameters developed from the consolidation tests include preconsolidation pressure (P_p'), compression (C_c) and recompression (C_r) indices and overconsolidation ratio (OCR). The average values of these parameters for the various soil units are presented in Table 4-2. The compression and recompression ratios ($C_{\epsilon C}$ and $C_{\epsilon R}$) were calculated using the void ratio (Appendix C). The representative preconsolidation pressures, P_p', of in-situ materials recommended for settlement analysis are plotted in Figure 4-6 for the overall site. The recommended Pp' value for each soil unit was determined by reducing the average value to a reasonable amount to allow for conservatism. Values from empirical correlations were calculated and used in the evaluation process. When averaging, extremely high values were deleted. These high values do not agree with values from empirical correlations and would introduce unconservatism into the analysis if used. A detailed study of the geologic, loading and preconsolidation history of each geologic unit may provide additional insight into the preconsolidation characteristics, but is beyond the scope of this report. As Figure 4-5 illustrates, all preconsolidation pressure values (except one) exceed the corresponding effective overburden consolidation pressures implying that all soil units are preconsolidated. The slight trend of preconsolidation pressure decreasing with depth for Clay Till and Basal Till is not conclusive, and therefore can be conservatively neglected. For settlement estimates in conjunction with the recommended representative P_p', the compression and recompression indices shown in Table 4-2 can be used. The table shows the average values calculated and the upper and lower bounds of values obtained from the test results. Again, the recommended values are slightly less than the calculated average to allow for uncertanties and conservatism.

4.4.4 Permeability of Soil Liners and Cover Components

The permeability of the soil liner and cover components are based on test results for remolded soil samples from potential borrow sources compacted to 95% of the maximum dry density at about 3% over OMC as determined in accordance with ASTM D698. The triaxial constant head permeability test results for remolded clayey material from potential Borrow Source No. 1 are shown in Table 3-15. The average



REPRESENTATIVE VALUES OF PRECONSOLIDATION PRESSURES

FIGURE 4-6

REPORT NO. MKES-3840R-7001	DRAWING NO.	
ORIGINATOR: ND	DRAWN : ND	DATE: OCT,1991

(logarithmic mean) coefficient of permeability was calculated as 2.7×10^{-8} cm/sec, which is almost an order of magnitude less than the maximum allowable permeability of 1×10^{-7} cm/sec. The material, from a laboratory test result standpoint, meets the required permeability criteria. However, because permeability values from field compacted condition are generally different than those prepared in laboratory, it is recommended that the permeability of the candidate soils be determined using test fills to obtain more accurate values.

4.4.5 Cracking Potential

Low-permeability soils that are required as a component of a cover system or as the compacted liner in a leachate collection system may have a potential for cracking due to soil characteristics and the following causes: 1) differential settlement and 2) shrinkage from drying. The cracking susceptibility of a soil can be assessed from soil indices such as the plastic index (from the Atterberg limits) and the shrinkage limit.

The potential effects of differential settlement can be analyzed by comparing the tesnile strains developed as a result of settlement to the tensile strains required to cause cracking

The tensile strain that causes cracking is a function of the plasticity index and the moisture content of the soil. For soils compacted at moisture contents which are no drier than about 3% below optimum moisture content, an equation for the lower bound failure tensile strain, ϵ_f, has been developed based on measured values (MKE 1989). The equation is:

$$\epsilon_f = 0.05 + 0.003PI.$$

Cracking potential is considered to be significant if the tensile strain from settlement analysis is larger than the failure tensile strain of the soil. For potential Borrow Source No. 1, the average PI is found to be 22. The failure tensile strain therefore is at least 0.12. This value can be compared with the results of settlement analyses to determine if the cracking potential is significant.

To avoid cracking due to soil shrinkage, a soil having a "low" shrink-swell potential should be used if possible. The "shrink-swell" (volume change) potential is defined in Table 4-3.

Soils Borrow Source No. 1 have an average shrinkage limit of 15 and an average PI of 22; based on Table 4-3 for a humid area, this soil is classified as having a low

"shrink-swell" potential. Based on this table, if this soil is used as radon barrier material, no extra thickness is needed to compensate for possible shrinkage effects.

Table 4-3
Relationship Between Atterberg Limits and Volume Change Potential
(Ref. MKE 1989)

Volume Change Potential	Plasticity Index, PI		Shrinkage Limit, w_s	Extra Radon Barrier Thickness to be Provided (inches)
	Arid Area	Humid Area		
Low	0-15	0-30	> 12	0
Moderate	15-30	30-50	10-12	6
High	30	50	< 10	12

4.4.6 Corrosiveness of Soils

Many tables exist for correlating corrosivity with electrical resistivity. The relationship of soil corrosivity to resistivity is generally divided into four or five classes. The resistivity classification presented in papers authored by Husock (Husock 1976) and McIntosh (McIntosh 1982) is as follows:

Soil Resistivity (ohm-cm)	Category
Less than 2,000	Very corrosive
2,000 - 5,000	Corrosive
5,000 - 10,000	Moderately corrosive
10,000 - 25,000	Mildly corrosive
Over 25,000	Progressively less corrosive

Compared to other published tables, this classification system is conservative.

The test results show that the resistivity values measured at the natural moisture content average about 1270 ohm-cm, which place the soil in the very corrosive category. In fact, with the exception of one test, all results are less than 2,000 ohm-cm for the moisture content range of 9 to 57 percent.

Because of the potential for corrosion of both ferrous and non-ferrous metal, protective measures such as coating or cathodic protection should be used for metal structures, or since the laboratory determined resistivity is a general indicator only, field resistivity testing could be performed to obtain more accurate values for final design.

Sulfates in soils can attack and cause the disintegration of concrete or the corrosion of metal pipes. The presence of chlorides in the ground can accelerate the corrosion of buried metals. Even at moderate concentrations, the chloride salts can lead to concrete deterioration. A soil sulfate content greater than 0.10% usually requires the use of Type II or V cement. A chloride content of less than 2% is considered to be innocuous.

The maximum and the average values from the test results (see Section 3.8.2) were 0.08 and 0.06%, respectively for sulfate content and 0.03 and 0.02% respectively for chloride content. All values are less than the corresponding limits of concern and therefore, deterioration of concrete due to the presence of inorganic salts in the soils is not anticipated.

The average pH value of the soils was determined as 6.7. This value is close to the neutral pH value of 7 which indicates that attack on the concrete or steel by acids is not likely.

4.5 Site Preparation and Earthwork

4.5.1 Clearing and Grubbing

Areas to be graded as part of remedial activities should be cleared of bushes and trees and stripped of organic topsoil, roots, grass, debris, loosefill, and other unsuitable materials at the time of grading. Uncontaminated stripped topsoils should be stockpiled for later use (see Section 4.2.1). In no case should the stripped topsoil be reused as engineered fill.

The exposed surface should be scarified to a minimum depth of 8 inches. The scarified material should be properly moisture-conditioned to near optimum moisture content and be compacted to at least 95% of maximum dry density as determined by the American Society of Testing Materials (ASTM D698 test method). If significant pumping or yielding, or both, occur during scarification or recompaction, it will be necessary to stabilize the upper portion of the permanent subgrade foundation by removing the unsuitable material and replaced with a suitable material, or by adding soil admixtures such as lime, cement or fly ash to the subgrade soil. For temporary subgrade foundations, stabilization may include the use of reinforcement such as geotextiles or geosynthetics.

4.5.2 Excavation, Filling and Backfilling

Conventional equipment such as bulldozers, backhoes or scrapers can be used for site grading, trench and foundation excavation. Unusual difficulty is not expected in excavating the on-site soils except the Residuum and weathered rock. However, excavation to these depths is not anticipated. Construction dewatering is generally not necessary unless some localized perched water is encountered. Areas adjacent to existing pads such as the raffinate pits or Ash Pond could be a source of perched ground water. In all cases where excavation dewatering is required, all proper health and safety precautions should be taken to avoid contamination of personnel and equipment.

Temporary construction slopes and excavations should be stabilized as follows: In excavations less than 4 feet deep, a vertical cut slope may be used for short construction periods. In excavations deeper than 4 feet, either shoring or cuts sloped to 0.75 to 1 (H:V) may be used. Flatter slopes may be required in localized areas due to soil strength variation. Temporary slopes for specific construction facilities such as sediment ponds or dikes should be specifically analyzed and designed.

Permanent cut and fill slopes for facilities other than the disposal cell may follow the following general guidelines: 2:1 (H:V) slopes may be used for cuts that are not greater than 20 feet in height and 3:1 (H:V) slopes for heights up to 30 feet. Slopes greater than 30 feet high should be provided with intermediate benches at least 8 feet wide and spaced every 20 and 30 vertical feet for 2:1 (H:V) and 3:1 (H:V) cut slopes, respectively. The inside fill slopes for construction facilities such as dikes or ponds should be no steeper than 2:1 (H:V). The outside fill slopes should be no steeper

McIntosh, Donald H., 1982. Grounding Where Corrosion Protection is Required. IEEE Transactions on Industry Applications, Vol. IA-18, No. 6. November.

Mitchell, James K., 1976. Fundamentals of Soil Behavior. John Wiley & Sons.

MKES, see MK-Environmental Services

MK-Environmental Services, 1991a. *WSSRAP - Disposal Facility Geotechnical Investigation - MKE Phase III (1991) Technical Memorandum 5121-TM-776-00, Scope of Work and Guidelines for Drilling, Sampling and Laboratory Testing Program.* Prepared for MK-Ferguson and Jacobs Engineering Group. San Francisco. March.

MK-Environmental Services, 1991b. *WSSRAP - Disposal Facility Siting Study Report,* Rev. 1. MKES Report No. 5121R-722-1. Prepared for MK-Ferguson Company and Jacobs Engineering Group. San Francisco. April.

MK-Environmental Services, 1991c. *WSSRAP - Disposal Facility Liner and Foundation Assessment Report*, Rev. B. MKES Report No. 3840R-7001-B. Prepared for MK-Ferguson Company and Jacobs Engineering Group. San Francisco. October.

MK-Environmental Services, 1991d. *WSSRAP - Disposal Facility Grading Plan Supporting Study*, Rev. C. MKES Report No. 3840R-797-C. Prepared for MK-Ferguson and Jacobs Engieering Group. San Francisco. July.

MK-Environmental Services, 1991e. *WSSRAP - Disposal Facility Erosion Control Plan* Draft. Prepared for MK-Ferguson and Jacobs Engineering Group. Boise.

MKF and JEG, see MK-Ferguson Company and Jacobs Engineering Group.

MK-Ferguson Company and Jacobs Engineering Group, 1988. *Geophysical/Geotechnical Investigation Sampling Plan.* Rev. 1. DOE/OR/21548-014. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. July.

MK-Ferguson and Jacobs Engineering Group, 1990a. Suitability of the Weldon Spring Site for Potential Location of a Disposal Facility for the Weldon Spring Site Remediation Action PRoject, Weldon Spring, Missouri. DOE/OR/21548-102 Revision 0. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. September.

MK-Ferguson Company and Jacobs Engineering Group, 1990b. *WSSRAP - Chemical Plant Geotechnical Investigations.* Rev. 0. DOE/OR/21548-158. Prepated for U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. December.

MK-Ferguson Company and Jacobs Engineering Group, 1990c. *Remedial Investigation Report for the Weldon Spring Site Remedial Action Project*, DOE/21548-074, Rev. 0. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, St. Charles, Missouri. December (Draft)

MK-Ferguson Company and Jacobs Engineering Group, 1991. *WSSRAP - Geotechnical Investigation Sampling Plan.* Rev. 0. DOE/OR/21548-190. Prepated for U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. April.

Petry, Thomas M. et al., 1980. Relationships and Variations of Properties of Clay 4th International Conference on Expansive Soils, ASCE. June.

SCS, See U.S. Soil Conservation Service.

U.S. Army Corps of Engineers, Office of the District Engineer, St. Louis District, 1955. Report of Foundaton Investigation, United State Atomic Energy Commission, Weldon Spring, Missouri. February.

U.S. Army Corps of Engineers, 1970. Engineering Manual, Engineering Design Stability of Earth and Rockfill Dams. EM 1110-2-1902. Washington, D.C. April.

U.S. Environmental Protection Agency, 1982. Test Methods - Technical Additions to Methods for Chemical Analysis of Water and Wastes. Environmental Monitoring and Support Laboratory, Cincinnati, OH. December.

U.S. Environmental Protection Agency, 1988. SW846, Volume 1C.

U.S. Soil Conservation Service, 1967. Soil Survey Laboratory Methods and Procedures for Collecting Soild Samples. Soil Survey Investigations Report No. 1. U.S. Department of Agriculture. Washington, D.C.

APPENDIX A

MKES PHASE III FIELD INVESTIGATION PROGRAM

APPENDIX A-1

IOC REPORT ON PHASE III FIELD INVESTIGATION

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

INTER-OFFICE CORRESPONDENCE

		FILE NUMBER:	3840-D:EN-I-01-4165-00
		DATE:	14 May 1991
TO:	Ed Tom	FROM:	Eerik Rennat
LOCATION:	San Francisco	LOCATION:	San Francisco

SUBJECT: WSSRAP - DC
GEOTECHNICAL DRILLING
PHASE III

This report presents the edited field boring logs and the procedures performed during the drilling and soil sampling of 7 additional exploratory borings at the location of the proposed disposal cell, Weldon Springs Site Remedial Action Project (WSSRAP). Boring locations are shown on the accompanying Boring Location Plan. The investigation will provide additional geotechnical design parameters for construction of a waste disposal facility. The drilling program was prepared following the directions from the Department of Energy (DOE) document, Geophysical/Geotechnical Investigation Sampling Plan.

Drilling was conducted from April 5 through April 15, 1991 by Geotechnology Services, Inc. under subcontract WP228. Don Houston and Paul Guerrin performed as driller and driller's helper, respectively. Sample logging, documentation and drilling supervision was performed by Eerik Rennat of Morrison-Knudsen Environmental Services (San Francisco).

Prior to initiating the drilling, the drill rig and all drilling tools were thoroughly decontaminated with high pressure water. Additionally, the rear of the rig and drilling tools were decontaminated between borings. Personal protective equipment consisted of gloves, safety boots, hard hats and eye protection. Hearing protection was worn when within 15 feet of the drill rig during drilling operations. A safety meeting was held each day prior to the commencement of work.

All boreholes except GT-73 were located in uncontaminated areas. Radiation personnel from the PMC assisted in locating GT-73 and were present during drilling through the shallow contaminated materials.

All personnel had received the OSHA 40-hour hazardous waste safety training (29CFR 1910.120) plus site-specific WSSRAP radiation safety instruction conducted by a site health physicist. All personnel wore thermoluminescent dosimitry (TLD) badges and provided entrance and exit urine samples.

Drilling was accomplished with a CME-750 drill rig using continuous flight hollow-stem augers having an outside (O.D.) diameter of 7-1/2 inches and an inside (I.D.) diameter of 3-3/4 inches. All holes were drilled to auger refusal at the top of bedrock. No rock coring was performed.

Soil sampling was performed on 2-1/2 foot centers. Disturbed soil samples were obtained using a 2.0-inch O.D., 1.5-inch I.D. Standard Penetration (SPT) sampler. SPT samples were placed in capped glass jars. Relatively undisturbed samples were obtained using a California split-barrel sampler having an O.D. of 3.0 inches and I.D. of 2.5 inches. Four 6-inch long, 2.5-inch I.D. brass liners were placed inside the California sampler. Each retrieved 6-inch liner was capped and taped. Both the SPT and California samplers were driven a depth of 18 inches beyond the lead auger using a 140-pound safety hammer free-falling 30 inches. The number of blows required to drive each 6-inch interval was recorded and the final two 6-inch drives were summed and expressed as blows per foot. Undisturbed samples, where possible, were obtained by hydraulically pushing 3.0-inch diameter, 36-inch long steel Shelby tubes to a depth of 30 inches. Upon retrieval, both ends of the tube were sealed with molten bee's wax, capped, and taped. Any excess space in the tube after waxing was filled with cuttings to minimize movement of the sample within the tube.

Soils encountered were described in accordance with the Unified Soil Classification System. SPT samples were photographed.

A daily diary was maintained documenting all drilling activities. Chain-of-custody forms were completed showing soil samples collected. All samples were stored on-site in building 410.

All borings were abandoned by plugging with Volclay Grout manufactured by American Colloid Company. Volclay consists of a high-solids bentonite clay powder with a 4% added initiator which causes the grout to set up to a plastic consistency. Each 50-pound bag of Volclay powder was mixed with approximately 23 gallons of clear water to yield a grout

mixture of 9.4 lbs/gal or denser. Density was verified with a scale. The Volclay powder was jetted through a hopper into a tub and thoroughly mixed by circulating through the rig mud pump. Two pounds of initiator were added per 50-pound bag of Volclay. Once mixed, the grout slurry was pumped through the hollow stem augers, the augers were retrieved, and the hole topped off. Holes were checked for settling of the grout after 24 hours and topped off if necessary.

Upon completion of the drilling, the drill rig, all drilling tools, and the water truck were decontaminated with high pressure water prior to demobilizing the site.

EAR:afp

APPENDIX A-2

LOGS OF PHASE III BORINGS

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

SOIL BORING LOG

Sheet 1 of 2
Project Number: 3840
Hole Number: GT-68

Project: Weldon Springs Site Remedial Action Project	Location: NW of MSA
Coordinates: (AEC) N101328.5, W51437.0	Drilling Contractor: Geotechnology Services, Inc.
Drill Make and Model: CME 750, ATV mounted	Depth Top of Rock: 53.5
Depth Casing & Size: --	Hole Size: 7 1/2" (Auge
Elevation: 643.0	Angle from Vert. and Bearing: Vertical
Depth Bottom of Hole: 53.5	
Water Level: Dry	Fluid & Additives: None
Date Start: 4/5/91 9:00	Date Finish: 4/5/91 15:45
Logger: E. Rennat	

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
							ORGANIC SILT (ML) Lt-med brown, dry, hard, some organics TOPSOIL
							Silty Clay
		2.5-4	SS 6801	14"	10-34-41		Mottled lt brown and lt. gray, moist, stiff, plasti some Fe and Mn staining, occasional small (1/4") clasts. CL
	5	5-7.5	ST 6802	26"			
		7.5-9	SS 6803	14"	3-6-8 (14)		
	10	10-12.5	ST 6804	25"			
		12.5-14	SS 6805	18"	4-9-15 (24)		FERRELVIEW
	15	15-16	ST 6806	13"			-ST pushed only 15"
							Clay
		17.5-19	SS 6807	6"	3-21-20 (41)		Mottled lt. orange and lt. gray, slightly moist to moist, stiff, some Fe staining, Mn staining along irregular fractures, 10% subrounded sand, occasiona small gravel (chert and feldspor) CL - CH
	20	20-22.5	ST 6808	26"			
		22.5-24	SS 6809	17"	6-9-12 (21)		
	25						CLAY TILL

SS = Split Spoon ST = Shelby Tube CS = California Sampler (3")

MK-ENVIRONMENTAL SERVICES

Project Number: 3840	Boring Number: GT - 68	Sheet 2 of 2

SOIL BORING LOG

Project: Weldon Springs Site RAP Location:

Elevation: Drilling Contractor:

Drilling Method and Equipment:

Water Level and Date: Start Finish: Logger:

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION: Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		25-27.5	ST 6810	28"			(cont'd)
		27.5-29	SS 6811	19"	5-9-11 (20)		
	30	30-31	ST 6812	10"			- ST pushed only 12" CLAY TILL
							Clay Sand and Sandy Clay
		32.5-34	SS 6813	20"	4-6-12 (18)		Lt. orange to pinkish brown, moist, medium to stiff, plastic, angular gravel clasts. SC - CL BASAL TILL
	35	35-36.5	SS 6814	14"	25-19-26 (45)		Gravelly Clay and Clayey Gravel
		37.5-39	SS 6815	14"	15-19-43 (62)		Red-orange, moist, stiff, less plastic, 40-60% angular sand and gravel, often Fe stained, mostly chert GC - CL
	40	40-41.5	SS 6816	15"	20-43-50/5" ---		
		42.5-44	SS 6817	17"	13-14-25 (39)		
	45	45-46.5	SS 6818	14"	12-47-20 (67)		- less red coloring, wet toward bottom
		47.5-49	SS 6819	12"	8-8-7 (15)		
	50	50-51.5	SS 6820	12"	10-8-10 (18)		RESIDUUM
							Auger Refusal at 53.5 feet
	55						

ST - California Sampler (3")

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

SOIL BORING LOG

Sheet 1 of 2
Project Number: 3840
Hole Number: GT-69

Project: Weldon Springs Site Remedial Action Project	Location: 200' NW of Bldg. 109, at foot of slope
Coordinates: (AEC) N101092.9, W50327.1	Drilling Contractor: Geotechnology Services, Inc.

Drill Make and Model	Depth Top of Rock	Depth Casing & Size	Hole Size
CME 750, ATV mounted	31.5	--	7 1/2" (Auge

Elevation	Angle from Vert. and Bearing	Depth Bottom of Hole
647.1	Vertical	31.5

Water Level	Fluid & Additives	Date Start	Date Finish	Logger
Dry	None	4/08/91 15:00	4/11/91 9:00	E. Rennat

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
							Silty Clay Mottled lt. to med. brown and lt. gray, moist, medium stiff, plastic, occasional Fe and Mn staining Dk brown organics near top CL
		2.5-4	SS 6901	14"	1-4-5 (9)		
5		5 7.5	ST 6902	15"			FERRELVIEW
		7.5-9	SS 6903	18"	2-7-10 (17)		Clay Orange-brown, moist, stiff, plastic, Mn staining along irregular fractures, 10% quartz sand considerable whitish calcite below 12.5' CL - CH
10		10-12.5	ST 6904	28"			
		12.5-14	SS 6905	18"	3-10-15 (25)		
15		15-17.5	ST 6906	24"			- ST pushed only 24" CLAY TILL
		17.5-19	SS 6907	18"	6-14-20 (34)		Clayey Sand and Sandy Clay Mottled lt. gray and lt. brown, slightly moist, sti low plasticity, Fe and Mn staining, some calcite SC - CL
20		20-22.5	ST 6908	27"			BASAL TILL
		22.5-24	SS 6909	19"	6-11-29 (40)		Reddish, moist, stiff, plastic, Mn staining along irregular fractures; angular chert gravel, increasi with depth Gravelly Clay and Clayey Gravel
25							

SS = Split Spoon ST = Shelby Tube CS = California Sampler (3")

MK-ENVIRONMENTAL SERVICES

Project Number: 3840	Boring Number: GT - 69	Sheet 2 of 4

SOIL BORING LOG

Project: Weldon Springs Site RAP Location:

Elevation: Drilling Contractor:

Drilling Method and Equipment:

Water Level and Date: Start Finish: Logger:

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION: Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		25-26.5	CS 6910	12"	(52-41-31)		(cont'd)
		27.5-29	SS 6911	17"	3-20-18 (38)		- orange-brown color, 50% chert gravel, occasional calcite encrustation GC - CL
	30	30	CS --	2"	(100/1")		RESIDUUM
	35						Auger Refusal at 31.5'
	40						
	45						
	50						
	55						

SS = Split Spoon ST = Shelby Tube CS = California Sampler (3")

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

SOIL BORING LOG

Sheet 1 of 2

Project Number: 3840

Hole Number: GT - 70

Project: Weldon Springs Site Remedial Action Project	Location: W of MSA
Coordinates: (AEC) N10082[illegible].1 W51328.1	Drilling Contractor: Geotechnology Services, Inc.
Drill Make and Model: CME 750, ATV mounted	Depth Top of Rock: 29.5 / Depth Casing & Size: -- / Hole Size: 7 1/2" (Auger)
Elevation: 634.5	Angle from Vert. and Bearing: Vertical / Depth Bottom of Hole: 29.5
Water Level: Dry	Fluid & Additives: None / Date Start: 4/08/91 9:45 / Date Finish: 4/08/91 12:30 / Logger: E. Rennat

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
							Silty Clay
		2.5-4	SS 7001	14"	3-4-7 (11)		Grey-brown, moist to very moist, Fe staining, occasional chert clasts. CL
	5	5-6.5	ST 7002	18"			- ST pushed only 18"
		7.5-9	SS 7003	18"	3-6-7 (13)		
	10	10-12.5	ST 7004	24"			
		12.5-14	SS 7005	18"	4-16-30 (46)		- 1" chert piece in shoe of SS
							FERRELVIEW
	15	14-15.5	SS 7006	12"	43-40-26 (66)		Silty Clay and Clayey Sand
							Brown, slightly moist to moist, very stiff, very Fe rich, up to 50% 1/4" chert fragments CL - SC
		17.5-19	SS 7007	11"	12-9-20 (29)		
	20	20-21	ST 7008	12			- ST pushed only 1'
		22.5-24	SS 7009	12"	8-6-7 (13)		
							CLAY TILL/BASAL TILL
	25						

SS = Split Spoon ST = Shelby Tube CS = California Sampler (3")

MK-ENVIRONMENTAL SERVICES

Project Number: 3840	Boring Number: GT - 70	Sheet 2 of 2

SOIL BORING LOG

Project: Weldon Springs Site RAP Location:

Elevation: Drilling Contractor:

Drilling Method and Equipment:

Water Level and Date: Start Finish: Logger:

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
		25-26	ST 7010	12"			(cont'd) - ST pushed only 1'
		27.5-28.5	SS 7011	10"	30-34-50/4" (=)		Gravelly Clay Brown, moist, Fe rich - sand lens from 28 to 28.4', with gravel RESIDUUM
	30						Auger Refusal at 29.5'
	35						
	40						
	45						
	50						
	55						

SS = Split Spoon ST = Shelby Tube CS = California Sampler (3")

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

SOIL BORING LOG

Sheet 1 of 2
Project Number: 3840
Hole Number: GT - 71

Project: Weldon Springs Site Remedial Action Project	Location: 70'W of SW corner of Bldg. 201
Coordinates: (AEC) N99758.2, W50300.1	Drilling Contractor: Geotechnology Services, Inc.

Drill Make and Model	Depth Top of Rock	Depth Casing & Size	Hole Size
CME 750, ATV mounted	34.5	--	7 1/2" (Auger)

Elevation	Angle from Vert. and Bearing	Depth Bottom of Hole
659.3	Vertical	34.5

Water Level	Fluid & Additives	Date Start	Date Finish	Logger
Dry	None	4/11/91 10:50	4/11/91 15:05	E. Rennat

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
							Silty Clay
		2.5-4	SS 7101	12"	4-6-8 (14)		Mottled lt. to med. brown and gray, moist, plastic, stiff, occasional Fe and Mn staining. CL
	5						
		5-7.5	ST 7102	21"			
		7.5-9	SS 7103	13"	1-5-8 (13)		
	10						
		10-12.5	ST 7104	27"			
		12.5-14	SS 7105	18"	2-6-8 (14)		
							FERRELVIEW
	15						Clay
		15-17.5	ST 7106	26"			Mottled lt. brown and gray, moist, plastic, stiff, 5% medium to coarse subrounded chert sand, occasional 1/4" chert clasts. CL - CH
		17.5-19	SS 7107	19"	3-6-8 (14)		
	20						
		20-22.5	ST 7108	27"			
		22.5-24	SS 7109	18"	4-7-7 (14)		
							CLAY TILL
	25						

MK-ENVIRONMENTAL SERVICES

Project Number: 3840	Boring Number: GT - 71	Sheet 2 of 2

SOIL BORING LOG

Project: Weldon Springs Site RAP Location:

Elevation: Drilling Contractor:

Drilling Method and Equipment:

Water Level and Date: Start Finish: Logger:

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
		25-27.5	ST 7110	27"			Sandy Clay Lt. brown, moist, plastic, stiff, occasional Fe and Mn staining, chert clasts CL
		27.5-29	SS 7111	19"	6-10-15 (25)		
							BASAL TILL
	30	30-31.5	CS 7112	15"	(21-36-20)		Gravelly Clay Lt orange, moist, plastic, stiff, some Mn staining along fractures; angular chert clasts up to 1", up to 30% toward bottom CL
		32.5-34	SS 7113	11"	15-15-50/5		
							RESIDUUM
	35						Auger Refusal at 34.5'
	40						
	45						
	50						
	55						

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

SOIL BORING LOG

Sheet 1 of 2
Project Number: 3840
Hole Number: GT - 72

Project: Weldon Springs Site Remedial Action Project	Location: 200' E of Bldg. 302
Coordinates: (SEC) N39200.8, W50074.0	Drilling Contractor: Geotechnology Services, Inc.

Drill Make and Model	Depth Top of Rock	Depth Casing & Size	Hole Size
CME 750, ATV mounted	34'	--	7 1/2" (Auger)

Elevation	Angle from Vert. and Bearing	Depth Bottom of Hole
657.5	Vertical	34'

Water Level	Fluid & Additives	Date Start	Date Finish	Logger
Dry	None	4/12/91 8:00	4/12/91 11:20	E. Rennat

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
							- Dark brown organics near surface
		2.5-4	SS 7201	13"	4/5/6 (11)		Silty Clay Mottled lt. to med. brown and gray, moist plastic, stiff, occasional Fe and Mn staining, occasional angular chert clasts. CL
5		5-7.5	ST 7202	25"			
		7.5-9	SS 7203	17"	3/5/6 (11)		
10		10-12.5	ST 7204	26"			
		12.5-14	SS 7205	16"	2/5/7		
15		15-16.5	CS 7206	18"	(4/9/13)		
		17.5-19	SS 7207	17"	2/7/9 (16)		
20		20-22.5	ST 7208	28"			FERRELVIEW Clay Mottled lt. brown, orange and lt. gray, moist, plasti stiff to very stiff, Fe and Mn staining, often along fractures 5% coarse angular chert sand, occasional angular chert clasts up to 1". CL - CH
		22.5-24	SS 7209	20"	5/10/15 (25)		
25							

MK-ENVIRONMENTAL SERVICES

Project Number: 3840	Boring Number: GT - 72	Sheet 2 of 2

SOIL BORING LOG

Project: Weldon Springs Site RAP Location:

Elevation: Drilling Contractor:

Drilling Method and Equipment:

Water Level and Date: Start Finish: Logger:

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION: Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol
		25-27.5	ST 7210	26"			(cont'd)
		27.5-29	SS 7211	18"	10/14/16 (30)		CLAY TILL
	30	30-31.5	CS 7212	11"	(14-100/2")		Gravelly Sandy Clay Black with brown, moist, stiff, plastic, 40% fine to medium subrounded chert gravel, whitish calcite encrustations below 30'. CL
		32.5-34	SS 7213	6"	50/5"		BASAL TILL
	35						Auger Refusal at 34'
	40						
	45						
	50						
	55						

SS = Split Spoon ST = Shelby Tube CS = California Sampler (3")

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

SOIL BORING LOG

Sheet 1 of 2
Project Number: 3840
Hole Number: GT - 73

Project: Weldon Springs Site Remedial Action Project	Location: 100' W of SW corner of Bldg. 302
Coordinates: (AEC) N99072.7 W50456.6	Drilling Contractor: Geotechnology Services, Inc.

Drill Make and Model	Depth Top of Rock	Depth Casing & Size	Hole Size
CME 750, ATV mounted	45.5'	--	7 1/2" (Auger

Elevation	Angle from Vert. and Bearing	Depth Bottom of Hole
660.0	Vertical	45.5'

Water Level	Fluid & Additives	Date Start	Date Finish	Logger
Dry	None	4/15/91 11:20	4/15/91 16:10	E. Rennat

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
							Silt Dk brown with organics, moist (radiologically contaminated up to 400 cts/min) ML FILL
		2.5-4	SS 7301	13"	2/4/6 (10)		Silty Clay Lt. to med. brown with gray, moist, plastic, stiff, Fe and Mn staining increasing with depth, occasional angular chert clast: CL
	5	5-7.5	ST 7302	28"			
		7.5-9	SS 7303	16"	1/5/8 (13)		
	10	10-12.5	ST --	4"			- no sample
		12.5-14	SS 7305	16"	1/4/7 (11)		
	15	15-17.5	ST 7306	23"			FERRELVIEW
		17.5-19	SS 7307	20"	4/8/12 (20)		Clay Lt. gray-brown, moist, plastic, slight Fe and Mn staining, 5% medium to coarse subrounded chert and quartz sand, occasional whitish calcite, occasional gravel-size chert clasts. CL - CH
	20	20-22.5	ST 7308	28"			
		22.5-24	SS 7309	18"	5/8/12 (20)		
	25						

SS = Split Spoon ST = Shelby Tube CS = California Sampler (3")

MK-ENVIRONMENTAL SERVICES

Project Number: 3840	Boring Number: GT - 73	Sheet 2 of 2

SOIL BORING LOG

Project: Weldon Springs Site RAP Location:

Elevation: Drilling Contractor:

Drilling Method and Equipment:

Water Level and Date: Start Finish: Logger:

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
		25-27.5	ST 7310	27"			(cont'd)
		27.5-29	SS 7311	21"	5/12/16 (28)		
	30	30-32.5	ST 7312	15"			- ST pushed only 20"
		32.5-34	SS 7313	21"	6/10/11 (21)		CLAY TILL Silty Clay Gray, moist, plastic, medium stiffness (softer than above), little sand, no gravel, some Fe staining. CL
	35	35-36.5	CS 7314	19"	(7/11/15)		
		37.5-39	SS 7315	17"	5/9/20 (29)		BASAL TILL Gravelly Sandy Clay Lt. to dk brown to 40', orange below 40', medium to coarse sand, increasing angular chert gravel with depth. CL
	40	40-41.5	CS 7316	15"	(24/37/		
		42.5-44	CS 7317	7"	34-50/2"		
	45						RESIDUUM
							Auger Refusal at 45.5'
	50						
	55						

CS = California Sampler (3")

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

SOIL BORING LOG

Sheet 1 of 2
Project Number: 3840
Hole Number: GT - 74

Project: Weldon Springs Site Remedial Action Project	Location: Proposed Water Treatment Plant Area
Coordinates: (AEC) N98676.0 W50266.6	Drilling Contractor: Geotechnology Services, Inc.

Drill Make and Model:	Depth Top of Rock:	Depth Casing & Size:	Hole Size:
CME 750, ATV mounted	34.5	--	7 1/2" (Auge

Elevation:	Angle from Vert. and Bearing:	Depth Bottom of Hole:
653.2	Vertical	34.5

Water Level:	Fluid & Additives:	Date Start:	Date Finish:	Logger:
Dry	None	4/16/91	4/16/91	E. Rennat

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
							Clayey Silt and Silty Clay Med. brown, moist, plastic; dk brown organics near top, occasional chert clast up to 1/2". CL - ML
		2.5 -4	SS 7401	5"	2/3/6 (9)		
	5	5- 7.5	ST 7402	26"			TOPSOIL/FILL
		7.5 9	SS 7403	14"	1/4/6 (10)		Silty Clay Mottled lt. brown and lt. med. gray, moist, plastic CL
	10	10- 12.5	ST 7404	27"			FERRELVIEW
		12.5 -14	SS 7405	18"	1/5/7 (12)		Clay Lt. brown, orange and gray, moist, plastic, stiff, 5% medium to coarse rounded to subrounded chert sand, Fe and Mn staining. CL - CH
	15	15- 17.5	ST 7406	28"			- ST pushed only 28"
		17.5 -19	SS 7407	18"	3/8/9 (17)		- 10% fine subrounded gravel, gray
	20	20- 22.5	ST 7408	23"			- ST pushed only 26"
		22.5 -24	SS 7409	22"	3/8/9 (17)		
	25						

SS - Split Spoon ST - Shelby Tube CS = California Sampler (3")

MK-ENVIRONMENTAL SERVICES

Project Number: 3840	Boring Number: GT - 74	Sheet 2 of 2

SOIL BORING LOG

Project: Weldon Springs Site RAP Location:

Elevation: Drilling Contractor:

Drilling Method and Equipment:

Water Level and Date: Start Finish: Logger:

ELEVATION	DEPTH BELOW SURFACE	SAMPLE INTERVAL	SAMPLE TYPE & NUMBER	SAMPLE RECOVERY	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SYMBOLIC LOG	SOIL DESCRIPTION (Name, Gradation or Plasticity, Particle Size Distribution, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Mineralogy, USCS Group Symbol)
		25-27.5	ST 7410	24"			(cont'd)
		27.5-29	SS 7412	14"	9/23/25 (48)		CLAY TILL Clayey Gravel Whitish with orange Fe staining, angular chert, 30% sandy clay, whitish calcite encrustations. GC
	30	30-30.5	CS -	3"	(100/5")		- no sample
		32.5-33	SS -	2"	50/2"		- no sample
	35						Auger Refusal at 34.5'
	40						
	45						
	50						
	55						

APPENDIX B

MKES PHASE III INVESTIGATION TEST RESULTS

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

IN-SITU MOISTURE AND DENSITY DETERMINATION

SITE ID: WSSRAP

DATE: 8-17-91

LAB NAME: CNI

CHECKED BY: LAB SKM

TAC

* Average of three values

LOCATION ID	SAMPLE ID	DEPTH INTERVAL (FT)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	
Disposal Facility	GT-6810	25.0-25.7	16.5	110.0	
"	GT-6906	15.0-17.5	14.1	112.1	*
"	GT-6908	20.0-22.5	15.6	116.3	
"	GT-6910	25.0-26.5	9.6	NP	
"	GT-7004	10.0-12.5	18.8	110.1	
"	GT-7108	20.0-22.5	16.3	111.0	*
"	GT-7110	25.0-27.5	20.9	106.2	*
"	GT-7112	30.0-31.5	22.5	88.0	
"	GT-7306	15.0-17.5	32.4	92.4	
"	GT-7314	35.0-36.5	22.5	102.3	
"	GT-7316	40.0-41.5	10.2	NP	
"	GT-7402	5.0-7.5	24.2	99.9	
"	GT-7406	15.0-17.5	17.8	110.3	*

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

MECHANICAL SIEVE TEST RESULTS

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-8-91

CHECKED BY: LAB SKM

LAB NAME: CNI

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	% PASSING STANDARD SIEVE NUMBERS *										
		3"	1 1/2"	3/4"	3/8"	#4	#8	#16	#30	#50	#100	#200
GT-6510	25.0-27.5		100	95	95	95	95	94	92	88	78	71
6513	32.5-34.0			100	99	99	98	98	97	97	96	95
6515	37.5-39.0			100	94	91	89	88	87	86	85	84
6706	15.0-17.5					100	99	97	94	89	80	72
6708	20.0-22.5				100	90	89	88	86	82	74	67
6710	25.0-26.5	100	62	55	47	35	28	24	22	20	19	18
7104	10.0-12.5							100	99	98	94	93
7108	20.0-22.5						100	99	97	91	77	68
7110	25.0-27.5							100	99	99	99	98
7112	30.0-31.5		100	82	70	64	62	61	60	59	58	57
7306	15.0-17.5						100	99	98	94	88	84
7314	35.0-36.5					100	99	99	99	98	97	96
7316	40.0-41.5		100	66	56	40	36	32	29	27	24	23
7402	5.0-7.5					100	99	98	97	93	85	79
7406	15.0-17.5			100	99	99	97	96	94	89	79	72

*ENTER ONLY VALUES LESS THAN 100%. TEST PROCEDURE: ASTM D 422-63 (1990)

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

HYDROMETER ANALYSIS TEST RESULTS

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-8-91

CHECKED BY: LAB SKM

LAB NAME: CNI

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	% FINER THAN (mm) *							
		.074 mm	.05 mm	.037 mm	.019 mm	.009 mm	.005 mm	.002 mm	.001 mm
GT- 6810	25.0-27.5	71	—	(.030) 61	54	(.008) 45	(.006) 43	(.003) 36	33
GT- 6813	32.5-34.0	95	—	(.028) 72	59	(.008) 42	(.006) 38	(.003) 33	30
GT- 6815	37.5-39.0	—	—	—	—	—	—	—	—
GT- 6906	15.0-17.5	72	—	(.029) 61	55	(.008) 42	(.006) 40	(.003) 32	29
GT- 6908	20.0-22.5	67	—	(.029) 61	51	(.011) 44	(.006) 37	(.003) 31	28
GT- 6910	25.0-26.5	—	—	—	—	—	—	—	—
GT- 7004	10.0-12.5	93	—	(.028) 72	60	(.008) 39	(.006) 35	(.003) 30	27
GT- 7108	20.0-22.5	68	—	(.030) 57	(.026) 51	(.008) 42	(.006) 39	(.003) 34	31
GT- 7110	25.0-27.5	98	—	(.027) 84	(.018) 71	(.008) 51	(.006) 49	(.003) 44	40
GT- 7112	30.0-31.5	57	—	(.028) 52	(.018) 50	(.008) 48	(.006) 46	(.003) 45	44
GT- 7306	15.0-17.5	84	—	(.028) 74	(.018) 66	(.008) 54	(.006) 51	(.003) 46	42
GT- 7314	35.0-36.5	96	—	(.023) 77	60	(.011) 47	(.006) 34	(.003) 30	28
GT- 7316	40.0-41.5	23	—	(.031) 22	(.026) 21	(.011) 20	(.006) 19	(.003) 17	16
GT- 7402	5.0-7.5	79	—	(.028) 70	(.018) 63	(.009) 54	(.006) 51	(.003) 44	41
GT- 7406	15.0-17.5	72	—	(.030) 61	56	(.008) 44	(.006) 41	(.003) 37	32

TEST PROCEDURE: ASTM D 422-63 (1990)

* ENTER ONLY VALUE LESS THAN 100%

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

PHYSICAL PROPERTY TEST RESULTS

SITE ID: WSSRAP
DATE: 8-8-91
LAB NAME: CNI

LOCATION ID: Disposal Facility
CHECKED BY: LAB SKM
TAC

SAMPLE ID	DEPTH INTERVAL (FT)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	SPECIFIC GRAVITY
GT-6310	25.0-27.5	47	13	34	2.69
GT-6313	32.5-34.0	40	13	27	—
GT-6906	15.0-17.5	41	12	29	—
GT-6908	20.0-22.5	40	15	25	2.77
GT-6910	25.0-26.5	—	—	—	(-4) 2.74 (+4) G_a = 2.59
GT-7004	10.0-12.5	41	15	26	2.75
GT-7108	20.0-22.5	47	14	33	—
GT-7110	25.0-27.5	54	15	39	2.72
GT-7112	30.0-31.5	—	—	—	(-4) 2.74 (+4) G_a = 2.44
GT-7306	15.0-17.5	64	19	45	2.74
GT-7314	35.0-36.5	38	16	22	2.71
GT-7316	40.0-41.5	50	17	33	(-4) 2.70 (+4) G_a = 2.56
GT-7402	5.0-7.5	55	13	42	—
GT-7406	15.0-17.5	42	12	30	—

TEST PROCEDURE: ASTM D-4318-84 AND ASTM D854-83 (1990)

CONSOLIDATION TESTS

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATION TEST RESULTS

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-20-91

CHECKED BY LAB: SKM

LAB NAME: CNI

TAC:

SAMPLE ID	DEPTH INTERVAL (FT)	BEGINNING SUBMERGED STRESS (PSF)	COMPACTION (%)
GT-6E10	25.0-27.5	250	N/A

INITIAL CONDITIONS			
DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
110.3	15.6	80.3	0.525

FINAL CONDITIONS			
DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
118.0	18.3	100+	0.425

TEST RESULTS		
AXIAL STRESS (PSF)	VOID RATIO e	COEFFICIENT OF CONSOLIDATION (cm^2/sec)
250	0.515	N/A
WATER ADDED	0.547	N/A
500	0.542	1.35×10^{-4}
1000	0.535	N/A
2000	0.522	6.20×10^{-4}
4000	0.507	1.67×10^{-3}
8000	0.487	7.99×10^{-4}
16,000	0.454	5.24×10^{-4}
32,000	0.409	1.56×10^{-4}
64,000	0.350	1.03×10^{-4}
128,000	0.283	6.98×10^{-4}
32,000	0.304	N/A
8000	0.351	N/A
2000	0.404	N/A
500	0.424	N/A
250	0.425	N/A

TEST PROCEDURE: ASTM D 2435-90

NOTE: INDIVIDUAL TIME-RATE INCREMENTS TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS

TEST NO. [illegible] #5810 CONSOL ENTERED BY SKM CHECKED BY SKM

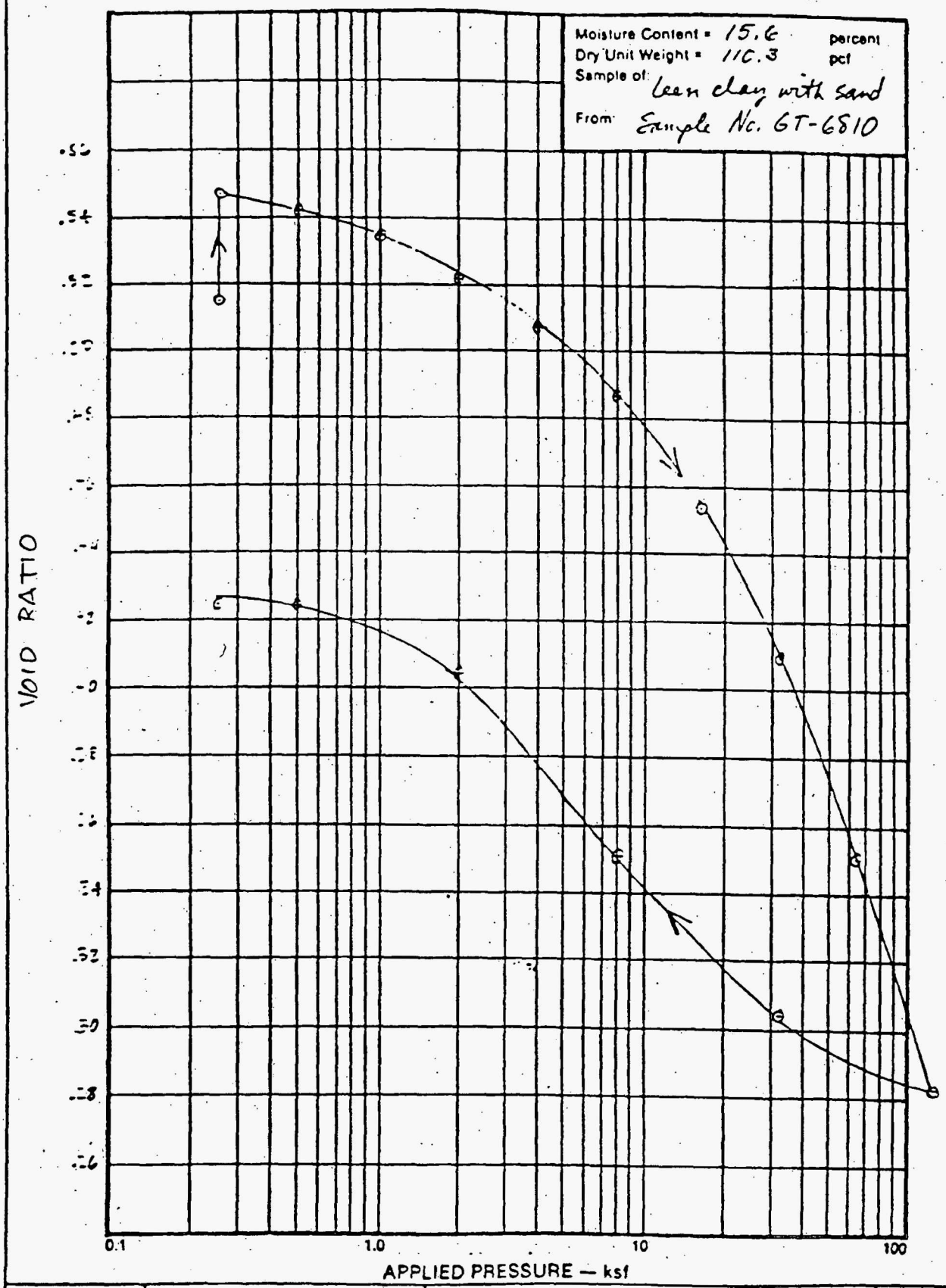
INITIAL WET WEIGHT OF SAMPLE g = [illegible]
INITIAL DRY WEIGHT OF SAMPLE g = 62.46
FINAL WET WEIGHT OF SAMPLE g = 73.91
FINAL DRY WEIGHT OF SAMPLE g = 62.46
INITIAL SAMPLE DIAMETER in = 1.9270
INITIAL SAMPLE HEIGHT in = 0.7400
SPECIFIC GRAVITY = 2.654
NUMBER OF INPUT DATA = 17
TIME USED TO CALCULATE C/ sec =T50
DIAL READING FORWARD OR BACKWARD ? =BW

NO.	PRESSURE(ksf)	DIAL READING(in)	T90/T50(sec)
1	0	.2012	0
2	.25	.20598	0
3	.25	.1905	0
4	.5	.1926	1020
5	1	.19619	0
6	2	.20247	252
7	4	.20968	103
8	8	.21964	210
9	16	.23554	309
10	32	.2571	554
11	64	.2857	1020
12	.25	[illegible]	[illegible]
13	32	.2081	0
14	8	.2056	0
15	2	.1948	0
16	.5	.18	0
17	.25	.2497	0

TEST NO. [illegible] #5810 CONSOL ENTERED BY SKM CHECKED BY SKM

INITIAL MOISTURE CONTENT. % = 15.6
INITIAL DRY UNIT WEIGHT PCF =110.0
INITIAL DEG. OF SATURATION. % = 80.0
INITIAL VOID RATIO. =0.525
FINAL MOISTURE CONTENT. % = 18.3
FINAL DRY DENSITY. PCF =113.0
FINAL DEG. OF SATURATION. % =116.0

σ	e	ΔH	Cv	Av	mv	k
ksf		%	cm2/sec	ft2/k	ft2/k	cm/sec
0.00	0.5246	0.0000	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.250	0.5148	0.6459	0.00E+00	0.94E-02	2.58E-02	0.00E+00
0.250	0.5247	+1.4459	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.5000	0.5235	+1.1622	1.35E-04	1.73E-02	1.14E-02	3.14E-09
1.0000	0.5149	+0.6770	0.00E+00	1.48E-02	9.70E-03	0.00E+00
2.0000	0.5220	0.1716	6.20E-04	1.29E-02	8.49E-03	1.08E-08
4.0000	0.5071	1.1459	1.67E-03	7.43E-03	4.87E-03	1.66E-08
8.0000	0.4870	2.4649	7.99E-04	5.03E-03	3.30E-03	5.38E-09
16.0000	0.4539	4.6405	5.24E-04	4.15E-03	2.72E-03	2.91E-09
32.0000	0.4092	7.5676	1.56E-04	2.79E-03	1.83E-03	5.83E-10
64.0000	0.3505	11.4189	1.03E-04	1.83E-03	1.20E-03	2.54E-10
128.0000	0.2834	15.8243	6.98E-05	1.05E-03	6.88E-04	9.82E-11
32.0000	0.3044	14.4459	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8.0000	0.3507	11.4054	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2.0000	0.4039	7.9189	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.5000	0.4241	6.5546	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.2500	0.4247	6.5541	0.00E+00	0.00E+00	0.00E+00	0.00E+00



1-369-91	Chen-Northern, Inc.	SWELL-CONSOLIDATION TEST RESULTS	Fig.

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATION TEST RESULTS

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-10-91

CHECKED BY LAB: SKM

LAB NAME: CNI

TAC:

SAMPLE ID	DEPTH INTERVAL (FT)	BEGINNING SUBMERGED STRESS (PSF)	COMPACTION (%)
GT-69CE	22.0-22.5	250	N/A

INITIAL CONDITIONS			
DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
117.6	15.1	89.7	0.467

FINAL CONDITIONS			
DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
128.7	14.6	100+	0.344

TEST RESULTS		
AXIAL STRESS (PSF)	VOID RATIO e	COEFFICIENT OF CONSOLIDATION (cm^2/sec)
250	0.461	N/A
WATER ADDED	0.483	N/A
500	0.482	1.18×10^{-4}
1000	0.478	3.31×10^{-4}
2000	0.472	1.80×10^{-3}
4000	0.461	1.45×10^{-3}
8000	0.447	1.23×10^{-3}
16,000	0.427	1.28×10^{-3}
32,000	0.398	5.79×10^{-4}
64,000	0.344	2.73×10^{-4}

TEST PROCEDURE: ASTM D 2435-90

NOTE: INDIVIDUAL TIME-RATE INCREMENTS TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS

[illegible]-91 WESRAF #6908 CONSOL ENTERED BY SVM CHKED BY SVM

INITIAL WET WEIGHT OF SAMPLE g = 80.0[illegible]

INITIAL DRY WEIGHT OF SAMPLE g = 69.49

FINAL WET WEIGHT OF SAMPLE g = 79.61

FINAL DRY WEIGHT OF SAMPLE g = 69.49

INITIAL SAMPLE DIAMETER in = 1.9300

INITIAL SAMPLE HEIGHT in = 0.7681

SPECIFIC GRAVITY = 2.7700

NUMBER OF INPUT DATA = 11

TIME USED TO CALCULATE Cv sec = T50

DIAL READING FORWARD OR BACKWARD = BW

NO.	PRESSURE(ksf)	DIAL READING(in)	T90/T50(sec)
1	0	.19052	0
2	.25	.19351	0
3	.25	.18186	0
4	.5	.18243	1620
5	1	.1845	576
6	2	.18808	105
7	4	.1937	129
8	8	.2011	150
9	16	.2115	141
10	32	.2268	300
11	64	.2849	600

[illegible]-789-91 WESRAF #6908 CONSOL ENTERED BY SVM CHKED BY SVM

INITIAL MOISTURE CONTENT % = 18.1

INITIAL DRY UNIT WEIGHT PCF = 117.9

INITIAL DEG. OF SATURATION. % = 89.7

INITIAL VOID RATIO. = 0.457

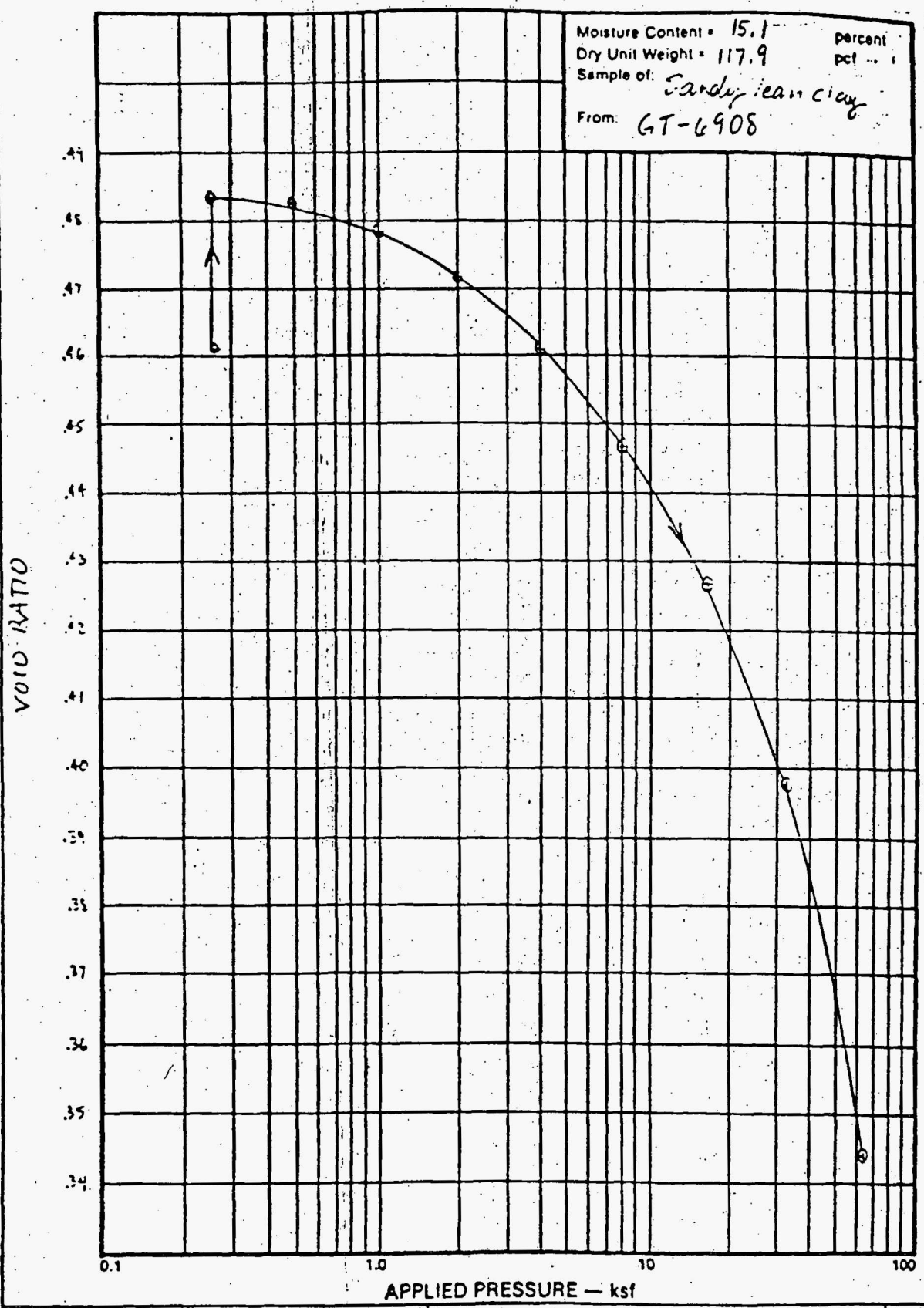
FINAL MOISTURE CONTENT. % = 14.6

FINAL DRY DENSITY. PCF = 125.7

FINAL DEG. OF SATURATION. % = 117.3

P ksf	e	ε	Cv cm2/sec	Av ft2/k	Mv ft2/k	k cm/sec
0.0000	0.4669	0.0000	0.00E-00	0.00E-00	0.00E+00	0.00E+00
0.2500	0.4612	0.3693	0.00E+00	2.28E-02	1.56E-02	0.00E+00
0.2500	-0.4874	+1.1250	0.00E-00	0.00E+00	0.00E-00	0.00E+00
0.5000	0.4824	+1.0534	1.19E-04	4.20E-03	2.86E-03	5.92E-10
1.0000	0.4734	+0.7839	7.31E-04	7.91E-03	5.39E-03	3.65E-09
2.0000	0.4716	+0.3203	1.80E-03	6.80E-03	4.64E-03	1.71E-08
4.0000	0.4608	0.4141	1.45E-03	5.39E-03	3.67E-03	1.09E-08
8.0000	0.4467	1.3776	1.23E-03	3.53E-03	2.41E-03	6.04E-09
16.0000	0.4288	2.7318	1.28E-03	2.48E-03	1.69E-03	4.41E-09
32.0000	0.3976	4.7240	5.79E-04	1.83E-03	1.25E-03	1.47E-09
64.0000	-0.3439	8.3828	2.73E-04	1.68E-03	1.14E-03	6.37E-10

* 128 KSF LOAD,
REBOUND NOT POSSIBLE
DUE TO UNEVEN COLLAPSE
OF SAMPLE DURING 128K LOADING.
(SEE DIAGRAM)



1-369-91	Chen-Northern, Inc.	SWELL-CONSOLIDATION TEST RESULTS	Fig.

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATION TEST RESULTS

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-20-91

CHECKED BY LAB: SKM

LAB NAME: CNI

TAC:

SAMPLE ID	DEPTH INTERVAL (FT)	BEGINNING SUBMERGED STRESS (PSF)	COMPACTION (%)
GT-7004	12.0-12.3	250	N/A

INITIAL CONDITIONS			
DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
96.6	25.1	88.8	0.775

FINAL CONDITIONS			
DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
103.2	25.8	100+	0.661

TEST RESULTS		
AXIAL STRESS (PSF)	VOID RATIO e	COEFFICIENT OF CONSOLIDATION (cm^2/sec)
250	0.772	N/A
WATER ADDED	0.785	N/A
500	0.782	1.96×10^{-4}
1000	0.776	7.92×10^{-4}
2000	0.765	3.97×10^{-4}
4000	0.746	3.56×10^{-4}
8000	0.723	4.49×10^{-4}
16,000	0.690	2.07×10^{-4}
32,000	0.640	3.51×10^{-4}
64,000	0.584	3.30×10^{-4}
128,000	0.514	2.39×10^{-4}
32,000	0.534	N/A
8000	0.563	N/A
2000	0.601	N/A
500	0.650	N/A
250	0.661	N/A

TEST PROCEDURE: ASTM D 2435-90

NOTE: INDIVIDUAL TIME-RATE INCREMENTS TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS

TEST NO. #1-389-91 #7004 CONSOL ENTERED BY SKM CHECKED BY SKM

INITIAL WET WEIGHT OF SAMPLE = 58.00
INITIAL DRY WEIGHT OF SAMPLE = 54.40
FINAL WET WEIGHT OF SAMPLE = 58.43
FINAL DRY WEIGHT OF SAMPLE = 54.40
INITIAL SAMPLE DIAMETER in = 1.9190
INITIAL SAMPLE HEIGHT in = 0.7420
SPECIFIC GRAVITY = 2.0470
NUMBER OF INPUT DATA = 17
TIME USED TO CALCULATE Cv sec =T50
DIAL READING FORWARD OR BACKWARD = FW

No.	PRESSURE(ksf)	DIAL READING(in)	T90/T50(sec)
1	0	.208	0
2	.25	.20657	0
3	.25	.21224	0
4	.5	.21092	900
5	1	.20849	222
6	2	.2037	438
7	4	.1959	480
8	8	.1862	372
9	16	.1725	780
10	32	.1516	478
11	64	.1287	438
12	128	.1091	858
13	32	.1077	0
14	8	.1198	0
15	2	.1287	0
16	.5	.1287	0
17	.25	.1605	0

TEST NO. #1-389-91 #7004 CONSOL ENTERED BY SKM CHECKED BY SKM

INITIAL MOISTURE CONTENT. % = 25.1
INITIAL DRY UNIT WEIGHT PCF = 96.6
INITIAL DEG. OF SATURATION. % = 88.8
INITIAL VOID RATIO. =0.775
FINAL MOISTURE CONTENT. % = 25.8
FINAL DRY DENSITY. PCF =103.2
FINAL DEG. OF SATURATION. % =107.1

σ ksf	e	ΔH %	Cv cm2/sec	mv ft2/lb	Mv ft2/lb	k cm/sec
0.0000	0.7749	0.0000	0.00E+00	0.00E+00	0.00E+00	0.00E+00
.2500	0.7716	0.1900	0.00E+00	1.32E-01	7.60E-03	0.00E+00
0.2500	0.7851	+0.5714	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.5000	0.7819	+0.3935	1.96E-04	1.26E-02	7.12E-03	2.85E-09
1.0000	0.7761	+0.0660	7.92E-04	1.16E-02	6.55E-03	1.06E-08
2.0000	0.7647	0.5795	3.97E-04	1.15E-02	6.46E-03	5.24E-09
4.0000	0.7460	1.6307	3.56E-04	9.33E-03	5.26E-03	3.83E-09
8.0000	0.7228	2.9380	4.49E-04	5.80E-03	3.27E-03	3.00E-09
16.0000	0.6900	4.7944	2.07E-04	4.10E-03	2.31E-03	9.78E-10
32.0000	0.6400	7.6011	3.51E-04	3.12E-03	1.76E-03	1.26E-09
64.0000	0.5843	10.7412	3.30E-04	1.74E-03	9.81E-04	6.61E-10
128.0000	0.5144	14.6766	2.39E-04	1.09E-03	6.15E-04	3.00E-10
32.0000	0.5741	13.5714	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8.0000	0.5632	11.9272	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2.0000	0.6010	9.7978	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.5000	0.6498	7.0485	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.2500	0.6613	6.4016	0.00E+00	0.00E+00	0.00E+00	0.00E+00

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATION TEST RESULTS

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-22-91

CHECKED BY LAB: SWM

LAB NAME: CNI

TAC:

SAMPLE ID	DEPTH INTERVAL (FT)	BEGINNING SUBMERGED STRESS (PSF)	COMPACTION (%)
GT-711C	25.8-25.9	250	N/A

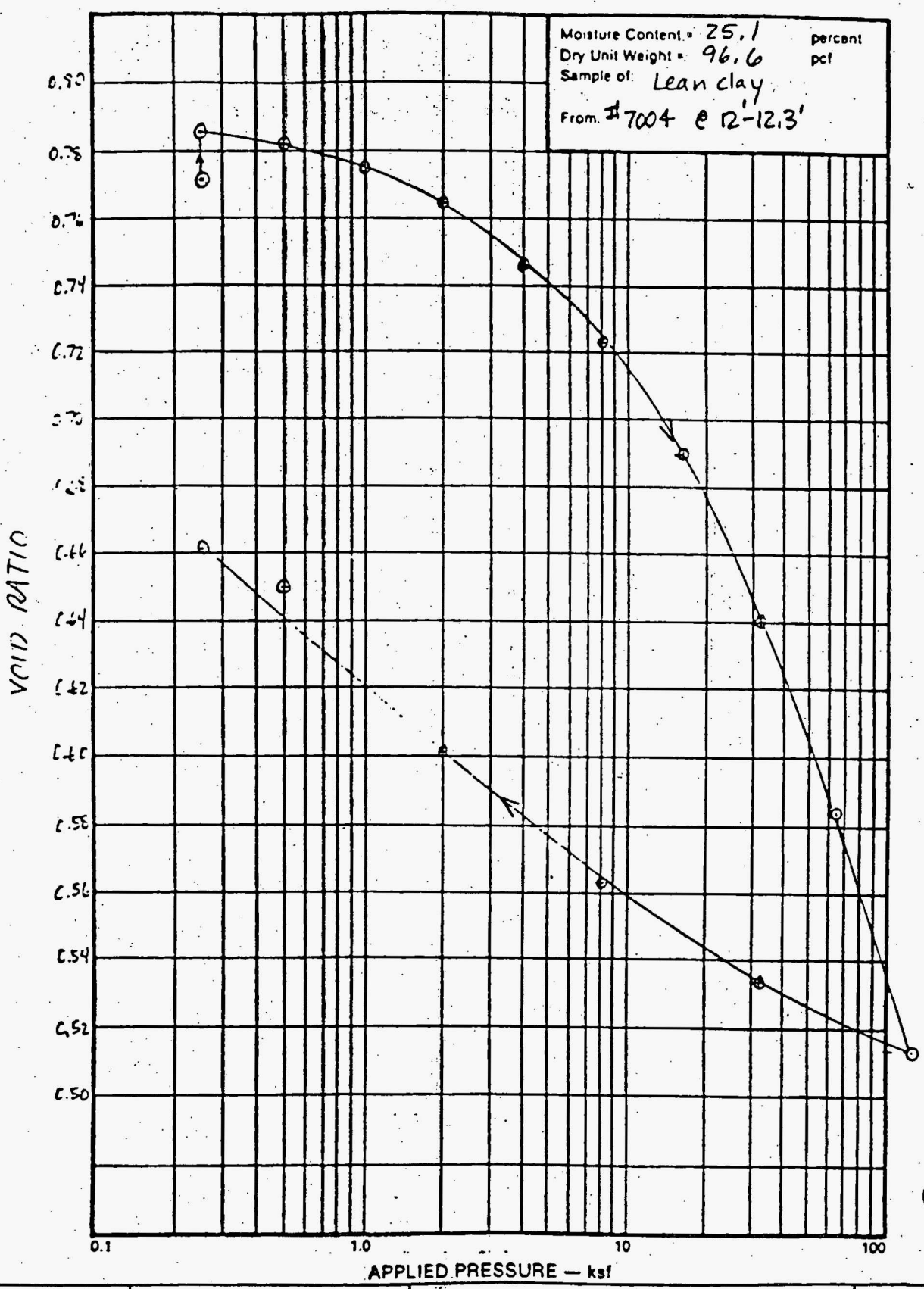
INITIAL CONDITIONS			
DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
100.-	25.7	100.8	0.693

FINAL CONDITIONS			
DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
115.4	23.8	100+	0.473

TEST RESULTS		
AXIAL STRESS (PSF)	VOID RATIO e	COEFFICIENT OF CONSOLIDATION (cm^2/sec)
250	0.687	N/A
WATER ADDED	0.718	N/A
500	0.717	N/A
1000	0.712	N/A
2000	0.704	2.12×10^{-4}
4000	0.690	2.23×10^{-4}
8000	0.672	2.34×10^{-4}
16,000	0.645	3.27×10^{-4}
32,000	0.598	1.55×10^{-4}
64,000	0.473	2.34×10^{-4}

TEST PROCEDURE: ASTM D 2435-90

NOTE: INDIVIDUAL TIME-RATE INCREMENTS TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS



1-369-91	Chen-Northern, Inc.	SWELL-CONSOLIDATION TEST RESULTS	Fig.

[illegible] Entered by [illegible] Checked by [illegible]

[illegible] WEIGHT OF SAMPLE g = 74.45
INITIAL DRY WEIGHT OF SAMPLE g = 59.24
FINAL WET WEIGHT OF SAMPLE g = 73.35
FINAL DRY WEIGHT OF SAMPLE g = 59.24
INITIAL SAMPLE DIAMETER in = 1.5500
INITIAL SAMPLE HEIGHT in = 0.7690
SPECIFIC GRAVITY = 2.7100
NUMBER OF INPUT DATA = 11
TIME USED TO CALCULATE Cv sec = T50
DIAL READING FORWARD OR BACKWARD = FW

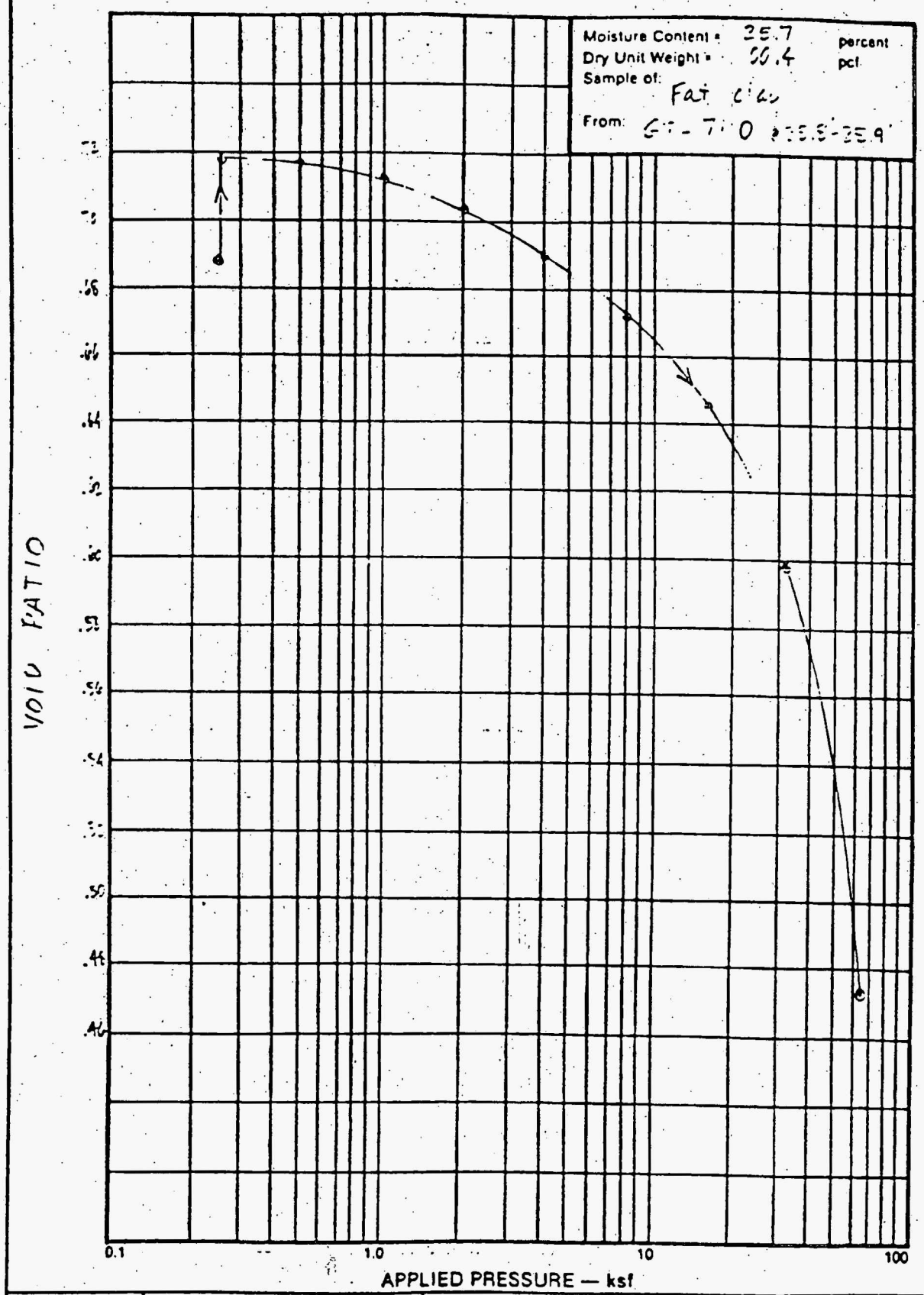
NO.	PRESSURE(ksf)	DIAL READING(in)	T90/T50(sec)
1	0	.1891	0
2	.25	.1917	0
3	.25	.17792	0
4	.5	.17828	0
5	1	.18034	0
6	2	.18438	500
7	4	.19056	345
8	8	.1986	792
9	16	.21105	552
10	32	.23209	1110
11	64	.2891	660

[illegible] (Consol) Entered by [illegible] Checked by [illegible]

INITIAL MOISTURE CONTENT, % = 25.7
INITIAL DRY UNIT WEIGHT PCF = 100.4
INITIAL DEG. OF SATURATION % = 100.8
INITIAL VOID RATIO, = 0.693
FINAL MOISTURE CONTENT, % = 27.8
FINAL DRY DENSITY, PCF = 115.4
FINAL DEG. OF SATURATION, % = 107.1

P	e	CR	Cv	Av	Mv	k
ksf		%	cm2/sec	ft2/k	ft2/k	cm/sec
[illegible]	0.6931	0.0000	0.00E+00	0.00E+00	0.00E+00	[illegible]E-00
[illegible]	0.6874	0.0781	[illegible]00E-00	2.29E-02	1.35E-02	0.00E+00
[illegible]	0.7177	+1.4528	0.00E-00	0.00E+00	0.00E-0[illegible]	0.00E+00
[illegible]	[illegible]169	+1.[illegible]70	0.00E-00	3.17E-02	1.87E-02	0.00E+00
[illegible]	[illegible]120	+1.[illegible]791	0.00E-00	4.07E-02	2.75E-02	0.00E+00
[illegible]	[illegible]025	+0.[illegible]73	2.12E-04	2.89E-02	5.28E-02	2.23E-09
[illegible]	[illegible]6[illegible]	0.1899	1.[illegible]3E-04	6.60E-03	4.02E-[illegible]	[illegible]E-09
8.[illegible]	0.5722	1.2754	2.34E-04	4.47E-03	2.61E-02	1.25E-09
16.[illegible]	0.5448	2.8544	3.27E-04	3.43E-03	2.02E-02	1.25E-09
32.[illegible]	0.5285	5.5904	1.55E-04	2.90E-03	1.71E-02	5.43E-10
64.0000	0.4729	13.0039	2.34E-04	3.92E-03	2.32E-03	1.11E-09

*128 KSF LOAD, REBOUND NOT POSSIBLE DUE TO UNEVEN COLLAPSE OF SAMPLE DURING 128K LOADING.



1-369-91	*Chen-Northern, Inc.*	SWELL-CONSOLIDATION TEST RESULTS	Fig. ...

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATION TEST RESULTS

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-10-91

CHECKED BY LAB: SKM

LAB NAME: CNI

TAC:

SAMPLE ID	DEPTH INTERVAL (FT)	BEGINNING SUBMERGED STRESS (PSF)	COMPACTION (%)
GT-7356	17.0-17.5	250	N/A

INITIAL CONDITIONS			
DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
92.4	32.4	104.4	0.851

FINAL CONDITIONS			
DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
107.2	25.0	100+	0.596

TEST RESULTS		
AXIAL STRESS (PSF)	VOID RATIO e	COEFFICIENT OF CONSOLIDATION (cm^2/sec)
250	0.840	N/A
WATER ADDED	0.938	N/A
500	0.935	5.90×10^{-5}
1000	0.920	2.26×10^{-5}
2000	0.885	2.27×10^{-5}
4000	0.833	2.13×10^{-5}
8000	0.767	2.00×10^{-5}
16,000	0.688	2.11×10^{-5}
32,000	0.622	2.06×10^{-5}
64,000	0.535	3.22×10^{-5}
128,000	0.421	1.57×10^{-5}
32,000	0.480	N/A
8000	0.569	N/A
2000	0.596	N/A

TEST PROCEDURE: ASTM D 2435-90

NOTE: INDIVIDUAL TIME-RATE INCREMENTS TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS

TEST NO. =1-TS-F1 WESRAF #7306 CONSOL ENTERED BY SKM CHKED BY SKM

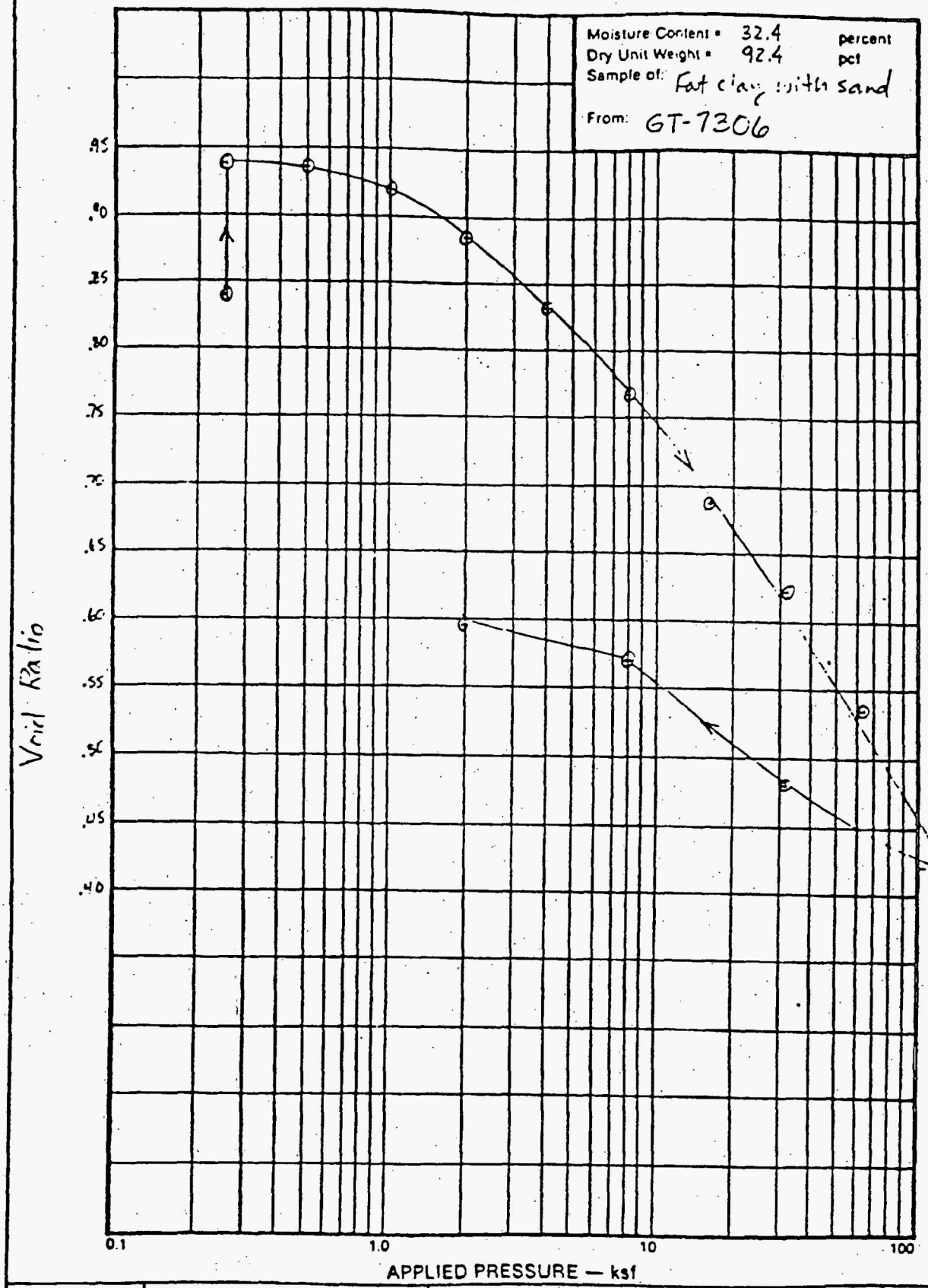
INITIAL WET WEIGHT OF SAMPLE g = 69.49
INITIAL DRY WEIGHT OF SAMPLE g = 52.85
FINAL WET WEIGHT OF SAMPLE g = 66.04
FINAL DRY WEIGHT OF SAMPLE g = 52.85
INITIAL SAMPLE DIAMETER in = 1.9260
INITIAL SAMPLE HEIGHT in = 0.7480
SPECIFIC GRAVITY = 2.7410
NUMBER OF INPUT DATA = 15
TIME USED TO CALCULATE Cv sec =T50
DIAL READING FORWARD OR BACKWARD F =FW

NO.	PRESSURE(ksf)	DIAL READING(in)	T90/(50) sec
1	0	.2145	0
2	.25	.20982	0
3	.25	.2497	0
4	.5	.24836	3300
5	1	.24227	8520
6	2	.226	8320
7	4	.20701	8400
8	8	.18035	8400
9	16	.1485	7720
10	32	.1219	8900
11	64	.0888	4020
12	128	.0405	7200
13	32	.0647	0
14	8	.1005	0
15	2	.1112	0

TEST NO. =1-TS-F1 WESRAF #7306 CONSOL ENTERED BY SKM CHKED BY SKM

INITIAL MOISTURE CONTENT. % = 32.4
INITIAL DRY UNIT WEIGHT PCF = 92.4
INITIAL DEG. OF SATURATION. % =104.4
INITIAL VOID RATIO. =0.851
FINAL MOISTURE CONTENT. % = 25.0
FINAL DRY DENSITY. PCF =107.2
FINAL DEG. OF SATURATION. % =114.9

σ ksf	e	σF	Cv cm2/sec	Av ft2/k	Mv ft2/k	k cm/sec
[illegible]	0.9512	0.[illegible]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
[illegible]	0.9[illegible]	0.6287	0.00E+00	4.67E-02	2.50E-02	0.00E+00
[illegible]	0.9[illegible]	+4.7059	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.5000	0.9350	+4.5267	5.90E-05	1.33E-02	7.17E-03	5.64E-10
1.0000	0.9199	+3.7126	2.26E-05	3.01E-02	1.63E-02	7.53E-10
2.0000	0.8946	+1.8048	2.27E-05	3.53E-02	1.91E-02	8.84E-10
4.0000	0.8326	1.0013	2.13E-05	2.60E-02	1.40E-02	6.12E-10
8.0000	0.7667	4.5655	2.00E-05	1.65E-02	8.91E-03	3.64E-10
16.0000	0.6878	8.8235	2.11E-05	9.85E-03	5.32E-03	2.30E-10
32.0000	0.6218	12.3930	2.06E-05	4.13E-03	2.23E-03	9.39E-11
64.0000	0.5351	17.0722	3.22E-05	2.71E-03	1.46E-03	9.61E-11
128.0000	0.4206	23.2620	1.57E-05	1.79E-03	9.67E-04	3.11E-11
32.0000	0.4804	20.0267	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8.0000	0.5690	15.2406	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2.0000	0.5955	13.8102	0.00E+00	0.00E+00	0.00E+00	0.00E+00



1-369-91	Chen-Northern, Inc.	SWELL-CONSOLIDATION TEST RESULTS	Fig.

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATION TEST RESULTS

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-8-91

CHECKED BY LAB: SKM

LAB NAME: CNI

TAC:

SAMPLE ID	DEPTH INTERVAL (FT)	BEGINNING SUBMERGED STRESS (PSF)	COMPACTION (%)
GT-7314	35.0-36.5	250	N/A

INITIAL CONDITIONS			
DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
102.3	22.5	93.3	0.651

FINAL CONDITIONS			
DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
115.3	20.0	100+	0.466

TEST RESULTS		
AXIAL STRESS (PSF)	VOID RATIO e	COEFFICIENT OF CONSOLIDATION (cm^2/sec)
250	0.646	N/A
WATER ADDED	0.652	N/A
500	0.648	5.76×10^{-5}
1000	0.637	N/A
2000	0.619	4.08×10^{-4}
4000	0.588	6.21×10^{-4}
8000	0.552	1.49×10^{-3}
16,000	0.510	1.63×10^{-3}
32,000	0.467	1.34×10^{-3}
64,000	0.424	1.47×10^{-3}
128,000	0.370	1.65×10^{-3}
32,000	0.381	N/A
8000	0.398	N/A
2000	0.427	N/A
500	0.454	N/A
250	0.466	N/A

TEST PROCEDURE: ASTM D 2435-90

NOTE: INDIVIDUAL TIME-RATE INCREMENTS TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS

[illegible] SEEPAGE RATIO CONSOL ENTERED BY EVM CHKED B. EVM

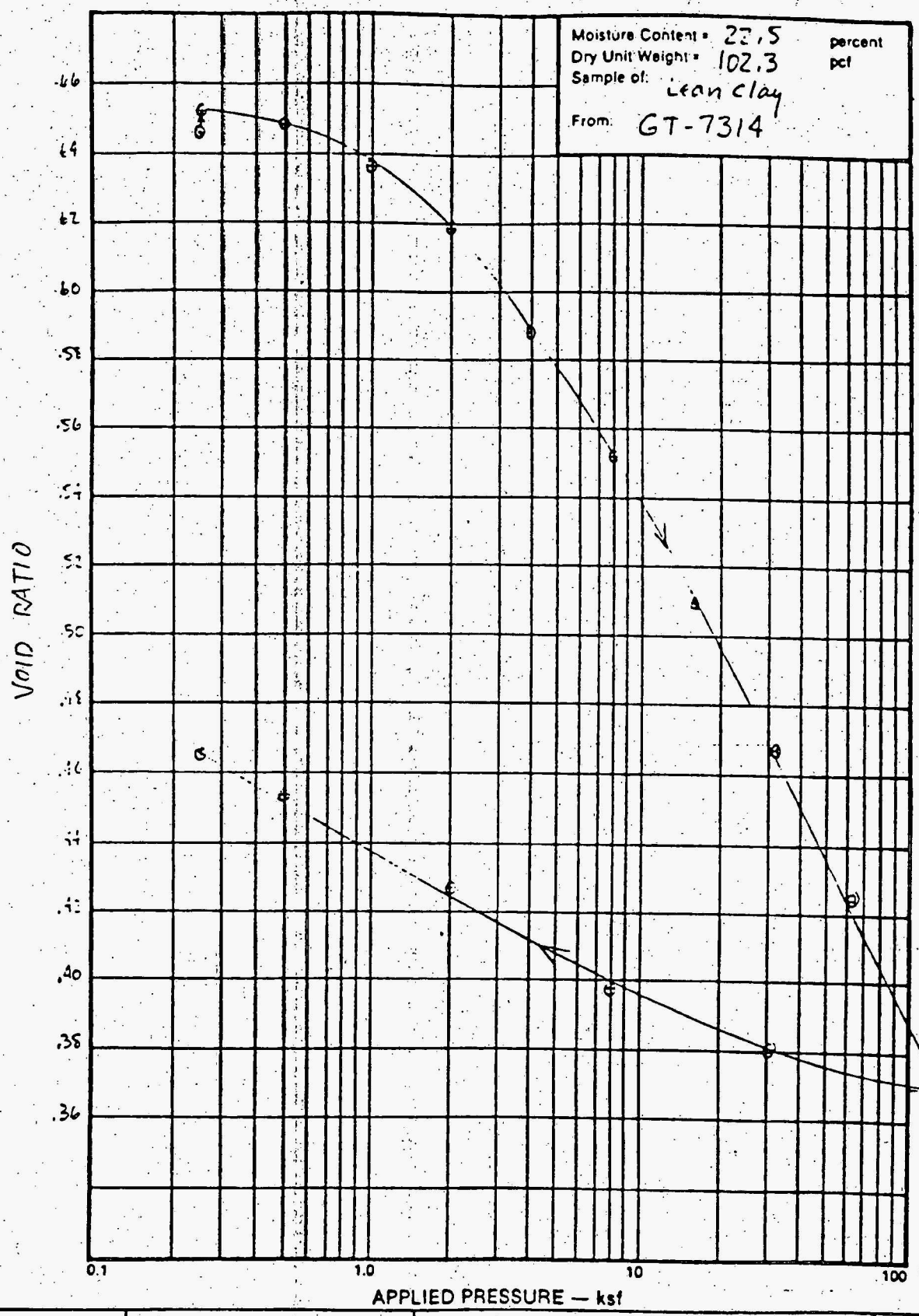
INITIAL WET WEIGHT OF SAMPLE = 67.4g
INITIAL DRY WEIGHT OF SAMPLE = 51.8g
FINAL WET WEIGHT OF SAMPLE = 63.1g
FINAL DRY WEIGHT OF SAMPLE = 51.8g
INITIAL SAMPLE DIAMETER in = 1.9300
INITIAL SAMPLE HEIGHT in = 1.6600
SPECIFIC GRAVITY = 2.706
NUMBER OF INPUT DATA = 17
TIME USED TO CALCULATE Cv sec = T50
INITIAL READING FORWARD OR BACKWARD = FW

No.	PRESSURE(ksf)	DIAL READING(in)	T50(T90) sec
1	0	.2106	0
2	.25	.2085	0
3	.25	.21086	0
4	.5	.20937	2400
5	1	.20495	0
6	2	.19771	330
7	4	.18516	210
8	8	.17[illegible]6	24
9	16	.1[illegible]	73
10	2	.[illegible]68	84
11	64	.1197	[illegible]
12	.25	.0963	[illegible]
13	32	.1025	[illegible]
14	8	[illegible]	[illegible]
15	2	.1[illegible]9[illegible]	0
16	.5	.1115	[illegible]
17	.25	.1[illegible]4	[illegible]

[illegible] NO. [illegible] SEEPAGE RATIO CONSOL ENTERED BY EVM CHKED BY EVM

INITIAL MOISTURE CONTENT. % = 22.8
INITIAL DRY UNIT WEIGHT PCF = 102.[illegible]
INITIAL DEG. OF SATURATION. % = 9[illegible].[illegible]
INITIAL VOID RATIO. = 0.651
INITIAL POROSITY. % = 39.0
[illegible] DENSITY. PCF = 115.[illegible]
[illegible] DEG. OF SATURATION. % = 118.[illegible]

[illegible]	[illegible]	[illegible]	Cv cm2/sec	[illegible] ft2/[illegible]	[illegible] ft2/[illegible]	[illegible] in/sec
[illegible]	1.2814	0.0000	1.00E+00	0.00E+00	0.00E+00	0.00E+00
0.1250	0.6462	0.[illegible]	0.00E+00	1.1[illegible]E-02	1.27E-02	1.10E-00
0.2500	0.6521	+0.0394	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.5000	0.6483	0.1924	5.76E-05	1.50E-02	9.27E-03	1.09E-09
1.0000	0.6374	0.8500	0.00E+00	2.17E-02	1.32E-02	0.00E+00
2.0000	0.6192	1.9530	4.08E-04	1.82E-02	1.10E-02	9.19E-09
4.0000	0.5878	3.8545	6.21E-04	1.57E-02	9.51E-03	1.21E-08
8.0000	0.5515	6.0515	1.49E-03	9.07E-03	5.49E-03	1.67E-08
16.0000	0.5096	8.5909	1.63E-03	5.24E-03	3.17E-03	1.06E-08
32.0000	0.4668	11.1818	1.34E-03	2.67E-03	1.62E-03	4.43E-09
64.0000	0.4240	13.7727	1.47E-03	1.34E-03	8.10E-04	2.44E-09
128.0000	0.3704	17.0152	1.65E-03	8.37E-04	5.07E-04	1.71E-09
32.0000	0.3809	16.3788	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8.0000	0.3980	15.3485	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2.0000	0.4269	13.5985	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.5000	0.4535	11.9848	0.00E+00	0.00E+00	0.00E+00	0.00E+00
0.2500	0.4658	11.2424	0.00E+00	0.00E+00	0.00E+00	0.00E+00



1-369-91	Chen-Northern, Inc.	SWELL-CONSOLIDATION TEST RESULTS	Fig.

CA-1A-79

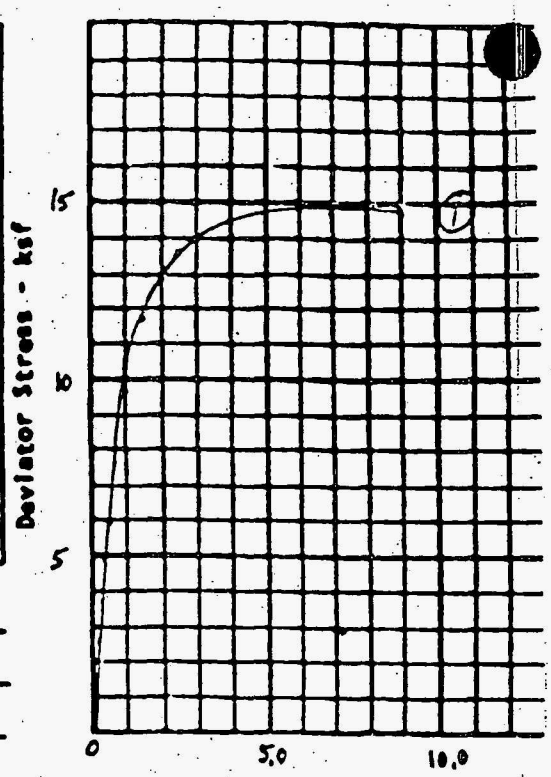
UNCONSOLIDATED UNDRAINED TESTS

Chen & Northern, Inc.

Consulting Engineers

Consulting Soil and Foundation Engineers

TEST NUMBER	1	2	3	4
LOCATION	GT 68 #6810 @ 26'-26.5'			
HEIGHT - INCH	5.546			
DIAMETER - INCH	2.860			
WATER CONTENT - %	16.5			
DRY DENSITY - pcf	110.0			
$\sigma_1 - \sigma_3$ - ksf	14.83			
σ_3 - ksf	5.00			
σ_1 - ksf	19.83			



TYPE OF SPECIMEN: Shelby tube

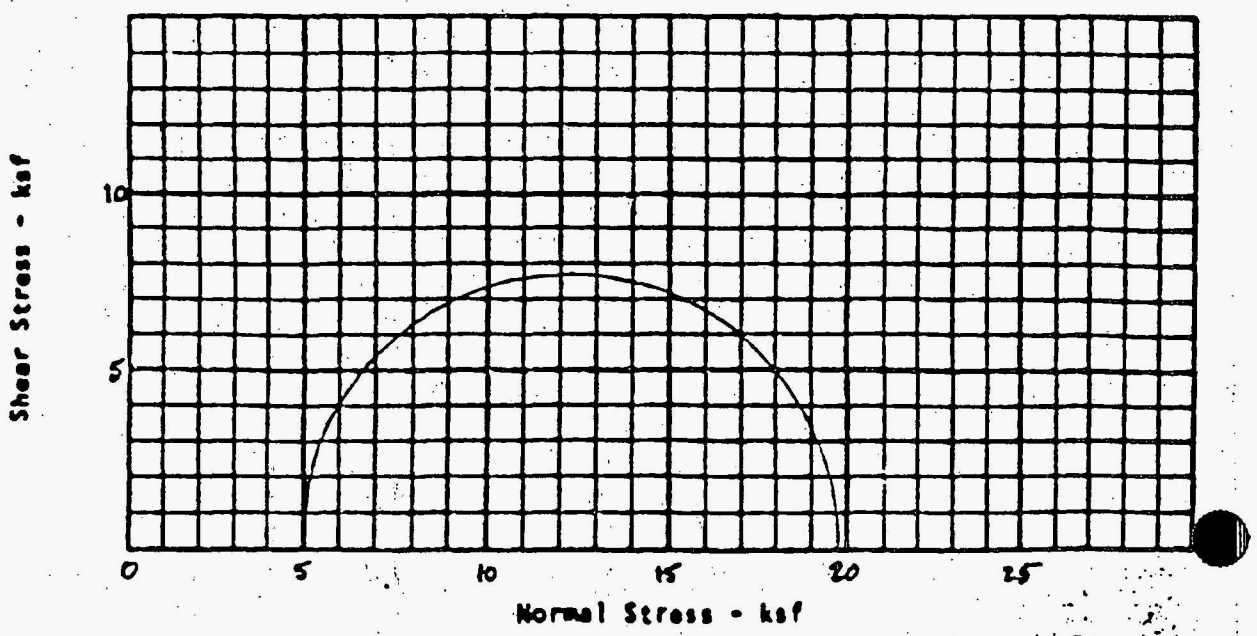
SOIL DESCRIPTION: Lean clay with sand

TYPE OF TEST: unconsolidated undrained unsaturated triaxial compressive strength (UU)

TAN ϕ _____

ϕ _____

COHESION - ksf _____



1-369-91

TRIAXIAL SHEAR TEST RESULTS

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

UNCONSOLIDATED - UNDRAINED TRIAXIAL "Q" TEST

SITE ID: Disposal Facility

LOCATION ID: WSSRAP

DATE: 8-7-91

LAB NAME: CNI

CHECKED BY: LAB SKM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION (%)	CELL CONFINING PRESSURE (PSF)
GT-6810	26.0-26.5	N/A	4996

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
110.0	16.5	83.9	0.530

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
110.0	16.3	83.0	0.530

TEST RESULTS

AXIAL STRESS (PSF)	AXIAL STRAIN (%)	AXIAL STRESS (PSF)	AXIAL STRAIN (%)	AXIAL STRESS (PSF)	AXIAL STRAIN (%)
0	0	14 710	10.0		
1568	0.1	14 672	10.1		
2685	0.2	14 542	10.6		
3800	0.3	14 461	10.9		
4869	0.4	14 421	11.0		
5979	0.5	14 389	11.1		
9699	1.0				
11 728	1.5				
12 876	2.0				
13 575	2.5				
13 986	3.0				
14 464	4.0				
14 698	5.0				
14 795	6.0				
14 826	7.0				
14 830	8.0				
14 793	9.0				

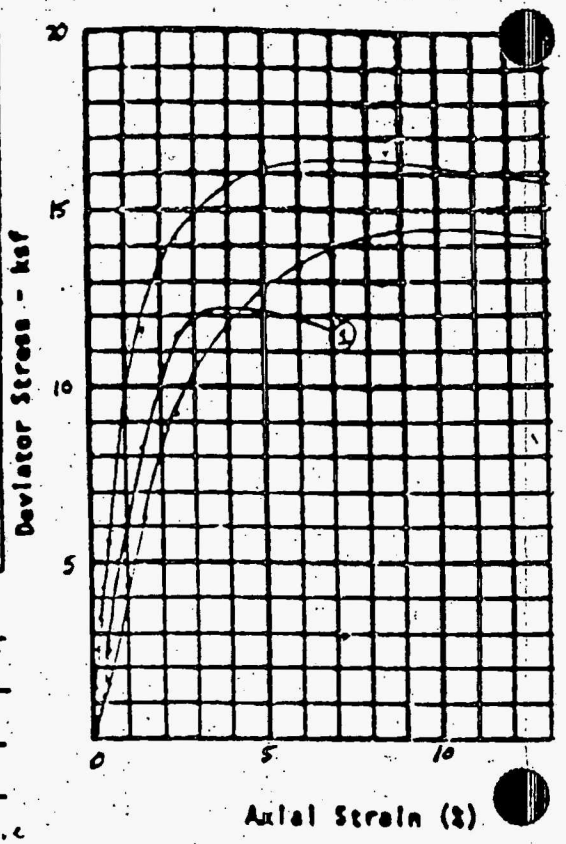
ATTACHMENT 11

Chen Northern, Inc.

Consulting Engineers and

Consulting Soil and Foundation Engineers

TEST NUMBER	1	2	3	4
LOCATION	GT 68 — 16'-17.5'	#6906 → 16.5'-17.5'	16.0'-16.5'	
HEIGHT - INCH	5.826	5.778	5.875	
DIAMETER - INCH	2.852	2.869	2.870	
WATER CONTENT - %	14.1	14.1	14.0	
DRY DENSITY - pcf	112.4	113.7	110.2	
$\sigma_1 - \sigma_3$	12.14	16.35	14.42	
σ_3 - ksf	2.00	5.00	9.99	
σ_1 - ksf	14.14	21.35	24.41	



TYPE OF SPECIMEN: shelby tube

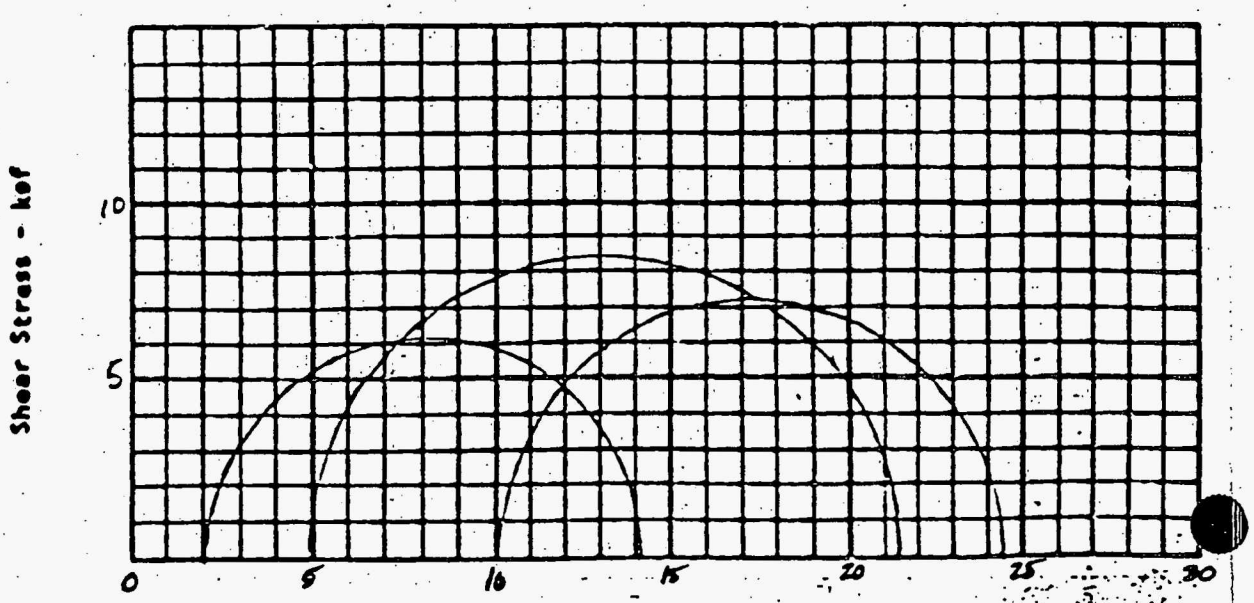
SOIL DESCRIPTION: lean clay with sand

TYPE OF TEST: unconsolidated, undrained unsaturated, triaxial compressive strength (UU)

TAN ϕ

ϕ

COHESION - ksf



MK-FERGUSON
A MORRISON KNUDSEN COMPANY

UNCONSOLIDATED - UNDRAINED TRIAXIAL "Q" TEST

SITE ID: Disposal Facility

LOCATION ID: WSSRAP

DATE: 8-7-91

LAB NAME: CNI

CHECKED BY: LAB SKM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION (%)	CELL CONFINING PRESSURE (PSF)
GT-6906	17.0-17.5	N/A	2002

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
112.4	14.1	76.3	0.500

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
112.4	14.1	76.1	0.500

TEST RESULTS

AXIAL STRESS (PSF)	AXIAL STRAIN (%)	AXIAL STRESS (PSF)	AXIAL STRAIN (%)	AXIAL STRESS (PSF)	AXIAL STRAIN (%)
0	0				
225	0.1				
630	0.2				
1348	0.3				
1931	0.4				
2534	0.5				
5445	1.0				
8193	1.5				
10206	2.0				
11406	2.5				
11916	3.0				
12140	4.0				
12027	4.7				
11930	5.3				
11846	5.8				
11763	6.1				

ATTACHMENT 11

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

UNCONSOLIDATED - UNDRAINED TRIAXIAL "Q" TEST

SITE ID: Disposal Facility
LOCATION ID: WSSRAP
DATE: 8-7-91
LAB NAME: CNI
CHECKED BY: LAB SKM
TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION (%)	CELL CONFINING PRESSURE (PSF)
GT-6906	16.5-17.0	N/A	4996

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
113.7	14.1	78.9	0.482

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
11[illegible]	14.1	78.9	0.482

TEST RESULTS

AXIAL STRESS (PSF)	AXIAL STRAIN (%)	AXIAL STRESS (PSF)	AXIAL STRAIN (%)	AXIAL STRESS (PSF)	AXIAL STRAIN (%)
0	0	16194	10.0		
1429	0.1	16074	11.0		
2476	0.2	15953	12.0		
3432	0.3	15830	13.0		
4386	0.4	15648	14.0		
5605	0.5	15485	15.0		
9095	1.0				
11647	1.5				
13231	2.0				
14166	2.5				
14874	3.0				
15665	4.0				
16075	5.0				
16242	6.0				
16318	7.0				
16349	8.0				
16293	9.0				

ATTACHMENT 11

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

UNCONSOLIDATED - UNDRAINED TRIAXIAL "Q" TEST

SITE ID: Disposal Facility
LOCATION ID: WSSRAP
DATE: 8-7-91
LAB NAME: CNI
CHECKED BY: LAB SLM
TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION (%)	CELL CONFINING PRESSURE (PSF)
GT-6906	16.0-16.5	N/A	9994

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
110.2	14.0	71.5	0.529

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
110.2	13.8	70.5	0.529

TEST RESULTS

AXIAL STRESS (PSF)	AXIAL STRAIN (%)	AXIAL STRESS (PSF)	AXIAL STRAIN (%)	AXIAL STRESS (PSF)	AXIAL STRAIN (%)
0	0	14424	10.0		
445	0.1	14422	11.0		
622	0.2	14378	12.0		
843	0.3	14252	13.0		
1286	0.4	14051	14.0		
1750	0.5	13850	15.0		
4341	1.0				
6249	1.5				
7897	2.0				
9159	2.5				
9846	3.0				
11774	4.0				
12815	5.0				
13475	6.0				
13890	7.0				
14171	8.0				
14341	9.0				

ATTACHMENT 11

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

UNCONSOLIDATED - UNDRAINED TRIAXIAL "Q" TEST

SITE ID: Disposal Facility

LOCATION ID: WSSRAP

DATE: 8-7-91

LAB NAME: CNI

CHECKED BY: LAB SKM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION (%)	CELL CONFINING PRESSURE (PSF)
GT-6908	21.3-21.8	N/A	9994

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
117.0	15.3	88.9	0.478

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
[illegible]0	15.3	88.7	0.478

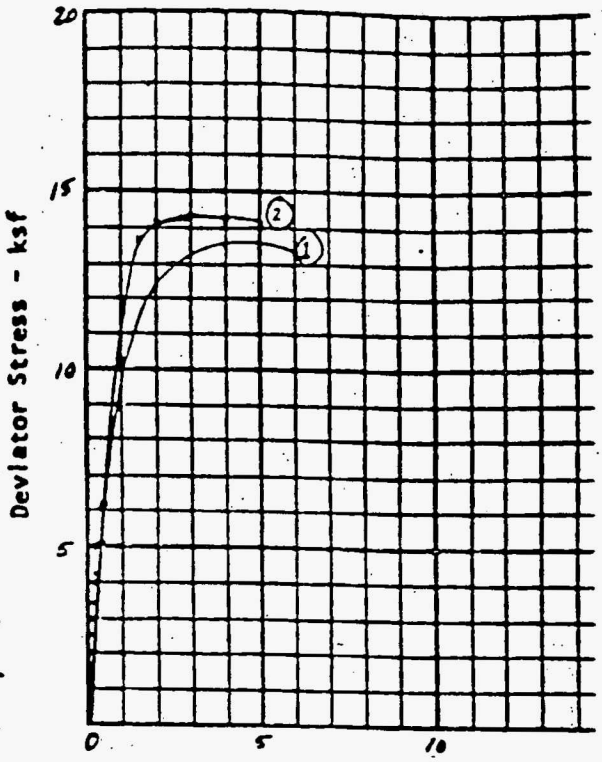
TEST RESULTS

AXIAL STRESS (PSF)	AXIAL STRAIN (%)	AXIAL STRESS (PSF)	AXIAL STRAIN (%)	AXIAL STRESS (PSF)	AXIAL STRAIN (%)
0	0				
1688	0.1				
2950	0.2				
4033	0.3				
5092	0.4				
6171	0.5				
10255	1.0				
12655	1.5				
13680	2.0				
14174	2.5				
14317	3.0				
14276	4.0				

ATTACHMENT 11

Chen & Northern, Inc.

TEST NUMBER	1	2	3	4
LOCATION	CT 69 20.7-22.3 ~6908	CT 69 21.3-21.8 ~6908		
HEIGHT - INCH	5.903	5.906		
DIAMETER - INCH	2.874	2.872		
WATER CONTENT - %	15.7	15.3		
DRY DENSITY - pcf	116.5	117.0		
$\sigma_1 - \sigma_3$ - ksf	13.52	14.32		
σ_3 - ksf	5.00	10.00		
σ_1 - ksf	18.52	24.32		



TYPE OF SPECIMEN Shelby Tube

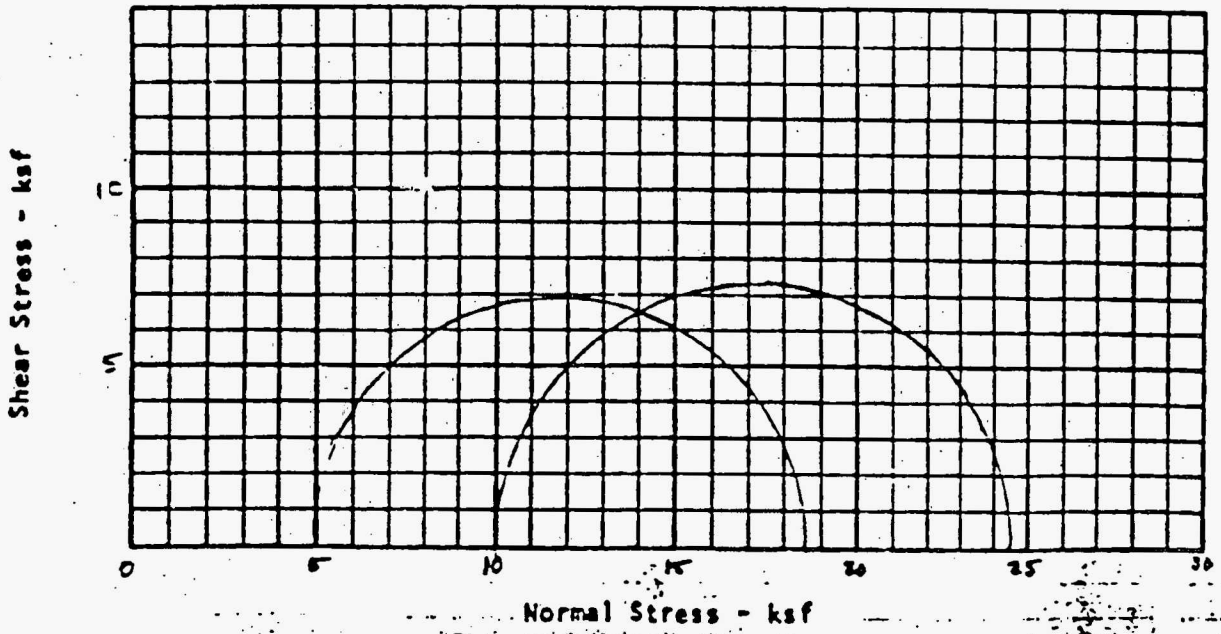
SOIL DESCRIPTION ~~Clay with trace sand~~ Sandy lean clay

TYPE OF TEST Unconsolidated undrained unsaturated triaxial compressive strength (UU)

TAN ϕ

ϕ

COHESION - ksf



TRIAXIAL SHEAR TEST RESULTS

1-369-91

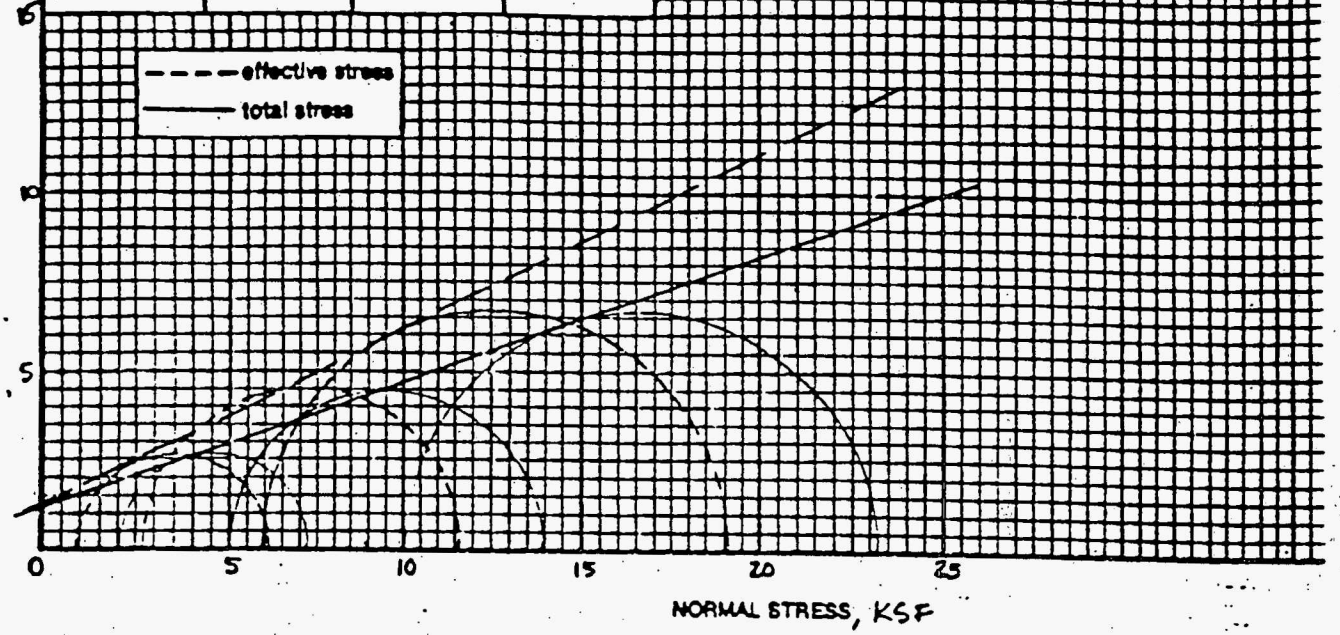
CONSOLIDATED UNDRAINED TESTS

Chen & Northern, Inc.

SHEAR STRENGTH OF SOIL IN TRIAXIAL COMPRESSION

Job No. 1-369-91
Date 8-6-91
Type of Test MULTI-STAGED, SATURATED, CONSOLIDATED, UNDRAINED WITH PORE PRESSURE MEASUREMENTS

SHEAR VALUES			
Effective Stresses		Total Stresses	
$\bar{\phi}$ = 26°	$\bar{C}$ = 1.3 ksf	ϕ = 19°	C = 1.2 ksf

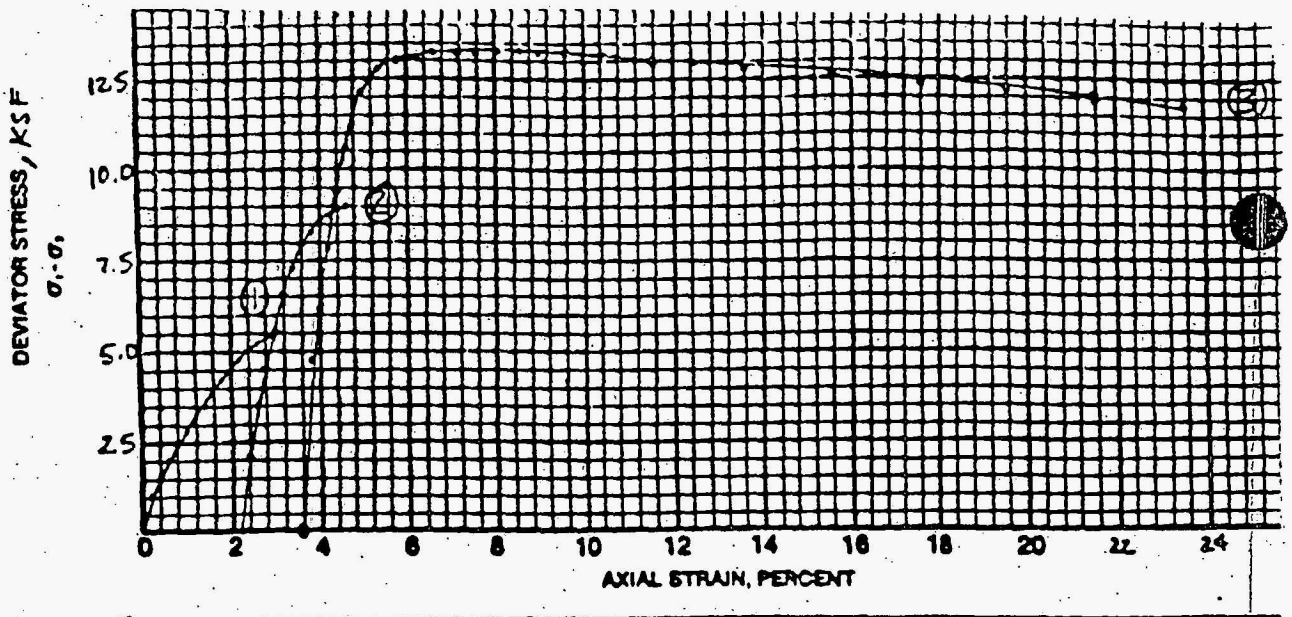


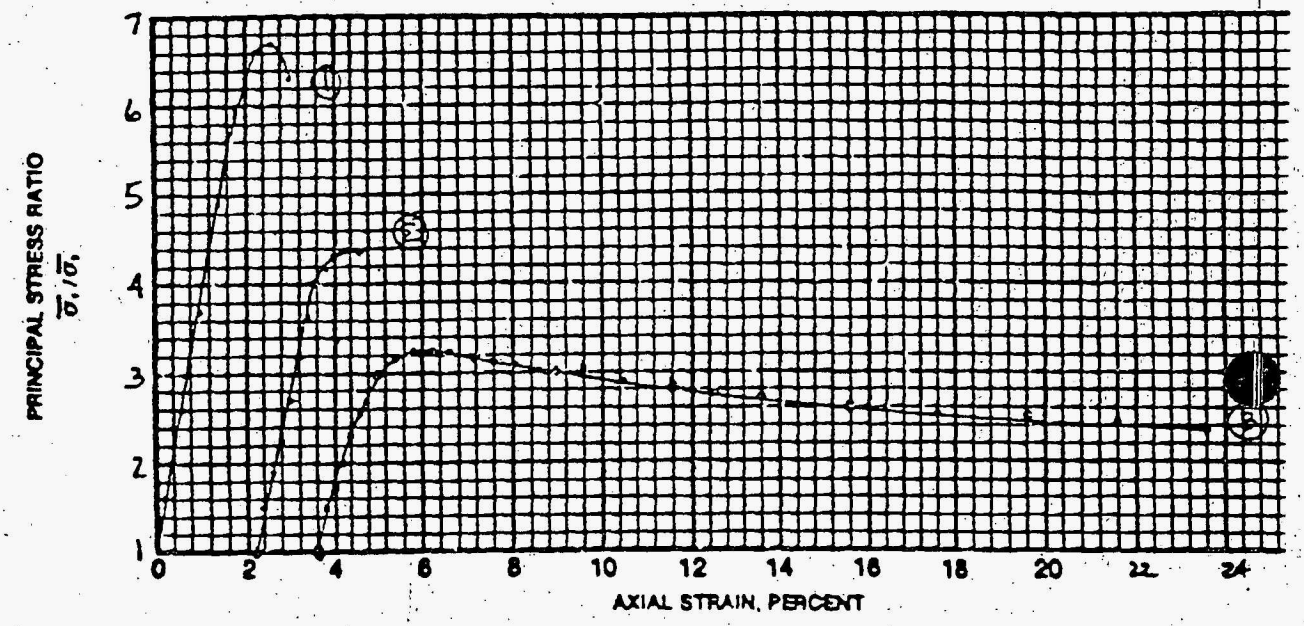
STAGE ~~Specimen~~ Number	Specimen Location		Initial Specimen Data					Soil Descrip
	Boring Number	Depth (Ft)	Sample Type	Length (in)	Diameter (in)	Dry Density (P.C.F.)	Moisture Content (%)	
1	GT-6908	21.8-22.3	Shelby	5.787	2.870	116.3	15.6	Sandy le
2	"	"	"	—	—	—	—	"
3	"	"	"	—	—	—	—	"

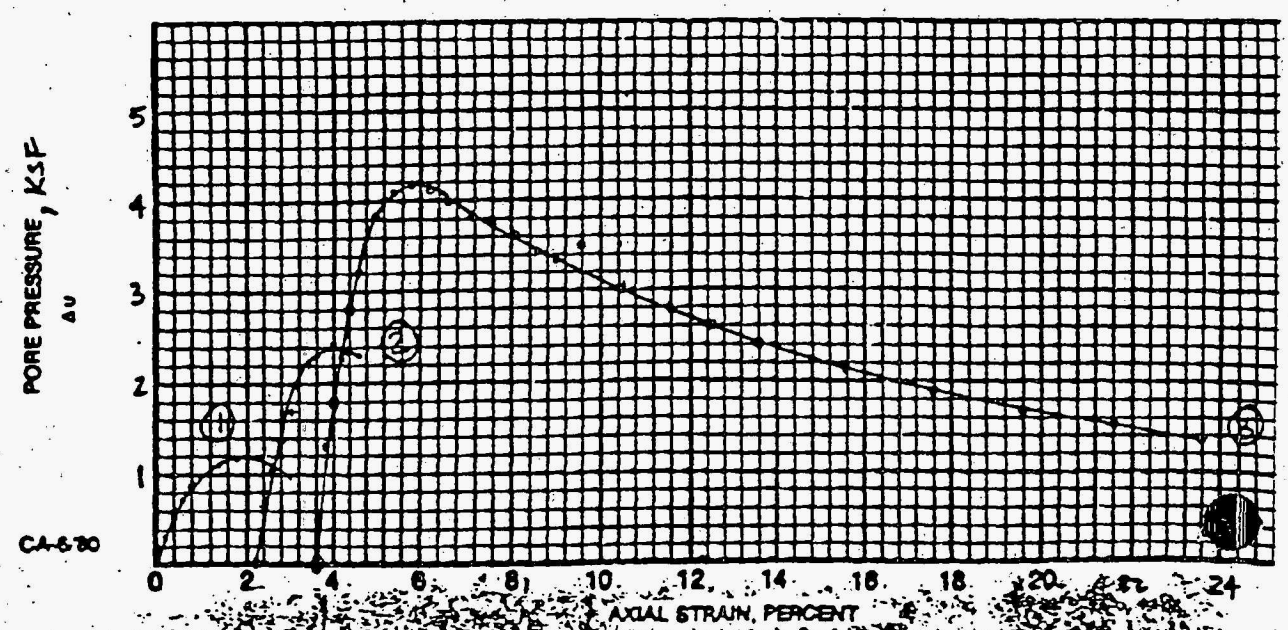
STAGE ~~Specimen~~ Number	"B" Parameter	Test Values at ~~Failure~~ Maximum Principal Stress Ratio							Remar
		Total Confining Stress σ_3	Total Axial Stress σ_1	Deviator Stress $\sigma_1-\sigma_3$	Effective Lateral Stress $\bar{\sigma}_3$	Effective Axial Stress $\bar{\sigma}_1$	Pore Pressure μ	Percent Strain ϵ%	
1	0.99	2.00	7.17	5.17	0.91	6.07	1.09	2.6	UNITS IN k
2	—	5.00	13.91	8.91	2.64	11.54	2.36	2.2	"
3	—	10.00	23.16	13.16	5.90	19.07	4.09	2.6	"

Remarks:

Fk







CA-680

CU TRIAX

Northe

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED – UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-17-91

LAB NAME: CNI

CHECKED BY: LAB SKM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-6908	21.8-22.3	N/A	2002

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
116.3	15.6	88.7	0.487	0.99

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
114.9	17.6	96.7	0.506

TEST RESULTS

AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	2002	0			
0.21	2739	317			
0.40	3011	547			
0.60	3258	734			
0.80	3518	864			
1.00	3811	979			
1.40	4445	1094			
1.80	5064	1152			
2.19	5607	1152			
2.61	6073	1094			
3.01	6466	979			

NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS. USE ONE FORM PER PHASE OF MULTI-PHASE TRIAXIAL TESTS.

TEST PROCEDURE: EM-1110-2-1906

ATTACHMENT 12

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED - UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-17-91

LAB NAME: CNI

CHECKED BY: LAB SKM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-6908	21.8-22.3	N/A	4997

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
114.9	17.6	96.7	0.506	N/A

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
116.7	17.0	96.5	0.488

TEST RESULTS

AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	4997	0			
0.19	6422	662			
0.41	7453	1037			
0.60	8184	1382			
0.79	8895	1699			
1.01	9573	2002			
1.20	10 098	2218			
1.40	10 526	2333			
1.61	10 881	2390			
1.80	11 135	2419			
2.00	11 339	2390			
2.21	11 541	2362			
2.40	11 708	2304			

NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS.

TEST PROCEDURE: EM-1110-[illegible]906

ATTACHMENT 12

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED - UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-17-91

LAB NAME: CNI

CHECKED BY: LAB SVM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-6908	21.8-22.3	N/A	9994

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
116.2	17.0	96.5	0.488	N/A

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
117.4	16.5	96.4	0.473

TEST RESULTS

AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	9994	0	4.50	19 643	3629
0.20	12912	1325	5.04	19 761	3456
0.39	14 351	1800	5.50	19 853	3341
0.59	15 538	2304	6.00	19 650	3514
0.81	16 573	2822	7.01	20129	2995
1.00	17346	3254	7.99	20 212	2794
1.40	18 261	3859	9.00	20 296	2606
1.79	18 642	4090	10.00	20 380	2419
2.20	18 870	4147	12.00	20 459	2131
2.60	19 066	4090	13.99	20 498	1901
2.99	19 225	4003	16.00	20 566	1670
3.64	19 414	3830	18.01	20 489	1526
4.00	19 514	3744	20.12	20 427	1382

NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS.
USE ONE FORM PER PHASE OF MULTI-PHASE TRIAXIAL TESTS

TEST PROCEDURE: EM-1110-2-1906

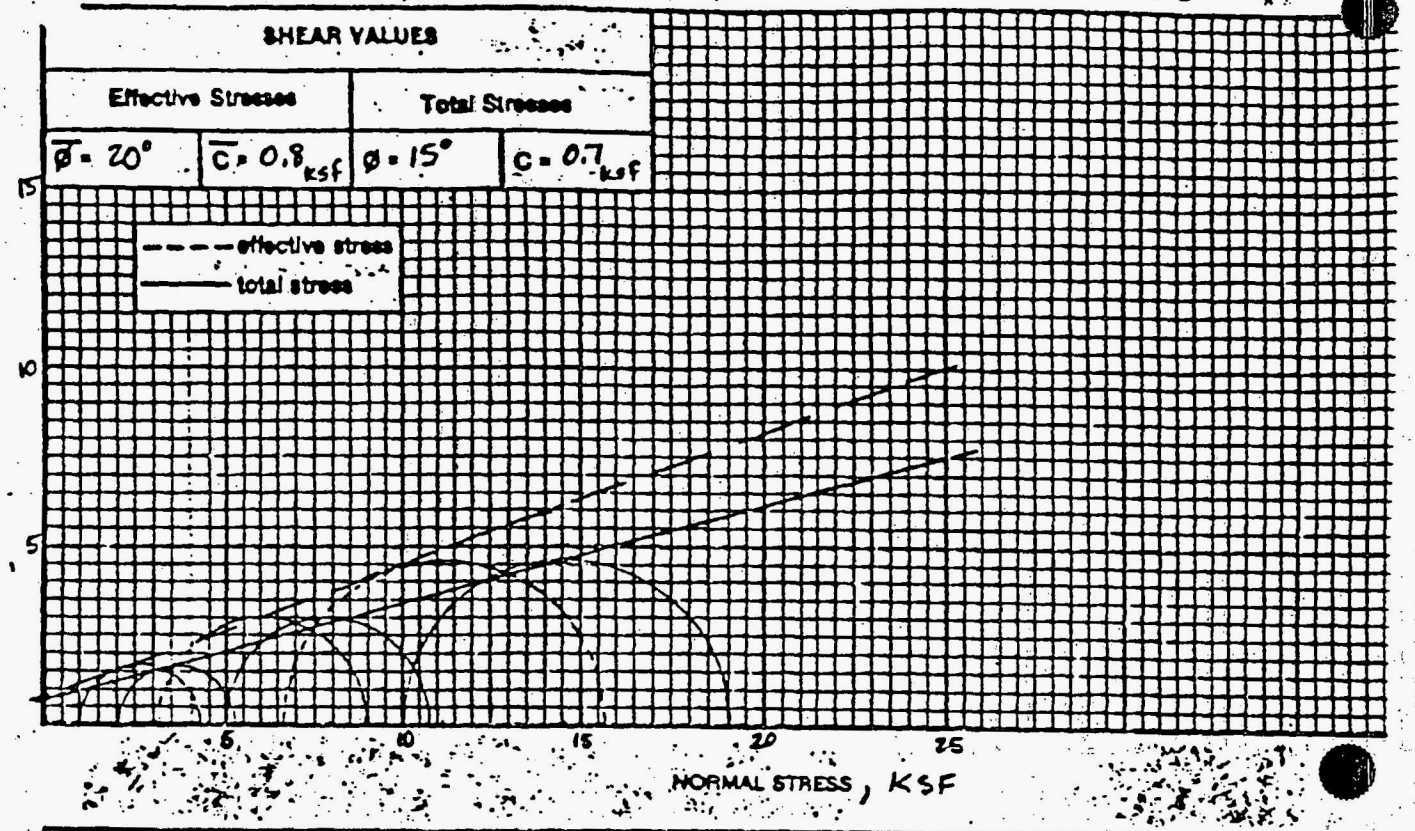
ATTACHMENT 12

Chen & Northright, Inc.

SHEAR STRENGTH OF SOIL
IN TRIAXIAL COMPRESSION

Job No. 1-369-91
Date 8-7-91
Type of Test MULTI-STAGED SATURATED, CONSOLIDATED, UNDRAINED, WITH PORE PRESSURE MEASUREMENTS

SHEAR VALUES			
Effective Stresses		Total Stresses	
$\bar{\phi}$ = 20°	$\bar{c}$ = 0.8 ksf	ϕ = 15°	c = 0.7 ksf

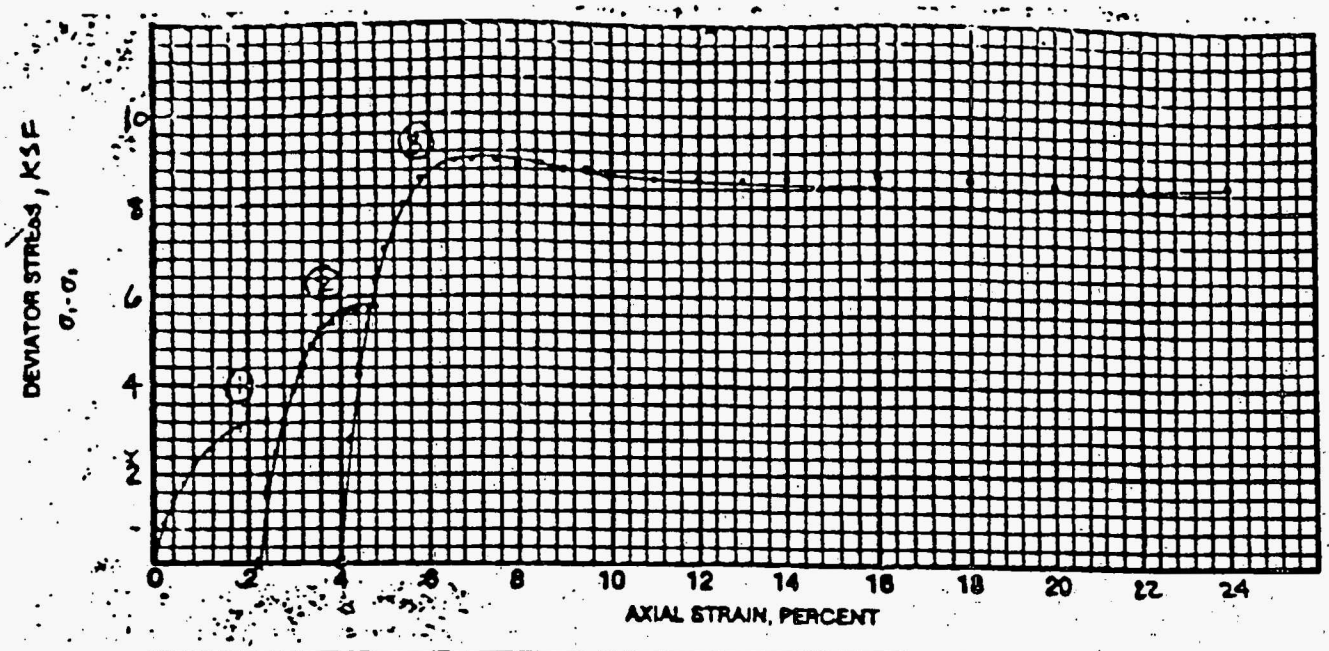


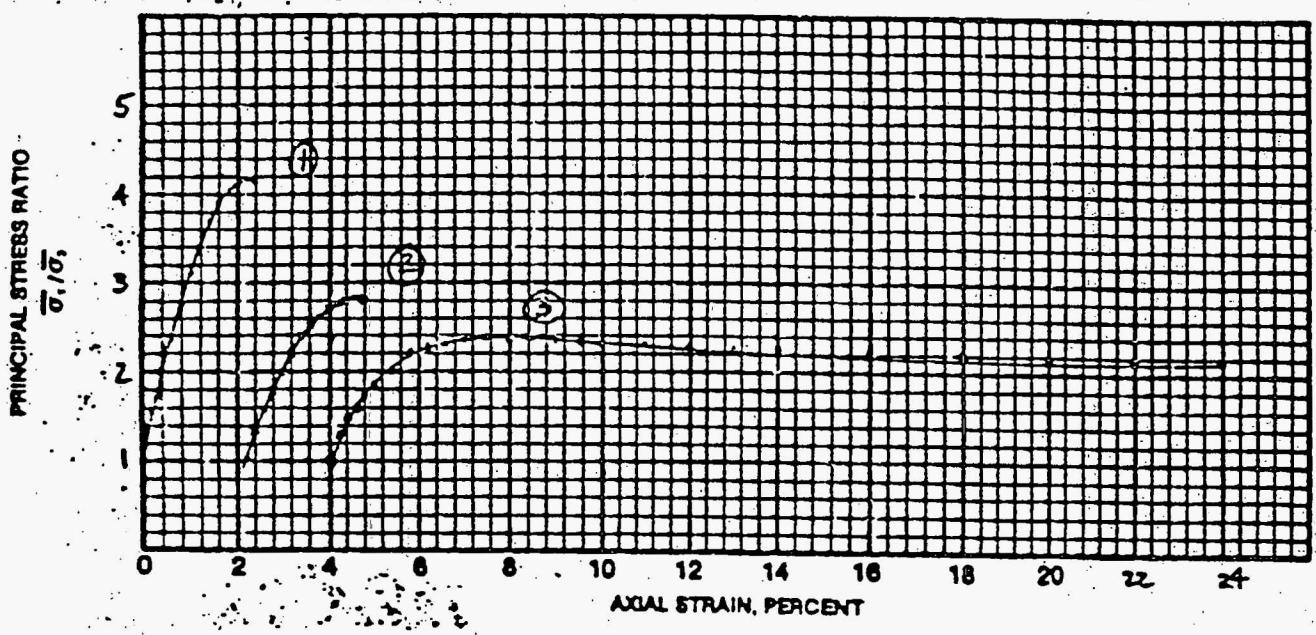
STAGE Specimen Number	Specimen Location		Initial Specimen Data					Soil Description
	Boring Number	Depth (Ft)	Sample Type	Length (in)	Diameter (in)	Dry Density (P.C.F.)	Moisture Content (%)	
1	GT-7004	10.8-11.3	Shelby	6.115	2.868	110.1	18.8	lean clay
2	"	"	"	—	—	—	—	"
3	"	"	"	—	—	—	—	"

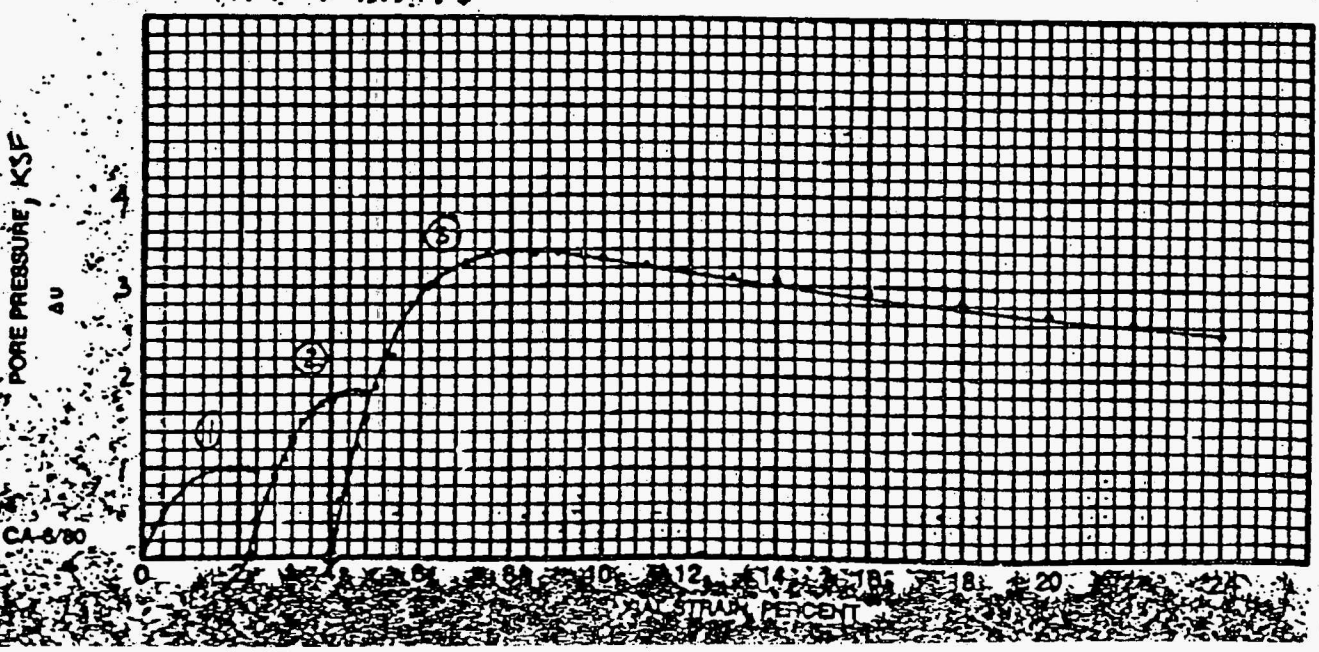
STAGE Specimen Number	"B" Parameter	Test Values at Failure-Maximum Principal Stress Ratio							Remarks
		Total Confining Stress σ_3	Total Axial Stress σ_1	Deviator Stress $\sigma_1-\sigma_3$	Effective Lateral Stress $\bar{\sigma}_3$	Effective Axial Stress $\bar{\sigma}_1$	Pore Pressure μ	Δ Percent Strain ε%	
1	0.98	2.00	5.23	3.23	1.02	4.25	0.98	2.2	UNITS IN
2	—	5.00	10.74	5.74	3.15	8.89	1.84	2.4	
3	—	10.00	18.98	8.98	6.65	15.63	3.34	3.8	

Remarks:

Fig


DEVIATOR STRESS, KSF
$\sigma_1 - \sigma_3$
0
2
4
6
8
10
12
14
16
18
20
22
24
AXIAL STRAIN, PERCENT


PRINCIPAL STRESS RATIO
$\bar{\sigma}_1/\bar{\sigma}_3$
1
2
3
4
5
0
2
4
6
8
10
12
14
16
18
20
22
24
AXIAL STRAIN, PERCENT


PORE PRESSURE, KSF
Δu
1
2
3
4
0
2
4
6
8
10
12
14
16
18
20
22
24
AXIAL STRAIN, PERCENT

CA-6/80

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED - UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-16-91

LAB NAME: CNI

CHECKED BY: LAB SAM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-7004	10.8 - 11.3	N/A	2002

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
110.1	18.8	92.7	0.558	0.98

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
108.7	21.5	100 +	0.578

TEST RESULTS

AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	2002	0			
0.20	2579	346			
0.39	2930	518			
0.60	3155	662			
0.80	3364	778			
1.00	3535	864			
1.20	3712	922			
1.41	3894	950			
1.60	4012	979			
1.80	4114	979			
2.00	4194	979			
2.19	4252	979			
2.40	4338	950			

NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS. USE ONE FORM PER PHASE OF MULTI-PHASE TRIAXIAL TESTS.

TEST PROCEDURE: EM-1110-2-1906

ATTACHMENT 12

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED - UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-16-91

LAB NAME: CNI

CHECKED BY: LAB SKM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-7004	10.8-11.3	N/A	4997

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
108.7	21.5	100+	0.578	N/A

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
110.8	20.4	100+	0.548

TEST RESULTS

AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	4997	0	2.59	8952	1814
0.20	6163	432			
0.40	6825	662			
0.60	7353	893			
0.80	7725	1123			
1.00	8117	1310			
1.20	8397	1498			
1.40	8553	1613			
1.61	8694	1699			
1.81	8798	1757			
2.01	8865	1786			
2.19	8868	1814			
2.39	8892	1843			

NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS. USE ONE FORM PER PHASE OF MULTI-PHASE TRIAXIAL TESTS

TEST PROCEDURE: EM-1110-2-1906

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED - UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-16-91

LAB NAME: CNI

CHECKED BY: LAB SVM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-7004	10.8 - 11.3	N/A	9994

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
110.8	20.4	100+	0.548	N/A

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
112.6	19.5	100+	0.524

TEST RESULTS

AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	9994	0	4.50	15 528	3370
0.20	12 127	662	5.01	15 468	3341
0.41	13 294	950	5.50	15 492	3312
0.60	14 064	1238	6.00	15 454	3283
0.80	14 713	1555	7.00	15 418	3226
1.00	15 163	1872	8.01	15 463	3168
1.40	15 797	2246	9.00	15 536	3082
1.81	15 796	2794	10.00	15 627	3053
2.20	15 824	3010	12.00	15 781	2938
2.61	15 778	3168	14.01	15 735	2822
3.00	15 741	3254	16.00	15 743	2707
3.50	15 630	3341	18.00	15 862	2621
4.00	15 553	3370	20.00	16 056	2534

NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS.

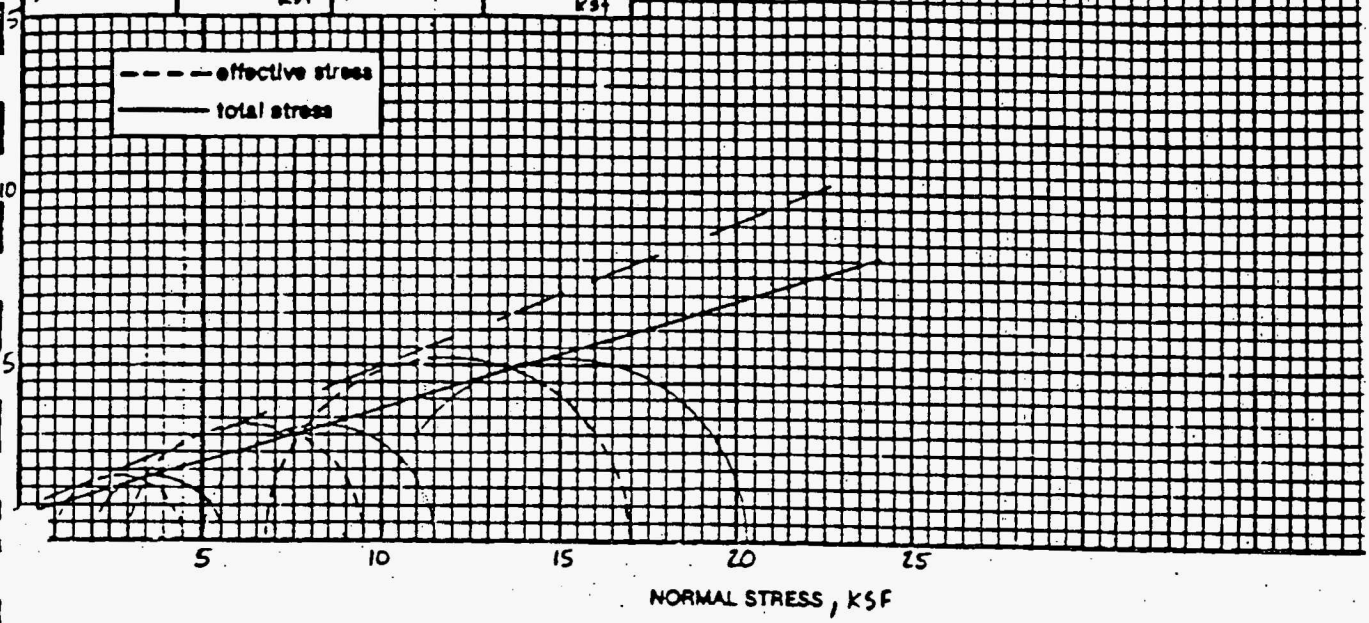
TEST PROCEDURE: EM-1110-2-

Chen Northern, Inc.

SHEAR STRENGTH OF SOIL IN TRIAXIAL COMPRESSION

Job No. 1-369-91
Date 8-7-91
Type of Test SATURATED, CONSOLIDATED, UNDRAINED WITH PORE PRESSURE MEASUREMENTS

SHEAR VALUES			
Effective Stresses		Total Stresses	
$\bar{\phi}$ = 32°	$\bar{C}$ = 0.9 ksf	ϕ = 17°	C = 0.7 ksf

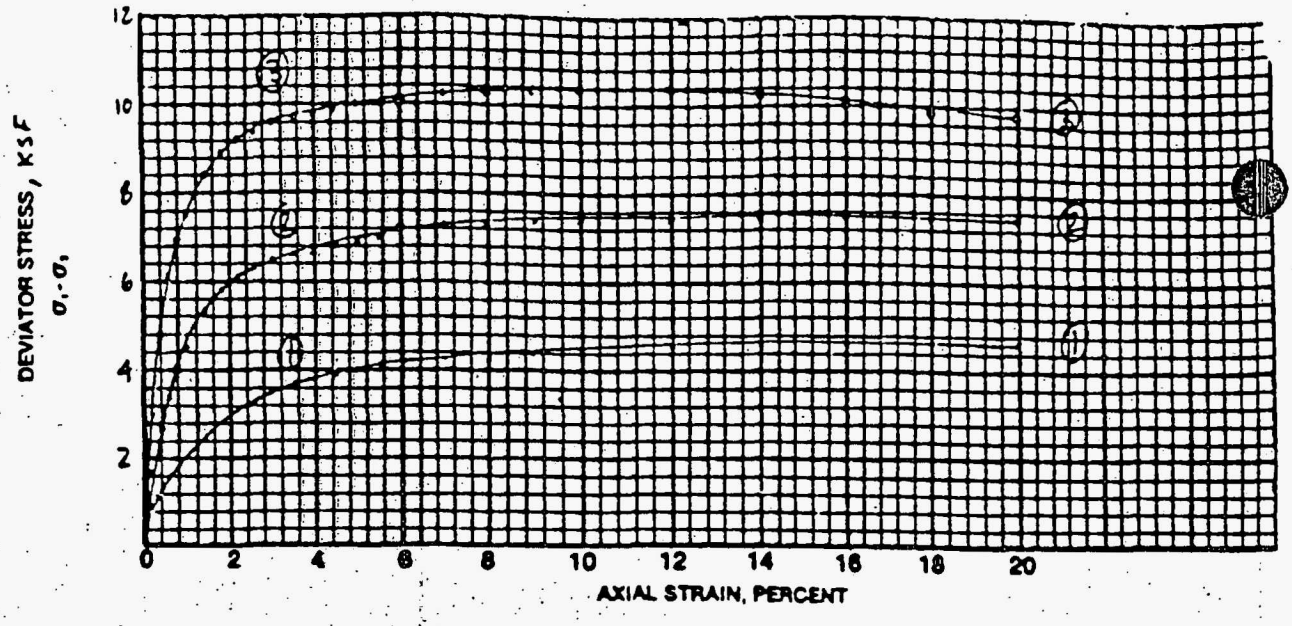


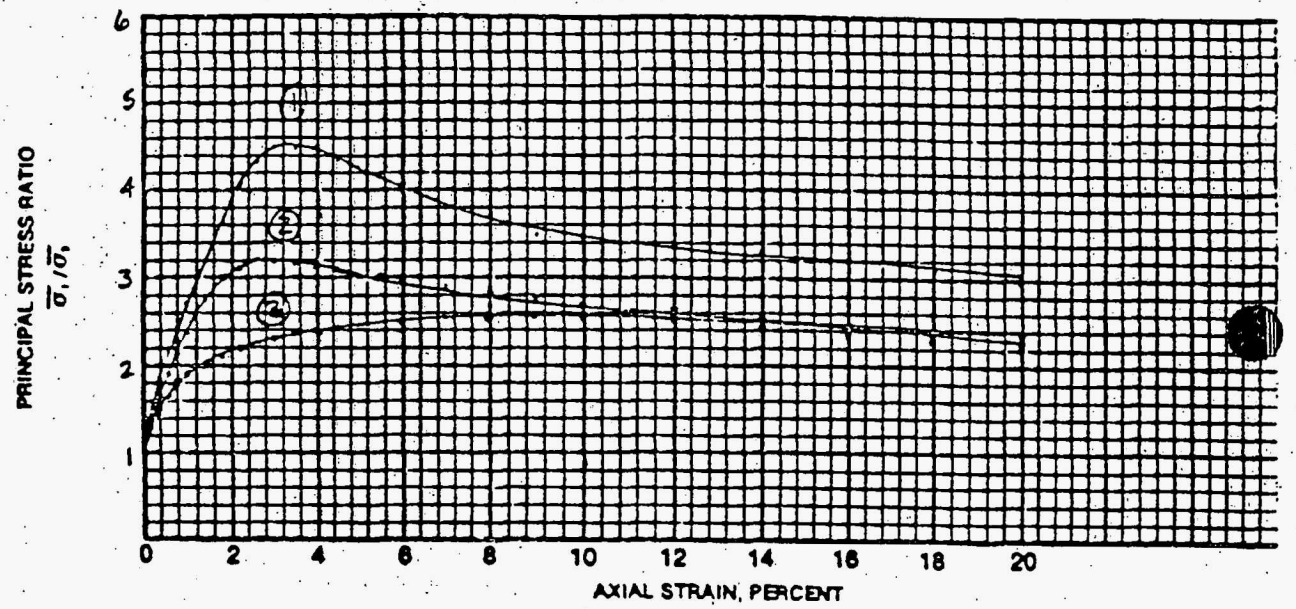
Specimen Number	Specimen Location		Initial Specimen Data					Soil Description
	Boring Number	Depth (Ft)	Sample Type	Length (in)	Diameter (in)	Dry Density (P.C.F.)	Moisture Content (%)	
1	GT-7108	20.3-20.9	Shelby	5.922	2.872	109.4	19.1	Sandy lean clay
2	"	20.9-21.5	"	6.030	2.880	111.8	17.5	"
3	"	21.5-22.0	"	6.170	2.878	111.7	12.3	"

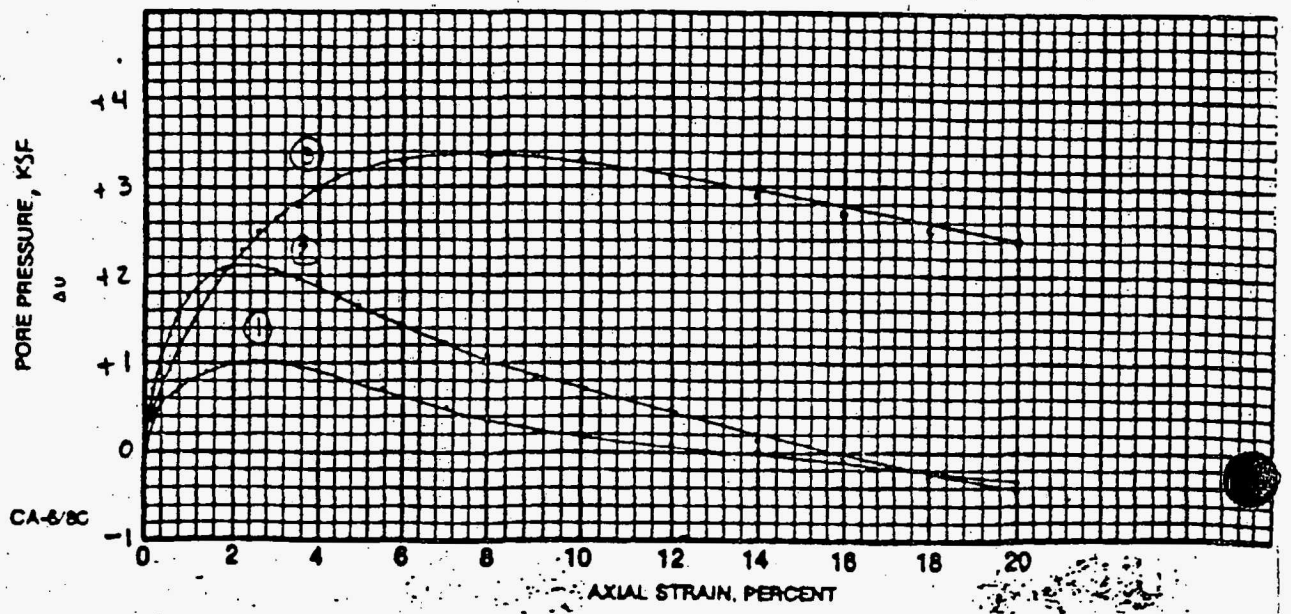
Specimen Number	"B" Parameter	Test Values at Failure-Maximum Principal Stress Ratio							Remarks
		Total Confining Stress σ_3	Total Axial Stress σ_1	Deviator Stress $\sigma_1-\sigma_3$	Effective Lateral Stress $\bar{\sigma}_3$	Effective Axial Stress $\bar{\sigma}_1$	Pore Pressure μ	Percent Strain ϵ%	
1	0.99	2.00	5.47	3.47	0.99	4.46	1.01	3.00	UNITS IN KSF
2	0.99	5.00	11.49	6.49	2.96	9.45	2.04	3.00	"
3	0.97	10.00	20.33	10.33	6.66	16.99	3.34	9.00	"

Remarks:

Fig.







CA-6/8C

#7108 CU TRIAX

Chen Northern

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED - UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-16-91

LAB NAME: CNI

CHECKED BY: LAB SWM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-7108	20.3-20.9	N/A	2002

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
109.4	19.1	95.4	0.541	0.99

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
110.5	21.7	99.5	0.589

TEST RESULTS

AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	2002	0	4.50	5073	835
0.20	2458	403	5.01	5233	778
0.41	2727	518	5.50	5371	720
0.61	2952	634	6.06	5535	634
0.80	3097	720	7.04	5795	490
1.00	3241	806	8.00	5965	374
1.40	3571	893	9.00	6131	259
1.79	3842	950	10.05	6303	173
2.20	4068	1008	11.99	6444	86
2.60	4307	1008	14.00	6593	0
2.99	4461	1008	16.00	6718	-86
3.50	4708	950	18.00	6893	-230
4.01	4897	907	20.03	6996	-346

NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS. USE ONE FORM PER PHASE OF MULTI-PHASE TRIAXIAL TESTS.

TEST PROCEDURE: EM-1110-2-1906

ATTACHMENT 12

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED – UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-16-91

LAB NAME: CNI

CHECKED BY: LAB SKM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-7108	20.9-21.5	N/A	5000

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
111.8	17.5	93.2	0.507	0.99

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
111.8	18.6	98.7	0.508

TEST RESULTS

AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	5000	0	4.49	10 057	1757
0.20	6017	691	5.00	10 251	1642
0.40	6630	1037	5.50	10 423	1526
0.60	7057	1325	6.00	10 556	1440
0.80	7430	1555	7.00	10 846	1238
1.00	7720	1757	8.00	11 112	1037
1.40	8294	1987	9.00	11 347	864
1.80	8725	2074	10.07	11 573	691
2.20	9016	2102	12.00	11 909	432
2.61	9226	2102	14.00	12 171	173
3.01	9449	2045	16.00	12 425	– 86
3.51	9650	1958	17.99	12 650	–259
3.99	9851	1872	20.00	12 703	–432

NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS.
USE ONE FORM PER PHASE OF MULTI-PHASE TRIAXIAL TESTS

TEST PROCEDURE: EM-1110-2-1906

ATTACHMENT 12

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED – UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-16-91

LAB NAME: CNI

CHECKED BY: LAB SKM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-7108	21.5-22.0	N/A	9999

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
111.7	12.3	65.5	0.509	0.97

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
113.9	17.8	99.8	0.481

TEST RESULTS

AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	9999	0	4.50	16 828	3082
0.20	12647	374	5.03	16 835	3168
0.39	14 157	634	6.00	16 848	3283
0.61	15 171	893	7.00	16 889	3341
0.80	15 790	1123	8.00	16 963	3341
1.00	16 185	1354	9.00	16 993	3341
1.40	16 659	1728	10.00	17 077	3283
1.81	16 861	2016	12.12	17 309	3082
2.20	16 914	2275	14.00	17 337	2909
2.60	16 936	2477	16.00	17 374	2707
3.04	16 915	2650	18.00	17 398	2534
3.50	16 876	2794	20.01	17 424	2390
4.01	16 844	2966			

NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS. USE ONE FORM PER PHASE OF MULTI-PHASE TRIAXIAL TESTS.

TEST PROCEDURE: EM-1110-2-1906

Chen Northern, Inc.

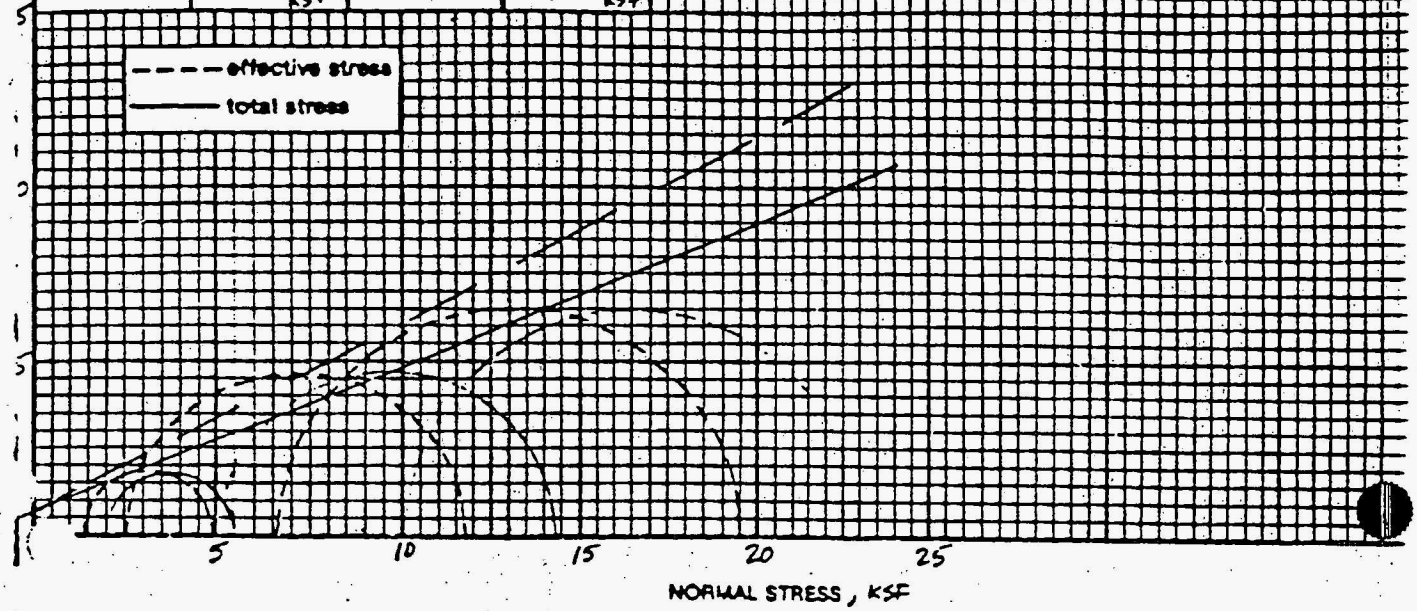
SHEAR STRENGTH OF SOIL IN TRIAXIAL COMPRESSION

Job No. 1-369-91

Date 8-15-91

Type of Test SATURATED, CONSOLIDATED, UNDRAINED WITH PORE PRESSURE MEASUREMENTS

SHEAR VALUES			
Effective Stresses		Total Stresses	
$\bar{\phi}$ = 29°	$\bar{C}$ = 0.76 ksf	ϕ = 22°	C = 0.67 ksf

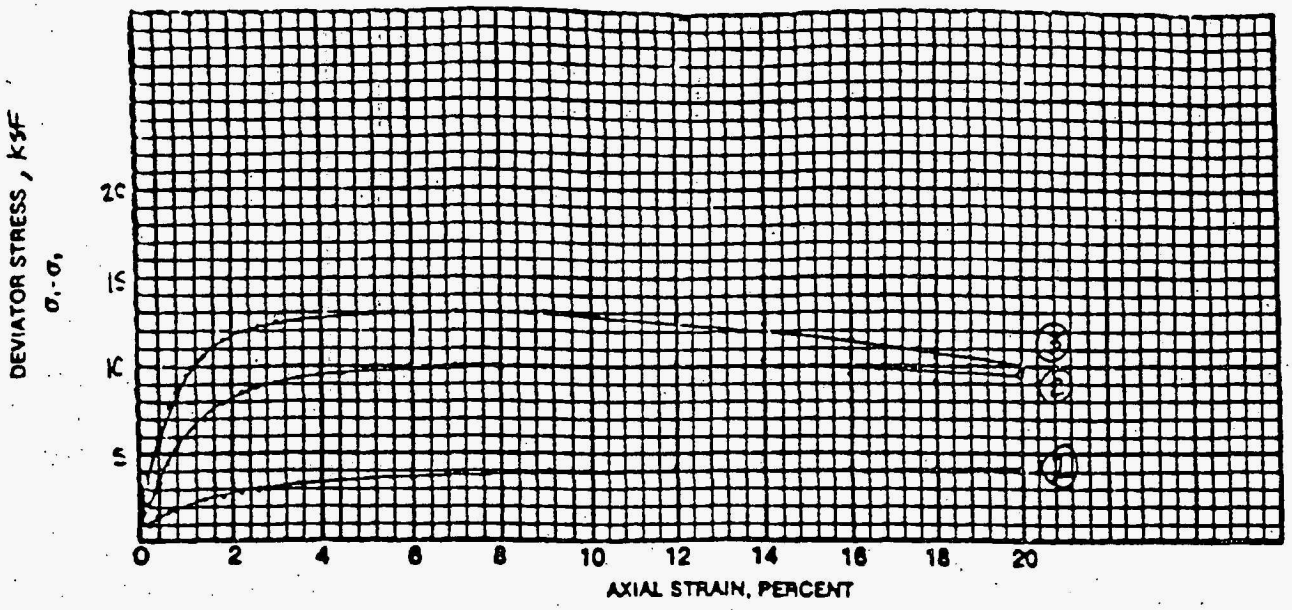


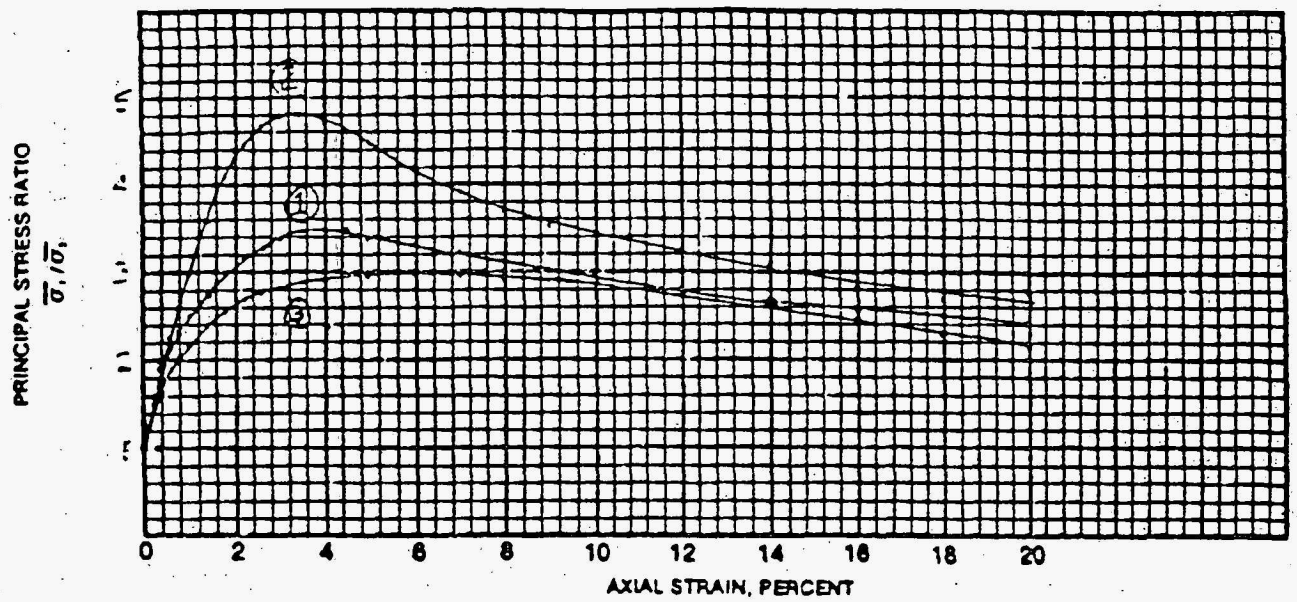
Specimen Number	Specimen Location		Initial Specimen Data					Soil Description
	Boring Number	Depth (Ft)	Sample Type	Length (in)	Diameter (in)	Dry Density (P.C.F.)	Moisture Content (%)	
1	GT-7110	26.9-27.4	Shelby	6.057	2.865	105.4	21.2	FAT CLAY
2	"	26.4-26.9	"	5.902	2.872	107.5	20.5	"
3	"		"	6.150	2.874	105.7	20.9	"

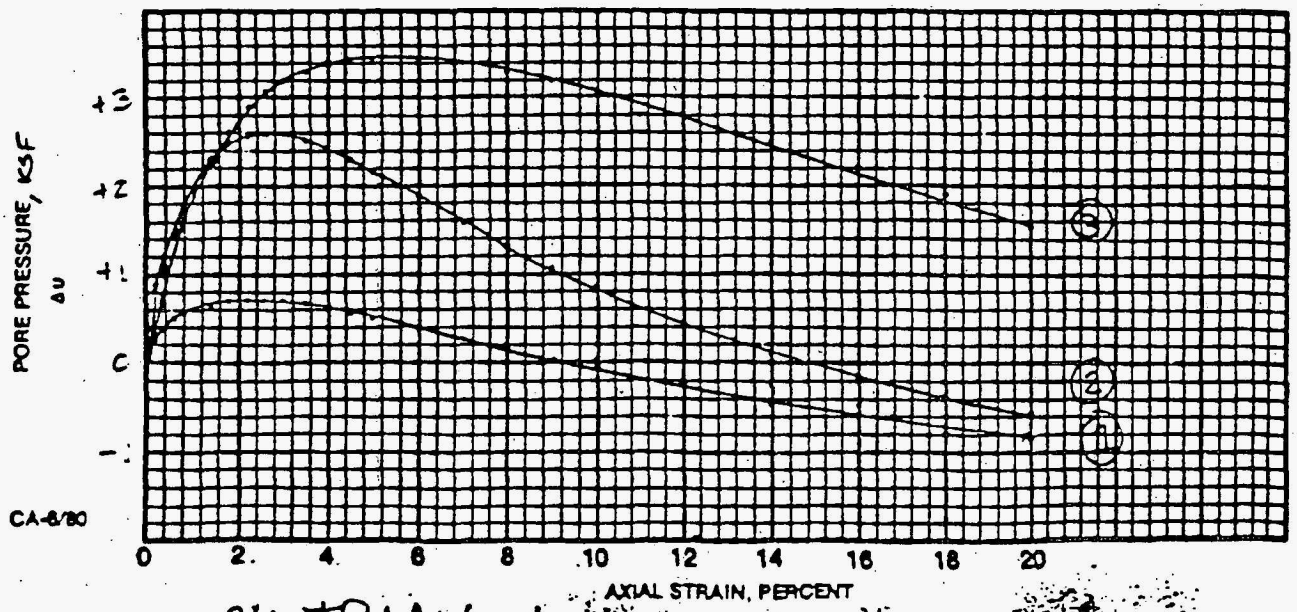
Specimen Number	"B" Parameter	Test Values at Failure-Maximum PRINCIPAL STRESS RATIO							Remarks
		Total Confining Stress σ_3	Total Axial Stress σ_1	Deviator Stress $\sigma_1-\sigma_3$	Effective Lateral Stress $\bar{\sigma}_3$	Effective Axial Stress $\bar{\sigma}_1$	Pore Pressure μ	Percent Strain ϵ%	
1	1.00	2.00	5.48	3.48	1.42	4.91	0.58	4.5	UNITS IN KSF
2	0.97	5.00	14.35	9.35	2.46	11.81	2.53	3.5	"
3	0.98	10.00	22.95	12.95	6.57	19.52	3.43	6.0	"

Remarks: NOTE: A LEAK DEVELOPED DURING THE CONSOLIDATION PHASE OF SPECIMEN 2 AND THE SAMPLE WAS RESATURATED AND RECONSOLIDATED BEFORE SHEARING.

Fig.







CA-6/80

CU TRIAX #7110

Geo Northern

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED - UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-20-91

LAB NAME: CNI

CHECKED BY: LAB SVM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-7110	26.9-27.4	N/A	2000

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
105.4	21.2	94.3	0.613	1.00

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
102.5	23.2	95.9	0.658

TEST RESULTS

AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	2000	0	4.50	4908	576
0.20	2781	259	5.01	5064	504
0.40	3060	389	6.00	5326	389
0.60	3216	490	7.01	5557	259
0.79	3370	547	8.00	5751	144
0.99	3481	605	9.09	5939	29
1.40	3692	662	10.00	6083	-58
1.80	3889	691	12.00	6348	-259
2.20	4112	691	14.00	6457	-461
2.60	4270	691	16.00	6737	-634
3.01	4426	691	18.00	7012	-792
3.50	4606	662	20.00	7056	-922
4.00	4793	605			

NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS. USE ONE FORM PER PHASE OF MULTI-PHASE TRIAXIAL TESTS.

TEST PROCEDURE: EM-1110-2-1906

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED - UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-20-91

LAB NAME: CNI

CHECKED BY: LAB SKM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-7110	26.4-26.9	N/A	5000

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
107.5	20.5	96.1	0.581	0.97

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
108.4	21.2	100+	0.567

TEST RESULTS

AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	5000	0	4.49	12 369	2304
0.21	6297	893	5.01	12 630	2160
0.39	7168	1210	6.00	13 086	1872
0.60	7908	1498	7.00	13 386	1570
0.81	8497	1757	8.01	13 613	1296
1.00	8966	1958	9.00	13 837	1066
1.41	9739	2275	10.00	14159	864
1.80	10 314	2477	12.00	14 661	461
2.20	10 804	2563	14.04	15 105	86
2.61	11 193	2592	16.00	14 705	-173
3.00	11 501	2592	18.00	14 461	-374
3.50	11 812	2534	19.99	15 346	-576
4.00	12 120	2434			

NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS. USE ONE FORM PER PHASE OF MULTI-PHASE TRIAXIAL TESTS.

TEST PROCEDURE: EM-1110-2-1906

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED - UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-20-91

LAB NAME: CNI

CHECKED BY: LAB SKM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-7110	25.9-26.4	N/A	9999

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
105.7	20.9	93.6	0.608	0.98

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
106.3	21.4	97.2	0.599

TEST RESULTS

AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	9999	0	4.50	19 391	3427
0.20	13 070	835	5.01	19 428	3427
0.40	14 638	1066	6.00	19 523	3427
0.68	16 291	1440	7.00	19 571	3384
0.81	16 831	1613	8.00	19 675	3283
1.00	17 497	1872	8.99	19 812	3168
1.40	18 335	2304	10.00	19 863	3053
1.80	18 801	2621	12.01	19 926	2779
2.21	19 056	2880	14.00	19 779	2506
2.60	19 180	3053	16.04	19 237	2218
3.00	19 265	3197	18.00	18 652	1901
3.51	19 319	3312	19.99	18 157	1555
4.00	19 359	3398			

NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS. USE ONE FORM PER PHASE OF MULTI-PHASE TRIAXIAL TESTS.

TEST PROCEDURE: EM-1110-2-

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED – UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-17-91

LAB NAME: CNI

CHECKED BY: LAB SKM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-7112	30.0 - 31.5	N/A	2000

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
88.0	22.5	68.5	0.860	0.97

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
94.7	29.4	100 +	0.727

TEST RESULTS

AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	2000	0	2.60	3101	835
0.21	2341	29			
0.39	2781	58			
0.60	2932	173			
0.80	3091	346			
1.01	3140	461			
1.19	3117	547			
1.40	3127	634			
1.61	3132	691			
1.79	3104	749			
2.00	3119	763			
2.20	3105	806			
2.41	3105	835			

NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS. USE ONE FORM PER PHASE OF MULTI-PHASE TRIAXIAL TESTS.

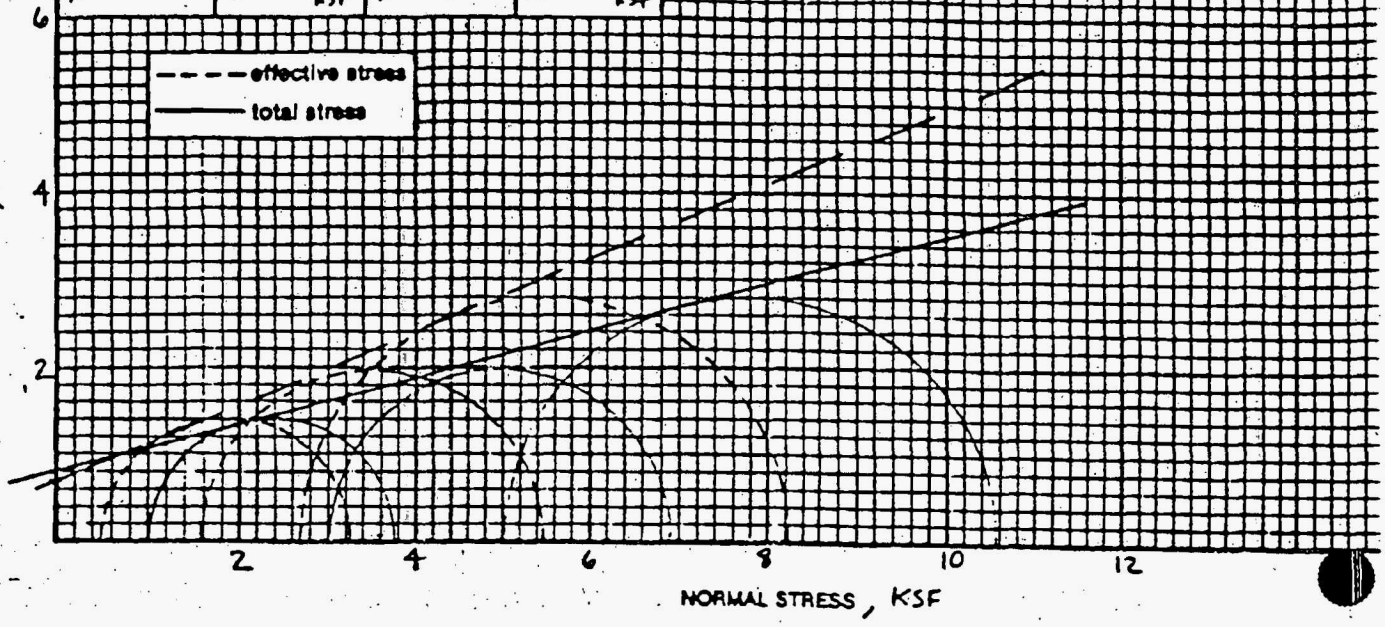
TEST PROCEDURE: EM-1110-2-1906

Chen & Northern, Inc.

SHEAR STRENGTH OF SOIL IN TRIAXIAL COMPRESSION

Job No. 1-369-91
Date 8-6-91
Type of Test MULTI-STAGED, SATURATED, CONSOLIDATED, UNDRAINED WITH PORE PRESSURE MEASUREMENTS

SHEAR VALUES			
Effective Stresses		Total Stresses	
$\bar{\phi}$ = 23°	$\bar{c}$ = 0.7 ksf	ϕ = 15°	c = 0.8 ksf

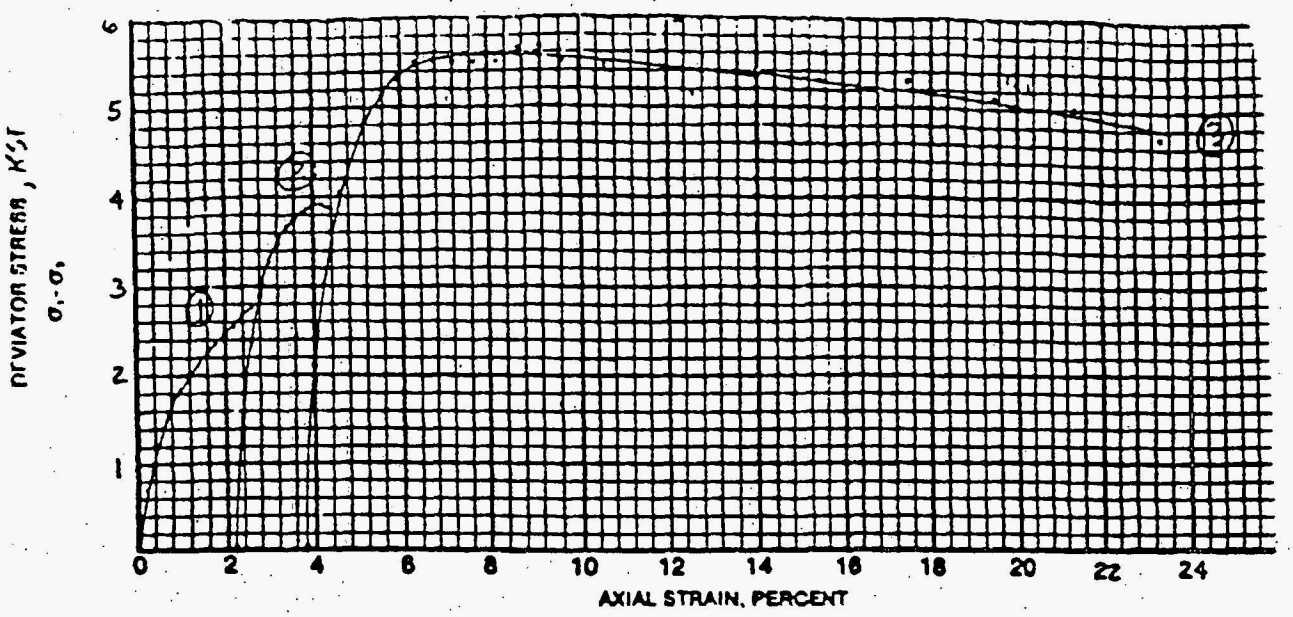


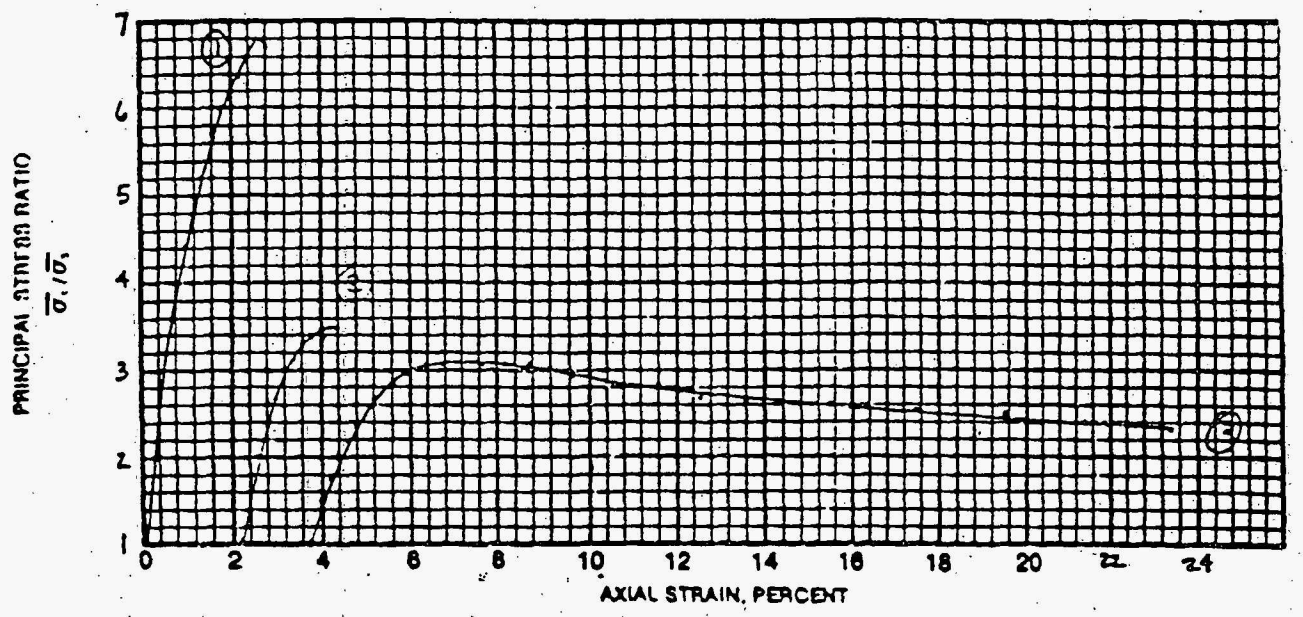
STAGE ~~Specimen~~ Number	Specimen Location		Initial Specimen Data					Soil Description
	Boring Number	Depth (Ft)	Sample Type	Length (in)	Diameter (in)	Dry Density (P.C.F.)	Moisture Content (%)	
1	GT-7402	5.0-7.5	Shelby	5.914	2.871	99.9	24.2	Fat clay wit
2	"	"	"	—	—	—	—	"
3	"	"	"	—	—	—	—	"

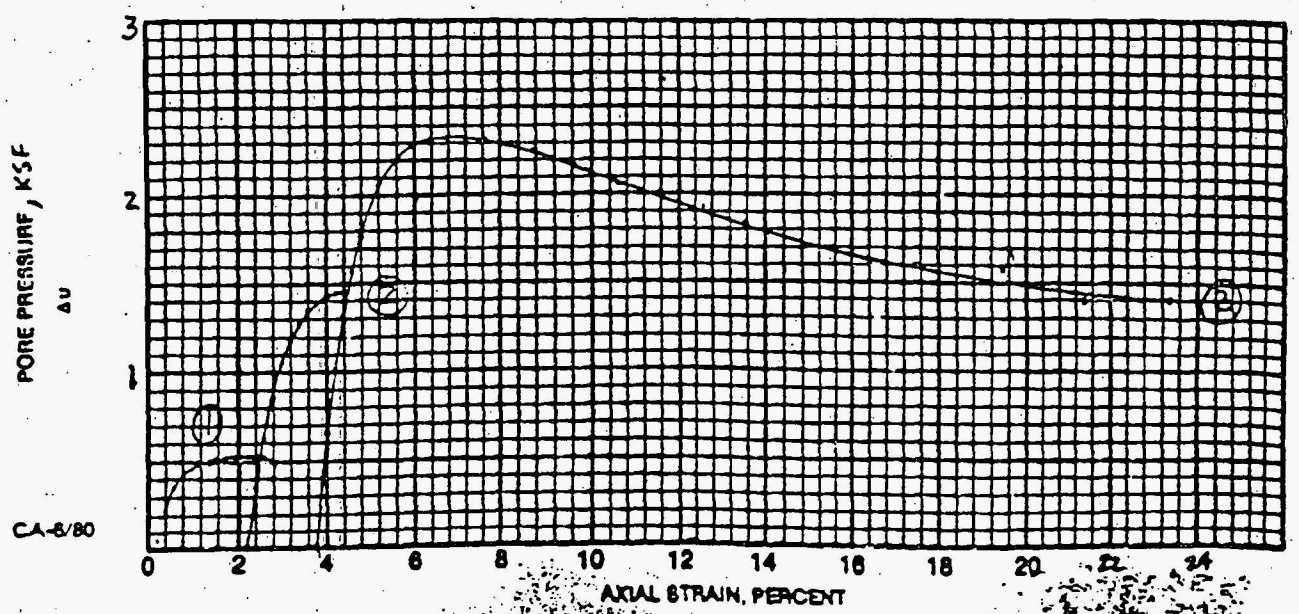
STAGE ~~Specimen~~ Number	"B" Parameter	Test Values at Failure ~~Maximum~~ Principal Stress Ratio							Remarks
		Total Confining Stress σ_3	Total Axial Stress σ_1	Deviator Stress $\sigma_1-\sigma_3$	Effective Lateral Stress $\bar{\sigma}_3$	Effective Axial Stress $\bar{\sigma}_1$	Pore Pressure μ	Percent Strain ϵ%	
1	0.98	1.00	3.75	2.75	0.48	3.23	0.52	2.6	UNITS IN KSF
2	—	3.00	6.88	3.88	1.56	5.43	1.44	2.0	"
3	—	5.00	10.55	5.55	2.68	8.23	2.32	3.4	"

Remarks:

Fig.







CA-6/80

7402 CU TRIAX

Chen & Northern, I

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED - UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-21-91

LAB NAME: CNI

CHECKED BY: LAB SKM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-7402	5.0-7.5	N/A	994

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
99.9	24.2	95.2	0.687	0.98

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
101.3	25.6	100.0	0.692

TEST RESULTS

AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	994	0	2.60	3228	518
0.20	1639	43	2.80	3359	490
0.40	1716	230			
0.61	2064	346			
0.79	2202	403			
1.00	2362	461			
1.20	2534	461			
1.40	2633	490			
1.60	2709	518			
1.80	2835	518			
1.99	2940	518			
2.19	3022	518			
2.39	3147	518			

NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS. USE ONE FORM PER PHASE OF MULTI-PHASE TRIAXIAL TESTS.

TEST PROCEDURE: EM-1110-2-[illegible]06

ATTACHMENT 12

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED - UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-21-91

LAB NAME: CNI

CHECKED BY: LAB SKM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-7402	5.0-7.5	N/A	2995

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
101.3	25.6	100.0	0.692	N/A

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
102.0	24.2	100.0	0.653

TEST RESULTS

AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	2995	0			
0.21	4224	346			
0.40	4751	634			
0.60	5002	864			
0.80	5198	1037			
1.00	5289	1181			
1.19	5372	1267			
1.40	5402	1339			
1.61	5438	1382			
1.80	5489	1411			
2.01	5430	1440			
2.20	5401	1440			

NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS. USE ONE FORM PER PHASE OF MULTI-PHASE TRIAXIAL TESTS.

TEST PROCEDURE: EM-1110-2-1906

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED - UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-21-91

LAB NAME: CNI

CHECKED BY: LAB SKM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-7402	5.0-7.5	N/A	4997

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
102.0	24.2	100.0	0.653	N/A

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
103.7	23.2	100.0	0.625

TEST RESULTS

AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	4997	0	4.40	8247	2290
0.19	6435	648	4.90	8376	2261
0.40	6985	1022	5.38	8427	2203
0.58	7301	1310	5.86	8384	2174
0.79	7463	1570	6.84	8378	2059
0.98	7613	1771	7.82	8441	2002
1.38	7778	2059	8.80	8242	1915
1.75	7906	2203	9.81	8353	1829
2.15	8021	2290	11.74	8627	1685
2.54	8148	2318	13.70	8674	1598
2.94	8170	2318	15.66	8544	1570
3.42	8231	2318	17.60	8618	1397
3.92	8158	2318	19.56	8334	1397

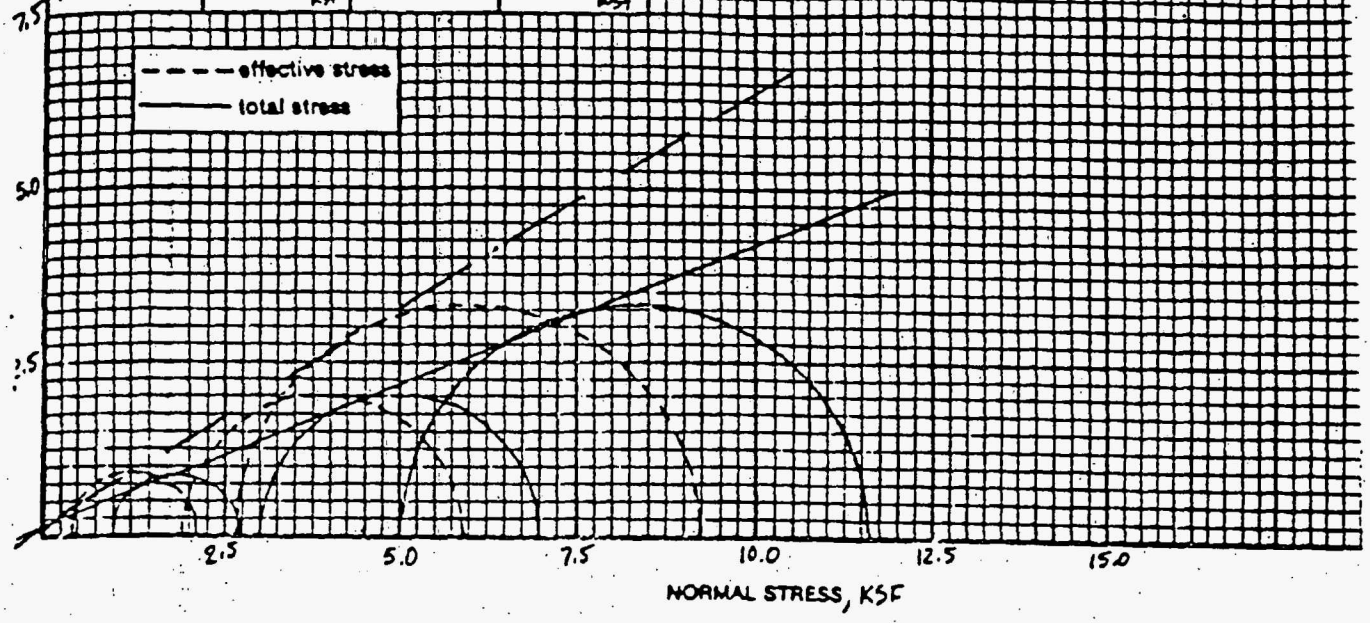
NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS. USE [illegible]E FORM PER PHASE OF MULTI-PHASE TRIAXIAL TESTS.

TEST PROCEDURE: EM-1110-2-[illegible]06

SHEAR STRENGTH OF SOIL
IN TRIAXIAL COMPRESSION

Job No. 1-369-91
Date 8-15-91
Type of Test SATURATED, CONSOLIDATED, UNDRAINED WITH PORE PRESSURE MEASUREMENTS

SHEAR VALUES			
Effective Stresses		Total Stresses	
$\bar{\phi}$ = 32°	$\bar{c}$ = 0.12 ksf	ϕ = 22°	c = 0.15 ksf

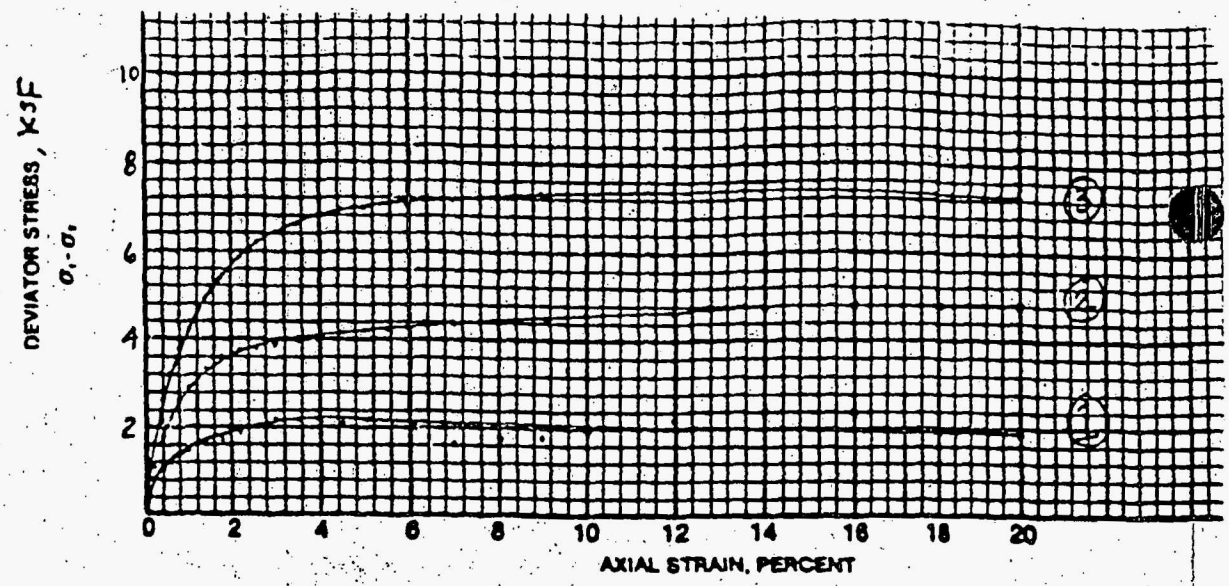


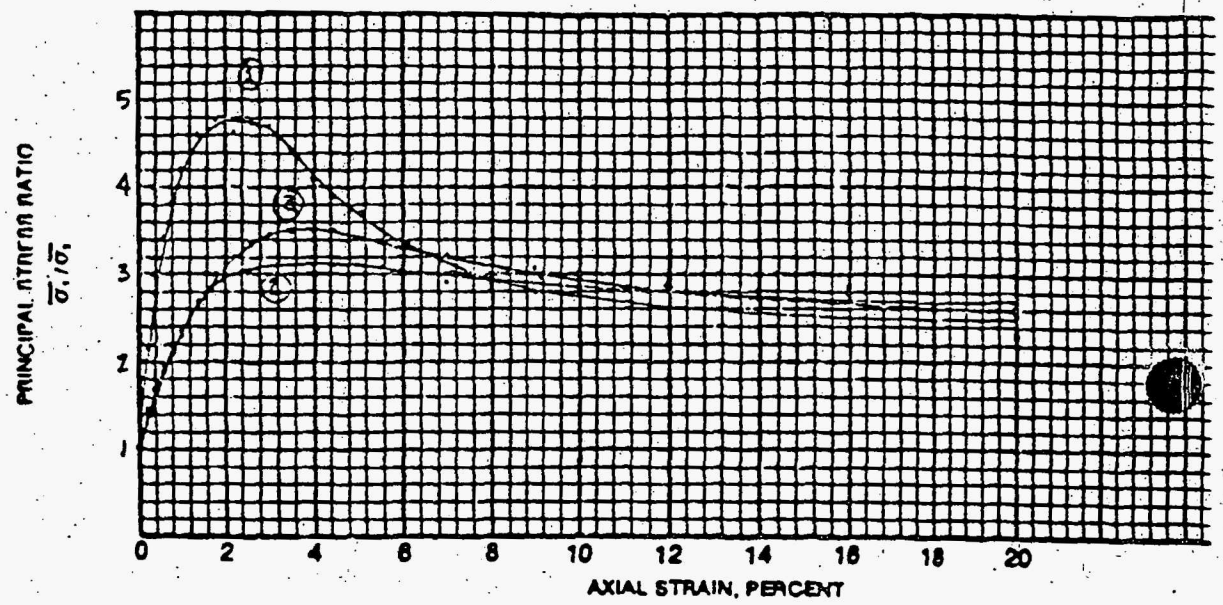
Specimen Number	Specimen Location		Initial Specimen Data					Soil Description
	Boring Number	Depth (Ft)	Sample Type	Length (in)	Diameter (in)	Dry Density (P.C.F.)	Moisture Content (%)	
1	GT-7406	15.8-16.3	Shelby	5.795	2.865	109.1	17.8	Lean clay w/sand
2	"	16.3-16.8	"	5.645	2.872	109.3	18.1	"
3	"	16.8-17.3	"	5.644	2.865	112.4	17.5	"

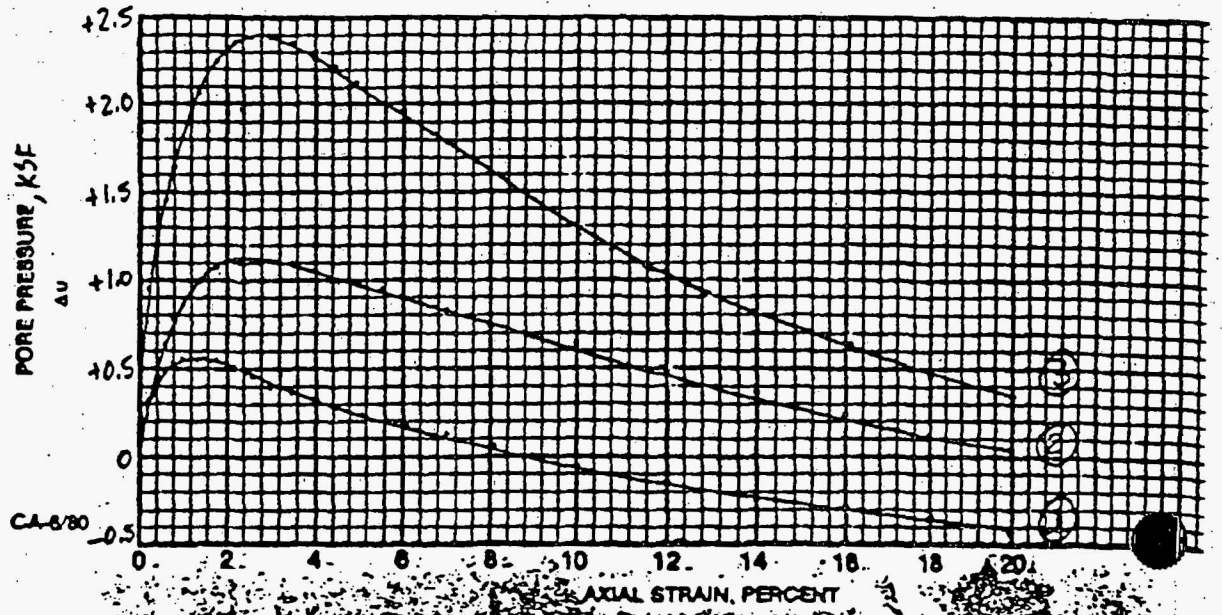
Specimen Number	"B" Parameter	Test Values at Failure-Maximum Principal Stress Ratio							Remarks
		Total Confining Stress σ_3	Total Axial Stress σ_1	Deviator Stress $\sigma_1-\sigma_3$	Effective Lateral Stress $\bar{\sigma}_3$	Effective Axial Stress $\bar{\sigma}_1$	Pore Pressure μ	Percent Strain ϵ%	
1	0.99	1.00	2.71	1.71	0.45	2.16	0.55	1.8	Units in ksf
2	0.98	3.00	7.00	4.00	1.90	5.90	1.09	3.5	" "
3	0.99	5.00	11.60	6.60	2.64	9.24	2.36	3.5	" "

Remarks:

Fig.







CA-6/80

CIU TRIAX #2407

Chen North

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED – UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-17-91

LAB NAME: CNI

CHECKED BY: LAB [illegible]

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-7406	15.8-16.3	N/A	999

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
109.1	17.8	88.4	0.545	0.99

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
105.8	21.2	96.7	0.594

TEST RESULTS

AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	999	0	4.49	2751	288
0.21	1466	317	5.15	2836	230
0.40	1660	403	6.09	2792	173
0.60	1745	490	7.00	2532	130
0.81	1854	518	8.06	2705	58
1.00	1898	547	9.00	2804	0
1.41	2085	547	10.00	3019	-58
1.80	2164	547	12.01	3368	-144
2.20	2364	490	14.00	3667	-230
2.61	2555	461	16.00	3686	-288
3.00	2795	403	17.99	3275	-346
3.50	2770	374	20.00	3315	-432
4.00	2785	317			

NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS. USE ONE FORM PER PHASE OF MULTI-PHASE TRIAXIAL TESTS.

TEST PROCEDURE: EM-1110-2-1906

ATTACHMENT 12

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED - UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-17-91

LAB NAME: CNI

CHECKED BY: LAB SPEM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-7406	16.3-16.8	N/A	2995

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
109.3	18.1	90.0	0.542	0.98

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
107.8	20.1	96.2	0.564

TEST RESULTS

AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	2995	0	4.50	6109	1008
0.20	3800	288	5.00	6199	979
0.41	4280	461	5.50	6268	950
0.60	4605	634	6.00	6366	893
0.83	4846	778	7.04	6553	821
0.99	4994	864	8.12	6695	749
1.40	5292	1008	9.08	6806	691
1.81	5472	1094	10.00	6916	634
2.20	5600	1123	12.01	7151	490
2.61	5713	1123	14.01	7368	374
3.00	5782	1123	16.00	7568	230
3.49	5897	1094	18.14	7686	115
4.01	6003	1051	20.01	7768	29

NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS. TEST PROCEDURE: EM-1110-2-1906
USE ONE FORM PER PHASE OF MULTI-PHASE TRIAXIAL TESTS

ATTACHMENT 12

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

CONSOLIDATED - UNDRAINED TRIAXIAL "R" TEST WITH PORE PRESSURE MEASUREMENT

SITE ID: WSSRAP

LOCATION ID: Disposal Facility

DATE: 8-17-91

LAB NAME: CNI

CHECKED BY: LAB SKM

TAC

SAMPLE ID	DEPTH INTERVAL (FT)	COMPACTION %	CELL CONFINING PRESSURE (PSF)
GT-7406	16.8-17.3	N/A	4997

INITIAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e	B PARAM.
112.4	17.5	94.6	0.500	0.99

FINAL CONDITIONS

DRY DENSITY (PCF)	MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	VOID RATIO e
111.8	19.1	100 +	0.508

TEST RESULTS

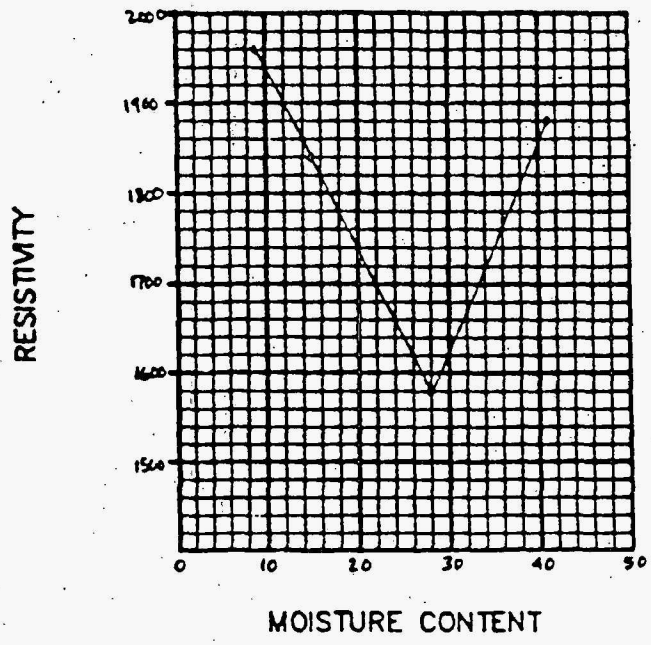
AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)	AXIAL STRAIN (%)	MAJOR PRINC. STRESS (PSF)	PORE PRESS. (PSF)
0	4997	0	4.50	9650	2218
0.20	5844	965	5.00	9806	2131
0.41	6345	1210	6.00	10 114	1958
0.60	6770	1440	6.99	10 377	1786
0.80	7111	1642	8.01	10 634	1613
1.00	7325	1814	9.00	10 870	1440
1.41	7813	2074	10.00	11 033	1296
1.80	8186	2246	11.99	11 325	1037
2.21	8502	2362	14.00	11 558	806
2.60	8774	2390	16.14	11 678	634
3.01	9027	2390	18.01	11 833	461
3.50	9236	2362	20.00	11 860	346
4.00	9501	2275			

NOTE: CONSOLIDATION DATA TO BE ATTACHED ON LABORATORY SUBCONTRACTOR FORMS. USE ONE FORM PER PHASE OF MULTI-PHASE TRIAXIAL TESTS.

TEST PROCEDURE: EM-1110-2-1906

ATTACHMENT 12

LABORATORY RESISTIVITY TESTS



Resistivity (Ohm-Cm)	Moisture content (%)
1960	8.7
1840	15.1
1580	27.9
1880	40.7

Natural Moisture Content 9.7 %

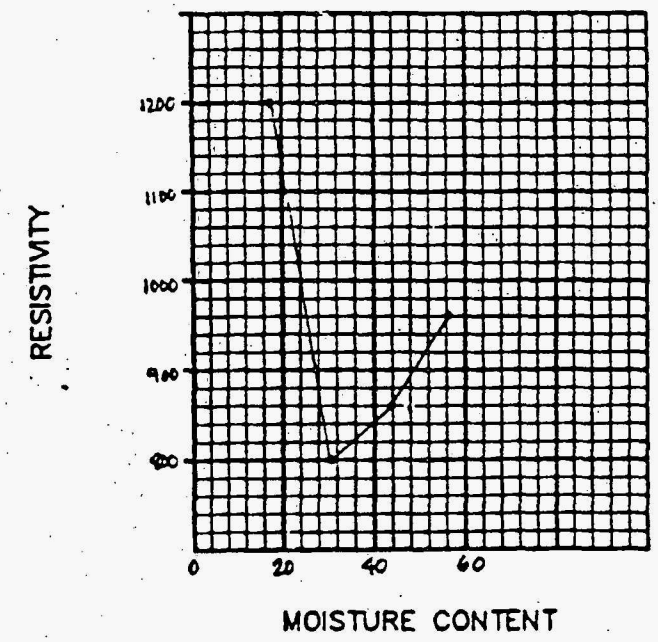
Natural Dry Density — pcf

pH —

Gravel — % Sand — % Silt and Clay — %

Liquid Limit — % Plasticity Index — %

Sample of From GT-6801 @ 2.5'-4.0'



Resistivity (Ohm-Cm)	Moisture content (%)
1200	17.6
800	30.7
860	43.7
960	56.8

Natural Moisture Content 22.0 %

Natural Dry Density — pcf

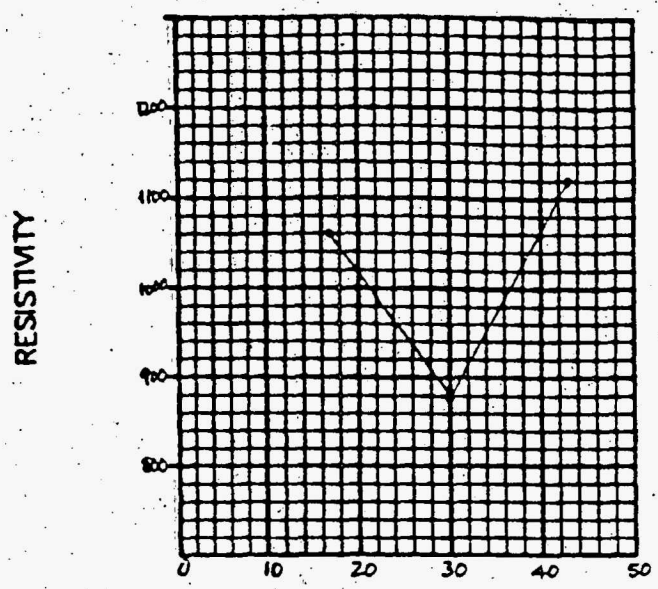
pH —

Gravel — % Sand — % Silt and Clay — %

Liquid Limit — % Plasticity Index — %

Sample of From GT-6901 @ 2.5'-4.0'

1-369-91	Chen Northern, Inc.	LABORATORY RESISTIVITY TEST RESULTS	Fig.



Resistivity (Ohm-Cm)	Moisture content (%)
1080	16.9
880	29.9
1120	42.9

Natural Moisture Content 19.3 %

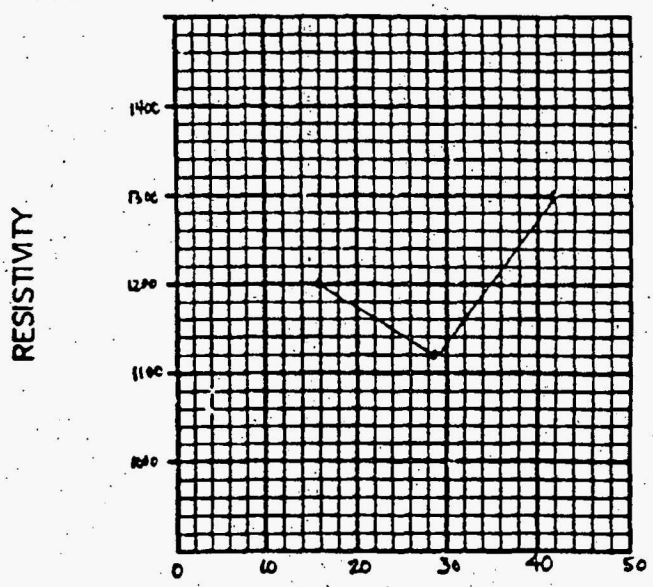
Natural Dry Density — pcf

pH —

Gravel — % Sand — % Silt and Clay — %

Liquid Limit — % Plasticity Index — %

Sample of From GT-6903 @ 7.5'-9.0'



Resistivity (Ohm-Cm)	Moisture content (%)
1200	15.8
1120	28.7
1300	41.6

Natural Moisture Content 22.8 %

Natural Dry Density — pcf

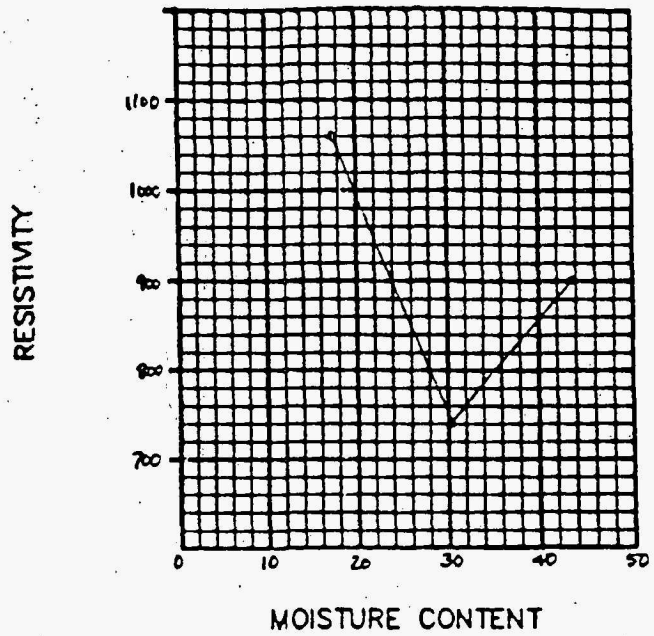
pH —

Gravel — % Sand — % Silt and Clay — %

Liquid Limit — % Plasticity Index — %

Sample of From GT-7003 @ 7.5'-9.0'

1-369-91	Chen Northern, Inc.	LABORATORY RESISTIVITY TEST RESULTS	Fig.



Resistivity (Ohm-Cm)	Moisture content (%)
1060	17.4
740	30.5
900	43.5

Natural Moisture Content 25.3 %

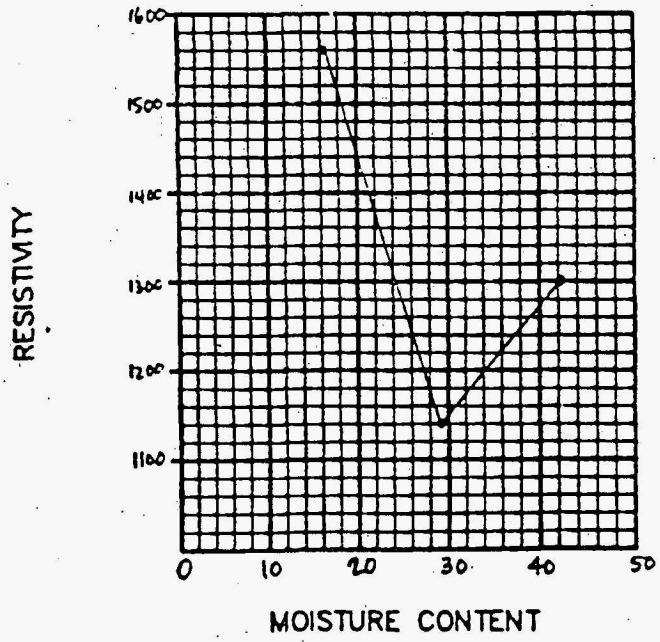
Natural Dry Density — pcf

pH —

Gravel — % Sand — % Silt and Clay — %

Liquid Limit — % Plasticity Index — %

Sample of From GT-7103 @ 7.5'-9.0'



Resistivity (Ohm-Cm)	Moisture content (%)
1560	16.5
1140	29.4
1300	42.4

Natural Moisture Content 24.1 %

Natural Dry Density — pcf

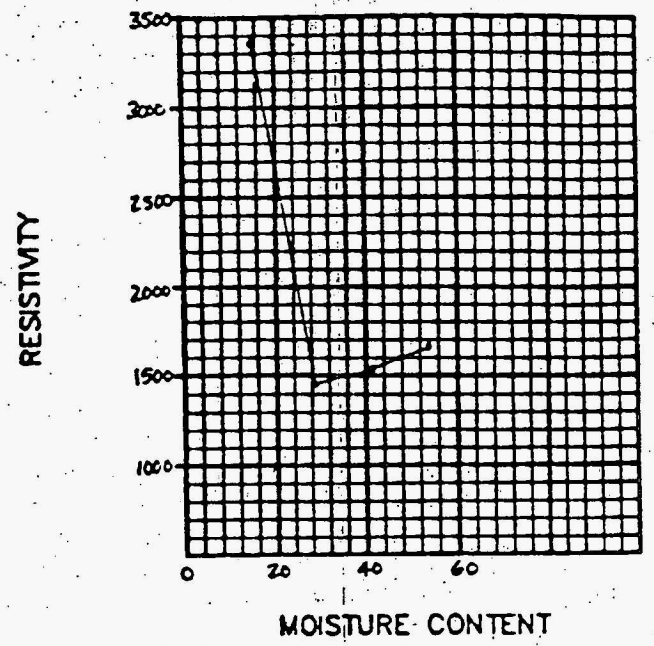
pH —

Gravel — % Sand — % Silt and Clay — %

Liquid Limit — % Plasticity Index — %

Sample of From GT-7201 @ 2.5'-4.0'

1-369-91	Chen Northern, Inc.	LABORATORY RESISTIVITY TEST RESULTS	Fig.



Resistivity (Ohm-Cm)	Moisture content (%)
3380	15.7
1460	28.6
1520	41.4
1660	54.3

Natural Moisture Content 27.5 %

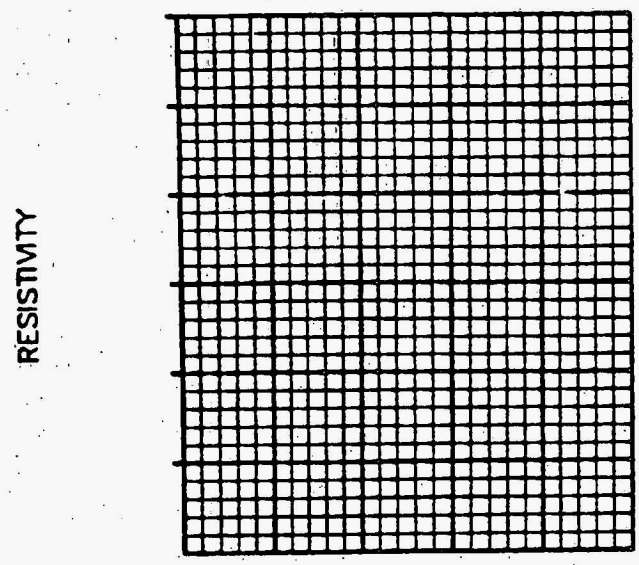
Natural Dry Density — pcf

pH —

Gravel — % Sand — % Silt and Clay — %

Liquid Limit — % Plasticity Index — %

Sample of From GT-7301 @ 2.5'-4.0'



Resistivity (Ohm-Cm)	Moisture content (%)

Natural Moisture Content ____ %

Natural Dry Density ____ pcf

pH ____

Gravel % Sand % Silt and Clay %

Liquid Limit % Plasticity Index %

Sample of From

1-369-91	Chen Northern, Inc.	LABORATORY RESISTIVITY TEST RESULTS	Fig.

ANALYTICAL RESULTS

WET CHEMISTRY ANALYSIS RESULTS

ID: 9106049-01A
Client ID: SS-6801-040591-B

Collected: 04/05/91
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Analyzed by	
Chloride	MCAWW 325.3	193	114	mg/Kg	VHM	06/26/91
Percent Solids	MCAWW 160.3	85.9	---	%	CS	06/12/91
Sulfate	MCAWW 375.4	864	223	mg/Kg	DJS	07/05/91
pH	MCAWW 150.1	7.30	---	pH	VM	07/08/91

ID: 9106049-02A
Client ID: SS-6901-040891-B

Collected: 04/08/91
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Analyzed by	
Chloride	MCAWW 325.3	297	113	mg/Kg	VHM	06/26/91
Percent Solids	MCAWW 160.3	88.2	---	%	CS	06/12/91
Sulfate	MCAWW 375.4	243	226	mg/Kg	DJS	07/05/91
pH	MCAWW 150.1	7.07	---	pH	VM	07/08/91

ID: 9106049-03A
Client ID: SS-6903-040891-B

Collected: 04/08/91
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Analyzed by	
Chloride	MCAWW 325.3	344	121	mg/Kg	VHM	06/26/91
Percent Solids	MCAWW 160.3	80.7	---	%	CS	06/12/91
Sulfate	MCAWW 375.4	BDL	241	mg/Kg	DJS	07/05/91
pH	MCAWW 150.1	6.37	---	pH	VM	07/08/91

ID: 9106049-04A
Client ID: SS-7003-040891-B

Collected: 04/08/91
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Analyzed by	
Chloride	MCAWW 325.3	214	114	mg/Kg	VHM	06/26/91
Percent Solids	MCAWW 160.3	84.6	---	%	CS	06/12/91
Sulfate	MCAWW 375.4	BDL	230	mg/Kg	DJS	07/05/91
pH	MCAWW 150.1	7.49	---	pH	VM	07/08/91

Notes and definitions for this report:
BDL = Below Quantitation Limit

WET CHEMISTRY ANALYSIS RESULTS

ID: 9106049-05A
Client ID: SS-7103-041191-B

Collected: 04/11/91
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Analyzed by	
Chloride	MCAWW 325.3	242	117	mg/Kg	VHM	06/26/91
Percent Solids	MCAWW 160.3	85.7	---	%	CS	06/12/91
Sulfate	MCAWW 375.4	509	230	mg/Kg	DJS	07/05/91
pH	MCAWW 150.1	6.91	---	pH	VM	07/08/91

ID: 9106049-06A
Client ID: SS-7201-041291-B

Collected: 04/12/91
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Analyzed by	
Chloride	MCAWW 325.3	272	110	mg/Kg	VHM	06/26/91
Percent Solids	MCAWW 160.3	88.5	---	%	CS	06/12/91
Sulfate	MCAWW 375.4	243	226	mg/Kg	DJS	07/05/91
pH	MCAWW 150.1	6.35	---	pH	VM	07/08/91

ID: 9106049-07A
Client ID: SS-7301-041591-B

Collected: 04/15/91
Matrix: SOIL

Parameter	Method	Result	Det.Lim.	Units	Analyzed by	
Chloride	MCAWW 325.3	170	129	mg/Kg	VHM	06/26/91
Percent Solids	MCAWW 160.3	76.8	---	%	CS	06/12/91
Sulfate	MCAWW 375.4	428	260	mg/Kg	DJS	07/05/91
pH	MCAWW 150.1	5.39	---	pH	VM	07/08/91

Notes and definitions for this report:
BQL = Below Quantitation Limit

WASTE QUANTITIES QUARTERLY REPORT TABLE: 01/01/92 - 03/31/92					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
SOILS & SEDIMENTS					
Raffinate Pits	1.52 ton/cyd	153,500 cyd	153,500	233,320	MOD 8 estimate and RI Report Rev. D December 1990 DOE/OR/21548-074 Plate 3 (Radiological Site Soil Zones) Includes Region 4 Zone 6 Region 9 Zones 1 & 2
Ash Pond	1.52 ton/cyd	8,200 cyd	8,200	12,460	RI Report Rev. D December 1990 DOE/OR/21548-074 Plate 3 (Radiological Site Soil Zones) Includes Region 4 Zones 1,2,3,5
Frog Pond	1.52 ton/cyd	7,000 cyd	7,000	10,640	RI Report Rev. D December 1990 DOE/OR/21548-074 Plate 3 (Radiological Site Soil Zones) Region 3 Zones 1,2,3 & 4

WASTE QUANTITIES QUARTERLY REPORT TABLE: 01/01/92 - 03/31/92					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
North Dump	1.52 ton/cyd	7,600 cyd	7,600	11,550	RI Report Rev. D December 1990 DOE/OR/21548-074 Plate 3 (Radiological Site Soil Zones) Region 1 Zones 1 & 2
South Dump	1.52 ton/cyd	16,900 cyd	16,900	25,690	RI Report Rev. D December 1990 DOE/OR/21548-074 Plate 3 (Radiological Site Soil Zones) Includes Region 4 Zone 4
TSA Area	1.52 ton/cyd	4,100 cyd	4,100	6,230	RI Report Rev. D December 1990 DOE/OR/21548-074 Plate 3 (Radiological Site Soil Zones) Includes Region 11 Zone 2 Region 8 Zones 1,2,3 & 4

WASTE QUANTITIES QUARTERLY REPORT TABLE: 01/01/92 - 03/31/92					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
Site WT Plant Area	1.52 ton/cyd	7,100 cyd	7,100	10,792	RI Report Rev. D December 1990 DOE/OR/21548-074 Plate 3 (Radiological Site Soil Zones) Includes Region 11 Zone 1 and 1990 ASER
Around Chemical Plant Buildings	1.52 ton/cyd	26,400 cyd	26,400	40,130	RI Report Rev. D December 1990 DOE/OR/21548-074 Plate 3 (Radiological Site Soil Zones) Includes Region 5 Zone 1 which is associated with contamination from the coal stroage area and Region 5 Zones 1-11 Region 6 Zones 1-6 Region 10 Zones 1-14
Beneath Chemical Plant Buildings and Open Areas	1.52 ton/cyd	59,000 cyd	59,000	89,680	IOC: M. Peterson to S. Green Date: 4-18-90 Region 5 Zones 1-11 Region 6 Zones 1-6 Region 10 Zones 1-14

WASTE QUANTITIES QUARTERLY REPORT TABLE: 01/01/92 - 03/31/92					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
Lakes 34, 35, 36	1.52 ton/cyd	20,000 cyd	20,000	30,400	Engineering assumption
Quarry (Bulk Waste Excavation)	2 ton/cyd	52,000 cyd	52,000	104,000	QY CDD February 1991 DOE/OR/21548-145
Vicinity Properties					
Femme Osage	1.52 ton/cyd	80,500 cyd	80,500	122,360	Mod 8 estimate and Draft WSSRAP VP Femme Osage Slough Special Study June 1989
Army 1,2 & 3	1.52 ton/cyd	1,400 cyd	1,400	2,130	Vicinity Property CDR October 1987
Busch 3,4 & 5	1.52 ton/cyd	500 cyd	500	760	Vicinity Property CDR October 1987
Army 5 & 6	1.52 ton/cyd	1,700 cyd	1,700	2,580	Vicinity Property CDR October 1987
Southeast Drainage	1.52 ton/cyd	10,000 cyd	10,000	15,200	Vicinity Property CDR October 1987
TOTAL SOILS & SEDIMENTS			455,900	717,922	

WASTE QUANTITIES QUARTERLY REPORT TABLE: 01/01/92 - 03/31/92					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
SLUDGE					
Raffinate Pits	1.01 ton/cyd	220,000 cyd	220,000	222,200	Rev D December 1990 DOE/OR/21548-074 RI Report
Quarry	1.40 ton/cyd	4,100 cyd	4,100	5,740	QY CDD February 1991 DOE/OR/21548-145
Site Water Treatment Plant	70 #/cft	3,100 cyd	3,100	2,930	QY CDD February 1991 DOE/OR/21548-145
Quarry Water Treatment Plant	70 #/cft	500 cyd	500	470	Waste Managment Plan for QY WTP IOC Steffen to Tucker September 15, 1990 Assume 5 yr Operating life
TOTAL SLUDGE			227,700	231,340	

WASTE QUANTITIES QUARTERLY REPORT TABLE: 01/01/92 - 03/31/92					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
CLEAR & GRUB					
Quarry	.63 ton/cyd	5,300 cyd	5,300	3,340	QY PER October 1989 DOE/OR/21548-094
Raffinate Pits	.63 ton/cyd	5,900 cyd	5,900	3,720	Assume 50% of Mod 8 Estimate
Chemical Plant	.63 ton/cyd	17,500 cyd	17,500	11,030	Assume 50% of Mod 8 Estimate. Includes MSA grubbing.
Vicinity Property Femme Osage	.63 ton/cyd	1,000 cyd	1,000	630	Assume 50% of Mod 8 Estimate
Quarry RR Ties	40 #/cft	130 cyd	130	70	Mod 8 Estimate. Quarry = 130 cyd Haul Road = 1070 cyd will be disposed of off site
Chemical Plant RR Ties	40 #/cft	300 cyd	300	160	Mod 8 Estimate
TOTAL CLEAR & GRUB		31,200 cyd	30,130	18,950	

WASTE QUANTITIES QUARTERLY REPORT TABLE: 01/01/92 - 03/31/92					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
RUBBLE					
Quarry Bulk Metal	5 cyd/ton	10,500 cyd	10,500	2,100	QY Per October 1989 DOE/OR/21548-094
Quarry Bulk Rock/Concrete	4,100 #/cyd	30,200 cyd	30,200	61,910	QY PER October 1989 DOE/OR/21548-094 Density = Average of concrete and limestone densities
Quarry Residuals (Rock)	4,200 #/cyd	20,100 cyd	20,100	42,210	Mod 8 Estimate Density = Density of Limestone
Quarry WTP (Closure)	150 #/cft	300 cyd	300	610	Mod 8 Estimate
TSA (Closure Foundation)	4,100 #/cyd	22,000 cyd	22,000	45,100	Mod 8 Estimate Does not include material on TSA Density = Average of concrete and limestone densities
Raffinate Pits	5 cyd/ton	500 cyd	500	100	RI Report Rev. D December 1990 DOE/OR/21548-074

WASTE QUANTITIES QUARTERLY REPORT TABLE: 01/01/92 - 03/31/92					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
Site WTP (Closure Foundation)	150 #/cft	400 cyd	400	810	Mod 8 Estimate
MSA (Closure Foundation)	3620 #/cyd	14,500 cyd	14,500	26,250	Mod 8 Estimate - Includes soil and gravel but does not include material on MSA. Density = Average of soil and limestone densities.
Treatment Facility (Closure)	150 #/cft	900 cyd	900	1,820	Mod 8 Estimate Density = Average of concrete and metal densities
Volume Reduction Facility (closure)	150 #/cft	500 cyd	500	1010	Mod 8 Estimate Density = Average of concrete and metal densities
Chemical Plant					
ACM					
Friable	46 #/cft	4,716 cyd	4,716	2,929	WITS Data Includes Fiberglass

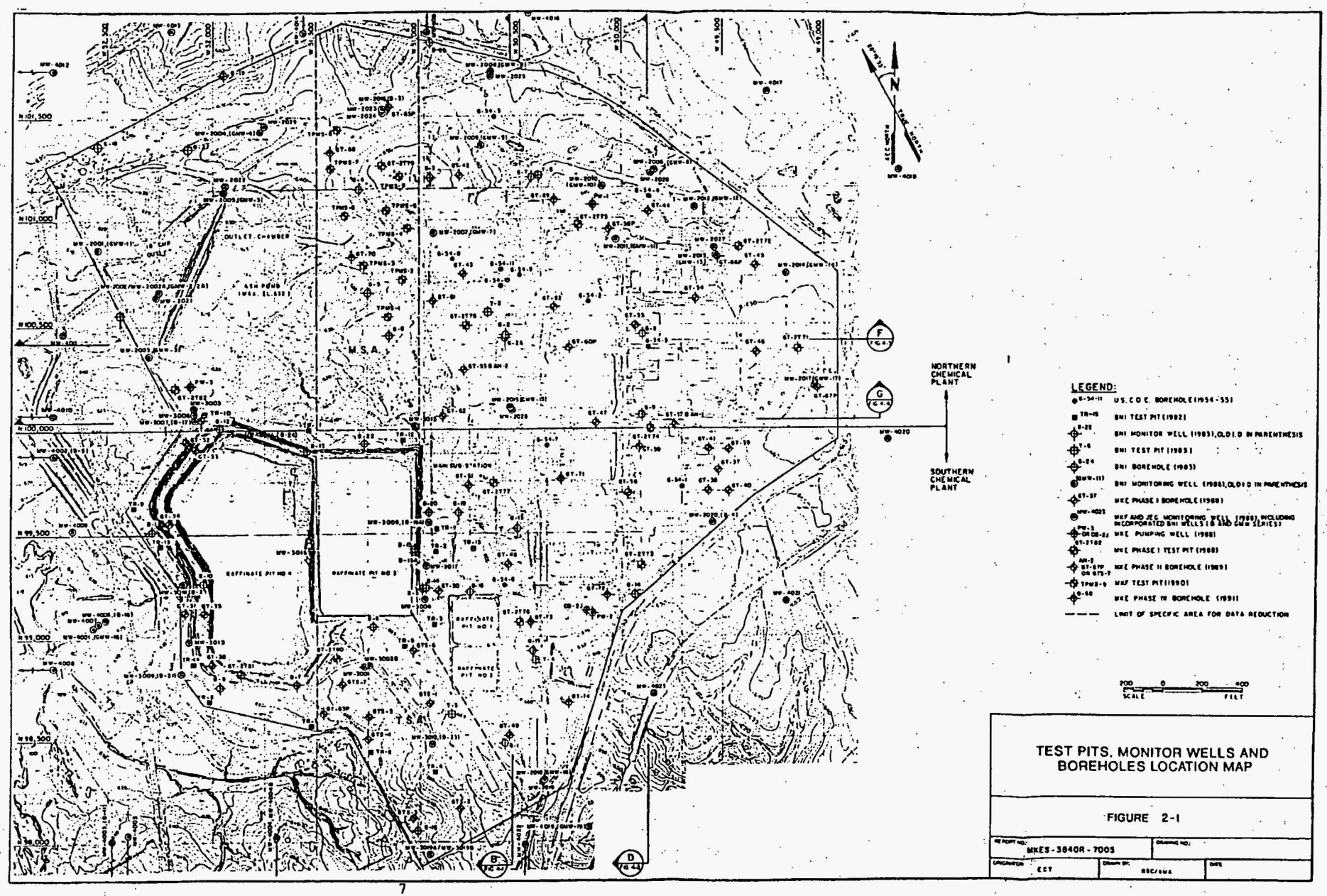
WASTE QUANTITIES QUARTERLY REPORT TABLE: 01/01/92 - 03/31/92					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
Non-Friable (Roofing, Siding, Flooring)	158 #/cft	5,111 cyd	5,111	10,902	WITS Data
Ceramic	135 #/cft	327 cft	12	22	WITS Data
Concrete					WITS Data
Masonry Block	56 #/cft	7,300 cyd	7,300	5,519	WITS Data Assume 8" x 8" x 10" Includes Brick
Slab (Deck, Foundation)	150 #/cft	51,514 cyd	51,514	104,316	WITS Data Includes Road and Foundations
Debris	100 #/cft	190 cyd	190	257	WITS Data
Glass	162 #/cft	1,284 cft	48	104	WITS Data
Graphite	135 #/cft	492 cft	18	33	WITS Data
Metal					WITS Data
Conduit	.064 cft/1f 5.793 #/1f	380,334 1ft	902	1,102	WITS Data Assume average diameter = 2-1/2 in.
Piping	.11 cft/1ft 15 #/1ft	558 cft + 550 tons + 298,027 1ft	1,534	2,823	WITS Data Assume average diameter = 4 in.

WASTE QUANTITIES QUARTERLY REPORT TABLE: 01/01/92 - 03/31/92					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
HVAC Ductwork	490 #/cft	333 ton	63	333	WITS Data Use 25% increase in volume because density gives vol. of solid block
Tanks	5 cyd/ton	995 ton + 1545 cyd	6,520	1,304	WITS Data Assume 3/8 in. plate
Misc. Equip. (process equipment, trucks, forklifts, etc.)	5 cyd/ton	80,778 cft + 7564 tons	40,812	8,162	WITS Data Used 5 cyd/ton as average
Furniture	20 cyd/ton	6,849 cft	254	13	WITS Data
Side/Roof Aluminum	156 #/cft	2,995 cft	111	234	WITS Data
Side/Roof Carbon Steel	490 #/cft	890 cft	33	218	WITS Data
Structural	490 #/cft	7,257 ton + 24 cft	1098	7,263	WITS Data
RR Rails	490 #/cft	293 ton + 364 cft	58	382	WITS Data
Paper	58 #/cft	43 cft	2	1	WITS Data

WASTE QUANTITIES QUARTERLY REPORT TABLE: 01/01/92 - 03/31/92					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
Porcelain	20 #/cft	356 cft	13	4	WITS Data
Underground Piping (Clay, Concrete, etc.)	.55 cft/1ft 54 #/1ft	64,240 1ft	1,309	1,734	WITS Data Assume average diameter = 12 in.
Wood (no grubbing or RR Ties)					
Furniture	20 cyd/ton	429 cyd	429	21	WITS Data
Solid	40 #/cft	1,649 cyd	1,649	890	WITS Data
TOTAL RUBBLE			223,596	330,486	

WASTE QUANTITIES QUARTERLY REPORT TABLE: 01/01/92 - 03/31/92					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
ROADS & EMBANKMENTS CLOSURE					
Raffinate Pits					
Bottom	1.52 ton/cyd	15,400 cyd	15,400	23,410	Mod 8 Estimate
Roads	1.52 ton/cyd	10,800 cyd	10,800	16,420	Mod 8 Estimate
Retention Pond	1.52 ton/cyd	1,830 cyd	1,830	2,780	50% of Mod 8 Estimate
Vicinity Property					
Femme Osage	1.52 ton/cyd	1,600	1,600	2,430	50% of Mod 8 Estimate
Southeast	1.52 ton/cyd	6,750	6,750	10,260	50% of Mod 8 Estimate
Army 5 & 6	1.52 ton/cyd	1,800	1,800	2,740	50% of Mod 8 Estimate
Chemical Plant					
Ash Pond Bottom	1.52 ton/cyd	4,000 cyd	4,000	6,080	Mod 8 Estimate
Frog Pond Bottom	1.52 ton/cyd	800 cyd	800	1,220	Mod 8 Estimate
Retention Pond Dikes	1.52 ton/cyd	25,900 cyd	25,900	39,370	50% of Mod 8 Estimate
Haul Roads	1.52 ton/cyd	16,400 cyd	16,400	29,930	50% of Mod 8 Estimate
Quarry Haul Road	1.52 ton/cyd	3,500 cyd	3,500	5,320	25% of Mod 8 Estimate
TOTAL ROADS AND EMBANKMENTS			88,780	139,960	

WASTE QUANTITIES QUARTERLY REPORT TABLE: 01/01/92 - 03/31/92					
MATERIAL	CONVERSION FACTOR	ORIGINAL AMOUNT	CONVERTED VOLUME (CYD)	CONVERTED WEIGHT (TON)	COMMENTS/REFERENCE
PERSONAL PROTECTIVE EQUIPMENT (PPE)		7,800 cyd	7,800		Based on 10 year estimate uncompacted. IOC Myers to Hixson May 1, 1991 Subject: Forecasted PPE Usage Quantities
CONTAINERIZED CHEMICALS		70 cyd	70		RCRA Waste 55 gal. = 7.5 ft^3 WITS
		293 cyd	293		Non-RCRA Waste 55 gal. = 7.5 ft^3 WITS
GRAND TOTAL			1,034,269	1,438,658	



TEST PITS, MONITOR WELLS AND BOREHOLES LOCATION MAP

FIGURE 2-1

REPORT NO.: MKES-3840R-7003	DRAWING NO.:	
CALCULATOR: ECT	DRAWN BY: RSC/AMA	DATE